



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
23.11.2022 Bulletin 2022/47

(51) International Patent Classification (IPC):
F24F 1/50 ^(2011.01) **F24F 1/54** ^(2011.01)
F24F 1/56 ^(2011.01) **F24F 1/60** ^(2011.01)

(21) Application number: **22174311.5**

(52) Cooperative Patent Classification (CPC):
F24F 1/50; F24F 1/54; F24F 1/56; F24F 1/60

(22) Date of filing: **19.05.2022**

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

(72) Inventors:
• **FAASSEN, Antonius Theodorus Adrianus BEST (NL)**
• **VAN SWAM, Dave BEST (NL)**

(74) Representative: **Algemeen Octrooi- en Merkenbureau B.V.**
P.O. Box 645
5600 AP Eindhoven (NL)

(30) Priority: **19.05.2021 NL 2028240**

(71) Applicant: **We Heat B.V.**
5683 CC Best (NL)

(54) **HEAT PUMP AND HEATING SYSTEM**

(57) A heat pump comprising a housing, a fan, and a tube system for circulating circulation fluid:
- the housing adapted to be arranged on a substantially horizontal base area, the housing having a bottom profile including at least one supporting element with which the housing, when installed, rests on the base area and a portion that is recessed with respect to the supporting

element, the recessed portion spaced apart from the base area so that air can flow into the housing from below;
- the tube system surrounded by the housing, arranged in a horizontal plane,; and
- the fan operable to generate an air flow through the housing and across the tube system, for the exchange of heat between the air and the circulation fluid.

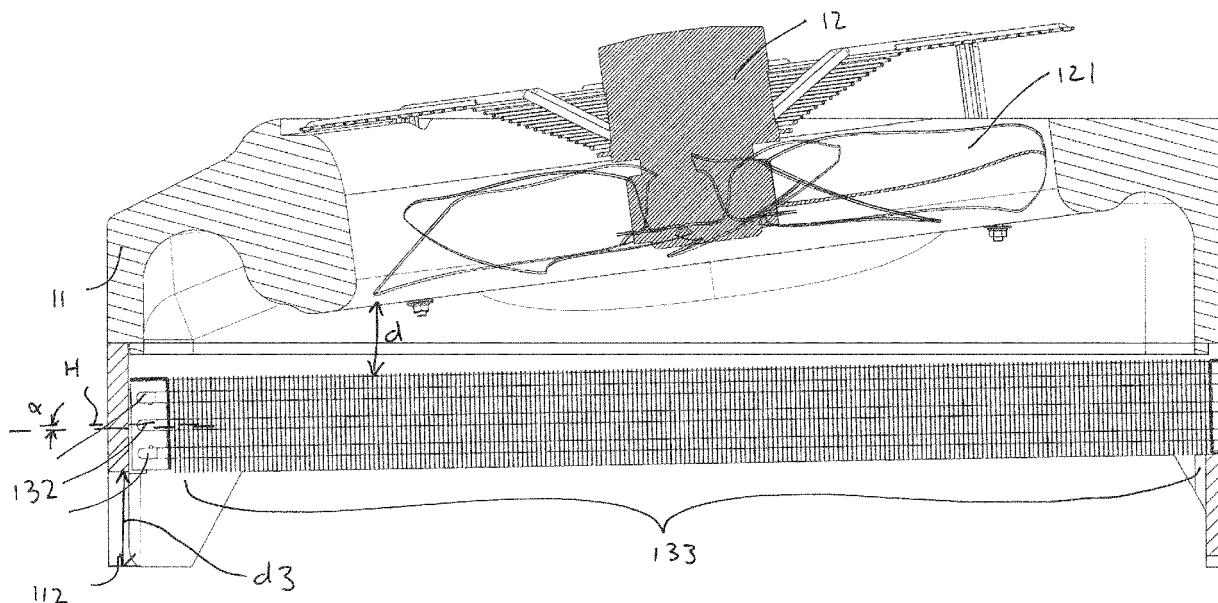


Fig. 4

Description

[0001] The present invention relates to a heat pump for the exchange of heat between the air and a circulation fluid circulated in a tube system of the heat pump. The invention further relates to a heating system for e.g. heating a pool or a building, such as a residential building.

