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(54) Heat pump laundry dryer

(57) The present invention relates to a laundry dryer including: a casing, rotatably supporting a drum (3), a basement (24) defining a basement plane (X, Y) and in which a first longitudinal half (24 first half) and a second longitudinal half (24 second half) of said basement (24) are identifiable by means of a first plane (P1) perpendicular to said basement plane (X, Y) and passing through a rotational axis (R) of the drum;

a heat pump system (30), being arranged in the process air conduit within said first longitudinal half of said basement;

a process air conduit (18) in fluid communication with the drum, including a basement process air duct formed in said basement, comprising a basement duct portion (28) wherein an exit plane (Pex), a basement outlet plane (P19) and an intermediate plane (P3) are defined, all three perpendicular to said basement plane (X, Y) sectioning said basement duct portion (28) respectly at said condenser process air exit (28in), at said basement process air outlet (19) and in a point belonging to said first half of said basement not at said exit plane (Pex); said planes defining respectly three basement duct portion sections; wherein each basement duct section defines a vertical centerline (C) dividing each basement duct section in two halfs, having respectly a first, second and third lowest points (LPO), (LPV), (LP3) of said outer halfs at a vertical height respectly (A0), (AV), (A1); wherein A0 < AV and A0 < A1 < AV.

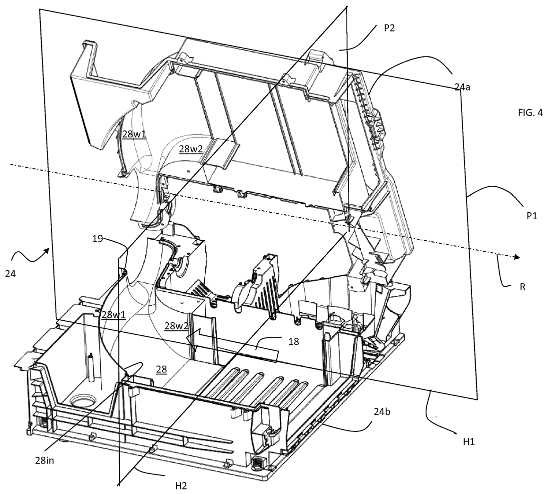

FIG. 4

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Description

Technical field

[0001] The present invention relates to a laundry dryer including a heat pump system having an improved process air duct within the basement of the laundry dryer.

Background of the invention

[0002] The heat pump technology in a laundry dryer is at present the most efficient way to dry clothes in terms of energy consumption. In a heat pump system of the laundry dryer an air stream flows in a closed air stream circuit. Further, the heat pump system includes a closed refrigerant circuit. The air stream is moved by a fan, passes through a laundry chamber, which is preferably formed as a rotatable laundry drum, and removes there water from wet clothes. Then, the air stream is cooled down and dehumidified in an evaporator, heated up in a condenser and re-inserted into the laundry drum again.

[0003] The refrigerant is compressed by a compressor, condensed in the condenser, expanded in an expansion device and then vaporized in the evaporator.

[0004] Thus, the condenser and the evaporator are components of the air stream circuit as well as of the refrigerant circuit. The condenser and the evaporator are heat exchangers between the air stream circuit and the refrigerant circuit.

[0005] Usually, the components of the heat pump system (described above) are placed in a basement of the laundry dryer. The basement of a laundry dryer is part of a casing, which includes in addition to the basement also walls, substantially vertically supported from the basement, such as a front wall and a rear wall, and lateral walls. In the casing, a drum, where the laundry is introduced in order to dry the same, is rotatably supported. In particular, the compressor, the evaporator and the condenser are arranged in said basement below the laundry drum. An air duct of the air stream circuit has to pass the basement of the dryer, bringing the humid air to the evaporator and reintroducing the dry air from the condenser in the drum. The duct in the basement can be formed in an advantageous embodiment by joining together two shells, an upper shell portion and a lower shell portion, which forms the basement.

[0006] In laundry dryer according to the prior art, the basement includes an outlet for the air. A fan is generally positioned in proximity of such an outlet in order to blow the process air dried by the heat pump back to the drum. The fan however, and in particular the impeller of the same has a certain minimum dimension.

[0007] Due to the size of the heat exchangers and the limited space within the basement of the laundry, an exit of the air from the heat exchanger, in particular from the condenser, is located at a given height from the ground or floor where the dryer is located. Preferably, the height of the starting point from the ground of the exit of the process air from the condenser is as low as possible to maximize the vertical extension of the heat exchangers and therefore to maximize their heat exchanger surfaces. The outlet of the air from the basement is commonly located at a higher location, due as said to the size of the impeller. The process air has thus to flow from the exit of the condenser to the outlet of the basement changing heights, e.g. flowing uphill.

[0008] In common dryers, however, the flow of air exiting the condenser has to perform a substantially 90 vertical turn, at least for a portion of the stream, in order to reach the outlet of the duct in the basement where the fan is located, the change in height being sharp or abrupt.

[0009] Such angles in the air stream circuit cause pressure drops and turbulences increasing the energy consumption and the noise. Indeed, such a duct is far away from the best aerodynamic shape, this latter being the shape that is supposed to considerably reduce air resistance during the flow.

[0010] However, it is rather complex to modify the outline and shape of the process air duct where process air flows within the basement. The various component of the heat pump system, with particular reference to the heat exchangers and the compressor, as well as the motor of the dryer, are rather "bulky", and repositioning of the same are limited due to the confined volume present in the basement of the dryer.

[0011] It is an object of the present invention to provide a laundry dryer with a heat pump system, wherein the flow of the air stream is improved, with particular reference to the air stream flow within the basement of the laundry dryer.

[0012] Applicant has realized via numerous experiments that the efficiency of the heat pump system can be improved including in the dryer a process air duct which comprises a smooth curvature, which means, more precisely, a basement process air duct which gradually changes height. The whole process air duct therefore starts having a bottom wall at a lower position and ends with a bottom wall of the duct at a higher location, gradually changing height and avoiding sharp turns or placing obstacles in the flow of process air or abrupt changes.

[0013] The core of the present invention is the combination of the "gently rising shape" of the process air duct in the basement of the laundry dryer on the one hand and the arrangement of the evaporator and the condenser inside said the basement on the other hand. The "gently rising shape" portion of the process air duct prevents the formation of "sharp corners" inside the process air duct, so that the pressure drops in the process air duct are reduced. The air flow from the condenser to the basement outlet is optimized. The heat exchange between the refrigerant circuit and the air stream circuit increases. The dimensions of the evaporator and condenser may be reduced.

[0014] In addition, the energy consumption of the motor or the motors for the compressor and the fan is reduced. Further, the noise of the laundry dryer is reduced.

[0015] According to an aspect, the invention relates to a laundry dryer including:

- a casing, rotatably supporting a drum for receiving a load to be dried, said drum being apt to rotate around a rotational axis, said casing including

  o a basement defining a basement plane and in which a first longitudinal half and a second longitudinal half of said basement are identifiable by means of a first plane perpendicular to said basement plane and passing through said rotational axis of the drum;

- A process air conduit in fluid communication with the drum where a process air stream is apt to flow;

- A heat pump system 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 is heated up, and a second heat exchanger where the refrigerant is heated up and the process air is cooled off; said first heat exchanger and/or said second heat exchanger being arranged in the process air conduit within said first longitudinal half of said basement for the majority of their respective volumes in order to perform heat exchange between said refrigerant flowing in said heat pump circuit and said process air;

- Said process air conduit including a basement process air duct formed in said basement, said basement process air duct comprising a basement duct portion channeling said process air between a condenser process air exit where process air exits from said first heat exchanger and a basement process air outlet where process air exits said basement, said basement process air outlet (19) being located within said second longitudinal half of said basement;

- said basement duct portion including one or more duct walls which in a section along a sectioning plane parallel to said basement plane defines an inner curve and an outer curve, said outer curve being the curve closer to the rear wall of the casing among the two curves;

- Wherein an exit plane perpendicular to said basement plane sectioning said basement duct portion at said condenser process air exit defines a first basement duct portion section; a basement outlet plane perpendicular to said basement plane sectioning said basement duct portion at said basement process air outlet defines a second basement duct portion section; and an intermediate plane perpendicular to said basement plane sectioning said outer curve of said basement duct portion in a point belonging to said first half of said basement not at said exit plane and said inner curve in a point in either said first or in said second half of said basement defines a third basement duct portion section;

- Wherein each of said first, second and third basement duct portion sections defines a vertical centerline dividing each first, second and third basement duct section in an outer half including a point of the outer curve and an inner half including a point of said inner curve, said first basement duct portion section having a first lowest point of said outer half at a first vertical height, said second basement duct portion section having a second lowest point of said outer half at a second vertical height and said third basement duct section having a third lowest point of said outer half at a third height; said third lowest point belonging to said first longitudinal half of said basement;

- wherein said first vertical height is lower than said second vertical height and said third vertical height is comprised between, but not equal to, said first vertical height and said second vertical height.

[0016] The dryer of the invention includes a drying chamber, such as a drum, in which the load, e.g. clothes or laundry, to be dried is placed. The drum is part of an air process circuit which includes an air conduit for channeling a stream of air to dry the load. The process air circuit is connected with its two opposite ends to the drum. More specifically, hot dry air is fed into the drum, flowing over the laundry, and the resulting humid (and cooler) air exits the same. The humid air stream rich in water vapor is then fed to an evaporator (or second heat exchanger) of a heat pump, where the moist warm process air is cooled and the humidity present therein condenses. The resulting cool dry air is then heated up before entering again in the drying chamber by means a condenser (or first heat exchanger) of the heat pump, and the whole loop is repeated till the end of the drying cycle.

[0017] The dryer furthermore includes a casing or bearing structure, comprising preferably a basement, a front wall and a rear wall. The front wall is advantageously provided with a through opening, at which a door is mounted to access the drum in order to locate or remove the laundry. Preferably, a rim of the rear end of the drum abuts against the rear wall of the cabinet and even more preferably a gasket is interposed therein between; as well as a rim of the front end of the drum abuts against the front wall with also preferably a gasket therein between.

[0018] Within the casing, the drum is rotatably mounted for rotating according to a horizontal, or at least substantially horizontal, or tilted rotational axis. Support element(s) for rotatably supporting the drum are provided for within the casing. The drum is rotated preferably by means of a motor which defines a motor axis, for example which corresponds to the axis of a motor shaft.

[0019] In an advantageous embodiment, said drum support element includes a shaft, said shaft passing through said back wall, said shaft defining said axis of rotation of said drum. Alternatively or in addition, said drum support element includes a roller, the axis of the roller being substantially parallel to the drum axis of rotation.

[0020] The basement of the dryer of the invention includes a portion of the process air circuit, called basement air conduit, which includes substantially a duct formed in the basement. Within said basement air conduit both heat exchangers of the heat pump system are located. Furthermore, the basement air conduit channels the process air exiting the condenser to an outlet of the basement. From the outlet of the basement, the process air- dried by the condenser - is fed, for example via an additional portion of the process air conduit realized preferably in the rear wall of the cabinet, to the drum so as to dry the laundry therein. The portion of basement air conduit comprised between an exit of the condenser, i.e. a location in which the process air exits the condenser, and the outlet of the basement where the process air exits from the basement is called basement air duct portion.

[0021] The location of the exit of the condenser is defined as the location of a section of the basement air duct portion at the surface of the first heat exchanger from which process air exits. Preferably, process air passes through the first heat exchanger in a direction towards said rear wall of the casing.

[0022] The basement air duct portion includes one or more lateral walls depending on its geometry. If the geometry of the duct is substantially cylindrical or of a cylindroid form, the duct portion includes a single lateral wall having substantially circular cross section, which may change in diameter depending on the position in which the cross section is measured. Alternatively, two opposite lateral walls can be present, for example one substantially parallel to the other and defining substantially parallel planes.

