(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
31 December 2014 (31.12.2014)

WIPO | PCT

(10) International Publication Number
WO 2014/206441 A1

(51) International Patent Classification:
D06F 58/20 (2006.01) *F28D 1/053* (2006.01)
D06F 58/24 (2006.01)

(21) International Application Number:
PCT/EP2013/063160

(22) International Filing Date:
24 June 2013 (24.06.2013)

(25) Filing Language: English

(26) Publication Language: English

(71) Applicant: **ELECTROLUX APPLIANCES AKTIEBOLAG** [SE/SE]; St Göransgatan 143, S-10545 Stockholm (SE).

(72) Inventor: **CAVARRETTA, Francesco**; Electrolux Italia S.p.A., Corso Lino Zanussi 30, I-33080 Porcia (PN) (IT).

(74) Agents: **NARDONI, Andrea** et al.; Electrolux Italia S.p.A., Corso Lino Zanussi 30, I-33080 Porcia (PN) (IT).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

(54) Title: HEAT PUMP LAUNDRY DRYER

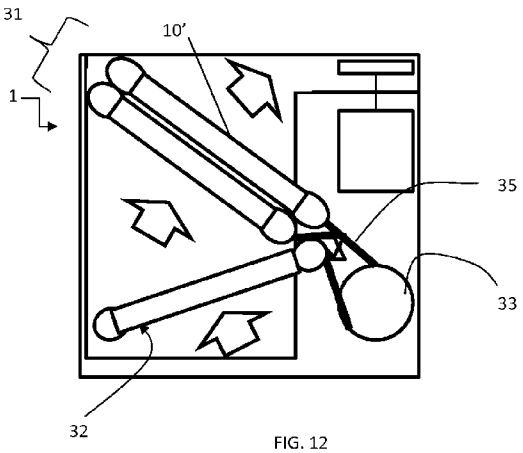


FIG. 12

(57) Abstract: The present invention relates to a laundry dryer (1) comprising a casing (2) supporting a drying chamber (3) for receiving a load to be dried; a process air conduit (11) in communication with the drying chamber (3) where a process air stream is apt to flow and including an air duct; and a heat pump (30) having a heat pump circuit in which a refrigerant (R) 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. The first and/or second heat exchanger are 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 and the first and/or second heat exchanger (31;32) further comprising a heat exchanger module (10; 10'). The module includes an inlet header (5;5') to direct a flow of said refrigerant into said module; an outer header (6;6') to discharge said refrigerant from said module; and a plurality of heat exchanger layers (8,8') fluidly connecting said inlet (5;5') to said outlet header (6;6') to enable said refrigerant (R) to flow from said inlet to said outlet header and/or vice versa; said layers (8,8') being stacked one on top of the others and each layer including a plurality of channels. Furthermore, said plurality of heat exchanger layers (8;8') is at least partially arranged inside said air duct and in that the inlet header and/or the outlet header of said module is located at least partially outside said air duct.

WO 2014/206441 A1

Heat pump laundry dryer

Field of the invention

The present invention relates to a laundry dryer including a heat pump, in particular to a laundry dryer which optimizes the energy consumption and/or the duration of the drying cycles.

Background art

Most dryers consist of a rotating drum called a tumbler, thus called tumble dryer, through which heated air is circulated to evaporate the moisture from the load. The tumbler is rotated around its axis.

Known laundry dryers include two categories: condense laundry dryers and vented laundry dryers. Dryers of the first category circulate air exhausted from the drum through a heat exchanger/condenser to cool the air and condense the moisture; they subsequently re-circulate the air back through the drum, after having heated the same using a heater. Dryers of the second category draw air from the surrounding area, heat it, blow it into the drum during operation and then exhaust it through a vent into the outside.

Generally, dryers of the first category are the most common in the market, due to the fact that they do not require special means for proper installation such as an exhaust duct to exhaust the humid hot air coming from the drum. However, commonly, for the same power and the same amount of load, the drying cycle of a condensed dryer is longer than an equivalent cycle in a vented dryer.

Several solutions have been proposed according to the prior art in order to improve the efficiency of condense and vented dryers. In particular, heat pump technology has been applied to laundry dryer in order to enhance the efficiency in drying clothes. In traditional heat pump drier, air flows in a close loop. The air, moved by a fan, passes through a drum removing water from wet clothes, and then it is cooled down and dehumidified in a heat pump evaporator and heated up in a heat pump condenser to be re-inserted into the drum. In order to function, the heat pump includes a refrigerant with which the air is in thermal exchange, and the refrigerant is compressed by a compressor, condensed in the condenser laminated in an expansion device and then vaporized in the evaporator.

EP 1209277 discloses a heat-pump clothes drying machine in which the motor used to drive the drum holding the clothes to be dried is also connected to a first fan, which circulates the drying air, as well as a second fan that cools the compressor.

US 2011/0280736 relates to a control method of a dryer. A control method of a dryer including a heat pump having a variable velocity type compressor, the control method includes steps of selecting at least one course supplying air or dried air; increasing an activation velocity of the compressor to a target velocity, as the selected course is implemented; and adjusting an open degree of an expansion valve provided in the heat pump.

Summary of the invention

The present invention is relative to a laundry dryer for drying clothes and other garments including a heat pump having a first and a second heat exchanger. The dryer of the invention may include either a vented or a condense dryer. The configuration and location of the heat exchangers in the laundry dryer of the invention is such that a high ratio between the heat transfer capacity and the heat exchanger volume is achieved. Therefore, in case the heat transfer capacity is kept constant with respect to prior art dryers, in the dryer of the invention more free space is available for the other dryer's components (e.g. compressor, motor, electronic board, etc.). For example, the amount of space occupied by the heat exchanger(s) in the casing of the dryer can be reduced without affecting the amount of exchanged heat. Alternatively, using the same space for the heat exchanger(s) as in the prior art, an improved heat transfer capacity is achieved in the dryer of the invention.

A heat pump dryer includes a drying chamber, such as a drum, in which the load, e.g., clothes, to be dried 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. More specifically, hot 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 of a 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 air circuit is then heated up before entering again in the drying chamber by means of a condenser 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.

The heat pump of the apparatus includes a refrigerant circuit in which a refrigerant can flow and which connects via piping a first heat exchanger or condenser, a 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, called 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.

In some embodiments, in the first and/or second heat exchanger, the refrigerant may not be subject to a phase transition.

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.

Applicants have considered a heat pump dryer wherein the first and/or the second heat exchanger of the heat pump includes one or more modules realized as follows. Each module includes two headers, which can be an inlet header to allow the inflow of refrigerant into the module and an outlet header to allow the refrigerant to discharge from the module. Further, the module includes a plurality of heat exchange layers stacked in a stackwise direction (e.g., the layers are disposed one on top of the other along a given direction). Each heat exchange layer includes more than one channel for the refrigerant flow, the channels being located one adjacent to the other(s) within the layer. The channels are in fluid communication with the inlet and/or the outlet header so that the refrigerant is allowed to flow from the inlet to the outlet header and/or vice versa. Preferably, the plurality of channels is parallel to each other within each heat exchanger layer. Each heat exchange layer defines two opposite ends, one of which is fixed to said either inlet or outlet header, the layers thus departing from the inlet and/or the outlet header.

As an example, each heat exchange layer includes an upper plate and a lower plate attached to each other, each of which is stamped or otherwise formed to partially define the lower or upper half of a plurality of internal channels, completely formed when the two plates are attached together.

Preferably, within each heat exchange layer, the plurality of channels is also substantially parallel to each other, however they can also be angled or they can have an irregular shape.

Preferably, the stackwise direction is a vertical direction and the heat exchange layers are stacked one on top of the other.

The heat exchange layers have a given width which depends on the number of channels realizing the heat exchange layer, and a longitudinal extension, which corresponds to the longitudinal extensions of the channels forming the same. The width and the longitudinal extension direction preferably define a plane. This plane might be perpendicular to the vertical stacking direction of the layers, or it can form an angle with the same. Alternatively, the layers may be tilted one with respect to the other or may form arches one on top of the other; the arches could be parallel to each other, e.g., having a constant distance one with respect to the other(s), or tilted.

Preferably, channels of neighboring heat exchange layers in the stacking direction are connected by fins.

It is to be understood that the inlet and outlet headers may be at a given distance from each other, so that the heat exchange layers are connected at their opposite ends to the inlet and outlet headers, respectively, e.g., the heat exchange layers are interposed between the inlet and the outlet headers, or the inlet and outlet headers can be located one in contact or adjacent to the other for example one on top of the other, so that the heat exchange layers are attached with one end to the inlet or to outlet header and with the opposite end to an intermediate header. In the first case, the refrigerant flows from the inlet to the outlet header bridging a single heat exchange layer, while in the second case from the inlet header the refrigerant has to flow through at least two heat exchange layers, one flowing in one direction and one flowing in substantially the opposite direction, in order to reach the outlet header.

The plurality of channels is subjected to, at least in part, the process air stream so that there is heat exchange between the refrigerant flowing within the channels and the process air. For this purpose, therefore, at least partially, preferably for their whole extension, the channels of the heat exchange layers of the modules of the first and/or second heat exchanger are located within the air duct, part of the process air circuit.

The headers have the function of holding the various heat exchange layers and as an inlet and/or outlet for the refrigerant into the module.

Due to the fact that the heat exchange takes place mainly in the channels forming the layers, and optionally in fins connecting the stacked layers, Applicants have realized that the headers occupy “useful space” within the air duct of the dryer, without providing any benefit from this positioning. In other words, the headers to not contribute in a relevant way to the heat exchange between refrigerant and process air. Applicants have therefore realized that the headers of the modules of either the first or the second – or of

both – heat exchanger, can be placed, at least partially, outside the air duct where the process air stream flows.

In a first aspect, the inventions relates to a laundry dryer comprising:

- a casing supporting a drying chamber for receiving a load to be dried;
- A process air conduit in communication with the drying chamber where a process air stream is apt to flow and including an air duct;
- A heat pump having a heat pump circuit 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; said first and/or second heat exchanger further comprising a heat exchanger module, said module including
    - An inlet header to direct a flow of said refrigerant into said module;
    - an outer header to discharge said refrigerant from said module; and
    - a plurality of heat exchange layers fluidly connecting said inlet to said outlet header to enable said refrigerant to flow from said inlet to said outlet header and/or vice versa; said heat exchange layers being stacked one on top of the others and each layer including a plurality of channels;

characterized in that said plurality of heat exchange layers is at least partially arranged inside said air duct and in that the inlet header and/or the outlet header of said module is located at least partially outside said air duct.

Placing the headers, or at least some (or one) of the headers outside the air duct, frees some space within the air duct itself. Therefore, the lateral width, e.g., the dimension substantially perpendicular to the air flow, of the duct itself can be reduced, for example by the amount which was occupied by the header now located outside the duct, without reducing the heat exchange capacity of the first and/or second heat exchanger. In this way, the other components present within the dryer can be more easily arranged in the casing of the layer and/or additional component(s) can find space in the casing as well. Alternatively, the lateral width of the air duct can be kept constant and the heat exchange layers can be lengthened of the amount which was occupied by the header now located outside the duct, thus increasing the heat transfer

capacity of the dryer, and at the same time without hindering the correct placement of other components in the air duct.

The air duct in which the modules are present can be in any location of the laundry dryer, depending on the layout of the same, and it can have any configuration, e.g., it can be straight, curved, realized integral to another portion of the casing of the laundry dryer or separated from the same; it may include further elements in addition to the modules of the heat exchangers or it may be empty otherwise, etc. The air duct has the function of a housing for the first and/or second heat exchanger and to direct the flow through the same.

Preferably, the air duct is air tight.

According to the aforementioned aspects, the dryer of the invention may include, alternatively or in combination, any of the following characteristics.

Preferably, each of said heat exchange layers includes a first and a second opposite ends, said first end being connected to said inlet header and said second end being connected to said outlet header.

In this embodiment, inlet and outlet headers are located at the two opposite ends of each heat exchange layer. The channels thus are transporting the refrigerant from the inlet to the outlet header directly.

Alternatively, said inlet and outlet header are located one on top of the other in said stackwise direction, each of said heat exchange layers includes a first and a second opposite ends, said first end being connected to said inlet or said outlet header and said second end being connected to an additional header.

The layout of the modules can change and different inlets and outlets can be present as well from the headers, e.g., a plurality of inlet and outlet headers can also be present for the same module. In this case, preferably, the inlet and outlet headers are stacked one on top of the other.

Preferably, said casing includes a basement. Said air duct, wherein said heat exchange layers are at least partially arranged, is realized in said basement.

In some dryers, the process air exits the chamber through an aperture realized in the boundary of a door of the casing and it bends downwards passing through a filter to collect lint. Furthermore, the process air bends again to flow within the basement of the casing, wherein there is generally available space to locate the heat exchanger(s) of the heat pump. In the basement, the air duct for the flow of the process air is preferably realized, to allow the process air to exchange heat with the heat exchangers, so that from humid it can turn hot and dehumidified in order to be redelivered within the chamber.

Different embodiments of air ducts are envisaged as well, for example the air duct and the heat exchangers can be located on top of the dryer, e.g., on top of the drying chamber; or it can be located on the basement like in the above described embodiment, however, differently from above, the process air exits the chamber through apertures realized in the uppermost region of the drying chamber and returns in the drying chamber via additional apertures realized in a lowermost region of the same.