[0002] The general principle of a heat pump is well known to those skilled in the art. Several types of heat pumps exist, e.g. gas/gas heat pumps, liquid/gas heat pumps and liquid/liquid heat pumps. The present invention is mainly directed to a heat pump of the air-liquid type and/or the air - air type, wherein heat is extracted from the outside air by circulation and evaporation of the circulation fluid at the heat pump. Using such a heat pump, a residential building can be heated using electricity - and without burning gas. As an alternative, when operation of the heat pump is reversed, a residential building can be cooled. Known heat pumps are relatively large, industrially-looking machines that are mounted on the wall of a building or that are arranged on a flat roof of a building. They have a relatively high height, which makes them visible from e.g. the street level even when placed on a flat roof. The street level, for this purpose, can be the garden at the back side of the house, as well as the street in front of the house. Of course, when the heat pump is attached to a wall of the building, it will also be visible from the street level. Although more and more consumers are willing to transition away from burning gas to heat their homes, mounting a big industrial machine to the wall or having it visible on the roof is an undesirable solution for them, and this presently hinders the transitioning away from gas.

[0003] This visibility, then, is one disadvantage of presently known heat pump. A further disadvantage of presently known heat pumps is that they generate quite some noise. The fan of the heat pump typically rotates about a horizontal axis, such that any noise produced by the fan is spread away from the building against which the heat pump is mounted, which is a generally horizontal direction when the heat pump is mounted to a wall of a building. In this way noise produced by the fan can be heard by the users of the heat pump as well as by other persons in the neighbourhood of the heat pump. This disadvantage is especially noticeable when the heat pump is used in a city environment. A third disadvantage of presently known heat pumps is that they are rather heavy. Not so heavy that structural improvements have to be made before the heat pump can be installed on or against a residential building, but heavy enough to make installation cumbersome and a multi-person (3 - 4 person) job, and therefore expensive.

[0004] It is an aim of embodiments of the present invention to at least partially overcome at least one of the above-mentioned disadvantages of presently known heat pumps.

[0005] Therefore, according to the invention a heat pump is presented for exchanging heat between the air

and a circulation fluid, the heat pump comprising a housing, a fan, and a tube system for circulating the circulation fluid, wherein:

- 5 - the housing is adapted to be arranged on a substantially horizontal base area such as a flat roof portion or a ground surface, the housing having a bottom profile that includes at least one supporting element with which the housing, when installed, rests on the base area and a portion that is recessed with respect to the supporting element, so that the recessed portion is spaced apart from the base area and so that air can flow into the housing from below;
- 10 - at least a portion of the tube system is surrounded by the housing, said portion substantially arranged in a horizontal plane, the circulation fluid in use flowing through the tube system; and
- 15 - the fan operable to generate an air flow through the housing and across the tube system, for the exchange of heat between the air and the circulation fluid inside the tube system.
- 20

[0006] For example, the tube system may operate as an evaporator, in which the circulation fluid enters in a liquid stage (typically at a relatively low pressure) and evaporates due to the indirect contact with the outside air. In that case, the heat pump can be used to make an object warmer, such as the water associated with a central heating system of a house or an office building, or the water of a pool. A suitable circulation fluid should in this example be chosen, to ensure that evaporation can also take place during the coldest days of the year. Such circulation fluids are known to one skilled in the art. A circulation fluid that is found to be especially suitable for this purpose is known by the name R290, also known as propane.

[0007] As is the convention in patent documents, the wording "fluid" covers both liquids and gasses, as well as a medium that is in the liquid state in a part of the circulation loop and in the gaseous state in another part of the circulation fluid.

[0008] In embodiments, it may be possible to "reverse" the operation of the heat pump, to also allow the heat pump to cool an object, such as the water associated with a central heating system of a house or an office building. This principle is known to a person skilled in that art and will not be further elaborated in this description; only the heating principle and the improvements thereto brought by the present invention will be discussed in more detail here. The same advantages may however also apply to operation of the heat pump as an air conditioner. As such, the wording "heating" in the present disclosure refers to both "making something warmer" as well as "making something less warm". Analogously, "heat exchange" refers both to "extracting / absorbing heat" and "give off heat", depending on the context.