[0023] In a standard operative position, the basement of the dryer is positioned on a floor or other substrate on which the dryer performs its standard operations (e.g. drying and/or washing and/or spinning cycles). Such positioning defines a horizontal or at least substantially horizontal plane, which is called the basement plane (X, Y). Planes parallel to the basement plane are therefore substantially horizontal planes.

[0024] In this standard operative position, also other terms are well defined: "front" or "rear" (or "back"), "top" or "bottom", "upper" or "lower" are always referred to the normal standard configuration of a dryer with the basement positioned on a floor. The front wall of the dryer is defined by the wall in which the door from which the drum is accessed is positioned. Given the horizontal plane on which the laundry is located, "top" and "bottom" - as their normal common meaning - refer to the position of an object along a vertical axis.

[0025] Preferably, on the basement of the dryer, the rear wall and the front wall are mounted. Even more preferably, the casing includes further walls, e.g. lateral walls and a top wall.

[0026] In a top view of the dryer, the basement can be considered as "divided" in two longitudinal halves by the axis of rotation of the drum (or the projection of said axis onto the basement plane). Whether the axis is horizontal (thus parallel to the basement plane (X,Y)) or tilted with respect to the latter, on a top view of the basement, the projection of the drum axis divides the basement in two halves, a first or left longitudinal half and a second or right longitudinal half. In other words, taking a plane which is perpendicular to the basement plane and which passes through the rotational axis of the drum, which generally coincides with the centerline of the basement, this plane virtually sections the basement in two longitudinal halves. This plane, called first plane, when sectioned by a plane parallel to the (X, Y) plane defines a line of division of the basement in two in a top view.

[0027] The two halves do not need to be identical. In other words with a first and a second half, a "right" and a "left" portion of the basement with respect of the above mentioned plane (first plane) passing through the rotational axis of the drum and perpendicular to the basement plane are meant. The projection on the basement of such rotational axis can be thus shifted from the centerline of the basement. Preferably, the centerline and the projection of the rotational axis of the drum coincide.

[0028] The layout of the heat pump system located in the basement of the dryer of the invention is the following.

[0029] The first heat exchanger and the second heat exchanger are preferably located within the basement air conduit and extend for the majority of their volume within the first longitudinal half of the basement, e.g. they are substantially located for the majority of their volume to the left of the rotational axis of the drum. The heat exchangers can be completely contained within the first longitudinal half of the basement or part of their volume, the minority, can also extend within the second longitudinal half of the basement. Also, the exit of process air from the condenser is located within the first longitudinal half of the basement, at least for most of its area.

[0030] On the other end, the outlet of process air from the basement is preferably located within the second longitudinal half of the basement, i.e. on the half of the basement right of the rotational axis of the drum. Preferably, the basement outlet is realized in the rear part of the basement, i.e. facing the real wall of the cabinet. Thus, in order to channel the process air outside the basement, the basement duct portion extends from the exit of the condenser to the outlet of the basement starting from the first longitudinal half of the basement and reaching the second longitudinal half of the basement. Due to this geometry and layout, which is forced by the positioning of the various elements of the heat pump system in the basement, although the best aerodynamic solution for a duct channelling air would be a straight duct, the duct portion has to include at least one "bend" or "turn".

[0031] The basement portion duct includes - as described - lateral walls. These lateral walls define, when sectioned by a plane parallel to the basement plane, e.g. by a horizontal plane, an inner curve and an outer curve. This plane parallel to the basement plane is called in the following "sectioning plane". The term "inner" curve and the term "outer" curve are understood to be the curves "more inside" and "more outside" the casing, i.e. closer to the center of the casing or farer away from the same, respectively.

[0032] The walls of the basement duct portion form a closed curve, in other words, in a section perpendicular to the basement plane, the walls of the basement duct portion define a closed line.

[0033] The inner curve and the outer curve start at the "exit" of the first heat exchanger or condenser, in other words each curve starts from a point defined by a section of the basement duct portion with a plane passing through the exit surface of the air from the first heat exchanger, and terminate at the outlet of the basement, i.e. each curve terminates at a point defined by a plane containing the outlet area and sectioning the basement duct portion. This line is preferably substantially the longitudinal median or center line of the basement in a top view.

[0034] Taking a condenser process air exit plane perpendicular to the basement plane and passing through the exit surface of the first heat exchanger or condenser, such plane sections the basement process air duct portion forming a basement duct portion first section. This first section may have any shape depending on the shape of the basement process air duct portion.

[0035] In an analogous manner, an additional plane, called basement outlet plane, which is perpendicular to the basement plane and sectioning the basement process air duct at the basement process air outlet (i.e. it is a plane containing the basement outlet), also defines a basement duct portion section, called second section. This second basement process air duct section can have - as above - any shape.

[0036] This first section has a lowest point, i.e. the curve defined by the section of the basement duct portion which is a closed curve has at least one point which has the smallest vertical height. Depending on the geometry of the first section taken at the exit of the first heat exchanger or condenser, such section may include a single lowest point or a plurality of lowest points. For example, if this section of the duct is a rectangle oriented parallel to the basement plane, the lowest point is any of the points of one side of the rectangle closest to the basement plane. The height of this lowest point or of these lowest points is called first vertical height A0' in the following. The heat exchangers are rather "bulky elements" and thus they are located as low as possible within the basement so that they can vertically extend as much as possible in order to guarantee a surface big enough for the heat exchange with the process air circuit. For this reason, the lowest point defined in the first duct section is preferably the lowest point in the whole basement process air duct portion which extends from the exit of the first heat exchanger or condenser to the outlet of the basement. Therefore, this lowest point is also considered as the "zero" for the calculation of the heights of the other points detailed below.

[0037] The above lowest point considered in the section at the exit surface of the condenser is the "global" lowest point, i.e. the global minimum of the whole closed curve defined by the section of the walls of the basement duct portion. However also local or relative lowest points can be considered. This local or relative lowest point is a local minimum, i.e. the minimum of a region of the curve defined by the section.

[0038] Taking again the first section, a vertical line or centreline can be defined passing through the middle of a dimension of the section. In this contest, being the duct not always circular, such dimension of the section is considered to be the longest dimension definable in the closed curve along a horizontal plane. This vertical line, or centreline of the section, divides the walls of the duct in two portions, a first or outer half which is the portion containing the outer curve and a second or inner half which is the portion containing the inner curve. A relative minimum can be thus defined, which is the minimum of the outer section, i.e. the minimum of the portion of closest curve within the outer half of the first section of the basement duct portion.

[0039] Preferably, the relative minimum in the outer half in the first section of the basement duct portion is then also lower than any other lowest point in the outer half of any other section of the basement duct portion that can be defined. The height of this relative lowest point in the outer half of the first section is called A0 in the following and, as above, this lowest point is also considered as the "zero" for the calculation of the heights of the other lowest points detailed below.

[0040] The same is applicable to also the section formed by sectioning the basement duct portion with the basement outlet plane. This second section has a lowest point, i.e. a point which has the smallest vertical height. Depending on the geometry of the first section taken at the exit of the first heat exchanger or condenser, such section may include a single lowest point or a plurality of lowest points. For example, if this section of the duct is a rectangle oriented parallel to the basement plane, the lowest point is any of the points of one side of the rectangle closest to the basement plane. The height of this lowest point or these lowest points is called AV'.

[0041] As in the case of the first section, also a relative lowest point can be defined. Taking again the second section, there is a vertical line passing through the middle of the above defined dimension of the section. In this contest, being the duct not always circular, the dimension of the section is considered to be the longest dimension definable in the duct section along a horizontal plane.

This vertical line, or centreline of the section, divides the walls of the duct in two portions, a first or outer half which is the portion containing the outer curve and a second or inner half which is the portion containing the inner curve. A relative minimum can be thus defined, which is the minimum of the outer half of the section, i.e. of the portion of closest curve within the outer half of the second section of the basement duct portion.

[0042] This height AV of the lowest point of the second section of the basement process air duct in its outer half is always higher than the height A0 of the lowest point of the first section of the basement process air duct in its outer half. This relation AV > A0 can be due for example by the presence of a fan outside the basement and facing the outlet of the basement which has certain dimensions which commonly exceed A0.

[0043] Preferably, the above applies not only to the relative lowest points but also to the global lowest points, i.e. preferably AV>A0'.

[0044] Due to this geometry and layout, which is forced by the positioning of the various elements of the heat pump system in the basement, the basement process air duct portion has to rise from the height A0 (A0') to the height AV (AV') in order to channel air outside the basement.

[0045] According to the invention, the basement duct portion is forming a "smooth" channel to channel process air from the condenser to the outside of the basement, in other words the rise from A0 to AV should be gradual and not in a single short duct part.

[0046] In order to form a smooth channels, Applicant has found out that an improved aerodynamic shape is obtained having a substantially smooth increase in height of the duct, without abrupt changes in height. Abrupt changes can be given for example by the presence of steps or similar obstacles for the air flow in the basement duct portion.

[0047] In this respect, Applicant has therefore designed a basement process air duct portion where the difference in height between A0 and AV is compensated in at least two steps, a first step in the first longitudinal half of the basement and a second step in the second longitudinal half of the basement.

[0048] Indeed, sectioning the basement of the dryer of the invention with an intermediate plane, perpendicular to the basement plane, which sections the basement duct portion in a given location, this location given by a point in the outer curve within the first half of the basement and a point of the inner curve within either the first or the second outer of the basement, a third basement duct portion section is defined. The point of the outer curve in which this section with the intermediate plane is taken should not contain the point at the exit plane (i.e. the plane passing through the exit surface of the condenser).

[0049] Also in this case, this third section has a lowest point, i.e. a point which has the smallest vertical height in the closed curve formed by the walls of the basement duct portion sectioned by the intermediate plane. Depending on the geometry of the third section, such third section may include a single lowest point or a plurality of lowest points. For example, if this section of the duct is a rectangle oriented parallel to the basement plane, the lowest point is any of the points of one side of the rectangle closest to the basement plane. The height of this lowest point or these lowest points is called A1'.

[0050] As in the case of the first and second sections, also a relative lowest point can be defined. Taking again the third section, there is a vertical line passing through the middle of the above defined dimension of the section. In this contest, being the duct not always circular, such dimension of the section is considered to be the longest dimension definable in the duct section along a horizontal plane. This vertical line, or centreline of the section, divides the walls of the duct in two portions, a first or outer half which is the portion containing the outer curve and a second or inner half which is the portion containing the inner curve. A relative minimum can be thus defined, which is the minimum of the outer half of the section, i.e. of the portion of closest curve within the outer half of the third section of the basement duct portion.

[0051] Thus, the third section so obtained has also another relative lowest point of the outer half the height of which is equal to A1. This value is considered only if it lies within the first half of the basement. In other words, the intermediate plane is a plane to be considered in the present construction only if such intermediate plane, when sectioning the basement duct portion in the way above described, defines a section having a relative minimum within the first half of the basement. In addition, the intermediate plane never section the duct portion at the exit of the condenser, in other words the beginning of the outer curve in front of the condenser is excluded.

[0052] This A1 - according to the invention - has a value in between the values of the other two lowest points A0 and AV, so that the raise in height of the basement process air duct portion is not obtained all in the first longitudinal half of the basement or all in the second longitudinal half of the basement, but at least in two steps physically separated from each other within the basement.

[0053] In other words preferably according to the invention A0 < A1 < AV.

[0054] According to the invention, there is at least an intermediate plane for which the above is true. More preferably there is a plurality of such intermediate planes.

[0055] Tests of the Applicant has shown that the dryer having such a basement process air duct portion has a flow of process air considerably improved, increasing the overall efficiency of both the heat pump system and of the fan which moves air within the total process air conduit.

[0056] According to this aspect, the invention may include, alternatively or in combination, any of the following characteristics.