In an advantageous embodiment, both said first and second heat exchangers include heat exchanger module, respectively called first and second heat exchanger module, the heat exchange layers of said first and second heat exchanger modules being located at least partially inside said air duct.

Preferably, both heat exchangers include modules having the headers and the plurality of stacked heat exchange layers. In this way, the heat transfer between the refrigerant and the process air is most efficient. In addition, also the space occupied by the heat exchangers is minimized, due to the modules' construction. The heat exchangers both exchange heat with the process air and thus they are both, at least partially, located within the air duct. More preferably, they are both located within the air duct realized in the basement of the dryer.

Preferably, said air duct includes a longitudinally straight portion wherein the heat exchange layers of said first and/or second heat exchanger modules are at least partially located.

The air duct realized in the dryer includes a straight portion to minimize the space occupied by it and to maximize the heat exchange between the process air and the modules. In addition to the straight portion, along the longitudinal extension of the duct, the air duct might include other portions as well, such as curved or bended portions. Alternatively, the air duct is straight for all its extension.

Preferably, the direction defined by the longitudinal extension of the heat exchange layers and the direction defined by the longitudinal extension of the straight portion of the air duct are substantially perpendicular one to the other, so that the air flow flowing parallel to the lateral walls of the air duct impinges on the heat exchange layers in a "frontal" manner.

In a preferred embodiment, both said first and second heat exchangers include the heat exchanger module, respectively called first and second heat exchanger module, and a first longitudinal direction of the heat exchange layers of said first module and a second longitudinal direction of the heat exchange layers of said second module are substantially parallel to each other.

More preferably, the first and/or second longitudinal direction is substantially perpendicular to the direction of flow of said process air inside said air duct.

It is preferable, in order to maximize heat exchange, that the process air stream flowing through the air duct "hits" the modules substantially in a perpendicular manner, i.e., in such a way that a vertical plane - defined by the module vertical and longitudinal extensions - and the direction of the process air stream within the air duct are substantially perpendicular. In this way, air turbulence is minimized and heat transfer maximized. For a process air stream flow, the preferred configuration is thus having two substantially parallel modules within the straight portion of the air duct. More preferably, these two modules are also perpendicular to the longitudinal extension of the air duct.

According to a different embodiment, both said first and second heat exchangers include the heat exchanger module, respectively called first and second heat exchanger module, and a first longitudinal direction of the heat exchange layers of said first module and a second longitudinal direction of the heat exchange layers of said second module form an angle between each other different from 0° and 180°.

The air flow within the air duct, regardless of the shape of the duct itself, is not always parallel to the air duct, for example it can enter the same forming an angle with the longitudinal extension of the latter. For the same reason above indicated, in this case it is preferable to place also the modules at a given angle with respect to the air flow, so that the modules are kept substantially perpendicular to the air flow direction. In addition or alternatively, in case the modules are tilted with respect to the longitudinal extension of the air duct, placing the modules at different angles can maximize the length of the heat exchange layers and thus maximize the heat exchange capacity, because the width of the duct is not any more the maximum extension available, the modules being positioned diagonally to it.

Advantageously, both said first and second heat exchangers include the heat exchanger module, respectively called first and second heat exchanger module. The said first module and said second module are both at least partially arranged inside said air duct, said air duct including first and second opposite lateral walls, and the inlet header or outlet header of said first module in proximity to said first or second lateral wall, and the inlet header or outlet header of said second module in proximity to the same of said first or second lateral wall, are located at least partially outside said air duct.

Preferably, both said inlet and said outlet header of said module of said first and/or said second heat exchanger positioned "on the same side" of the air duct, e.g., attached to the same either left or right wall, are located at least partially outside said air duct.

Even more preferably, all inlet and outlet headers of said first and said second heat exchanger are located outside said air duct.

In this way, the amount of saved space inside the air duct is maximized.

Advantageously, said air duct includes an upper portion and a lower portion connectable or connected to each other, and at least a lateral slot in said upper and/or lower portion in which said portion of said inlet or outlet header is inserted and from which said portion is apt to exit the air duct.

In this embodiment, the air duct has to be at least divided in two pieces which are then connected to each other in order to allow the insertion of the first and/or second heat exchanger. Moreover, due to the fact that a header has to protrude from the air duct outwardly, in order to make more space available from the air duct itself, a slot in one of the walls, e.g., in one or both upper and lower portions of the air duct, is preferably present.

More preferably, said air duct includes a sealing element apt to seal a gap formed between the slot and the inserted inlet or outlet header.

The header protruding from the air duct leaves a gap between the wall(s) of the air duct and the header itself. In order not to allow process air to exit the duct from such a gap, a sealing element is used to prevent this leakage.

According to a preferred embodiment, the outlet header of the module of the first heat exchanger is located at least partially outside said air duct and the laundry dryer further includes an additional fluid circuit where an additional fluid is apt to flow, located in such a way that the refrigerant flowing within the outlet header can exchange heat with said additional fluid.

Due to the fact that the header is placed outside of the air duct, it can be easily cooled down, using an additional fluid. Such a fluid can be for example air moved by a fan, condensed water or other fluids. The circuit can include a fan only, without any piping, with the name “circuit” simply indicating the movement of the fluid in a given direction. Alternatively, the circuit might be “designed” by the basement or casing itself which includes walls which confine the additional fluid motion. By cooling down the refrigerant present in or exiting the outlet header of the exchanger used as condenser (the header that collects the refrigerant before it leaves the condenser), it is possible to further cool down or to sub-cool the refrigerant flowing in the refrigerant circuit. In this way, the performance of the system can be increased and the working temperature in the heat pump can be kept relatively constant. This is an easy way to implement an “auxiliary condenser concept” without using an extra heat exchanger.

This additional fluid is not the process air.

In this embodiment, preferably the dryer includes a fan moving said additional fluid, said fan being located in such a way to cool down the refrigerant in or exiting the outlet header of the first heat exchanger.

Preferably, the fan is used to cool down only the outlet header. An air barrier or an insulating layer, suitably located, is preferably used to avoid that also the inlet header of the first heat exchanger is cooled by the fan.

The additional fluid in this preferred embodiment is air moved by a fan. The fan can be for example the same cooling fan already present in the dryer in order to cool down the compressor. Alternatively, in order to avoid compressor heating losses, a dedicated fan can be included in the dryer that cools down the refrigerant in or exiting the header without cooling down the compressor.

Preferably, the dryer also includes a temperature sensor apt to detect the temperature of the refrigerant flowing in said outlet header, said fan is apt to be commanded depending on the temperature sensed by said sensor.

The fan could for example operate in an on/off manner. A maximum temperature threshold can be selected, and the temperature of the refrigerant flowing inside the outlet header of the first heat exchanger, or of the refrigerant which has just exited the outlet header, is checked. In case such a temperature rises above the selected maximum temperature threshold, the fan is activated to cool the refrigerant.

Alternatively, the fan has a variable rotating speed which also depends on the detected temperature by the sensor, i.e., the higher the temperature of the refrigerant, the higher the rotational speed of the fan.

According to a preferred embodiment, the outlet header of the module of the second heat exchanger is located at least partially outside said air duct and the dryer further includes a second additional fluid circuit where an additional fluid is apt to flow, located in such a way that the refrigerant flowing within the outlet header can exchange heat with it.

In this embodiment, preferably the dryer includes a further fan moving said second additional fluid, said further fan being located in such a way to move said additional fluid so that it exchanges heat with the refrigerant in or exiting the outlet header of the second heat exchanger.

This even further fan is used to cool down the refrigerant exiting the second heat exchanger and directed towards the compressor. In this case, the additional fluid, which is preferably air moved by the fan, is warming up the refrigerant flowing towards the compressor and speed up the warm up process of the heat pump system. At the same time, due to the fact that the refrigerant is warmer before entering into the compressor, the risk of unwanted refrigerant droplets flowing into the compressor is minimized.

Outside the warming up phase of the heat pump, this further fan can be used to avoid overheating of the refrigerant and thus to cool down the same when it exits the module of the second heat exchanger.

This fan can also operate in an analogous manner than the fan described above with reference to the outlet of the first heat exchanger.

According to an advantageous embodiment, the cross-section of said inlet and/or said outlet header and/or said intermediate header is oblong, wherein its smallest diameter is smaller than a width of said layer.

Preferably, the headers of the heat exchangers' modules are oblong, e.g., they have an oval or rectangular cross section, in order to further reduce the internal volume of the exchangers, reducing space, and also in order to save some refrigerant. The refrigerant is indeed relatively expensive and it is preferred to minimize the same for a given heat exchange capacity. Moreover, the exchange surface (e.g., the total external surface of channels layers and fins which can enter into contact with the process air and exchange heat) can be increased since the portion of the process air duct used to locate the header is reduced, so the extension of the channels can be increased.

In one direction, the minimum dimension of the cross section of the inlet/outlet/intermediate header is fixed: it has to be wide enough to be connected to one end of the heat exchange layer and thus it has to be at least as wide as the heat exchange layer. In the perpendicular direction, however, the maximum width, or diameter, can be reduced below the layers' width.

More preferably, said cross section of said inlet and/or said outlet header and/or said intermediate header is oval or rectangular.

Advantageously, said channels have a hydraulic diameter smaller or equal than 5 mm.

According to an embodiment of the invention, the hydraulic diameter of each of the channel, where the hydraulic diameter D_H is defined as

$$D_H = \frac{4A}{P}$$

where *A* is the cross sectional area of the channel and *P* is the wetted perimeter of the cross-section of the channel, is smaller or equal than 5 mm, i.e. $D_H \leq 5$ mm, more preferably $D_H \leq 3$ mm, even more preferably $D_H \leq 1$ mm.

Due to the size of the hydraulic diameter, the module of the invention may include many channels, therefore the refrigerant flow is divided in a plurality of smaller refrigerant streams, one per channel. In this way the pressure drop of the refrigerant within the channels is reduced compared to the refrigerant pressure drop in bigger channels.

Additionally, it is known that the maximum pressure that a pipe can withstand is inversely proportional to its hydraulic diameter. A small hydraulic diameter therefore means that the channels can withstand higher pressures than bigger pipes. For this reasons, high pressures refrigerants, such as carbon dioxide, can be used in the heat pump circuit of the dryer of the invention.

Moreover, still due to the smaller size, a smaller amount of refrigerant is needed for the proper functioning of the module than in standard heat pump dryers. Use of hydrocarbons, which are flammable, can be therefore also considered, due to the low amount required.

The shape of the cross section of the channels is not relevant for the present invention, and it can be squared, rectangular, circular (in this case the hydraulic diameter coincide with the diameter of the circle), elliptic, and so on. The cross section of the plurality of channels does not have to be the same for all channels in the plurality, but it can be different and the various channels can have a combination of the possible above listed cross sections. In addition, the cross section may vary both in hydraulic diameter and/or in shape along the extension of the channel.

Preferably, said heat exchange layer includes a plurality of channels one parallel to the others.

Preferably, the channels extend along a direction which is substantially parallel to the horizontal plane and also perpendicular to the flow of the process air stream when the dryer is functioning. In other words, the channels, which preferably have a diameter much smaller than their length, extend from one header to another header in such a way that their longitudinal extension results substantially parallel to the horizontal plane and perpendicular to the flow of process air with which the heat exchange takes place.

In case the channels are rectilinear, their longitudinal extension (and longitudinal direction) corresponds to their longitudinal axis. In case the channels are not rectilinear, i.e. for example they are forming arches, their longitudinal extension (and longitudinal direction) corresponds to the line joining the point from which they depart from the inlet/outlet header and the first point having the maximum distance from the inlet/outlet header longitudinal axis.

The channels may include rectilinear portions and/or bumps or other turbulence-inducing elements that may enhance the heat transfer between the refrigerant and the air process stream. Additionally, channels may include smooth or corrugated inner and/or outer surfaces and may comprise bends or curves.

In a preferred embodiment of the invention, the channels are rectilinear. In an additional embodiment of the invention, the channels include a plurality of rectilinear portions connected to each other via U-bends. In this latter embodiment, the rectilinear portions are preferably stacked one on top of the other in a vertical direction. According to a different embodiment of the invention, the rectilinear portions are coplanar, more preferably in a plane parallel to the horizontal plane. According to a further embodiment,

the channels are bended forming an arch, their longitudinal extension being preferably still perpendicular to the process air flow. This latter embodiment is used in particular to place the module of the dryer of the invention in the most suitable location within the process air conduit. Indeed, it is known that there are portions of the process air conduit in which the process air flow is more uniform and less turbulent. Heat exchange between the process air flow and the refrigerant is therefore optimal in these locations. An arched channel allows the positioning of the module also in locations in which other objects are present or narrow thus in general to better exploit the available space and/or to reduce the limitations given by a not even distribution of the air flow.

Advantageously, said first heat exchanger includes more heat exchanger modules that said second heat exchanger.