[0009] The housing is adapted to be arranged on a substantially horizontal base area such as a flat roof por-

tion or a ground surface. Within the context of the present document it is not required, but it may be preferred, that the base area is perfectly horizontal. For example, the base area may be inclined at any angle in between +20 degrees and -20 degrees.

[0010] The housing has a bottom profile including a supporting element and a recessed portion. For example, the supporting element may be formed by a foot or one or more legs, that are mounted below the housing. For example, the supporting element may be integral to the housing. For example, the supporting element may be arranged near the sides of the housing. In another example, the supporting element may be arranged near the centre of the housing. With respect to the supporting element(s), the recessed portion may be elevated. When seen in the horizontal direction, a lower edge of the recessed portion may e.g. be arranged near a bottom layer of the tube system, or, more preferably, near a middle layer of the tube system (when the tube system has multiple layers).

[0011] Thus, according to the invention the substantially horizontal tubes of the tube system may be arranged in one or more layers, e.g. two three or four layers above each other. Each of the layers is substantially horizontally, but at different height levels.

[0012] In some embodiments, where the heat pump is a monoblock system, the entire tube system through which the circulation fluid runs may be arranged inside the heat pump. In such embodiments, the heat exchange between the circulation fluid and the object to be heated takes place in the heat pump itself. In other embodiments, the heat pump is of a "split unit design", wherein the tube system through which the circulation fluid runs may extend outside the heat pump itself. In such embodiments, heat exchange between the circulation fluid and the object to be heated typically takes place outside of the heat pump, e.g. in an inner unit. The portion of the tube system that is arranged in the housing is substantially arranged in a horizontal plane. For example, said portion may be inclined at an angle of between +30 degrees and -30 degrees. It is however only the portion of the tube system that is arranged inside the housing, i.e. the portion of the tube system that is actively involved in the heat exchange with the outside air, that is advantageously arranged in a (substantially) horizontal plane. When the heat pump is of the split unit design, the points where the tube systems enters and leaves the housing, i.e. the "inlet" and the "outlet" can in principle be arranged anywhere.

[0013] In a possible embodiment, the blades of the fan rotate about a substantially vertically arranged axis. This ensures that sound emitted by operation of the fan is transmitted mostly in the vertical direction - in preferred embodiments towards the sky. This not so much ensures that no sound is emitted, but rather ensures that any sound emitted is not heard by humans in the surroundings of the heat pump. Therefore, such a heat pump is advantageously perceived as very silent.

[0014] In practical embodiments the fan may be ar-

anged on top of the heat pump. The fan can e.g. be integrated in the housing, or it can be arranged on top of the housing. The fan moves a stream of air across the portion of the tube system inside the housing, where the heat exchange between the air and the circulation fluid can take place. A skilled person is familiar with such heat exchange principles, so this process is not described in detail. To allow air to flow into the housing, there should be some opening in the housing. The present solution is to create an empty space in between the base area on which the heat pump is placed and the bottom of the housing. For that reason, the housing comprises a recessed portion with respect to the supporting element on which the housing rests. In embodiments, e.g. a fenced structure may be part of the outer circumference of the housing, but flow of air from outside the housing towards the lower part of the housing should be possible. The housing is preferably open at both the upper and lower side when the fan is arranged on top of the heat pump, to allow air to flow through the housing and across the tubes.

[0015] In alternative embodiments the fan may be arranged below the tubes of the heat pump. This will result in the same benefits and this does not substantially change the working of the heat pump.

[0016] Whereas for the previously described embodiments the flow direction of the air through the housing is substantially vertical and aligned with the axis about which the fan rotates, fans which attract air in a direction substantially perpendicular to their rotation axis also exists. When such a fan is used, the fan may be mounted at the side of the housing, while still allowing air to flow into the housing from below and across the tubes in a substantially vertical direction.

[0017] The tubes of the tube system - at least the part thereof arranged inside the housing - allow the circulation fluid to flow in a substantially horizontal plane. Therefore, compared to known heat pumps which can be said to extend in a vertical direction, the present heat pump extends in the horizontal direction. This advantageously minimizes the height of the heat pump, and minimizes the visibility from the street level.