[0057] Preferably, the dryer is so construed that

- each first, second and third basement duct portion sections has a dimension defined as its longest dimension in a plane perpendicular to the basement plane and defines an outer portion including a point of the outer curve and an inner portion including a point of said inner curve, said outer and inner portions being divided by a vertical line passing at a point located at 2/3 of said dimension, the outer portion being the larger portion,

- said first basement duct portion section having a first lowest point of said outer portion at a first vertical height, said second basement duct portion section having a second lower point of said outer portion at a second vertical height and said third basement duct section having a third lowest point of said outer portion at a third vertical height; said third lowest point belonging to said first longitudinal half of said basement;
- wherein said first vertical height of said outer portion is lower than said second vertical height of said outer portion and said third vertical height of said outer portion is comprised between, but not equal to, said first vertical height and said second vertical height.

[0058] Instead of considering the centerline of the dimension of the basement duct portion sections, a different vertical line can be considered, which sections the dimension in two portions having a length equal to 1/3 and 2/3 of the total length of the dimension, respectively. The length of 2/3 of the total length belongs to the outer portion. i.e. to the portion including the outer curve.

[0059] Instead of calculating the relative minimum on the outer half of the section, the relative minimum can be calculated now on the outer portion of the duct, i.e. on that portion having a width equal to 2/3 of the total width and including the outer curve.

[0060] Also in this case, as in the calculation of the relative minimum (or lowest point) in half of the section, there is a "two-step" rise of the duct from A0 to A1 and then from A1 to AV. In other words, the lowest point of the bottom of the duct in the basement is always the relative lowest minimum in the outer portion of the first section. The highest point of the bottom of the duct is the lowest point at the outlet of the basement. The intermediate planes sectioning the duct obtain, at least for one intermediate plane, define a lowest point "in between" the relative lowest point defined in the first section and the relative lowest point defined in the second section.

[0061] Even more preferably,

- said first basement duct portion section has a global first lowest point at a first vertical height, said second basement duct portion section has a global second lower point and a second vertical height and said third basement duct section has a global third lowest point at a third vertical height; said third point belonging to said first longitudinal half of said basement; and
- said global first vertical height is lower than said global second vertical height and said global third vertical height is comprised between, but not equal to, said first vertical height and said second vertical height.

[0062] The two -step rise of the duct applies also when the global minimum (or lowest point), and not only the local relative minimum, of the sections of the duct is considered. In this embodiment, the equation A0' < A1' < AV' holds.

[0063] Preferably, a plurality of intermediate planes perpendicular to said basement plane (X,Y) sectioning said outer curve of said basement duct portion in a point belonging said first longitudinal half of said basement not at said exit plane and said inner curve always at the same point in either said first longitudinal half or in said second longitudinal half of said basement defines a family of third basement duct portion sections and a family of third lowest points at a third vertical height in said outer half of said third basement duct sections all belonging to said first longitudinal half of said basement; said family of intermediate planes being selected so that the following intermediate plane of the family sections the outer curve of said basement duct portion in a point closer to said basement outlet plane than the previous intermediate plane of said family; and said family of thirds lowest points defines a curve of third vertical heights which is monotone.

[0064] In order to obtain even a smoother duct, so that the air flow is gradually risen from A0 to AV (or from AV' to A0'), the basement process air duct portion is monotonously raising, i.e. there is a family of intermediate planes having a given plane order for which sections of the duct along said family of intermediate planes have each a relative lowest point higher than the lowest point defined by the section along the precedent plane in the family according to the given order. These sectioning intermediate planes are planes all sectioning the same point of the inner curve, but each a different point in the outer point. The family of intermediate planes has on order for which the sectioning point in the outer curve follows the flow of process air: the first planes in the family sections the duct closer to the exit plane and then the subsequent planes section the outer curve towards the basement outlet plane.

[0065] Continuing this sectioning according to the family order, i.e. following in the sectioning the direction of flow of process air from the exit of the condenser to the outlet of the basement, all sections defines a relative lowest point in the outer half of the section which has a lowest height. A curve of the value of heights of the lowest points is defined, and this curve preferably is a monotone curve.

[0066] Preferably, the above applies also when the global lowest points of the sections are considered, i.e. also the curve formed by the global lowest points is monotone.

[0067] More preferably, said curve of third vertical heights is an increasing monotone curve.

[0068] Advantageously, the difference in height (AV-A0) between said first and said second lowest points of said outer half of said first and second basement duct sections is comprised between 25 mm and 50 mm.

[0069] This difference in height is thus substantially "shared" between the two parts of the basement air duct portion, the first part located within the first longitudinal half of the basement and the second part located within the second longitudinal half of the basement.

[0070] Advantageously, said casing includes a rear wall and in said basement a first, a second, a third and a fourth quarters are identifiable by means of the intersection between said first plane and a second plane perpendicular to said first plane passing through a center line of the basement substantially parallel to said front wall; said basement process air outlet being realized in said second quarter, the second quarter being the quarter of the second longitudinal half of the basement closest to the rear wall of said casing, and said basement process air duct portion extending in said first quarter and second quarter of said basement, said first quarter being the quarter of the first longitudinal half closest to the rear wall of the casing.

[0071] As mentioned, the basement can be considered as virtually divided in two by the first plane, and in a top view of the basement, such a first plane is a line. The basement can also be considered to be divided in "quarters" by the first plane and a second plane perpendicular to it and passing through a center line of the basement parallel to the front (or rear) wall of the casing. The quarters could be indicated as the first quarter, the second quarter the third quarter and the fourth quarter in a clockwise manner. The first quarter is the rearmost quarter of the first longitudinal half, the second quarter is the rearmost quarter of the second longitudinal half and so on.

[0072] The basement process air duct portion has a part which extends in the first longitudinal half, starting from the exit of the first heat exchanger or condenser, and a part extending in the second longitudinal half of the first heat exchanger or condenser, reaching the basement process air outlet of the basement. In this second longitudinal half, the extension of the basement process air duct portion is limited to the second quarter, i.e. there is no basement process air duct portion in the third quarter of the basement.

[0073] In an embodiment, said casing includes a front wall and wherein said first heat exchanger and said second heat exchanger are located within said fourth quarter of said basement for the majority of their respective volume, said fourth quarter being the quarter of the first longitudinal half of said basement closest to said front wall of the casing.

[0074] Due to the size of the heat exchangers, normally the exit of the first heat exchanger or condenser is located within the first quarter, so the basement process air duct portion extends only within the first quarter and the second quarter.

[0075] Advantageously, said basement includes an upper shell portion and a lower shell portion, said basement process air duct portion being formed by the connection between said upper shell portion and said lower shell portion.

[0076] The basement air duct portion in the basement can be realized for example in an easy and reliable manner joining together the two shell portions so as to form the lateral wall of the basement process air duct portion.

[0077] Preferably, said basement is realized in plastic material and said basement air duct portion is realized integral to said basement.

[0078] It should also be observed that, in the present description and in the attached claims, the terms "plastic material" and the like, are used to indicate any plastic or synthetic material, or based on plastic or synthetic material, possibly added with fillers suitable to improve the functional and robustness characteristics thereof, such as minerals, textile synthetic fillers and so on and so forth.

[0079] The fact that the basement is realized in plastic allows a minimization of the numbers of elements included in the dryer of the invention. Indeed, with a single producing process, for example with the same molding process, the basement can be realized including a plurality of additional functional elements for the dryer that do not have to be realized separately and then assembled, such as the basement duct portion or others for example the seats for the heat exchangers.

[0080] Preferably, said dryer includes a fan, said main fan being located in proximity of the basement process air outlet of said basement downstream said first heat exchanger and said second heat exchanger in the direction of flow of said process air.

[0081] The fan is preferably located just outside the basement process air outlet of the basement and blows the process air exiting the basement into the drum.

[0082] Advantageously, said dryer includes a motor defining a motor axis, apt to rotate said drum, said motor axis being parallel to said first plane.

[0083] More preferably, said motor is located within said second longitudinal half of said basement for the majority of its volume.

[0084] More preferably, said rotational axis of the drum and said motor axis are substantially parallel to each other.

[0085] Due to the location of the heat exchangers within the first longitudinal half of the basement, the motor is preferably located in the second longitudinal half due to the size of the same. The motor is also preferably driving the fan of the dryer.

[0086] In an embodiment, said casing includes a rear wall and a front wall, and an aperture being realized on said front wall of the casing to access said drum.

Brief description of the drawings

[0087] Further advantages of the present invention will be better understood with non-limiting reference to the appended drawings, where:

- Fig. 1 is a perspective view of a laundry dryer realized according to the present invention;

- Fig. 2 is a perspective view of the laundry dryer of Fig. 1 with an element of the casing removed for showing some internal components;
- Fig. 3 is a perspective view, in a disassembled configuration, of the basement of the dryer of Fig. 1 or Fig. 2;
- Fig. 4 is a perspective view of the basement of Fig. 3 with all elements removed;
- Fig. 5 is a top view of the basement of Fig. 3;
- Fig. 5a is an additional top view of the basement of Fig. 3;
- Figs. 6 and 7 are lateral views along the condenser exit plane and the basement outlet plane of Fig. 5;
- Figs. 8, 9, 10 and 11 are lateral views in section along lines C-C, F-F, D-D and A-A, respectively, of the top view of the basement of Fig. 5; and
- Fig. 12 is a lateral view in section along line G-G of the top view of the basement of Fig. 5.

Detailed description of one or more embodiments of the invention

[0088] With initial reference to Figs. 1 and 2, a laundry dryer realized according to the present invention is globally indicated with 1.

[0089] Laundry dryer 1 comprises an outer box or 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 cabinet 2, so that it can rotate around a preferably horizontal axis R (in alternative embodiments, rotation axis may be tilted). Access to the drum 3 is achieved for example via a door 4, preferably hinged to cabinet 2, which can open and close an opening 4a realized on the cabinet itself.

[0090] More in detail, casing 2 generally includes a front wall 20, a rear wall 21 and two sidewalls 25, all mounted on a basement 24. Preferably, the basement 24 is realized in plastic material. Preferably, basement 24 is molded via an injection molding process. Preferably, on the front wall 20, the door 4 is hinged so as to access the drum. The cabinet, with its walls, defines the volume of the laundry dryer 1. Advantageously, basement 24 includes an upper and a lower shell portion 24a, 24b (visible in Figures 3 and 6 detailed below).

[0091] The dryer 1, and in particular basement 24, defines an horizontal plane (X,Y) which is substantially the plane of the ground on which the dryer 1 is situated, thus it is considered to be substantially horizontal, and a vertical direction Z perpendicular to the plane (X,Y).

[0092] Laundry dryer 1 also preferably comprises an electrical motor assembly 50 for rotating, on command, revolving drum 3 along its axis inside cabinet 2. Motor 50 includes a shaft 51 which defines a motor axis of rotation M.

[0093] Further, laundry dryer 1 may include an electronic central control unit (not shown) which controls both the electrical motor assembly 50 and other components of the dryer 1 to perform, on command, one of the user-selectable drying cycles preferably stored in the same central control unit. The programs as well other parameters of the laundry dryer 1, or alarm and warning functions can be set and/or visualized in a control panel 11, preferably realized in a top portion of the dryer 1, such as above door 4.

[0094] With reference to Figure 2, the rotatable drum 3 includes a mantle, having preferably a substantially cylindrical, tubular body 3c, which is preferably made of metal material and is arranged inside the cabinet 2 and apt to rotate around the general rotational axis R which can be - as said - horizontal, i.e. parallel to the (X,Y) plane, or tilted with respect to the latter. The mantle 3c defines a first end 3a and a second end 3b and the drum 3 is so arranged that the first end 3a of the mantle 3c is faced to the laundry loading/unloading opening realized on the front wall 20 of the cabinet 2 and the door 4, while the second end 3b faces the rear wall 21.

[0095] Drum 3 may be an open drum, i.e. both ends 3a and 3b are opened, or it may include a back wall (not shown in the appended drawings) fixedly connected to the mantle and rotating with the latter.

[0096] In order to rotate, support elements for the rotation of the drum are provided as well in the laundry of the invention. Such support elements might include rollers at the front and/or at the back of the drum, as well as or alternatively a shaft connected to the rear end of the drum (shaft is not depicted in the appended drawings). In Fig. 2, for example, a roller 10 connected to the basement via a boss 101 is depicted. Any support element for the rotation of the drum around axis R is encompassed by the present invention.