Brief description of the drawings

These and other features and advantages of the invention will better appear from the following description of some exemplary and non-limitative embodiments, to be read with reference to the attached drawings, wherein:

- Fig. 1 is a schematic view, where some elements have been removed for clarity, of a laundry dryer according to the invention;
- Fig. 2 is a perspective view of a portion of an embodiment of the dryer of the invention of fig. 1 with the casing removed;
- Fig. 3 is a perspective view in section of an element of the dryer of fig. 1;
- Figs. 4a and 4b are a schematic front view and top view, respectively, of an embodiment of the heat exchanger module of the dryer of the invention of fig. 1;
- Figs. 5a and 5b are a schematic front view and top view, respectively, of a further additional embodiment of the heat exchanger module of the dryer of the invention of fig. 1;
- Figs. 6a and 6b are a schematic front view and top view, respectively, of an embodiment of connection between two heat exchanger modules of any of the examples of figs. 4a-4b to figs. 5a-5b;
- Figs. 7a and 7b are a schematic top view of a comparison laundry dryer and a laundry dryer of the present invention, respectively, according to a preferred embodiment of the invention;
- Figs. 8a and 8b are a schematic top view of a comparison laundry dryer and a laundry dryer of the present invention of fig. 1, respectively, according to an additional preferred embodiment of the invention;

- Figs. 9a, 9b and 9c are two schematic top views (9a & 9c) of a laundry dryer of the present invention of fig. 1, and of an enlarged detail thereof, 9b, according to two further additional preferred embodiments of the invention;

- Figs. 10a, 10b and 10c are schematic front view of three different embodiments of a heat exchanger module used in the laundry dryer of the invention of fig. 1;

- Fig. 11 is a schematic top view of a laundry dryer of the present invention of fig. 1, according to a further additional preferred embodiment of the invention;

- Fig. 12 is a schematic top view of a laundry dryer of the present invention of fig. 1, according to a further additional preferred embodiment of the invention;

- Fig. 13 is a schematic lateral cross section of a heat exchanger module used in the laundry dryer of the invention of fig. 1; and

- Fig. 14 is a schematic lateral view of an element of the laundry dryer of fig. 1.

Detailed description of the preferred embodiments of the invention

With initial reference to fig. 1, a laundry dryer realized according to the present invention is globally indicated with 1.

Laundry dryer 1 comprises an outer box casing 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 casing, 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, preferably hinged to casing, which can open and close an opening realized on the casing itself.

More in detail, casing 2 generally includes a front panel 20, a rear wall panel 21 and two sidewall panel all mounted on a basement 24. Panels 20, 21 and basement 24 can be of any suitable material. Preferably, the basement 24 is realized in plastic material. Preferably, basement 24 is molded.

Preferably, basement 24 includes an upper and a lower shell (in fig. 2 only the lower shell 24a is visible).

The dryer 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').

Laundry dryer 1 also comprises an electrical motor assembly 1a (visible in figs. 7b and 8b) for rotating, on command, revolving drum 3 along its axis inside casing. Casing 2, revolving drum 3, door and motor 1a are

common parts in the technical field and are considered to be known; therefore they will not be described in details.

Dryer 1 additionally includes a process air circuit 4 which comprises the drum 3 and an air process conduit 11, schematically depicted in fig. 1 as a plurality of arrows showing the path flow of a process air stream through the dryer 1. In the basement 24, air process conduit 11 includes an air duct 11a which is formed by the connection of the two upper and lower shells 24a. Air process conduit 11 is preferably connected with its opposite ends to two opposite sides of drum 3. Process air circuit 4 may also include a fan or blower 12 (see fig. 1) and an electrical heater (not shown in the figures).

The air duct 11a can be integral with the basement 24 as depicted in fig. 2, or it can be a different element attached to the same, as depicted in fig. 14. Moreover, the air duct 11a can be located not only in the basement 24, but also in correspondence of a top or lateral part within the casing 2 of the laundry dryer 1.

The dryer 1 of the invention additionally comprises a heat pump 30 including a first heat exchanger called also condenser 31 and a second heat exchanger called also evaporator 32. Heat pump 30 also includes a refrigerant closed circuit (schematically depicted in the picture with lines connecting the first to the second heat exchanger and vice versa, see in detail fig. 1) in which a refrigerant fluid flows, when the dryer 1 is in operation, cools off and may condense in correspondence of the condenser 31, releasing heat, and warms up, potentially even evaporating, in correspondence of the second heat exchanger (evaporator) 32, 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.

More in detail, the heat pump circuit connects via piping 35 (visible in figs. 7b or 8b) the second heat exchanger 32 where the refrigerant warms up and may undergo a phase transition from the liquid to the vapor via a compressor 33 to the first heat exchanger 31, in which the refrigerant cools off and may condense again. The cooled or condensed refrigerant arrives via an expansion device 34, such as a choke, a valve or a capillary tube, back at the evaporator 32.

The condenser 31 and the evaporator 32 of the heat pump 30 are located in correspondence of the process air conduit 11. More preferably, they are located in correspondence of the air duct 11a, for example of basement 24, at least partially.

In case of a condense dryer – as depicted in fig. 1 – where the air process circuit 4 is a closed loop circuit, the condenser 31 is located downstream of the evaporator 32. The air exiting the drum 3 enters the conduit 11 and reaches the evaporator 32 which cools down and dehumidifies the process air. The

dehumidified cool process air continues to flow through the conduit 11 till it enters the condenser 31, where it is warmed up by the heat pump 30 before re-entering the drum 3.

A lint filter 103 to block the lint is preferably present in the dryer 1. The lint filter 103 is preferably located before the process air reaches the evaporator 32, e. g., when it exits the drum 3.

First and/or second heat exchanger 31, 32 further include – according to a characteristic of the invention - one or more heat exchanger modules 10 located along the process air conduit 11. In particular, the first and the second heat exchangers 31 and 32 are located in the air duct 11a. Thus the preferred location of the air duct 11a within the casing 2 is a volume of the same where enough space is available to host the modules 10.

With now reference to fig. 2, the basement 24 of a dryer 1 showing a plurality of modules 10 included in the evaporator 32 and in the condenser 31 of the heat pump 30 according to the invention is depicted. In the mentioned figures, the casing 2 and the drum 3 of the dryer 1 have been removed in order to show the heat exchangers located along the process air conduit 11, more specifically in air duct 11a. As stated above, although in the appended drawings both evaporator 32 and condenser 31 of the dryer 1 includes heat exchanger modules 10, it is to be understood that the evaporator 32 only or the condenser 31 only might include such module(s) 10. In addition, a single module 10 can be included in either evaporator 32 or condenser 31. Moreover, in case both evaporator and condenser include more than one module 10 according to the invention, the evaporator can include a different number of modules from the condenser (as per the appended figure 2 where the evaporator 32 includes two modules 10 and the condenser four modules 10). Preferably, the condenser 31 includes more modules than the evaporator 32. In case more than one module is included, the modules can be identical or different.

The structure of a single module 10 will be now be described, with reference to the different embodiments depicted in fig. 3, from figs. 4a-4b to figs .5a-5b and figs. 10a-10c.

A heat exchanger module 10 includes an inlet header 5 and an outlet header 6. Inlet and outlet headers 5,6 have preferably the structure of a pipe. The headers have a longitudinal extension along an axis, which corresponds to the main direction of flow of the refrigerant within the headers. The refrigerant is flowing into the module 10 via the inlet header 5 and exiting the same via the outlet header 6. A plurality of channels, each indicated with 7, is fluidly connecting the inlet to the outlet header and vice versa, so that the refrigerant can enter and exit the module. The plurality of channels is subject to the flow of process air, i.e., channels 7 are located within the air duct 11a of the dryer 1. The channels 7, due to their configuration, allow a better heat exchange between the refrigerant and the process air than known dryers.

Channel 7 defines a longitudinal direction X along which it extends, which correspond to the longitudinal extension of the heat exchange layer 8. Preferably, the channels 7 are mounted in the module 10 so that their longitudinal extension X is substantially perpendicular to a process air flow direction and substantially parallel to the horizontal plane. In other words preferably, when mounted, the longitudinal direction X lies on a plane parallel to the (X',Y') plane defined by the dryer 1.

Preferably, the refrigerant flow within channels 7 is substantially perpendicular to the process air flow. However, depending on the direction of the process air flow, the direction of the process air stream and the direction of the refrigerant flow can form an angle therebetween.

The channels 7 are grouped in heat exchange layers 8: each heat exchange layer includes a plurality of channels 7 which are preferably adjacent and parallel to each other. More preferably, each module 10 includes a plurality of heat exchange layers 8, more preferably all heat exchange layers 8 are stacked one on top of the other in a stackwise direction Z and even more preferably parallel to each other, substantially forming a plurality of parallel rows. Preferably the stackwise direction is the vertical direction, i.e., Z and Z' are parallel to each other.

According to an embodiment of the invention, heat exchange layer 8 includes a single tube, having for example an elongated cross section, including two substantially parallel flat surfaces 9a,9b. Within the tube, separators 8a are realized in order to longitudinally divide the interior of the tube in the plurality of channels 7. Such a structure is schematically depicted in the cross section of a heat exchange layer 8 of fig. 13. The cross section of the single channel 7 can be arbitrary. Each heat exchange layer 8 has a width W which depends on the number of channels which are located one adjacent to the other (see figures 4b and 5b).

Preferably, each couple of adjacent stacked heat exchange layers 8 is connected via fins 50. Preferably the upper surface 9a of a heat exchange layer 8 is connected via the plurality of fins 50 to the lower surface 9b of the adjacent heat exchange layer 8.

The width W of the layer 8 defines a direction Y which, together with the longitudinal direction X of channels 7 defines a heat exchange layer plane (X,Y). The heat exchange layer plane (X,Y) might be, when the module is mounted on the dryer, either parallel to the horizontal plane (X',Y') defined by the dryer 1 or tilted with respect to the same. Alternatively or in addition, the heat exchange layer plane (X,Y) can be perpendicular to the stackwise direction Z or form an angle with the same. Moreover, each heat exchange layer 8 can also be not planar, but for example curved, e.g., having a concavity pointing either up or down along the stackwise direction.

As an example, in fig. 3 a section of a header 5,6 is represented. The header 5,6 includes a cylindrical envelope 107 in which a plurality of holes 7a are realized, the channels 7 forming a heat exchange layer 8 being inserted therein. However different configurations are possible, as better detailed below.

According to a characteristic of the invention, visualized in figs. 10a-10c, the cross section of the headers 5,6 is circular, or preferably oblong. The cross section of the header refers to the cross section of the header along a plane perpendicular to the stackwise direction Z. Preferably, the oblong cross section is such that its smallest diameter, i.e., the smallest cord passing through the geometrical center of the cross section, is smaller than the width W of the heat exchange layer 8. In this way, as shown in the figures 10b and 10c, the cross section includes a "long side" 105 on which the heat exchange layer's 8 end can attach, and which has to have at least a width equal to (or wider than) W, and a "shorter side" 106 realized in order to minimize space. In fig. 10b, the cross section of the header 5,6 is an oval, in figure 10c a rectangle. However, a single module 10 may also include a header 5,6 having a given cross section and the other header 5,6 having a different cross section.

The refrigerant entering the module 10 via the inlet header 5 can come from the outlet header 6 of another module 10, from the compressor 33 or from the expansion device 34. Additionally, the refrigerant exiting the outlet header may be directed towards the inlet header 6 of another module 10, towards the expansion device 34 or towards the compressor 33. The connection between the compressor 33, modules 10 and expansion device 34 and between modules is made via piping 35, as it can be seen in figures 7b and 8b. In the following figures, the flow of the refrigerant R will be indicated with a dotted line having a pointing arrow in the direction of the flow.

The heat exchange layers 8 includes two opposite ends 8b,8c. In some embodiments, one end 8b is connected to the inlet header 5 and the opposite end 8c is connected to the outlet header 6. Alternatively, an additional intermediate header can be present, as detailed below.

According to a first specific embodiment of the module 10 of the dryer 1 of the invention depicted in figs. 4a and 4b, the two headers 5,6 are mounted vertically (i.e. their axis Z is the vertical axis Z' of the dryer 1) on the basement 24 of the dryer 1, parallel one to the other, and the channels 7 connecting the two headers 5,6 are substantially straight along the longitudinal direction X. Channels 7 are divided in heat exchange layers 8, each of which includes a different tube defining upper and lower surfaces 9a,9b (see fig. 14) within which the channels 7 are realized. A plurality of heat exchange layers 8 connects the inlet 5 to the outlet header 6, all layers having a first end 8b and a second end 8c longitudinally opposite to each other, the first end being connected to the inlet header and the second end being connected to the outlet header. Heat exchange layers are stacked one on the other along the vertical direction forming a plane (Z,X) defined by the longitudinal extension X of the channels 7 and the direction of stacking Z. This plane is

perpendicular to the horizontal plane (X',Y') and to direction of flow of process air as clear from figs. 4a, 4b. In addition, each heat exchange layer has a width direction Y perpendicular to the longitudinal extension X of the channels 7. In the present embodiment, this width direction Y is parallel to the horizontal plane (X',Y') and the air flow direction; i.e., the layer planes (X,Y) are horizontal (parallel to the horizontal plane (X',Y')). In other words, the module 10 is mounted so that the heat exchange layers 8 form parallel planes between which the process air flows. In each header 5,6, in correspondence of each heat exchange layer's end 8b,8c, a plurality of apertures 7a is realized, in each aperture 7a a channel 7 being inserted. The so-formed rows of apertures 7a (see fig. 5) are parallel one to the other and perpendicular to the longitudinal extension Z of the header 5,6.

The refrigerant enters the inlet header 5 of module 10 via an inlet aperture 5in along a flow direction parallel to the longitudinal extension Z of header 5 and branches off into the various channels 7 via apertures 7a. The heat exchange layers 8 are "parallel" to each other according to the refrigerant flow direction. In each channel 7, the flow of the refrigerant is substantially parallel to the flow direction of the refrigerant in the other channels and has the same direction. The refrigerant then exits the module via an outlet aperture 6out of outlet header 6.