[0018] In a manner known to a person skilled in the art, after the circulation fluid is heated and evaporated by the air it is compressed by a compressor. This increases the density and the temperature of the gas. This gas is then condensed to a liquid again. In this condensation process the temperature of the fluid decreases, and heat is exchanged with an object to be heated, to make said object warmer. This process can take place both inside the heat pump (when the heat pump is of the monoblock design) or outside of the heat pump (when the pump is of the split unit design). For example the object to be heated may be the water of a central heating system (which itself is a circulation fluid, of the central heating system).

[0019] In an embodiment of the present invention, the housing further comprises a compressor. Advantageously, providing the compressor inside the housing minimiz-

es the number of components that need to be installed at the inside of the building to be heated. This is usually appreciated by the owners and/or renters of such buildings - further lowering the hurdle to move away from gas.

[0020] In an embodiment of the present invention, the housing further comprises buffer vessel, e.g. a liquid receiver with an expansion valve associated to it. Such an expansion valve is found in virtually any heat pump, and controls the amount and/or pressure of liquid send to the evaporator. This amount and pressure is e.g. dependent on the outside temperature and the temperature of the body that is being heated. To minimize the number of components installed inside the building to be heated, advantageously such a buffer vessel is provided inside the housing.

[0021] In an embodiment of the present invention, the housing is made of an expanded plastic material, such as EPS, XPS, PIR and preferably EPP material. This material provides many advantages compared to a housing made of a metal such as steel, or aluminium, as well as a housing made of (non-expanded), "hard" plastic as is presently the convention. For one, EPP material inherently provides an excellent insulation against both noise produced by the heat pump and against heat that might otherwise be lost to the heat exchange process. Further, a housing made of EPP also has a relatively low weight compared to a housing made of metal so that the weight of the heat pump may be significantly reduced. In embodiments the weight of the heat pump is 70 kg or even less, allowing it to be carried and installed by (only) two persons, reducing the installation cost and therefore the unit cost. A further advantage of EPP is that it can be produced at low cost, e.g. by injection moulding, further reducing the unit cost. The use of EPP allows a great design freedom in the shape of the housing - stepping away from the 'rectangular box' with which the consumer is familiar. Also, compared to metal EPP can easily be dyed in a custom print - e.g. in the colour of the environment in which it is placed to further lower the visibility of the heat pump.

[0022] In an embodiment of the present invention, control components of the heat pump, e.g. the compressor, the buffer vessel, an expansion valve, a pressure sensor, a temperature sensor and/or a controller, are clamp-fitted in the EPP material. This allows a rapid assembly of the heat pump once all the individual components are manufactured, without requiring highly-skilled workers and without substantial costs.

[0023] In an embodiment of the present invention, at least one side of the housing is slanted downwards, the edge of said side having a lower height than the middle of the housing. An advantageous effect of this feature is that, when the heat pump is installed on a flat roof of a building, and when the lower edge is installed at the side of the roof that faces the street level, the visibility from the street level is reduced (even) further. When a slanted side is used, the fan of the housing may e.g. be oriented horizontally, inclined with respect to the horizontal orien-

tation by the slanting angle of the slanted side, or at an inclination angle in between 0 degrees with respect to the horizontal orientation and the slanting angle of the slanted side. Within the context of the present document, any angle in between -30 degrees and +30 degrees with respect to the horizontal orientation and/or with respect to the orientation of the base area, which in itself may have an inclination with respect to the horizon, is deemed to be "substantially horizontal". Of course, it remains possible to arrange one or more fans at the side of the housing when a slanted top side is present.

[0024] In an embodiment of the invention, the fan is operable to generate an air flow in two directions: upwards with respect to the recessed bottom portion as well as downwards with respect to the recessed bottom portion. When the fan is arranged near the top of the housing or on top of the housing, above the tube system and above the bottom, in a normal operational mode the fan may be operated to attract air from below, sucking it upwards through the housing, and blowing it away from the housing. With such an air flow, material such as e.g. leaves may gather below the bottom of the housing. To blow away such material, from time to time the operational direction of the fan may advantageously be reversed for a longer or shorter period of time. A further advantage of a fan that is operable in two directions is that the fan can blow away any condense that sticks to the tubes of the tube system when blowing the air from the fan towards said tubes.