[0097] Dryer 1 additionally includes a process air circuit which comprises the drum 3 and an air process conduit 18, depicted as a plurality of arrows showing the path flow of a process air stream through the dryer 1 (see Figures 3 and 4). In the basement 24, a portion of the air process conduit 18 is formed by the connection of the upper shell 24a and the lower shell 24b. Air process conduit 18 is preferably connected with its opposite ends to the two opposite sides of drum 3, i.e. first and second rear end 3a,3b of mantle 3c. Process air circuit also includes a fan or blower 12 (shown in Fig. 3).

[0098] The dryer 1 of the invention additionally comprises a heat pump system 30 including a first heat exchanger (called also condenser) 31 and a second heat exchanger (called also evaporator) 32 (see figure 3). Heat pump 30 also includes a refrigerant closed circuit (partly depicted) 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, in correspondence of the second heat exchanger (evaporator) 32, absorbing heat. A compressor receives refrigerant in a gaseous state from the evaporator 32 and supplies the condenser 31, thereby closing the refrigerant cycle. 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 (see Fig. 3) the second heat exchanger (evaporator) 32 via a compressor 33 to the condenser 31. The outlet of condenser 31 is connected to the inlet of the evaporator 32 via an expansion device (not visible), such as a choke, a valve or a capillary tube.

[0099] Preferably, in correspondence of evaporator 32, the laundry dryer 1 of the invention may include a condensed-water canister (also not visible) which collects the condensed water produced, when the dryer 1 is in operation, inside evaporator 32 by condensation of the surplus moisture in the process air stream arriving from the drying chamber (i.e. drum) 3. The canister is located at the bottom of the evaporator 32. Preferably, through a connecting pipe and a pump (not shown in the drawings), the collected water is sent in a reservoir located in correspondence of the highest portion of the dryer 1 so as to facilitate a comfortable manual discharge of the water by the user of the dryer 1.

[0100] The condenser 31 and the evaporator 32 of the heat pump 30 are located in correspondence of the process air conduit 18 formed in the basement 24 (see figure 3).

[0101] In case of a condense-type dryer - as depicted in the appended figures - where the air process circuit is a closed loop circuit, the condenser 31 is located downstream of the evaporator 32. The air exiting the drum 3 enters the conduit 18 and reaches the evaporator 32 which cools down and dehumidifies the process air. The dry cool process air continues to flow through the conduit 18 till it enters the condenser 31, where it is warmed up by the heat pump 30 before re-entering the drum 3.

[0102] It is to be understood that in the dryer 1 of the invention, an air heater, such as an electrical heater, can also be present, in addition to the heat pump 30. In this case, heat pump 30 and heater can also work together to speed up the heating process (and thus reducing the drying cycle time). In the latter case, preferably condenser 31 of heat pump 30 is located upstream the heater. Appropriate measures should be provided to avoid the electric heater to fuse plastic components of the dryer 1.

[0103] Further, with now reference to Figures 4 and 5, in the basement, the process air conduit 18 includes a duct formed by the upper and the lower shells 24a, 24b, having an inlet 19in from which process air is received from the drum 3 and an outlet 19 to channel process air out of the basement 24. Between inlet 19in and outlet 19, the duct is formed, preferably as two single pieces joined together and belonging to the upper and lower shell 24a, 24b, and including a first and a second portion 28 and 29. In the first portion 29 of this duct, seats 29s are formed for locating the first and the second heat exchangers 31, 32. Preferably, first and second heat exchanger 31, 32 are placed one after the other, the first heat exchanger 31 being downstream in the direction of flow of the process air the second heat exchanger 32. Further, the second portion 28, called basement air duct portion 28, channels the process air exiting from the first heat exchanger 31 towards the basement outlet 19.

[0104] The second portion 28 thus starts at the location of the exit 28in of the first heat exchanger 31, considered as the location of a plane sectioning the duct portion 28 and substantially in contact with a surface of the first heat exchanger 31 from which process air exits.

[0105] Preferably, the exit 28in may be defined on a plane perpendicular to the basement plane, e.g. on a vertical plane. A plane perpendicular to the basement plane and containing the exit of the condenser is called in the following Pex. The section of the basement 24 along Pex is shown in Fig. 7.

[0106] Furthermore, preferably also the outlet 19, defined as the area at which the air exits the basement, defines in turn a plane substantially perpendicular to the basement plane, e.g. a vertical plane. A plane perpendicular the basement plane and containing the outlet 19 is called in the following basement outlet plane P19. The section of the basement 24 along P19 is shown in Fig. 6.

[0107] Considering now a first plane P1 perpendicular to the basement plane (X,Y) and embedding the rotational axis R of the drum 3, this first plane P1 divides the basement 24 in two halves, called, with now reference to figure 6, basement first or right half 24 first half and basement second or left half 24 second half. These two halves 24 first half and 24 second half need not to be identical in dimension (i.e. they are not mathematical halves), however in the present depicted embodiment P1 also embeds a first - longitudinal - centerline H1 of the basement. Furthermore, still in the depicted embodiment, P1 is a vertical plane.

[0108] On the first half of the basement, 24 first half, the portion 29 of the duct is positioned, where also the first and the second heat exchanger 31, 32 of heat pump 30 are located. The heat exchanger can be completely contained within the first half of the basement 24 first half or they can also extend beyond the limit defined by the first plane P1. If a portion of the first and/or second heat exchanger 31, 32 is also located within the second half of the basement 24 second half, this portion is the minority of the whole volume occupied by the first and/or second heat exchanger 31, 32.

[0109] On the second half of the basement 24 second half, preferably the compressor 33 is located. More preferably, also the motor 50 is located in this second half.

[0110] Preferably, motor 50 including shaft 51 defining motor axis M has the motor axis substantially parallel to the first plane P1 (see Figure 5).

[0111] Again with reference to Figs. 4 and 5, considering now a second plane P2, perpendicular to P1 and to the basement plane (X,Y) and passing through a second centerline H2 of the basement, the basement 24 is divided, by a combination of the first and the second plane P1, P2, in four quarters Q1 - Q4. The quarters are numbered in a clockwise manner, the first quarter Q1 being the rearmost quarter of the first half of the basement 24 (e.g. the quarter facing the rear wall 21), the second quarter Q2 being the rearmost quarter of the second half of the basement 24, the third quarter Q3 the foremost quarter (e.g. the quarter facing the front wall 20) of the second half of the basement and the last fourth quarter Q4 the foremost quarter of the first half of the basement 24.

[0112] It can be therefore seen that the heat exchangers 31, 32 and the duct portion 29 are substantially contained for the majority of their volume within the fourth quarter Q4, the second heat exchanger closer to the front wall 20 than the first heat exchanger 31; preferably compressor 33 is contained within the third quarter Q3, and the outlet 19 of basement 19 is located in the second quarter Q2, preferably facing rear wall 21 of casing 2.

[0113] Motor 50 is preferably contained within the second quarter Q2 as well and its shaft 51 extends in such a way that it sticks out from the outlet 19, i.e. it exits the basement 24 with one of its ends through the basement outlet 19. Preferably, motor shaft 51 is also the shaft of fan 12, which is located in proximity of outlet 19, preferably facing the latter. Fan 12 blows the process air exiting the basement 24 through outlet 19 into the drum 3, preferably through a passage, not shown, part of the process air circuit 18, formed within the rear wall 21.

[0114] The duct portion 28 extends from the air exit of the compressor, 28in, which is located within the first quarter Q1 preferably close to the boundary with the fourth quarter Q4, i.e. close to centerline H2, to the outlet 19 of the basement, located in the second quarter Q4.

[0115] Preferably, but not necessarily, the planes containing the exit 28in and the outlet 19 are substantially parallel to each other and even more preferably they are both parallel to P2.

[0116] The duct portion 28 therefore has to comprise at least one curve or bend in order to extend from the first to the second quarter. Furthermore, duct portion 28 includes walls which form and delimit the duct portion itself, walls form a closed curve, in other words, when the duct portion 28 is sectioned on a plane perpendicular to the basement plane (X,Y), the section of the duct walls defines a closed curve. Walls include a first and a second lateral wall 28w1 and 28w2. In the depicted embodiment, the lateral walls 28w1 and 28w2 are for at least a part of duct portion 28 substantially locally parallel and facing each other and also locally planar. However the configuration of lateral walls 28w1 and 28w2 can change also along the extension of the duct, for example close to the outlet 19, the section of the duct portion 28 becomes substantially circular and thus lateral walls 28w1 and 28w2 become substantially curvilinear or each of them includes an arch of circumference. Any embodiment of the geometrical configuration of lateral walls 28w1 and 28w2 is encompassed in the present invention.

[0117] Preferably, first and second lateral walls 28w1 and 28w2 are each separated in half and each of the halves is integrally formed with the upper or lower shell 24a, 24b. That is to say, the upper shell 24a includes a part of first lateral wall 28w1 and a part of second lateral wall 28w2, both parts integrally formed with the upper shell 24a, while the lower shell 24b includes the remaining part of first lateral wall 28w1 and remaining part of second lateral wall 28w2, both remaining parts integrally formed with the lower shell 24b.

[0118] Considering now a further plane, called sectioning plane PT (visible in Fig. 5a, which is a section of the basement along plane PT), a section of the duct portion 28 is made as follows. Sectioning plane PT is a plane substantially parallel to the basement plane (X,Y), e.g. it is an horizontal plane. This plane PT is at a given distance from the basement plane so that it sections the lateral first and second walls 24w1, 24w2 at a certain height. For example, such a sectioning plane PT is the one which has been used to form the cross section of Fig. 5a; in Fig. 5a sectioning plane PT has been schematically depicted as a dotted rectangle.

[0119] Sectioning plane PT thus sections first lateral wall 28w1 and second lateral wall 28w2 generating - in a top view of such section - an inner curve 28b and an outer curve 28a, respectively. The inner and outer curve 28a, 28b are substantially the curves formed by the edges of the first and second lateral walls - respectively - in the location where they have been sectioned.

[0120] Inner curve 28b is called "inner" being generally closer to the center of casing 2 for most of its extension that the outer curve 28a.

[0121] Each of the inner and outer curve 28b, 28a, due to the fact that the duct portion 28 extends in the first and second half 24 first half and 24 second half of the basement 24, and preferably is contained within the first and the second quarter Q1 and Q2, extends for a given first length in the first half 24 first half and for a given second length in the second half 24 second half of the basement 24.

[0122] Coming back to Figs. 6 and 7, which are the sections of the basement 24 along the basement outlet plane P19 and the condenser exit plane Pex, respectively, each of these section shows a closed curve formed by the walls of the duct 18. Each of this curve, i.e. the curve defined in the section made by Pex and the curve defined in the section made by P19, can be divided in two halves by a centreline C. This centreline C is defined as the vertical line which divides the dimension Diam in two parts having equal length. The dimension of the section of the duct is not always a real dimension as in Fig. 6 where the section of the duct is substantially circular. When the section of the duct portion is not circular, the dimension Diam is defined as the longest dimension of the duct in a plane parallel to the basement plane.

[0123] The two halves of the curve defined by the walls of the duct and visible in the section of Figs. 6 and 7 are called inner half 28inner and outer half 28outer, being respectively the halves containing the inner 28b and the outer curve 28a. Each half has a relative minimum. In other words, the curve formed by the section of the duct walls within the inner half 28inner by plane P19 or Pex and centreline C has a lowest point in the vertical direction. In the same way, the curve formed by the section of the duct walls within the outer half 28inner by plane P19 or Pex and centreline C has a lowest point in the vertical direction. The two minima, i.e. the minimum in the inner half and the minimum in the outer half, can coincide, as in the case of the section along P19 of Fig. 6 and Pex of Fig. 7.

[0124] Furthermore, for any section of the duct portion 28 defined by any plane perpendicular to the basement plane (X,Y) a global minimum can also be identified. In other words, the closed curve defined by the section has a global minimum having a given height.