The direction of flow of refrigerant in the headers 5,6 is perpendicular to the process air flow. In addition, the flow of the refrigerant in the inlet header is parallel to the flow of the refrigerant in the outlet header, but with opposite direction.

In a different embodiment, not depicted, the refrigerant flow in the inlet and in the outlet header can also be parallel and have the same direction.

According to another embodiment of the module 10 of the present invention, depicted in figs. 5a and 5b, one of the two headers includes a transversal separator 17 which divides the header in two separated portions. In other words, there are still two parallel vertical headers connected by parallel heat exchange layers 8, but one of the headers is divided in two and the first portion represents the inlet header 5, while the second portion is the outlet header 6. The second header 5a is an intermediate header for the refrigerant flow. The flow of refrigerant entering the header 5 is therefore prevented by separator 17 to go from the first to the second portion 5,6 of the header. The heat exchange layers 8 are thus divided in two groups: the first group G1 connects the first portion 5 (the inlet header 5) to the intermediate header 5a and the second group G2 connects the intermediate header 5a to the second portion, outlet header 6.

The refrigerant flow which enters the first portion 5 (the inlet header 5) in a vertical Z direction is distributed via apertures 7a into the first group G1 of heat exchange layers 8 and the refrigerant flows within the parallel channels in the first group G1 towards the intermediate header 5a. Therefore, the heat exchange layers within the first group G1 are parallel with respect to the refrigerant flow. The refrigerant

streams exit the first group G1 of heat exchange layers 8 and enter the intermediate header 5a, where they merge. From the intermediate header 5a, the refrigerant flow then enters the second group G2 of heat exchange layers 8 reaching the outlet header 6. Thus, also the heat exchange layers within the second group G2 are parallel to each other with respect to the refrigerant flow. However the layers of the two groups G1, G2 are in series with respect to the refrigerant flow. Indeed, the refrigerant flows in parallel in all layers belonging to the same group, while it has to flow through the layers of first and the second group in a given order – the layers of the two groups being thus in series.

The connection between modules can be made according to the invention as follows. Referring to figs. 6a and 6b, a first and a second module 10, 10' are connected to each other. These two modules can for example both belong to the condenser 31, as depicted in the schematic drawings of figs. 7b and 8b. The two modules are realized parallel one to the other and one in front of the other in the direction of flow of the process air, both substantially perpendicular to the horizontal plane. Both modules have heat exchange layers 8,8' which are parallel to the horizontal plane. The refrigerant flow enters the inlet header 5 of the first module 10, it divides within the plurality of channels 7 and the various streams merges in the outlet header 6. The refrigerant exits the first module 10 via the outlet header 6, thus entering the inlet header 5' of the second module 10'. In the second module 10', again the refrigerant flow travels through the plurality of channels 7' and exits the second module via the outlet header 6' of the second module. In this case, therefore, the modules 10,10' are in series with respect to the process air flow and in series with respect to the refrigerant flow.

Alternatively, many other different connections can be realized.

With now reference to figs. 7b and 8b, where a simplified top view of the basement 24 of the laundry dryer 1 is shown, according to the invention, at least one of the module 10 of the first and/or of the second heat exchanger and more preferably both a modules 10 of the first and a module 10' of the second heat exchanger are located at least partially within the air duct 11a, as said above. Due to the fact that the heat exchange between the process air and the refrigerant take place in correspondence to the surface of the heat exchange layers 8,8' and of the fins 50, the heat exchange layers 8,8' and fins 50 are preferably completely located within the air duct 11a, so that the heat exchange is maximized. According to the invention, at least one header 5,6,5a of one module 10,10' is located – at least partially - outside the air duct 11a.

In order to locate modules 10, 10' inside the air duct 11a, air duct 11a is preferably "openable", e.g., it includes an upper and a lower portion 111, 112 which can be assembled after the modules 10,10' have been inserted. Upper and lower portion 111,112 can be integral with the basement or anyhow with a portion of casing 2, or can be separated elements as depicted in fig. 14.

Modules 10,10' are inserted within air duct 11a preferably in such a way that the process air (depicted as an arrow in fig. 14) flow passes through the heat exchange layers 8, 8' and it is substantially parallel to the layers itself. Preferably, the modules are mounted perpendicular to the air flow, i.e., the stackwise direction is substantially perpendicular to the process air flow direction.

In a preferred embodiment, the air duct 11a includes a straight portion 118 (see fig. 14), i.e., in the horizontal plane the air duct extends rectilinearly at least for a given length. As shown, the air duct 11a is straight for all its extension. Other configurations are possible, e.g., the air duct 11a may include curvilinear portions as well, such as an arc or bend (not shown in the appended drawings), to better follow the natural path of the process air stream entering the duct.

In case of an air duct 11a having a straight portion, preferably the process air flow entering the same is flowing substantially parallel to the straight portion itself, e.g., the air duct 11a includes an inlet 113 for the process air, an outlet 114 for the same and opposite lateral walls 117 (only one visible in fig. 14) parallel to which the process air can flow. The modules 10, 10' are thus preferably located substantially perpendicularly to the lateral walls 117. Moreover, in the appended drawings, the air duct 11a is parallel to the sidewall of casing 2. It is to be understood that the air duct 11a can also be diagonally placed within the basement 24.

In a preferred embodiment, shown in figs. 7b and 8b, all modules 10,10' of both evaporator 32 and condenser 31 adjacent or in proximity to the same side of the air duct 11a are located at least partially outside the air duct 11a. However, in other embodiment, not shown, only the headers 5,6 of the modules 10,10' of the condenser located in correspondence to the same side (e.g., of the same lateral wall 117) of the air duct 11a are positioned at least partially outside the air duct 11a. Alternatively, only the headers of the modules of the evaporator located in correspondence to the same side of the air duct 11a are located at least partially outside the air duct 11.

Alternatively, all headers 5,5a,6 of all modules 10,10' of all heat exchangers 31,32 are located outside the air duct 11a, at least partially.

In order to locate the header 5,6, or at least a portion of the same, outside the air duct 11a, a slot 115 is preferably realized in the air duct itself in order to allow for the header to protrude. Preferably, the slot is realized in correspondence of the lateral wall 117. More preferably, in the air duct 11a, a number of slots 115 equal to the number of headers 5,6 located outside the duct is formed. Slot 115 can be cut in the upper or in the lower portion 111,112 of air duct, or in correspondence to both, depending on the design of these two portions.

In order to avoid that the process air comes out from the slot(s) 115 realized in the air duct, a sealing element, such as gasket or sponge material, is located in correspondence of each gap present between the protruding header 5,6,5a and the wall 117 to close the same (not visible in the figures).

Locating one or more of the headers 5,6 of modules 10,10' outside the air duct 11a means that, in the direction of the longitudinal extension of the layers X, inside the air duct, a length equal to the diameter of the header (or a length smaller than the diameter if only a fraction of the header is located outside) in that direction is "free", compared to a dryer in which a header having the same diameter is completely located inside the air duct 11a. A volume of air duct 11a having a width equal to the diameter of the header along the X direction, a length equal to the length of the whole air duct and a height equal to the height of the air duct becomes usable in a different way.

Thus, considering a comparison dryer $1_{comparison}$ depicted in fig. 7a and 8a, the following alternatives arise.

In order to obtain a dryer of the invention 1 having the same heat exchange capacity as the comparison dryer $1_{comparison}$, the width of the air duct 11a can be made narrower with respect to the air duct of the comparison dryer. This is the solution chosen comparing figs. 8a and 8b. The heat exchange capacity remains the same, due to the fact that the same extension of heat exchanging surface is present in the comparison and the invention dryer: the same channels and fins having the same length are present inside the air duct 11a of dryer $1_{comparison}$ and invention dryer 1. Thus, outside the air duct 11a, narrower in the dryer of the invention 1 than in the comparison dryer $1_{comparison}$, more volume is available for the other elements and devices which have to be located inside the dryer.

As it can be seen in the drawings 7b, 8b, the process air stream, indicated with the arrow "air", is exchanging heat with the refrigerant flowing into the modules 10. The surface in which heat exchange takes place is substantially the same with the headers 5(6) located outside or inside the air duct 11.

Alternatively, comparing now figures 7a and 7b, the dryer 1 of the invention keeps an air duct 11 having the same width as the comparison duct of dryer $1_{comparison}$. In this way, the heat exchange capacity of the dryer of the invention is increased: the length of the channels and thus of the heat exchange layers is longer than in the comparison dryer, so there is a broader heat exchanging surface, being a "segment" of air duct 11a equal to the diameter of the header header-free and thus it can be occupied by longer heat exchange layers.

With now reference to fig. 11, the cross section of the header 5,6 located inside or outside the air duct 11a is not relevant for this aspect of the invention, any header having any type of cross section can be located outside the air duct 11. For an already "space-minimizing" header, such as the oblong header of figs. 10b or 10c, as also shown in fig. 11, placing the header outside the air duct allows to recover less space than in

case of a circular header, for example, however the reasoning above still apply. In this case, also the space outside the air duct 11a occupied by the header is minimized, due to the small volume occupied by an oblong header.

Preferably, the type of module 10,10' used in the heat exchangers 32,31 of figs. 7b and 8b is the one depicted with reference to the embodiment of fig. 5a,5b, thus the inlet and the outlet headers 5,6 are vertically stacked one on top of the other in the same stacking direction as the heat exchange layers 8. Thus if the inlet header 5 is located outside the air duct 11a, automatically in this embodiment also the outlet header 6 is located outside as well, and vice versa. However, also intermediate header 5a can be located outside air duct 11a.

In a preferred embodiment, the modules 10,10' of the first and of the second heat exchanger 32,31 are shown substantially parallel to each other, in other words the longitudinal extension X of a heat exchange layer of a module is substantially parallel to the longitudinal extension X of a heat exchange layer of another module. In this embodiment, preferably, the heat exchange layers 8 of all modules 10 are all extending all along the same X direction which is substantially perpendicular to the longitudinal extension Y of the air duct 11a. This configuration is preferred when the process air stream flowing within the air duct is substantially perpendicular to the X direction. However, this is not always the case, for example, due to the path that the process air has to follow from the drying chamber to the air duct, it may enter the latter at a given angle. In this case, having substantially parallel modules may not be the optimal configuration.

According to an embodiment of the invention, as shown in fig. 12, the process air enters the duct 11 at a given angle. The modules 10,10' belonging to the first and the second heat exchanger 32, 31, or to the same first or second heat exchanger when the latter includes more than one module, are arranged in such a way that they are inclined towards each other, in other words, the longitudinal extensions of the heat exchange layers 8 of the modules 10,10' are not parallel to each other, but form an angle which is different from 0° (and π multiples thereof). Preferably, thus, the modules 10,10' "follow" the path of the process air stream inside the air duct 11a, so that the process air always "hits" the module perpendicularly to the stackwise direction. Preferably, the modules are inclined with respect to each other and also in respect of the longitudinal extension of the air duct, allowing the use of longer module 10, 10' than in the embodiment in which the modules 10,10' are arranged perpendicular to the longitudinal extension of the air duct 11a.

According to a different aspect of the invention, as depicted in figs. 9a, 9b and 9c, preferably an additional heat exchange takes place between the refrigerant flowing within one of the header 5,6 located outside the air duct 11 and an additional fluid, different from the process air. The additional fluid may flow in an additional circuit, which does not need to be confined, e.g., a circuit simply indicates a direction of forced

flow of the fluid. Alternatively, the casing and/or basement of the dryer defines a conduit for the flow of such an additional fluid by walls or elements positioned in the same.

In a first embodiment depicted in fig. 9a, preferably, the header wherein the additional heat exchange takes place is the outlet header 6 of the condenser 31, before the refrigerant enters the expansion device 34. Cooling the refrigerant present within, or at the exit of, the header further decreases the temperature of the refrigerant, increasing the performances of the heat pump.

As depicted in figs. 9a and 9b, the additional fluid can be air, moved by a first fan 51. Preferably, the additional fluid is air coming from the outside of the casing 2. Alternatively, the additional fluid is air already present within casing 2. The first solution is preferred, being the external, ambient, air generally cooler than the air already present in the casing. According to the shown embodiment, the first fan 51 is a dedicated fan mounted in the basement 24 and directed towards the header 6. Preferably, the dimensions of the fan 51 are such that the whole outlet header 6 is subjected to a flow of additional air blown by the fan. Alternatively, a fan of the compressor (not shown) can be used to both cool down the compressor itself and the header 6.

In the embodiment of fig. 9a, inlet and outlet header 5,6, of the first heat exchanger are separated one from the other, but rather close in spatial distance. Therefore, care should be taken not to blow the additional fluid towards the inlet header 5 so that the refrigerant entering the condenser 31 is cooled, decreasing the performances of the heat pump. For this purpose, the inlet header 5 can be either insulated or a fluid deflector (not shown) can be placed in front of the same, so that the additional fluid is diverted away before it hits the inlet header of the condenser 31.

As shown in fig. 9b, in an alternative embodiment, the outer header 6 of the condenser's module is located on top of the inlet header 5 (alternatively, in another non-depicted embodiment, the inlet header can be located on top of the outer header). In this case, due to the close contact, it is preferable to avoid to direct the flow of additional fluid also towards the inlet header 5 of the condenser's module. For this purpose, the inlet header can be either insulated, for example by applying caulking, or a fluid deflector (not shown) can be placed in front of the same, so that the additional fluid is diverted away before it hits the inlet header.