[0125] In the section along plane Pex of Fig. 7, the section shows substantially planar lateral walls and the dimension Diam is constant for a given height. The centreline C divides the curve in two halves, the inner 28inner and the outer half 28outer. A plurality of relative minima both in the inner and in the outer halves is defined, due to the fact that the section along plane Pex is substantially rectangular and the bottom of the duct is substantially flat. Therefore, the whole bottom of the duct 28 is formed by relative lowest points LP0 at the lowest height A0 from the basement plane (X,Y). This lowest height A0 defines the "zero" of the further measures, i.e. all the following minimum of other sections along different planes will be calculated from the location of this lowest point LP0. This is due to the fact that the heat exchangers are located at the lowest possible point within the basement duct portion 28 so that they can extend in the vertical direction as much as possible so that the heat exchange surface is maximized. In this configuration of Fig. 7, the lowest relative point LP0 on the outer half 28outer of the curve defined by the walls and the global lowest point LP0' of the whole curve coincides, i.e. the relative minimum LP0 in the outer half 28outer is also the global minimum LP0' of the whole curve defined by the section by Pex.

[0126] In the section along plane P19 of Fig. 6, the section defines substantially a circle having a given dimension Diam. The circle has a lowest point LPV' which is on the centreline C as a global minimum of the whole curve. This point is also the local minimum of the outer half 28outer of the section. The height of the minimum (height of both relative and global minimum) is called AV=AV' and the single lowest point which is both the local and global minimum is called LPV=LPV'. Advantageously, this is the highest lowest point in the whole bottom of the basement duct portion 28, i.e. preferably in the basement duct portion, no other section along a plane perpendicular to the basement plane shows a minimum, either relative or global, having a height higher than LPV=LPV'.

[0127] The value of the height AV of the relative minimum LPV of the outer half 28outer of the section along outlet plane P19 is higher of the value of the height A0 of the relative minimum LP0 of the outer half 28outer of the section along the condenser exit plane Pex, i.e. AV > A0. Preferably, the above relationship holds also for the global minima, i.e. also AV' > A0'.

[0128] In order to obtain a smooth duct, the difference in height between A0 and AV, or between A0' and AV', is obtained in two steps, a first step in the first half of the basement and a second step in the second half of the basement.

[0129] With reference back to Figure 5, an intermediate plane P3 is now considered which is also perpendicular to the basement plane (X,Y) and sections the duct portion 28. The section made by the intermediate plane P3 is obtained in the following way: plane P3 (a plurality of such planes is shown in Figure 5) sections the inner curve 28b in any point and section the outer curve 28a in a point which belong to the first longitudinal half 24 first half of the basement 24 and preferably to the first quarter Q1. The initial point of the outer curve 28a, i.e. the point at the condenser exit plane Pex, is however excluded. This section of the basement duct portion along the intermediate plane defines a closed curve given by the walls of the basement duct portion 28. As above, this closed curve can be divided in an inner half 28inner and an outer half 28outer by a centerline C passing through the middle of the dimension Diam.

[0130] The outer half 28outer defines in turn a relative minimum LP3 of the half. The relative minimum can be a single point LP3, a plurality of points, etc.; it can be located at the centerline C or be far from it. Further, the closed curve also define a global minimum LP3', which is the minimum of the whole curve defined by the sectioned walls of the basement duct portion 28. This point of global minimum LP3' can also be a single point or a plurality of points. The height of the relative minimum LP3 is calculated with respect to the height of A0 and it is called A1. The height of the global minimum LP3' is calculated with respect to the height of A0' and it is called A1'. This minimum, relative or global, is considered, i.e. the intermediate plane P3 is a correct intermediate plane according to the present definition, only if the relative (global) minimum belong to the first half 24 first half of the basement 24.

[0131] In the drawing of Fig. 5, four intermediate planes P3 have been considered and the sections obtained by such planes are shown in Figs. 8-11.

[0132] In Fig. 8, the section along plane of lines C-C of Fig. 5 is shown. Such section shows a very small increase of the lowest point with respect of A0 (the A0 is substantially the height at the bottom of the heat exchangers 31, 32), so it is not depicted in the drawings for clarity.

[0133] A bigger increase in the height of the lowest point is shown in the further sections of Figs. 9-11 which are sections along line F-F, D-D and A-A (coinciding with P1) of Fig. 5. For each of these sections, a centerline C is drawn, which divides the section in an outer half 28outer including the outer curve 28a and an inner half 28inner including the inner curve 28b. A relative minimum LP3 of the outer half 28outer is calculated, as well as a global minimum LP3'.

[0134] As clear from such sections, the duct 28 is slowly rising from the lowest height A0 (A0') towards the height AV (AV') of point LPV (LPV') and the value of the height A1 of the lowest point LP3 of the various sections taken by different intermediate planes P3, both relative and global, is getting higher the closer the intermediate plane P3 gets to the outlet plane P19.

[0135] In the preferred embodiment, the highest relative lowest point LP3 within the outer half of the section realized by an intermediate plane P3 is obtained via the section by plane P1, depicted in Fig. 11.

[0136] In other words, according to the invention, there is at least an intermediate plane P3 sectioning duct 28 which has a relative lowest point LP3, i.e. the lowest point within the outer half 28outer, which has a height value A1 between A0 and AV, A0 < A1 < AV. More preferably, according to the invention, there is at least an intermediate plan P3 sectioning duct 28 which has a global lowest point, i.e. the lowest point within the whole curve 28lower + 28outer, which has a height value A1' between A0' and AV', A0' < A1' < AV'.

[0137] As mentioned, the intermediate plane P3 is considered only if the relative minimum LP3 or global minimum LP3' is located within the first longitudinal half 24 first half of the basement 24 and more preferably within the first quarter Q1.

[0138] In a different embodiment, instead of considering the centerline C dividing the curve of each section in two halves, a different vertical line is considered (not depicted in the drawings), which divides the curve defined by each section by a plane (e.g. Pex, P19, P3, etc.) perpendicular to the basement plane (X,Y) in two portions, one containing 2/3 of the total length of the dimension Diam and the outer curve, called outer portion, and the other containing 1/3 of the total length of the dimension Diam and the inner curve, called inner portion. The relative minimum of the outer portion, e.g. the relative lowest point of the outer portion, and its relative lowest height value are thus calculated, for the section obtained sectioning the basement duct portion by means of the condenser exit plane Pex, basement outlet plane P19 and intermediate plane P3 (the intermediate plane is defined as above). Also in this embodiment, according to the invention, the height of the relative lowest point of the outer half in the section obtained by means of the intermediate plane has a value between (but not comprising) the value of the height of the relative lowest point of the outer half at the section made by the exit plane and the value of the height of the relative lowest point of the outer half at the section made by the outlet plane.

[0139] More preferably, there is a plurality of such intermediate planes for which A0 < A1 < AV or for which A0' < A1' < AV'.

[0140] The smooth rising of the basement duct portion 28 can be visualized in its entirety in the section along line G-G of Fig. 5 depicted in Fig. 12.

[0141] Even more preferably, there is a family of plane having a given order within the family for which the value of A1 of one plane of the family is lower than the value A1 for the next plane in the family, i.e. taken the Nth and N+1th plane in the family, $A1_N < A1_{N+1}$ and this is valid for all intermediate planes in the family. The constraints above mentioned, i.e. the fact that the minimum should always belong to the first longitudinal half of the basement and that the plane should not section the outer curve at the condenser exit plane, apply to all planes in this family.

[0142] A family of intermediate planes P3 which shows this increase in the height of the bottom of the basement duct portion 28 of the invention is defined as follows. A fixed point in the inner curve 28b is considered. A family of intermediate planes P3 all passing through such a fixed point is then taken. Each of the intermediate plane in this family passes through the same point in the inner curve but through different points in the outer curve 28a. For each intermediate plane P3 of the family, this point in the outer curve 28a is taken so that the N+1 plane in the family is closer to the basement outlet plane P19 than the N plane in the family. In other words, in the family, the intermediate planes gradually get closer to the outlet plane P19. Each such intermediate plane P3 defines a section of the basement duct portion 28 and as above each of these sections defines both a relative minimum LP3 in the outer half of the section and a global minimum LP3'.

[0143] In a preferred embodiment of the invention, the values of the heights A1 of the local minima LP3 defined by the various intermediate planes P3 of the above identified family defines a monotone function, starting at a value close to A0 for the intermediate plane P3 sectioning the outer curve 28a at a point close to the exit plane Pex and gradually having an increasing value of A1 the closer the intermediate plane P3 of the family gets to P19. The value of the height A1 of the relative minimum LP3 of the sections increases towards the value AV for intermediate planes P3 in the family sectioning the outer curve 28a at a point close to the outlet plane P19.

[0144] This monotonically increasing function can be pictured looking at Figs. 8-11, which are sections taken along intermediate planes P3 of such a family (see Fig. 5). As shown, the point in which the family of intermediate planes sections the inner curve 28b is always the same, while the point in the outer curve moves from a point close to Pex till a point on P1. No further points are considered, i.e. the points on the outer curve belonging to the second half of the basement are not considered.

[0145] In this way, a very gradual increase of the height of the duct 28 is obtained, channeling process air from the condenser to the outlet of the basement minimizing turbulence.

Claims

1. A laundry dryer (1) including:

- a casing (2), rotatably supporting a drum (3) for receiving a load to be dried, said drum being apt to rotate around a rotational axis (R), said casing (2) including

  o a basement (24) defining a basement plane (X, Y) and in which a first longitudinal half (24 first half) and a second longitudinal half (24 second half) of said basement (24) are identifiable by means of a first plane (P1) perpendicular to said basement plane (X, Y) and passing through said rotational axis (R) of the drum (3);

- A process air conduit (18) in fluid communication with the drum (3) where a process air stream is apt to flow;
- A heat pump system (30) having a heat pump circuit in which a refrigerant can flow, said heat pump circuit including a first heat exchanger (31) where the refrigerant is cooled off and the process air is heated up, and a second heat exchanger (32) where the refrigerant is heated up and the process air is cooled off; said first heat exchanger (31) and/or said second heat exchanger being arranged in the process air conduit (18) within said first longitudinal half (24 first half) of said basement (24) of said basement (24) for the majority of their respective volumes in order to perform heat exchange between said refrigerant flowing in said heat pump circuit and said process air;
- Said process air conduit (18) including a basement process air duct formed in said basement (24), said basement process air duct comprising a basement duct portion (28) channeling said process air between a condenser process air exit (28in) where process air exits from said first heat exchanger (31) and a basement process air outlet (19) where process air exits said basement (24), said basement process air outlet (19) being located within said second longitudinal half (24 second half) of said basement (24);
- said basement duct portion (28) including one or more duct walls (28w) which in a section along a sectioning plane (PT) parallel to said basement plane (X, Y) defines an inner curve (28b) and an outer curve (28a), said outer curve (28a) being the curve closer to the rear wall (21) of the casing (2) among the two curves (28a, 28b);
- Wherein an exit plane (Pex) perpendicular to said basement plane (X, Y) sectioning said basement duct portion (28) at said condenser process air exit (28in) defines a first basement duct portion section; a basement outlet plane (P19) perpendicular to said basement plane (X, Y) sectioning said basement duct portion (28) at said basement process air outlet (19) defines a second basement duct portion section; and an intermediate plane (P3) perpendicular to said basement plane (X,Y) sectioning said outer curve (28a) of said basement duct portion (28) in a point belonging to said first half (24 first half) of said basement (24) not at said exit plane (Pex) and said inner curve (28b) in a point in either said first or in said second half of said basement defines a third basement duct portion section;
- Wherein each of said first, second and third basement duct portion sections defines a vertical centerline (C) dividing each first, second and third basement duct section in an outer half (28outer) including a point of the outer curve (28a) and an inner half (28inner) including a point of said inner curve (28b), said first basement duct portion section having a first lowest point (LP0) of said outer half (28outer) at a first vertical height (A0), said second basement duct portion section having a second lowest point (LPV) of said outer half (28outer) at a second vertical height (AV) and said third basement duct section having a third lowest point (LP3) of said outer half (28outer) at a third height (A1); said third lowest point (LP3) belonging to said first longitudinal half (24 first half) of said basement (24);
- wherein said first vertical height (A0) is lower than said second vertical height (AV; with A0 < AV) and said third vertical height (A1) is comprised between, but not equal to, said first vertical height (A0) and said second vertical height (A0 < A1 < AV).