In a different embodiment of the invention, depicted in fig. 9c, in addition or alternatively with respect to the heat exchange which takes place between the refrigerant first fan 51, preferably an even further heat exchange takes place between the refrigerant flowing within or exiting the outer header 6 of module 10 of evaporator 32. As depicted in fig. 9c, the heat exchange takes place between a further additional fluid and the refrigerant. The further additional fluid can for example be air, moved by a second fan 51a. More preferably, the further additional fluid is air coming from the outside of the casing 2. Alternatively, the further additional fluid is air already present within casing 2.

According to the shown embodiment, the fan 51a is a dedicated fan mounted in the basement 24 and directed towards the header 6. Preferably, the dimensions of the fan 51a are such that the whole outlet header 6 is subjected to a flow of additional air blown by the fan. The characteristics of this second fan 51a are preferably those already outlined with respect to the first fan 51.

The second fan 51a is preferably put into operation, i.e., it forces air towards the outlet header 6 of evaporator's 32 module 10, when the heat pump system is in the warming-up phase. Indeed, when the heat pump 30 is switched on, there is an initial phase in which the refrigerant has to be heated in the evaporator 32 in order to evaporate before entering into the compressor. A complete evaporation of the refrigerant avoids or at least minimizes the risk of droplets of refrigerant entering in the compressor and also speeds up the warming-up phase.

For this purpose, the second fan 51a blows air, which is at least at room temperature if not at higher temperature due to the heat releasing elements located in the casing (e.g., engine, heat pump, etc.), onto the header 6 at the outlet of refrigerant from the evaporator 32, before the refrigerant enters in the compressor, so that the blown air warms up the refrigerant.

Preferably, when the heat pump 30 has reached the steady state, the second fan 51a is switched off.

Alternatively or in addition, the second fan 51a is also used to prevent over-heating of the evaporator 32. As mentioned, it is preferred that all the refrigerant evaporates into the evaporator before entering the compressor, thus heating is provided to obtain the complete evaporation. It may happen that the refrigerant is over-heated and a relatively very high temperature is reached, which can damage some components of the heat pump. Therefore, in such cases, the second fan 51a can be activated in order in this case to cool down the refrigerant flowing in the outlet header 6 of evaporator 32.

Additionally, also the evaporator's module 10 can have the same configuration shown in fig. 9b, where the outer header 6 of the evaporator's module 10 is located on top of the inlet header 5 (alternatively, in another non-depicted embodiment, the inlet header can be located on top of the outer header). It is preferable to avoid directing the flow of the further additional fluid also towards the inlet header 5 of the evaporator's module. For this purpose, the inlet header can be either insulated, for example by applying caulking, or a fluid deflector (not shown) can be placed in front of the same, so that the further additional fluid is diverted away before it hits the inlet header.

According to a preferred embodiment not shown in the pictures, first and/or second fan 51, 51a are regulated depending on measurements obtained via respective temperature sensors (not depicted in the drawings). For example, a first temperature sensor is associated to the first fan 51, the temperature sensor being apt to measure the temperature of the refrigerant at or in proximity of the outlet header 6 of

condenser 31, before the refrigerant enters the expansion device 34. Preferably, a first temperature threshold is set, so that, if the temperature sensor detects a temperature higher than such first threshold, the first fan 51 is put into rotation and air is blown towards the outlet header 6 of the condenser's module. In case the temperature decreases below the same or below a second temperature threshold, then the fan is stopped.

Alternatively, the first fan 51 can include a variable speed motor, so that, if the temperature sensor detects a temperature higher than the first threshold, the first fan 51 is put into high speed rotation, while a low speed rotation is kept otherwise.

The second fan 51a can be controlled in cooperation with a second temperature sensor checking the temperature of the refrigerant within or exiting the outlet header of the evaporator 32 upstream of the compressor 33. The second fan 51a can be controlled in an on/off manner, for example – in order to avoid overheating – the second fan can be put into operation when the temperature of the refrigerant is above a third threshold, and stopped otherwise. In the warming-up phase, on the contrary, the second fan 51a is operated when the temperature of the refrigerant is below a fourth threshold, and it is stopped when the temperature of the refrigerant, measured by the second temperature sensor, is high enough.

Claims

1. A laundry dryer (1) comprising:

   - a casing (2) supporting a drying chamber (3) for receiving a load to be dried;
   - A process air conduit (11) in communication with the drying chamber (3) where a process air stream is apt to flow and including an air duct (11a);
   - A heat pump (30) having a heat pump circuit in which a refrigerant (R) 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; said first and/or second heat exchanger (31;32) further comprising a heat exchanger module (10; 10'), said module including
     - An inlet header (5;5') to direct a flow of said refrigerant into said module;
     - an outer header (6;6') to discharge said refrigerant from said module; and
     - a plurality of heat exchange layers (8,8') fluidly connecting said inlet (5;5') to said outlet header (6;6') to enable said refrigerant (R) to flow from said inlet to said outlet header and/or vice versa; said layers (8,8') being stacked one on top of the others and each heat exchange layer including a plurality of channels;

   characterized in that said plurality of heat exchange layers (8;8') is at least partially arranged inside said air duct and in that the inlet header (5) and/or the outlet header (6) of said module (10,10') is located at least partially outside said air duct (11a).

2. The laundry dryer (1) according to claim 1, wherein each of said heat exchange layers (8,8') includes a first and a second opposite ends (8b,8c), said first (8b) end being connected to said inlet header (5) and said second end (8c) being connected to said outer header (6).
3. The laundry dryer (1) according to claim 1, wherein said inlet and outlet headers (5,6) are located one on top of the other in said stackwise direction, and each of said heat exchange layers (8,8') includes a first and a second opposite ends (8b,8c), said first end (8b) being connected to said inlet or said outlet header (5,6) and said second end (8c) being connected to an additional header (5a).

4. The laundry dryer (1) according to any of the preceding claims, wherein said casing (2) includes a basement (24), wherein said heat exchange layers (8,8') are at least partially arranged, and said air duct (11a) is realized in said basement (24).
5. The laundry dryer (1) according to any of the preceding claims, wherein both said first and second heat exchangers (31,32) include the heat exchanger module (10,10'), respectively called first and second heat exchanger module (10,10'), the heat exchange layers (8,8') of both said first and of said second heat exchanger modules being located at least partially inside said air duct (11a).
6. The laundry dryer (1) according to any of the preceding claims , wherein said air duct (11a) includes a longitudinally straight portion (118) wherein the heat exchange layers (8,8') of said heat exchanger module (10,10') are at least partially located.
7. The laundry dryer (1) according to any of the preceding claims, wherein both said first and second heat exchangers (31,32) include the heat exchanger module (10,10'), respectively called first and second heat exchanger module (10,10'), and a first longitudinal direction (X) of the heat exchange layers (8,8') of said first module and a second longitudinal direction (X) of the heat exchange layers (8,8') of said second module are substantially parallel to each other.
8. The laundry dryer (1) according to claim 8, wherein said first and/or second longitudinal direction (X) of said heat exchange layers (8,8') is substantially perpendicular to a direction of flow of said process air inside said air duct (11a).
9. The laundry dryer (1) according to any of the preceding claims, wherein both said first and second heat exchangers (31,32) include the heat exchanger module (10,10'), respectively called first and second heat exchanger module (10,10'), and a first longitudinal of the heat exchange layers (8,8') of said first module and a second longitudinal direction of the heat exchange layers (8,8') of said second module form an angle between each other different from 0° and 180°.
10. The laundry dryer (1) according to any of the preceding claims, wherein both said first and second heat exchangers (31,32) include the heat exchanger module (10,10'), respectively called first and second heat exchanger module (10,10'), and both said first module (10,10') and said second module (10,10') are at least partially arranged inside said air duct (11a), said air duct including first and second opposite lateral walls (117), and the inlet header (5) or outlet header (6) of said first module in proximity to said first or second lateral wall (117), and the inlet header (5) or outlet header (6) of said second module in proximity to the same of said first or second lateral wall (117), are located at least partially outside said air duct (11a).
11. The laundry dryer (1) according to claim 10, wherein both said inlet and said outlet headers (5,6) of said first and second module (10,10') are located at least partially outside said air duct (11a).
12. The laundry dryer (1) according to any of the preceding claims, wherein said air duct (11a) includes an upper portion and a lower portion (111,112) connectable or connected to each other, and at

least a lateral slot (115) is realized in said upper and/or lower portion in which said portion of said inlet or outlet header (5,6) is inserted and from which said portion is apt to exit the air duct (11a).

13. The laundry dryer (1) according to claim 12, wherein said air duct (11a) includes a sealing element apt to seal a gap formed between the slot (115) and the inserted inlet or outlet header (5,6).
14. The laundry dryer (1) according to any of the preceding claims, wherein the outer header (6) of the module (10,10') of the first heat exchanger (31) is located at least partially outside said air duct (11a) and the dryer further includes an additional fluid circuit where an additional fluid is apt to flow, said additional fluid circuit being located in such a way that the refrigerant flowing within or exiting the outer header (6) of said first heat exchanger can exchange heat with said additional fluid.
15. The laundry dryer (1) according to claim 14, including a first fan (51) moving said additional fluid, said fan being located in such a way to cool down the refrigerant within or exiting said outlet header (6) of the first heat exchanger (31).
16. The laundry dryer (1) according to claim 15, including a temperature sensor apt to detect the temperature of the refrigerant flowing within or exiting said outlet header (6), said first fan (15) being apt to be controlled depending on the temperature sensed by said sensor.
17. The laundry dryer (1) according to any of the preceding claims, wherein the outer header (6) of the module (10,10') of the second heat exchanger (32) is located at least partially outside said air duct (11a) and the dryer (1) includes a further additional fluid circuit where a further additional fluid is apt to flow, said further additional fluid circuit being located in such a way that the refrigerant flowing within or exiting the outer header (6) of said second heat exchanger (32) can exchange heat with said further additional fluid.
18. The laundry dryer (1) according to claim 17, including a second fan (51a) moving said further additional fluid, said second fan (51a) being located in such a way to move said further additional fluid so that it exchanges heat with the refrigerant within or exiting the outlet header (6) of the second heat exchanger (32).
19. The laundry dryer (1) according to claim 18, including a temperature sensor apt to detect the temperature of the refrigerant flowing within or exiting said outlet header (6), said second fan (15a) being apt to be controlled depending on the temperature sensed by said sensor.
20. The laundry dryer (1) according to any of the preceding claims, wherein the cross-section of said inlet (5) and/or said outlet header (6) and/or said intermediate header (5a) is oblong, wherein its smallest diameter is smaller than a width (W) of said layer (8,8').

21. The laundry dryer (1) according to any of the preceding claims, wherein said heat exchange layer (8,8') includes a plurality of channels one parallel to the others.
22. The laundry dryer (1) according to any of the preceding claims, wherein said first heat exchanger (31) includes more heat exchanger modules (10,10') that said second heat exchanger (32).