2. The laundry dryer according to claim 1,

- wherein each first, second and third basement duct portion sections has a dimension (Diam) defined as its longest dimension in a plane perpendicular to the basement plane (X,Y) and defines an outer portion including a point of the outer curve (28a) and an inner portion including a point of said inner curve (28b), said outer and inner portions being divided by a vertical line passing at a point located at 2/3 of said dimension (Diam), the outer portion being the larger portion,
- said first basement duct portion section having a first lowest point of said outer portion at a first vertical height, said second basement duct portion section having a second lower point of said

outer portion at a second vertical height and said third basement duct section having a third lowest point of said outer portion at a third vertical height; said third lowest point belonging to said first longitudinal half (24 first half) of said basement (24);
- wherein said first vertical height of said outer portion is lower than said second vertical height of said outer portion and said third vertical height of said outer portion is comprised between, but not equal to, said first vertical height and said second vertical height.

3. The laundry dryer (1) according to claim 1 or 2,

- wherein said first basement duct portion section has a global first lowest point (LP0') at a first vertical height (A0'), said second basement duct portion section has a global second lower point (LPV') and a second vertical height (AV') and said third basement duct section has a global third lowest point (LP3') at a third vertical height (A1'); said third point belonging to said first longitudinal half (24 first half) of said basement (24); and
- wherein said global first vertical height (A0') is lower than said global second vertical height (AV'; with A0' < AV') and said global third vertical height (A1') is comprised between, but not equal to, said first vertical height (A0') and said second vertical height (A0' < A1' < AV').

4. The laundry dryer (1) of any of the preceding claims, wherein a plurality of intermediate planes (P3) perpendicular to said basement plane (X,Y) sectioning said outer curve (28a) of said basement duct portion (28) in a point belonging said first longitudinal half (24 first half) of said basement (24) not at said exit plane (Pex) and said inner curve (28b) always at the same point in either said first longitudinal half (24 first half) or in said second longitudinal half (24 second half) of said basement (24) defines a family of third basement duct portion sections and a family of third lowest points (LP3) at a third vertical height (A1) in said outer half (28outer) of said third basement duct sections all belonging to said first longitudinal half (24 first half) of said basement; said family of intermediate planes being selected so that the following intermediate plane (P3) of the family sections the outer curve (28a) of said basement duct portion (28) in a point closer to said basement outlet plane (P19) than the previous intermediate plane of said family; and said family of thirds lowest points (LP3) defines a curve of third vertical heights (A1) which is monotone.

5. The laundry dryer according to claim 4, wherein said curve of third vertical heights (A1) is an increasing monotone curve.

6. The laundry dryer (1) of any of the preceding claims, wherein the difference in height (AV-A0) between said first (LP0) and said second lowest points (LPV) of said outer half (28outer) of said first and second basement duct sections is comprised between 25 mm and 50 mm.

7. The laundry dryer (1) according to any of the preceding claims, wherein said casing (2) includes a rear wall (21) and a front wall (20) and wherein in the basement (24) a first, a second, a third and a fourth quarters are identifiable by means of the intersection between said first plane (P1) and a second plane (P2) perpendicular to said first plane passing through a center line (H2) of the basement substantially parallel to said front wall (20) of the casing (2); wherein said basement process air outlet (19) being realized in said second quarter, the second quarter being the quarter of the second longitudinal half (24 second half) of the basement (24) closest to the rear wall (21) of said casing (2), and said basement process air duct portion (28) extending in said first quarter and second quarter of said basement (24), said first quarter being the quarter of the first longitudinal half of the basement (24) closest to the rear wall (21) of the casing (2).

8. The laundry dryer (1) according to any of the preceding claims when dependent to claim 3, wherein said casing (2) includes a front wall (20) and wherein said first heat exchanger (31) and said second heat exchanger (32) are located within said fourth quarter of said basement (24) for the majority of their respective volumes, said fourth quarter being the quarter of the first longitudinal half (24 first half) of said basement (24) closest to said front wall (20).

9. The laundry dryer (1) according to any of the preceding claims, wherein said basement (24) includes an upper shell portion (24a) and a lower shell portion (24b), said basement process air duct portion (28), including said basement outlet (19) being formed by the connection between said upper shell portion (24a) and said lower shell portion (24b).

10. The laundry dryer (1) according to any of the preceding claims, wherein said basement (24) is realized in plastic material, and said basement process air duct portion (28) is realized integral to said basement (24).

11. The laundry dryer (1) according to any of the preceding claims, including a fan (12), said fan being located in proximity of the basement process air outlet (19) of said basement (24) downstream said first heat exchanger (31) and said second heat exchanger (32) in the direction of flow of said process air.

12. The laundry dryer (1) according to any of the preceding claims, including a motor (50) defining a motor axis (M), apt to rotate said drum (3), said motor axis (M) being parallel to said first plane (P1).

13. The laundry dryer (1) according to claim 12, wherein said motor (50) is located within said second longitudinal half (24 second half) of said basement (24) for the majority of its volume.

14. The laundry dryer (1) according to any of the preceding claims, wherein said rotational axis (R) of the drum (3) and said motor axis (M) are parallel or substantially parallel to each other.

15. The laundry dryer according to any of the preceding claims, wherein said casing (2) includes a rear wall (21) and a front wall (20), and an aperture (4a) being realized on said front wall (20) of the casing (2) to access said drum (3).