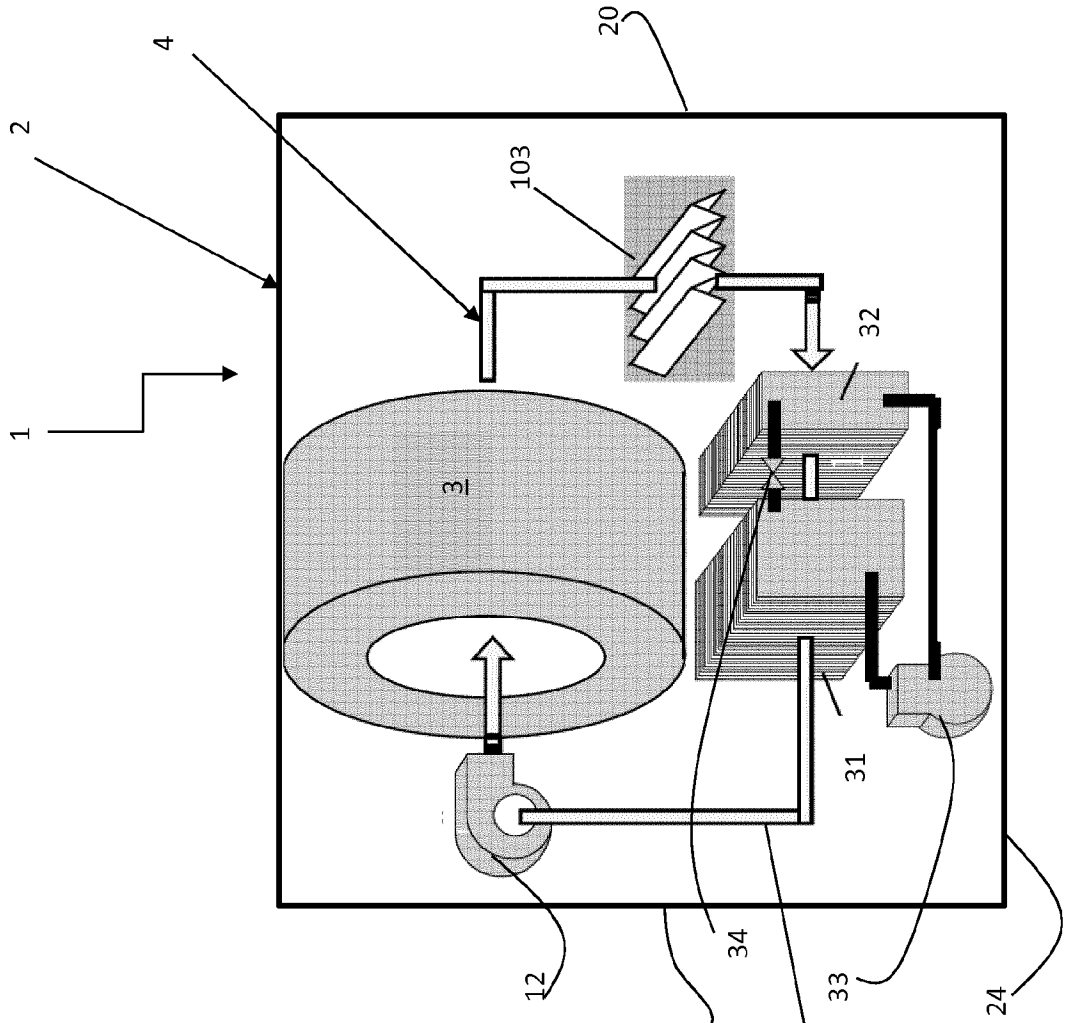


FIG. 1

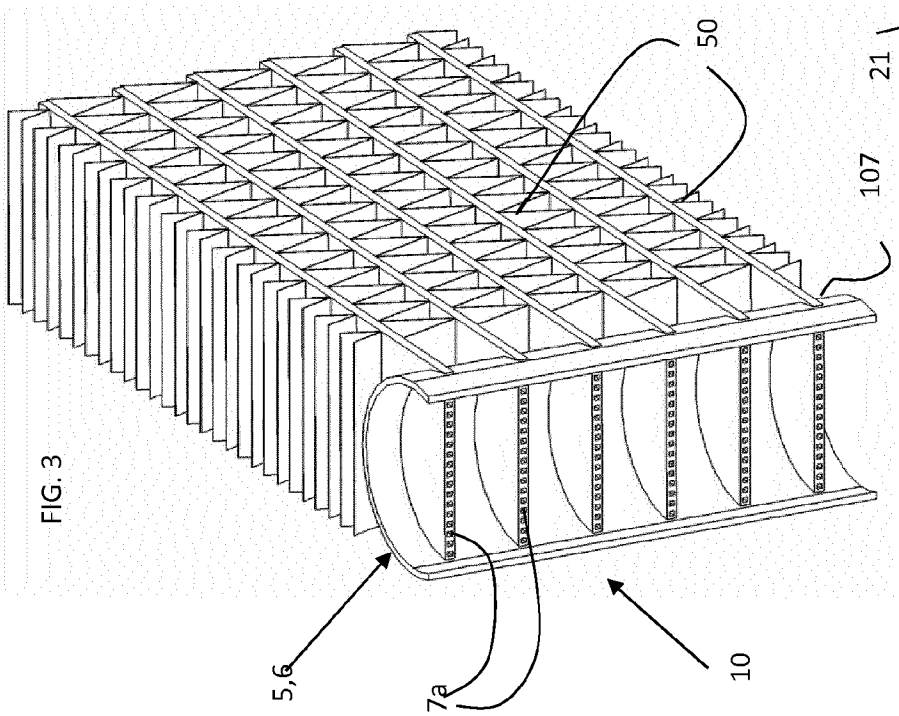


FIG. 3

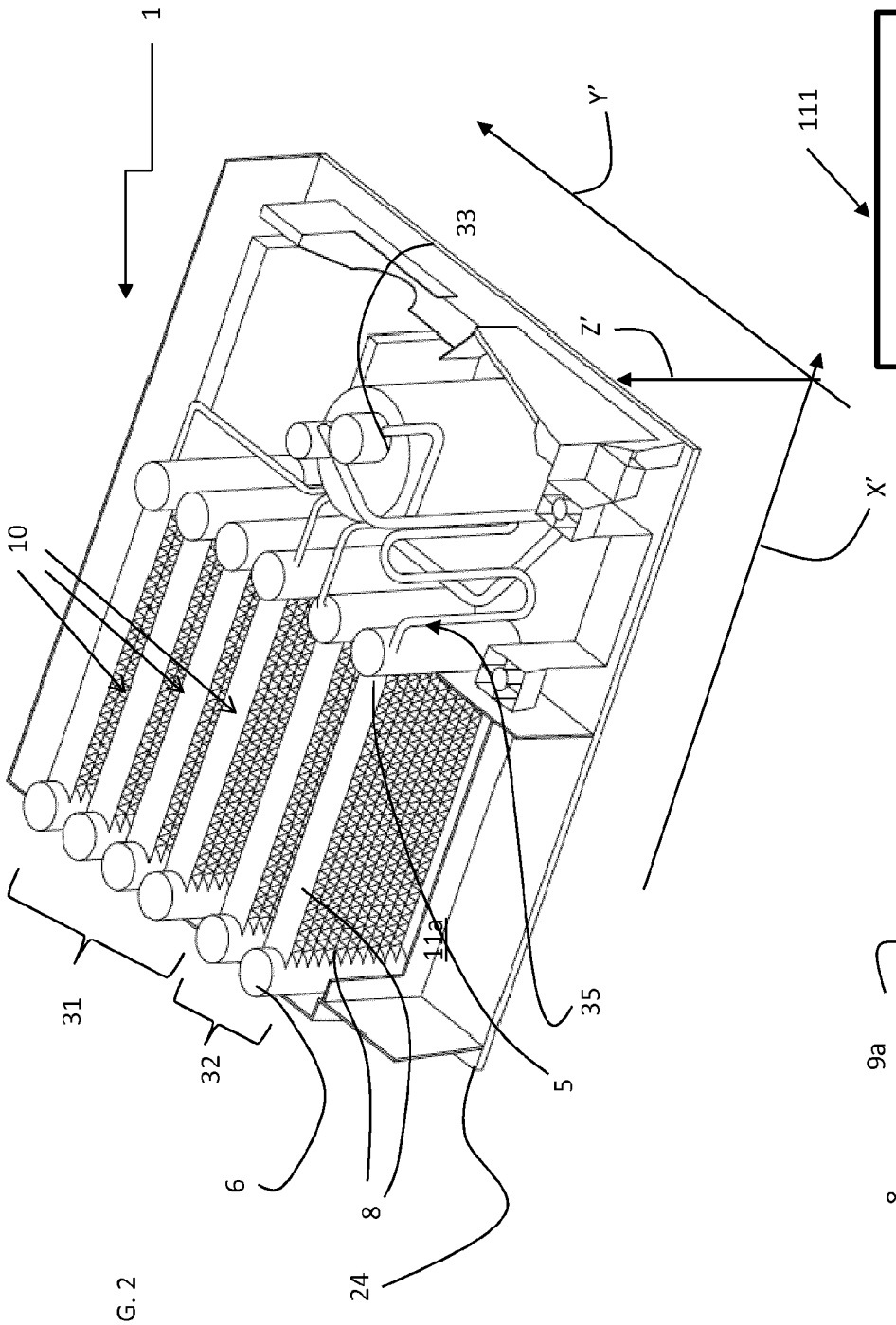


FIG. 2

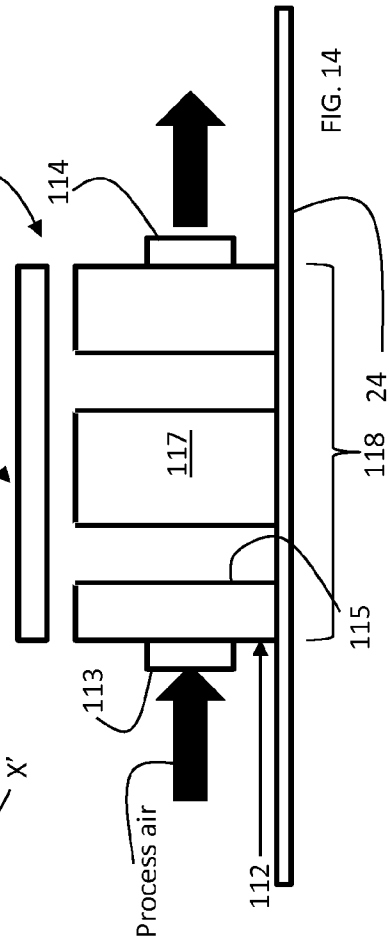


FIG. 14

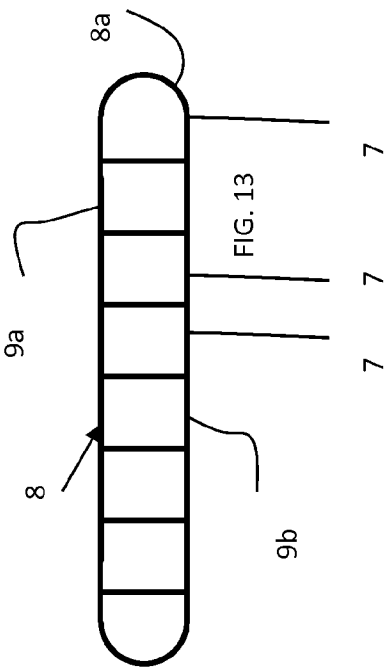