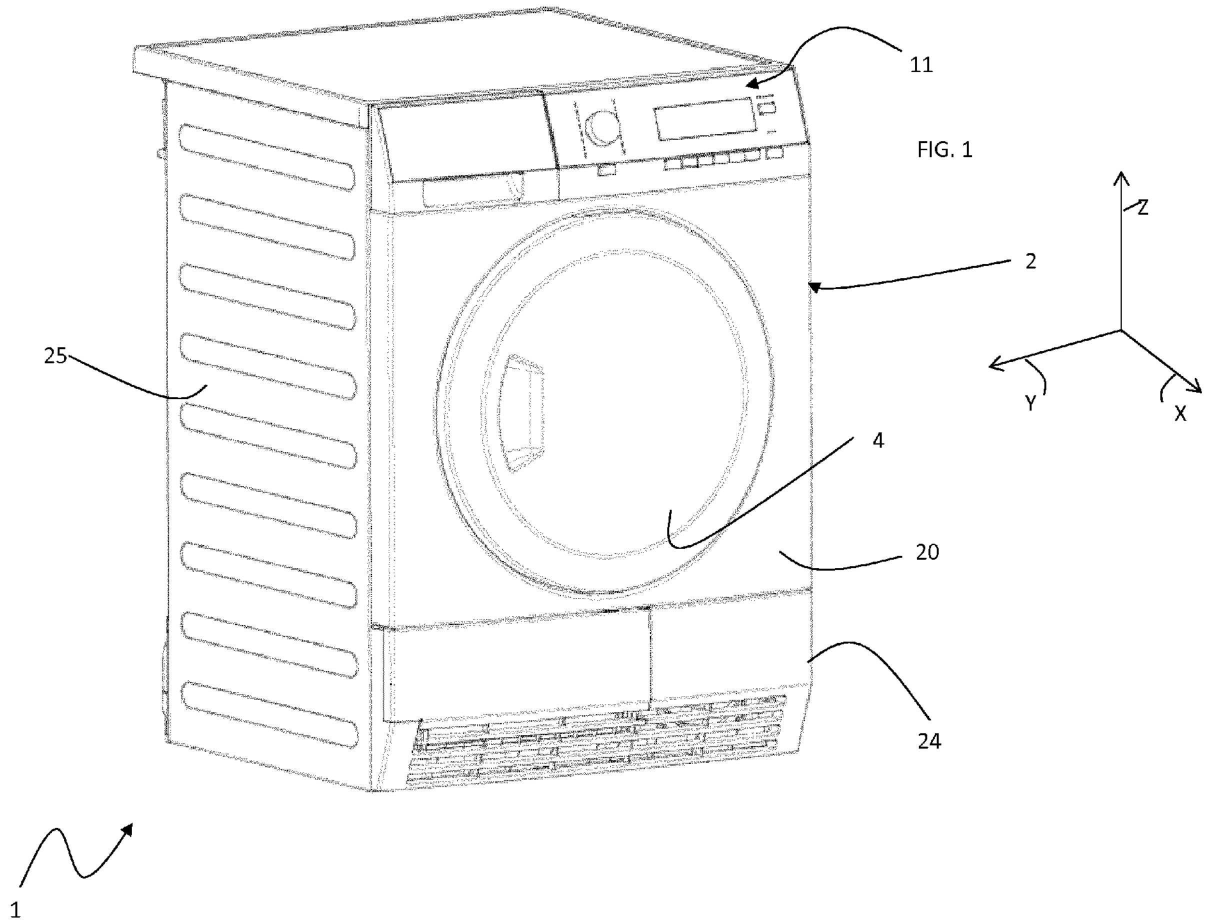


FIG. 1

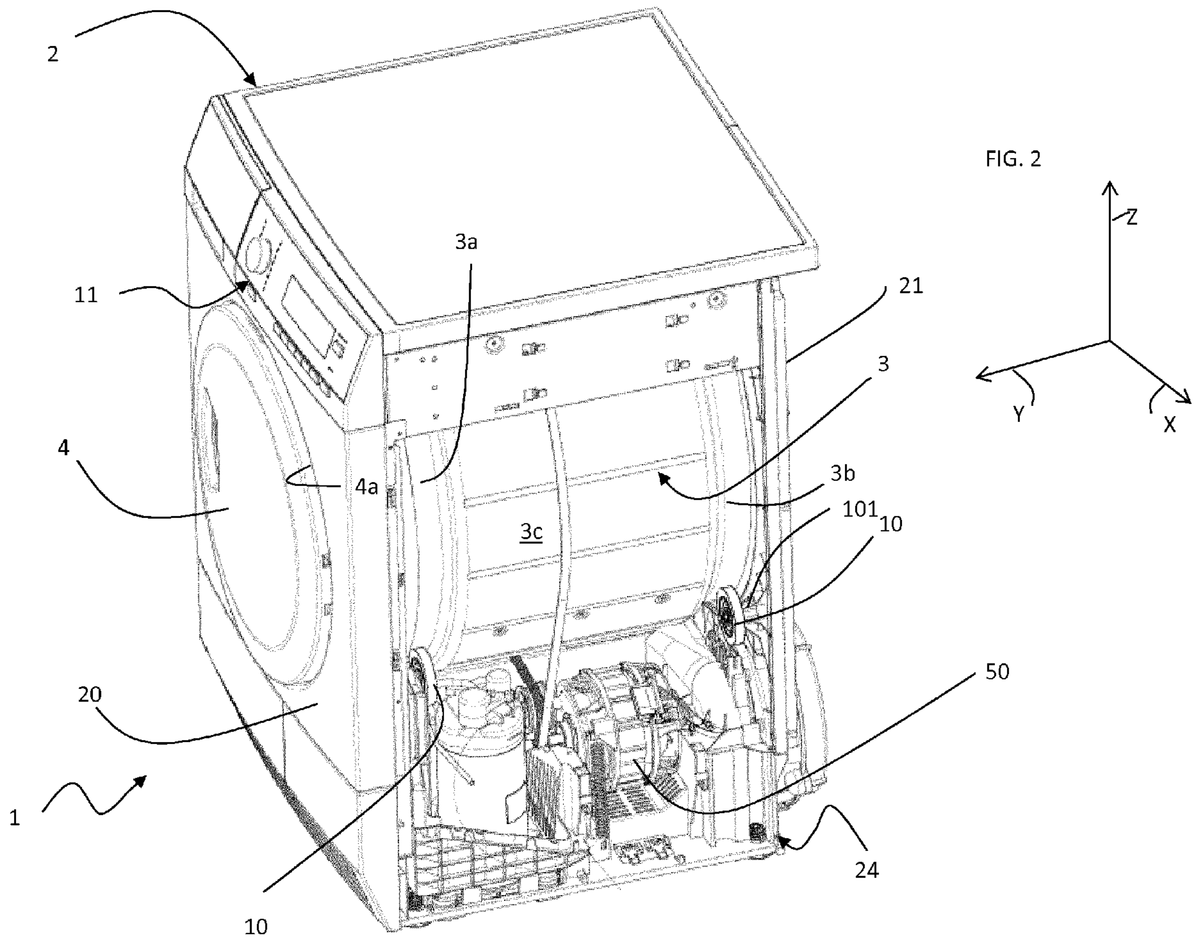
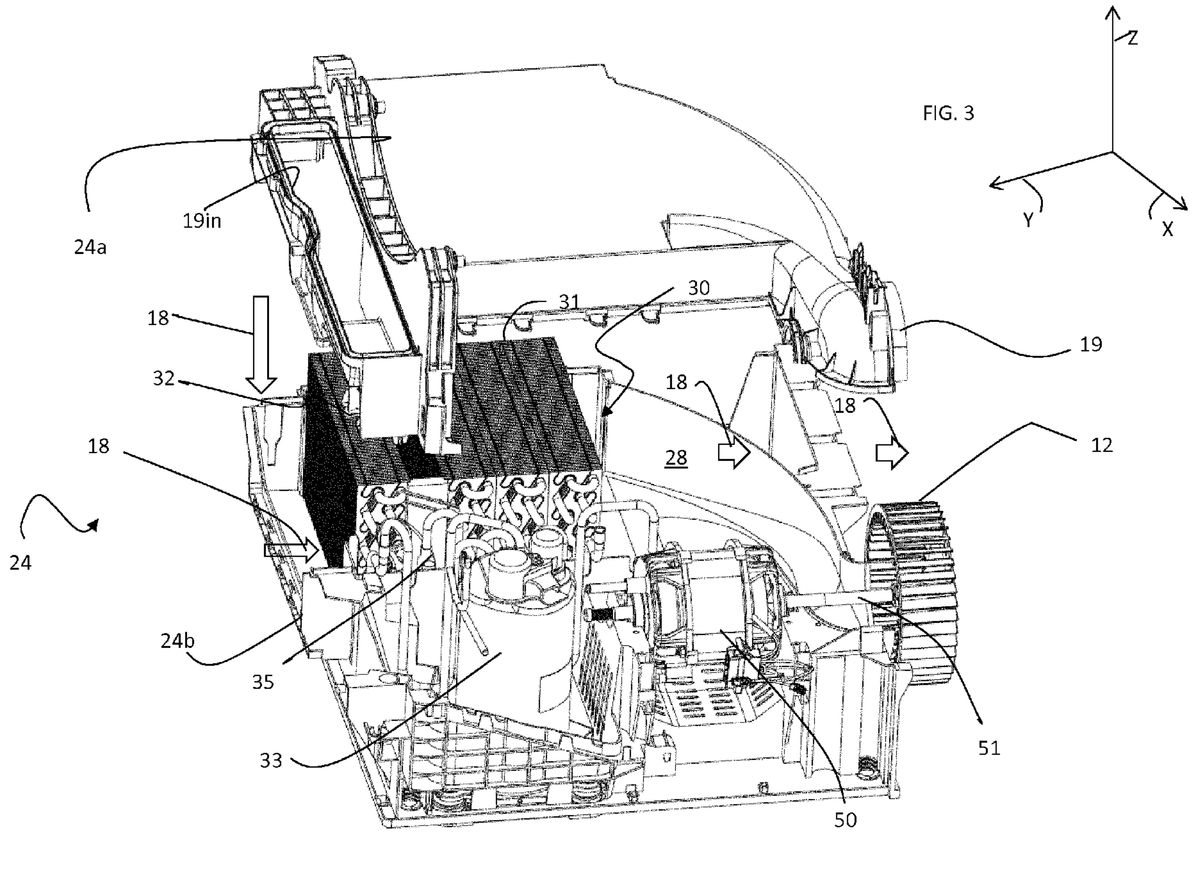


FIG. 2

FIG. 3



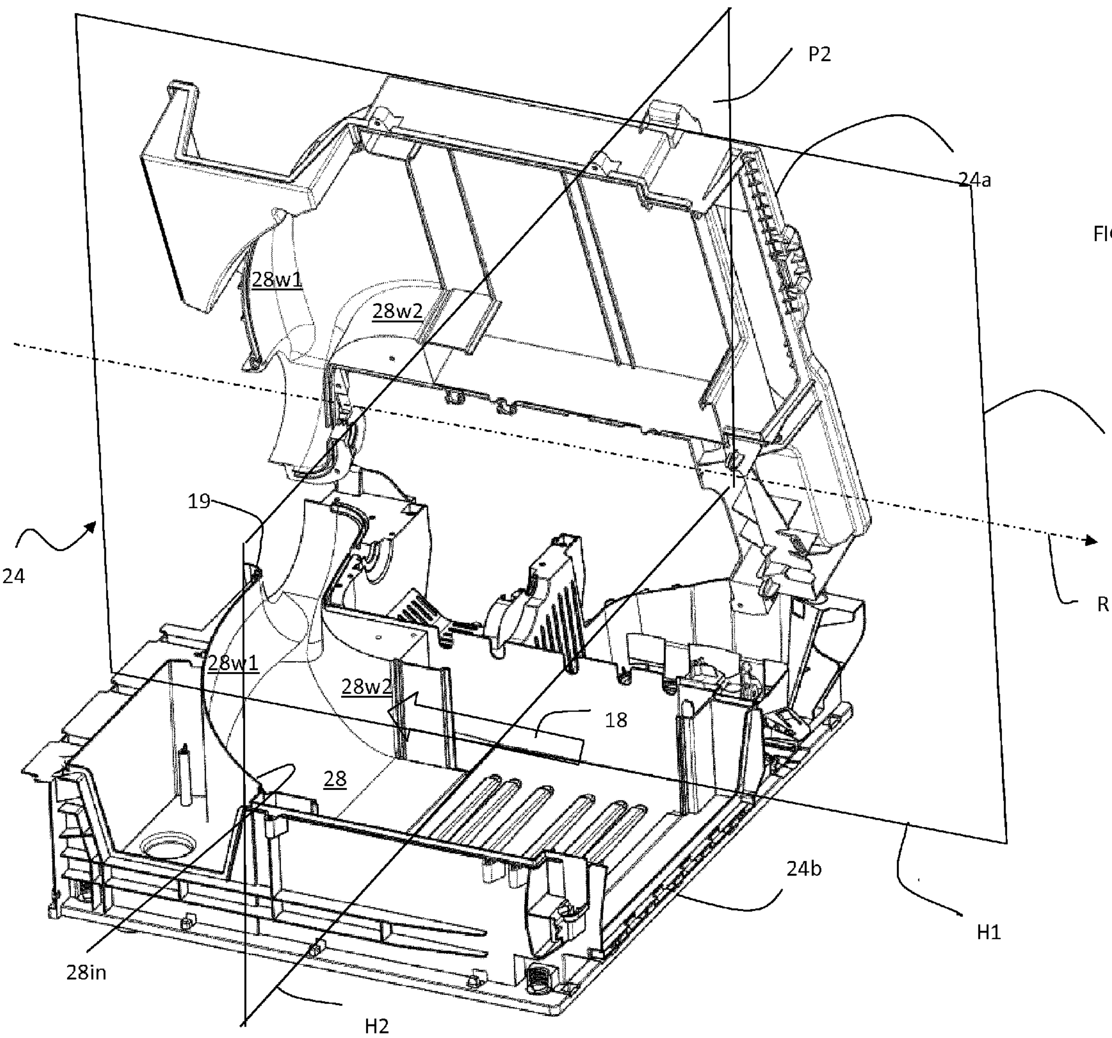
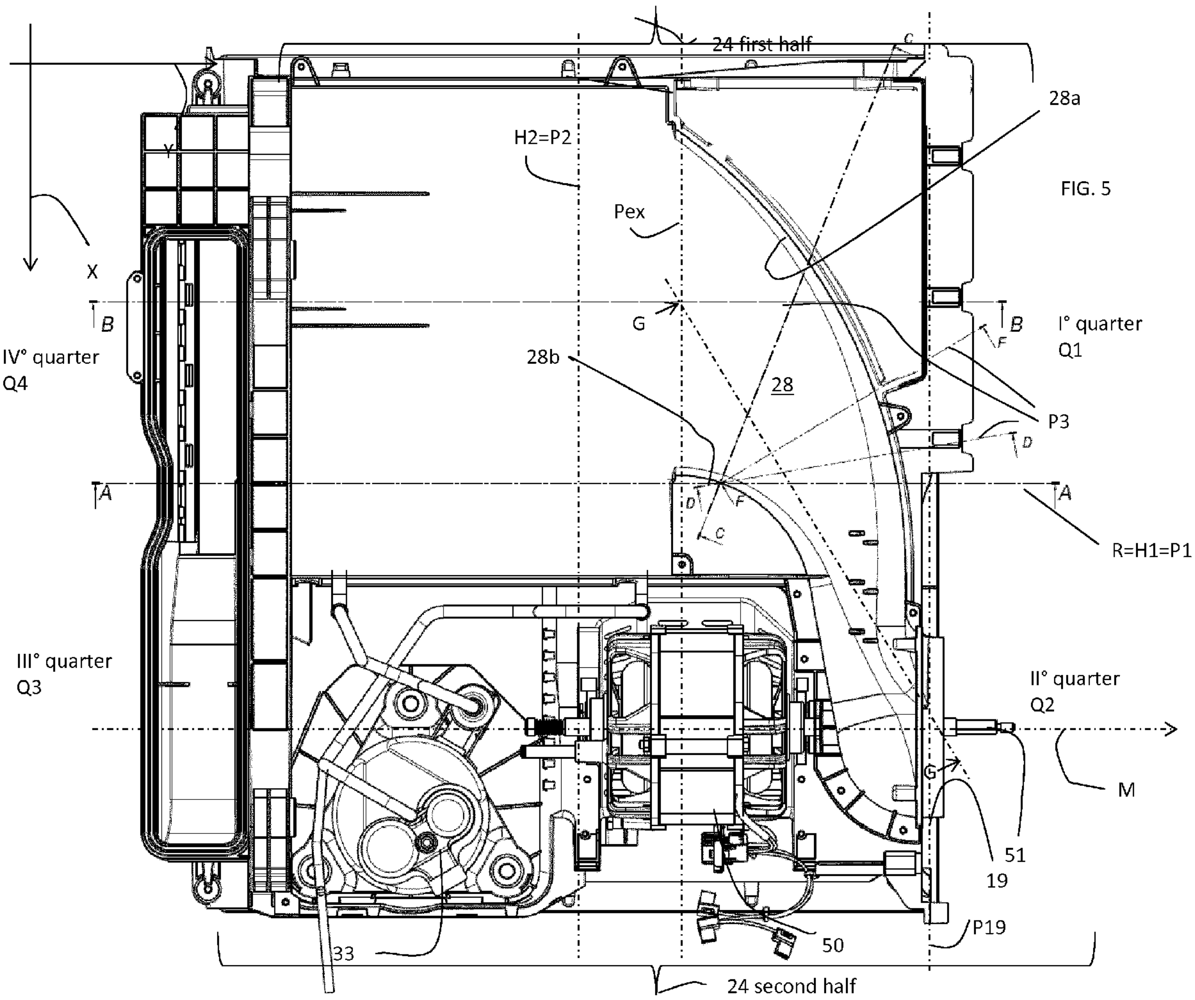