FIG. 13

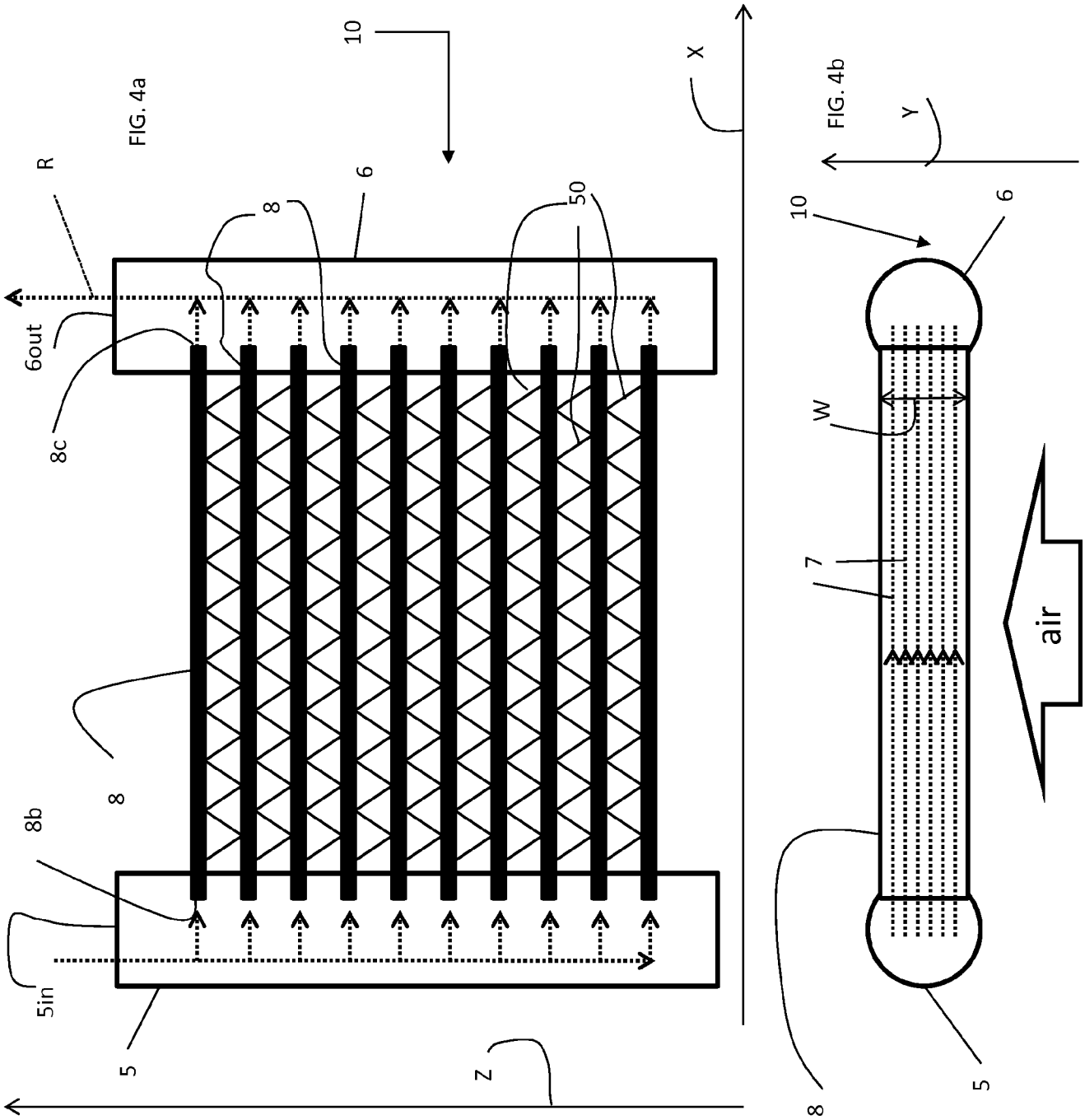

FIG. 4a
10
X
R
6
8
50
6out
8c
8
8b
5in
5
Z
FIG. 4b
Y
10
6
W
7
air
8
5

FIG. 5a

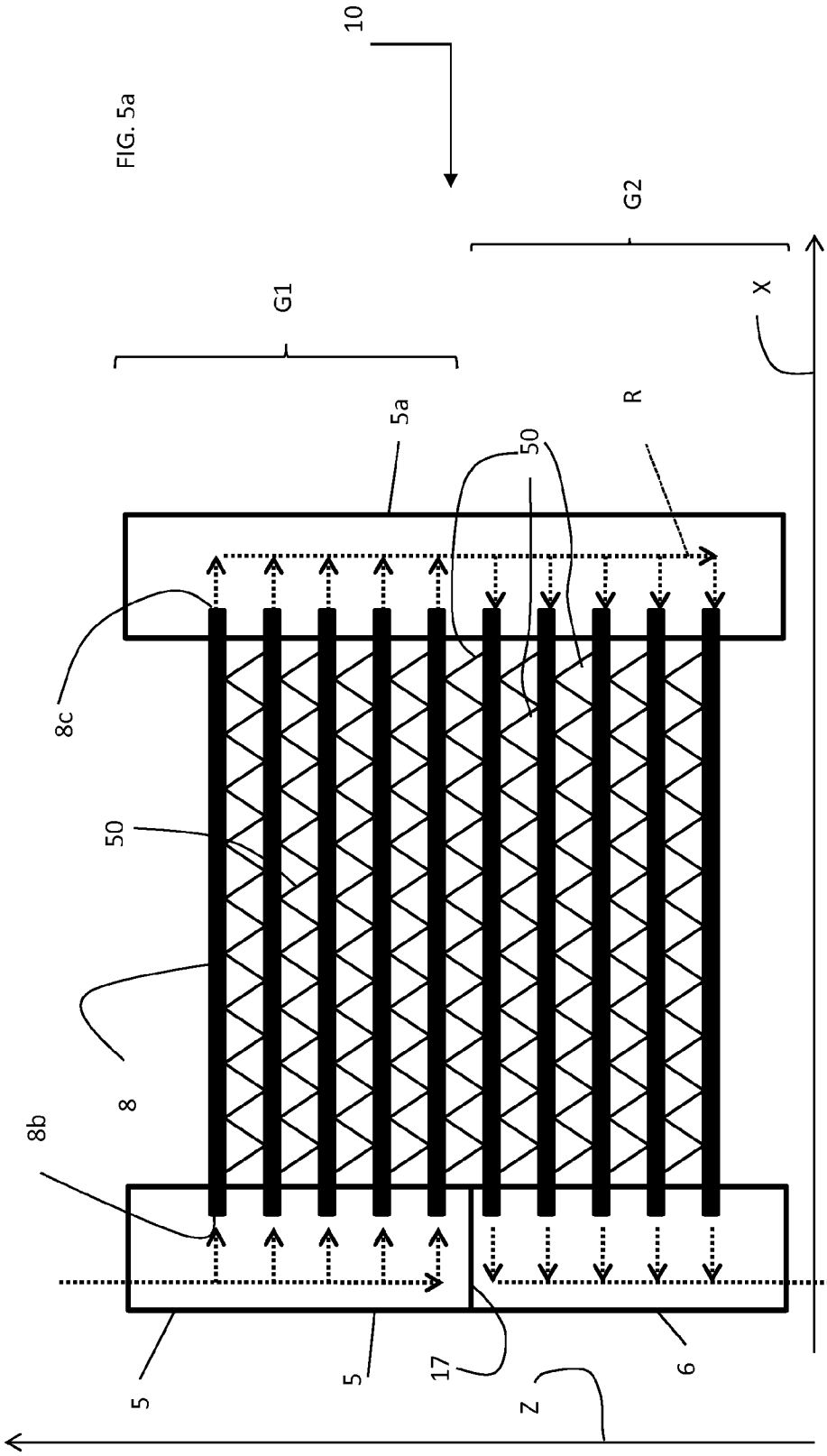
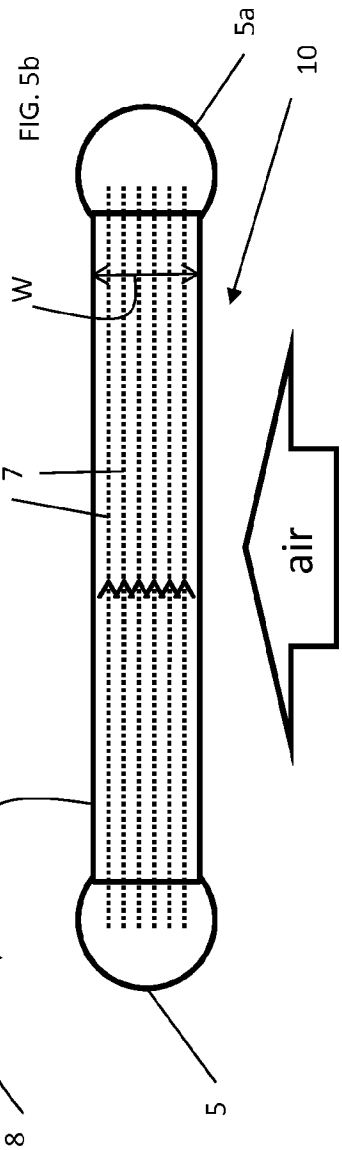
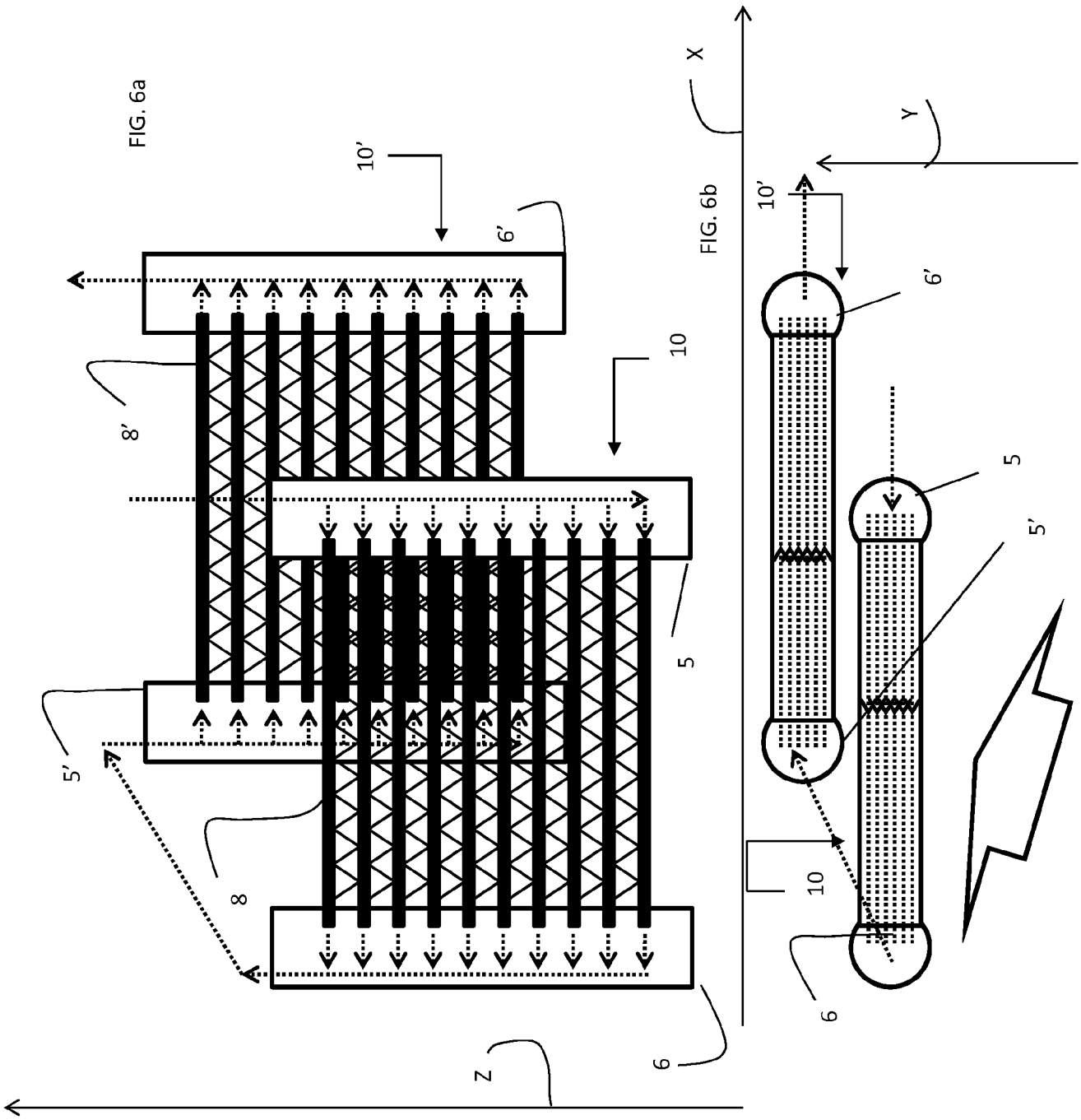


FIG. 5b




FIG. 6a
10'
6'
8'
10
5
5'
8
A
A
Z
6
FIG. 6b
X
Y
10'
6'
5
5'
10
6

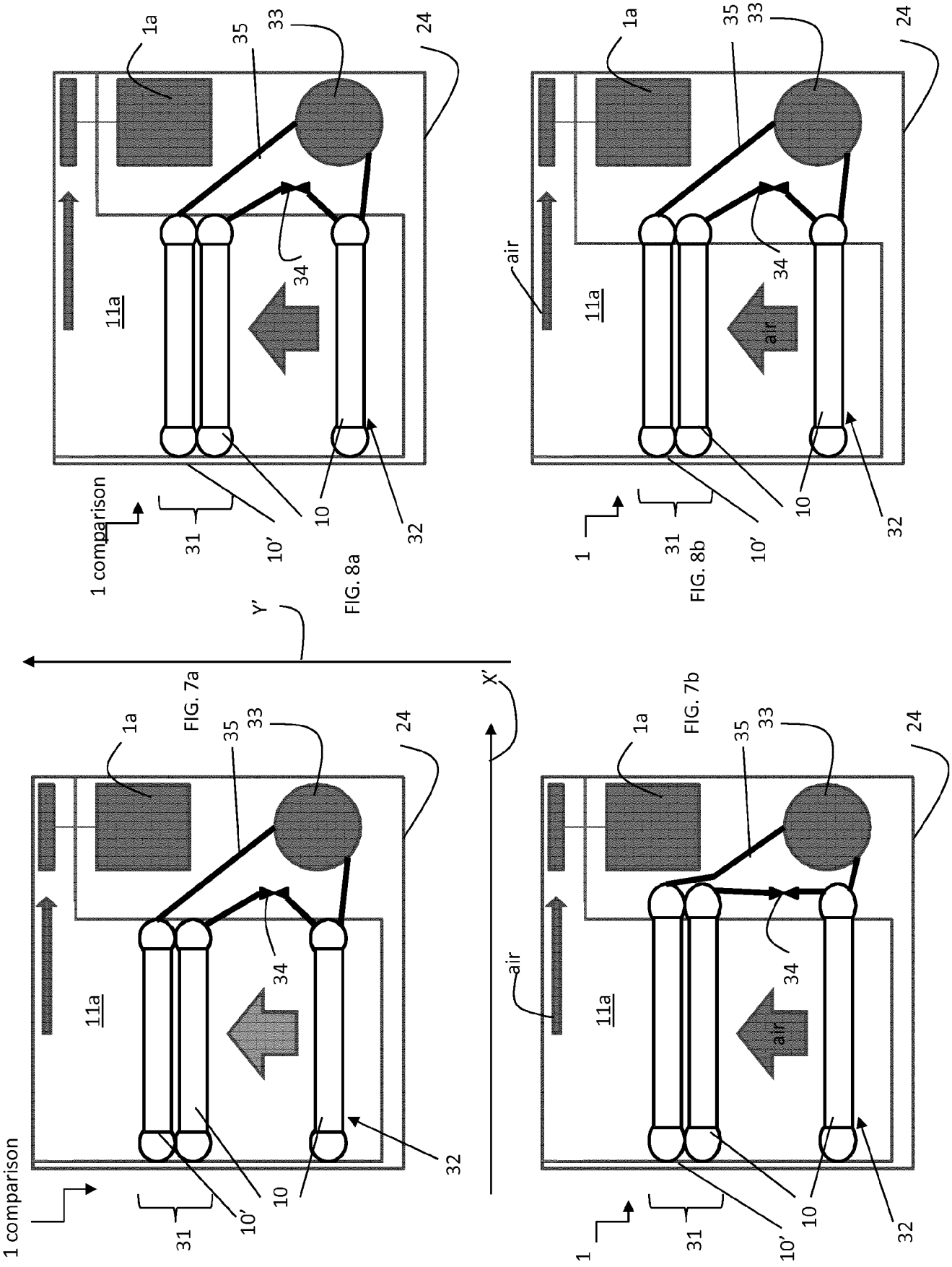


FIG. 7a

FIG. 7b

FIG. 8a

FIG. 8b

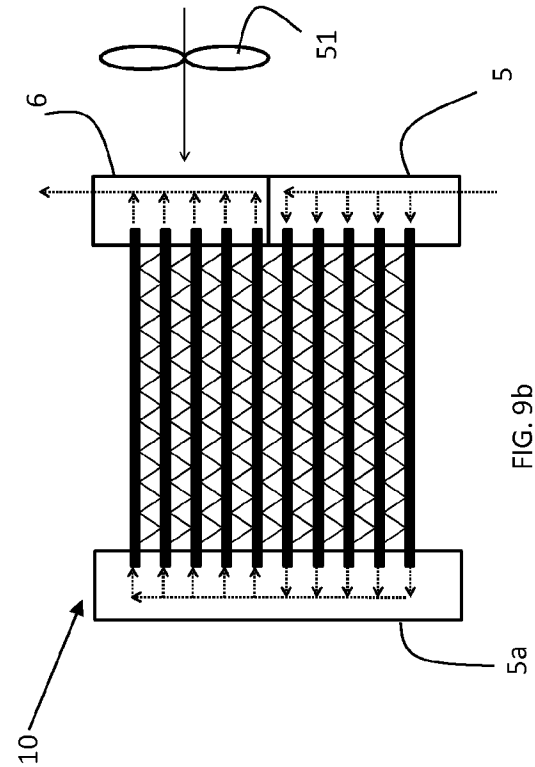


FIG. 9b

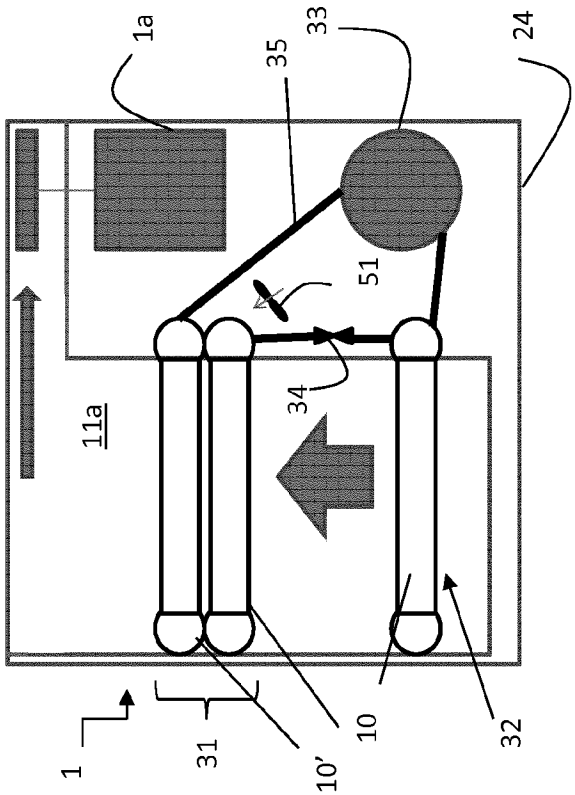


FIG. 9a

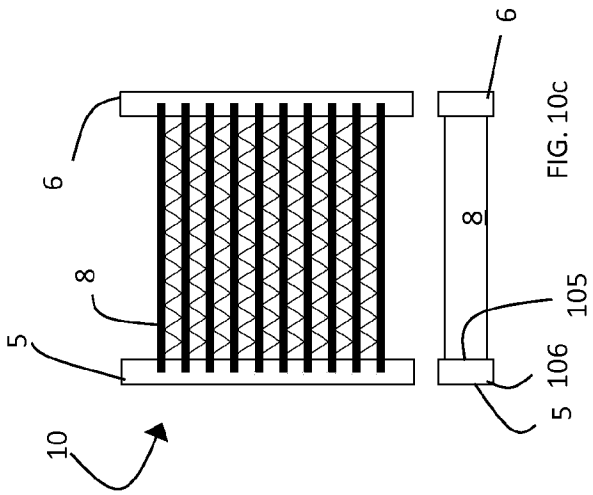


FIG. 10c

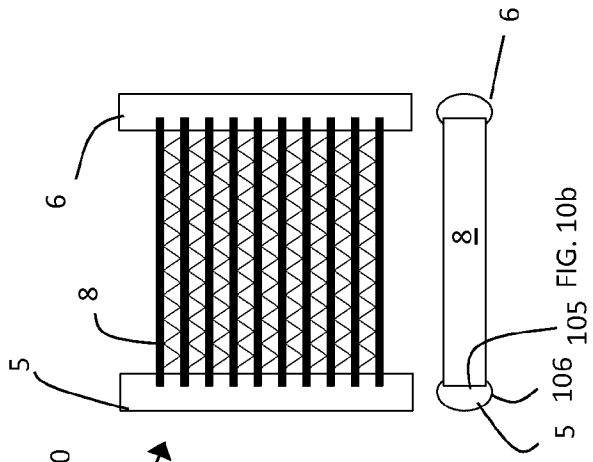


FIG. 10b

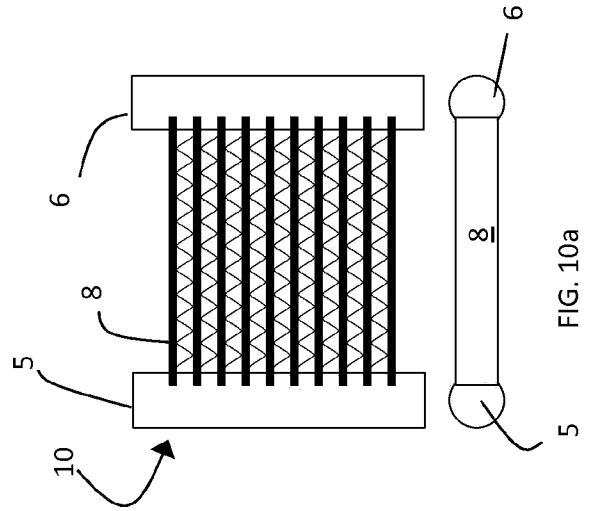


FIG. 10a

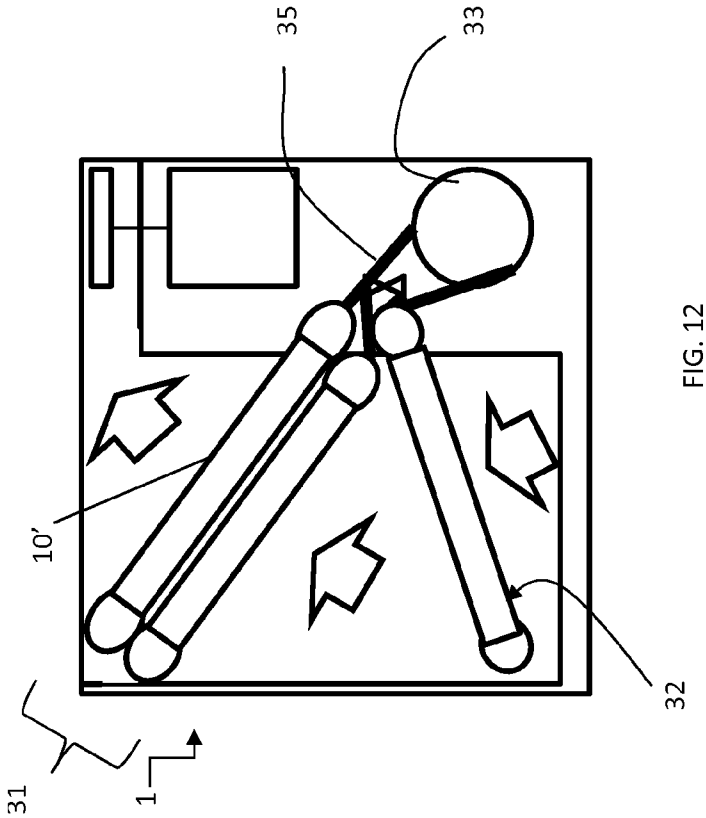


FIG. 12

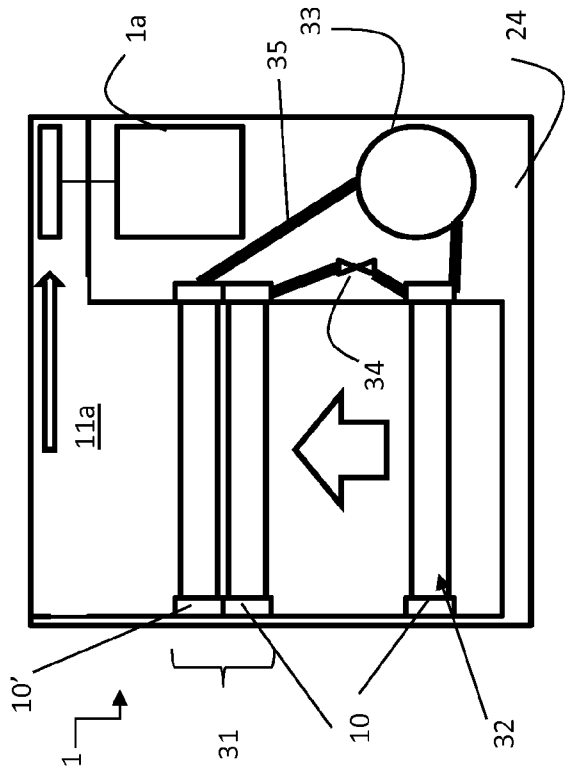


FIG. 11

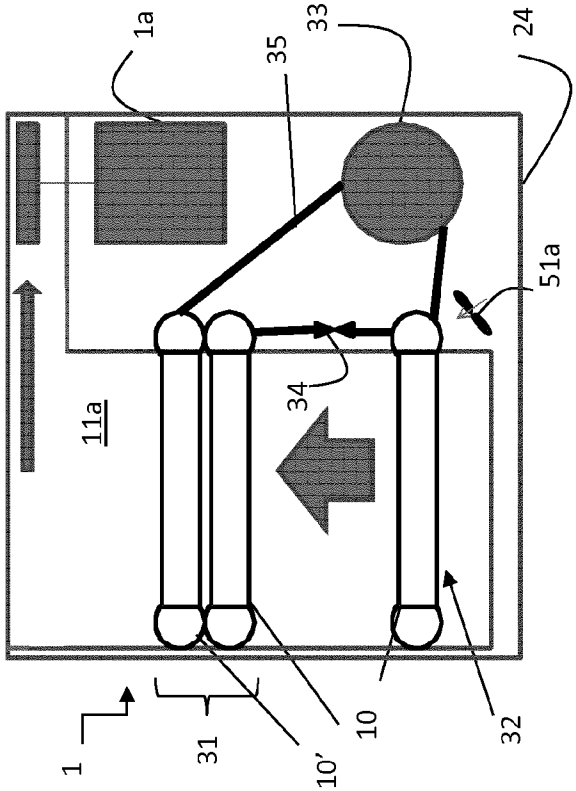


FIG. 9c

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/063160

A. CLASSIFICATION OF SUBJECT MATTER
INV. D06F58/20 D06F58/24 F28D1/053
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
D06F F28D

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2008 237390 A (SANYO ELECTRIC CO) 9 October 2008 (2008-10-09) abstract; figures 1-3	1,2,5-7, 10,11, 20,21
Y	US 5 048 602 A (MOTOHASHI TUTOMU [JP] ET AL) 17 September 1991 (1991-09-17) figure 2	1,2,5-7, 10,11, 20,21
A	EP 1 209 277 A2 (ELECTROLUX ZANUSSI ELETTRODOME [IT]) 29 May 2002 (2002-05-29) cited in the application figure 1	1

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 April 2014	28/04/2014

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

1

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/063160

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2011/280736 A1 (LEE YONGJU [KR] ET AL) 17 November 2011 (2011-11-17) cited in the application figures 1,2,7,8	1,4,5,15
A	EP 1 231 448 A2 (MODINE MFG CO [US]) 14 August 2002 (2002-08-14) paragraphs [0036], [0037], [0038]; figures 1-5,8	1,5,21
A	EP 2 549 008 A1 (ELECTROLUX HOME PROD CORP [BE]) 23 January 2013 (2013-01-23) figure 2b	1,4
A	EP 2 468 944 A1 (ELECTROLUX HOME PROD CORP [BE]) 27 June 2012 (2012-06-27) figures 1,2	1,7,15, 22

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2013/063160

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2008237390 A	09-10-2008	JP 4869119 B2	08-02-2012
		JP 2008237390 A	09-10-2008
US 5048602 A	17-09-1991	NONE	
EP 1209277 A2	29-05-2002	AT 256214 T	15-12-2003
		DE 60101445 D1	22-01-2004
		DE 60101445 T2	14-10-2004
		EP 1209277 A2	29-05-2002
		ES 2211711 T3	16-07-2004
US 2011280736 A1	17-11-2011	AU 2011245856 A1	06-09-2012
		CN 102762791 A	31-10-2012
		EP 2565323 A2	06-03-2013
		US 2011280736 A1	17-11-2011
		WO 2011136593 A2	03-11-2011
EP 1231448 A2	14-08-2002	AR 035737 A1	07-07-2004
		AR 044266 A2	07-09-2005
		AT 360183 T	15-05-2007
		AU 783870 B2	15-12-2005
		AU 1022202 A	08-08-2002
		BR 0200330 A	29-10-2002
		CA 2368871 A1	07-08-2002
		CN 1369680 A	18-09-2002
		DE 60219538 T2	20-12-2007
		EP 1231448 A2	14-08-2002
		EP 1691160 A1	16-08-2006
		JP 4050910 B2	20-02-2008
		JP 2002318087 A	31-10-2002
		KR 20020065840 A	14-08-2002
		MX PA02001239 A	19-09-2002
		TW 522215 B	01-03-2003
		US 2002134537 A1	26-09-2002
		US 2004149424 A1	05-08-2004
EP 2549008 A1	23-01-2013	AU 2012289035 A1	06-02-2014
		EP 2549008 A1	23-01-2013
		WO 2013014045 A1	31-01-2013
EP 2468944 A1	27-06-2012	AU 2011351627 A1	11-04-2013
		CN 103348056 A	09-10-2013
		EP 2468944 A1	27-06-2012
		US 2014082960 A1	27-03-2014
		WO 2012089585 A1	05-07-2012