FIG. 4


24 first half
28a
FIG. 5
Y
H2=P2
Pex
X
B
G
B
I° quarter
Q1
IV° quarter
Q4
28b
28
F
P3
D
A
D
F
A
C
R=H1=P1
III° quarter
Q3
II° quarter
Q2
G
M
51
19
P19
33
50
24 second half

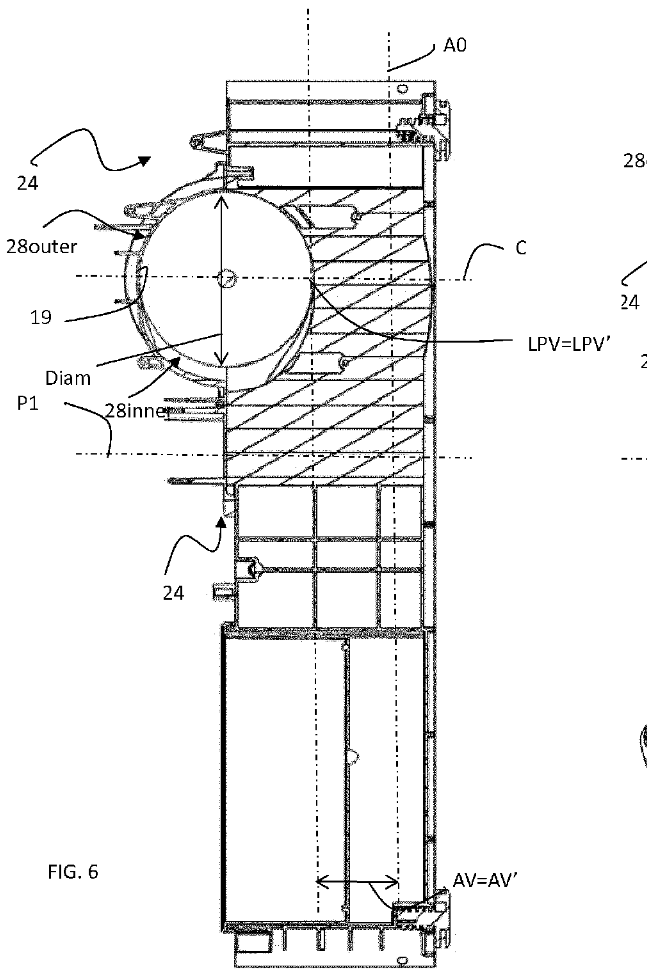

A0
24
28outer
C
19
LPV=LPV'
Diam
P1
28inner
24
AV=AV'

FIG. 6

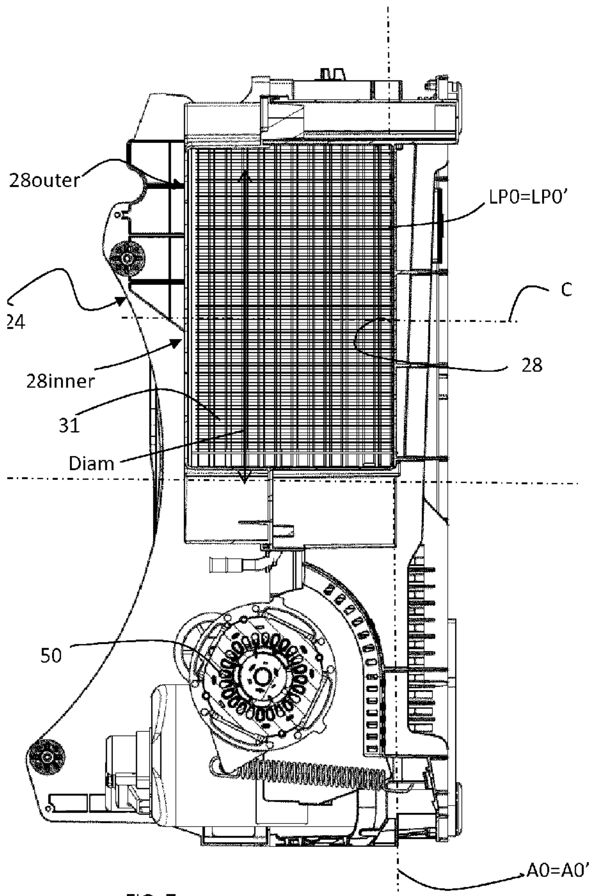

28outer
LP0=LP0'
C
24
28
28inner
31
Diam
50
A0=A0'

FIG. 7

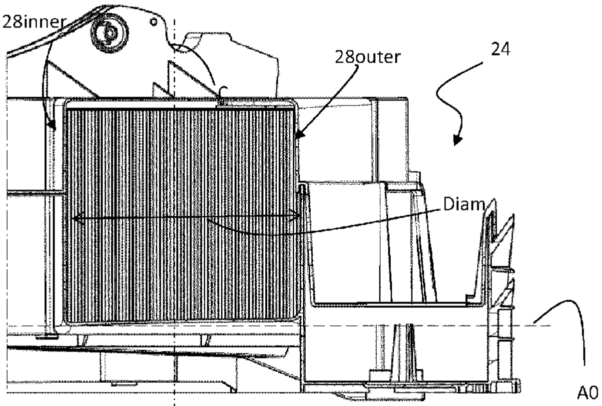


FIG. 8

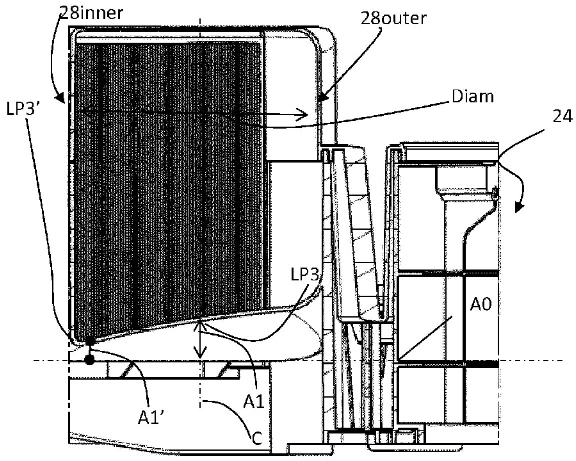


FIG. 9

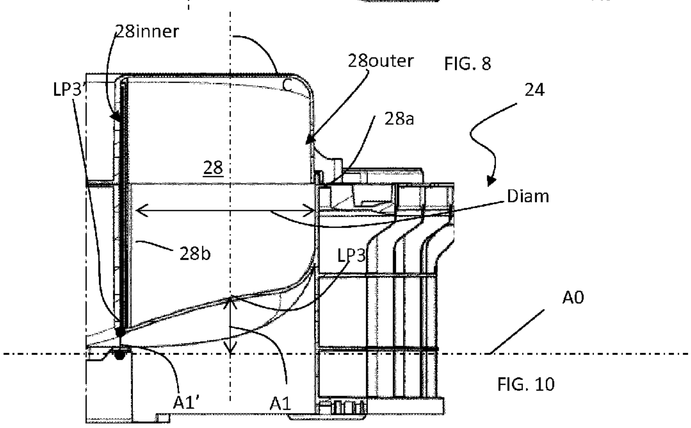


FIG. 10

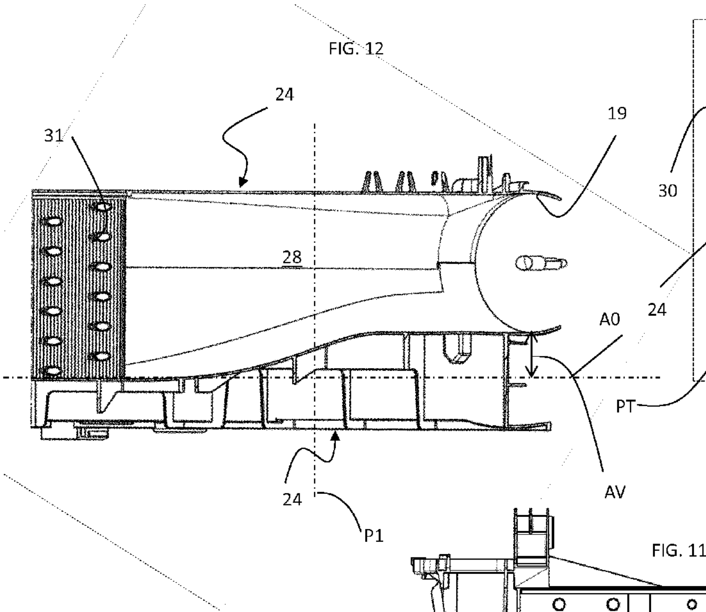


FIG. 12

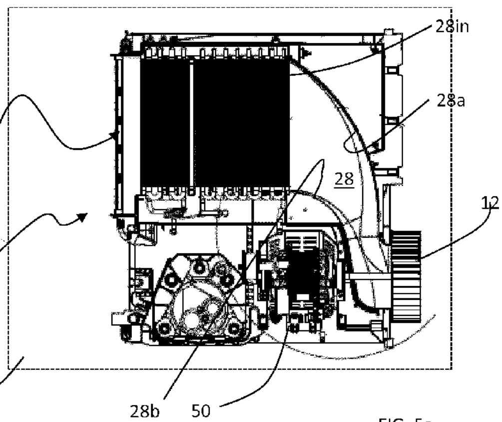


FIG. 5a

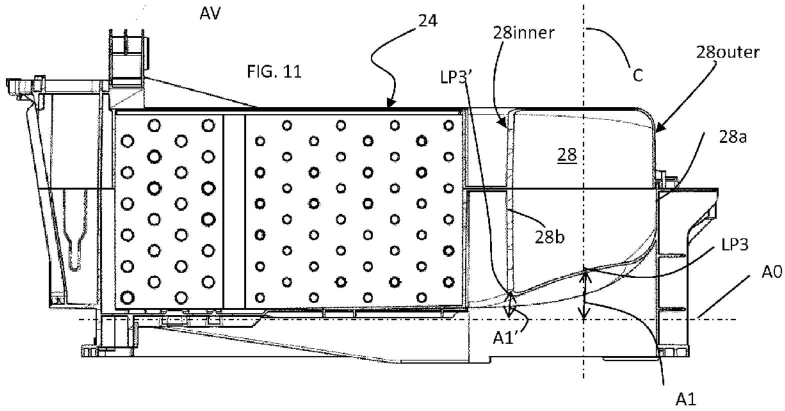


FIG. 11

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EUROPEAN SEARCH REPORT

Application Number
EP 14 18 2924

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	EP 2 527 528 A1 (ELECTROLUX HOME PROD CORP [BE]) 28 November 2012 (2012-11-28) * paragraph [0008] - paragraph [0010] * * paragraph [0023] - paragraph [0024] * * paragraph [0040] - paragraph [0042] * * paragraph [0049] - paragraph [0051] * * paragraph [0064] - paragraph [0070] * * figures 1-4 * -----	1-15	INV. D06F58/20 D06F58/02
A	EP 2 743 394 A1 (ELECTROLUX HOME PROD CORP [BE]) 18 June 2014 (2014-06-18) * paragraph [0009] - paragraph [0011] * * paragraph [0026] - paragraph [0032] * * paragraph [0047] - paragraph [0049] * * figures 1-3, 8, 9 * -----	1-15	
			TECHNICAL FIELDS SEARCHED (IPC)
			D06F

The present search report has been drawn up for all claims

2

Place of search	Date of completion of the search	Examiner
Munich	25 February 2015	Bermejo Pasetti, M

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
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P : intermediate document

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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 14 18 2924

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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25-02-2015

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 2527528 A1	28-11-2012	CN 103608511 A	26-02-2014
		EP 2527528 A1	28-11-2012
		US 2014165416 A1	19-06-2014
		WO 2012163615 A1	06-12-2012
EP 2743394 A1	18-06-2014	EP 2743394 A1	18-06-2014
		WO 2014090778 A1	19-06-2014

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