[0025] In an embodiment of the present invention, a maximum height of the heat pump does not exceed 50 cm, preferably does not exceed 45 cm, ideally does not exceed 40 cm. When placed on a flat roof, depending on the exact position of the fan on the roof and the height of the building, such a maximum height may ensure that the heat pump is not visible from the street level.

[0026] In an embodiment of the present invention, a height dimension of the heat pump is less than its width dimension and less than its length dimension. In other words, the heat pump may be of the 'horizontal type', extending in the horizontal direction mainly.

[0027] In an embodiment of the present invention, a distance between the blades of the fan and the tube system in the housing is less than 20 cm. In general, the distance between the blades of the fan and the tubes of the circulation system preferably is as small as possible, to optimally minimize the height of the heat pump and to maximally reduce the visibility thereof from the street level - while mitigating the risk that rotation of the blades harms either the blades themselves or the tubes of the tube system.

[0028] In an embodiment of the present invention, the portion of the tube system that is positioned inside the housing is arranged in a meandering shape, wherein when seen in a top view the distance between the central axis of two adjacent parallel tubes is between 10 and 50 mm. The meandering shape is well known to one skilled in the art of heat pumps and is a standard solution to

have as much heat exchange surface as possible on a fixed area of space. When choosing to arrange the tubes in a substantially horizontal plane and to operate the heat pump as an evaporator, condense and, depending on the evaporation pressure and outside conditions, possibly also ice will form on the tubes. After elaborate testing, the inventors have found that, in order for this condense and possibly ice to not accumulate on the lower portion of the tube system, in between the tubes, the tubes are preferably spread apart further than conventionally, i.e. when they are arranged in a vertical orientation. Further advantageously, when the tubes are arranged in a substantially horizontal plane, any ice and condense dripping from the tube system will immediately leave the area occupied by the tube system - and not accumulate on the lower portion of the tube system where it may lead to frost-buildup as would be the case when the tube system extends in a vertical plane.

[0029] In an embodiment of the present invention, the portion of the tube system that is positioned in the housing is arranged in a meandering shape, the tubes are connected to a plurality of spaced-apart fins, and the distance between two adjacent fins is more than 3 mm, preferably more than 3.5 mm, ideally more than 4 mm and less than 6 mm. The meandering shape is well known to one skilled in the art of heat pumps and is a standard solution to have as much heat exchange surface as possible on a fixed area of space. The fins also help to exchange as much heat as possible, by providing a large surface at which heat can be absorbed from the air. As the fins are mounted to the tubes through which the circulation fluid runs, the heat absorbed by the fins is ultimately absorbed by the fluid as well as the heat is transferred from the fins, to the tubes, to the circulation fluid. When choosing to arrange the tubes in a substantially horizontal plane, and to operate the heat pump as an evaporator, condense and, depending on the outside conditions, possibly also ice will form on the fins. After elaborate testing, the inventors have found that, in order for this condense to not accumulate in the space in between the tubes and the fins or in between the fins, the fins are preferably spread apart by at least 3 mm, which is further than when they are arranged in a vertical orientation. Further advantageously, when the tubes and fins are arranged in a substantially horizontal plane, any ice and condense dripping from the tube system will immediately leave the area occupied by the tube system - and not accumulate on the lower portion of the tube system where it may lead to frost-buildup as it would when the tube system extends in a vertical plane.

[0030] In an embodiment of the invention, a leakage element is arranged in between fins of the tube system, the leakage element extending downwards with respect to the tubes and fins of the tube system. By design, the leakage element forms the lowest point of the tube-and-fin system. As condense water has the natural tendency to flow towards the lowest point in a system, the condense water will flow towards any such leakage element. When

the leakage element is then shaped in such a way that water cannot easily "stick" to it, the condense will advantageously drip from the leakage element, away from the tube-and-fin system. For example, the leakage element may rest on an upper edge of the tube-and-fin system, and extend downwards with respect to the tubes and fins. For example, the leakage element may be mounted on at least one fin. For example, the leakage element may be clamped inside the tube-fin system. For an optimal working thereof, the leakage element contacts the water in between the fins.

[0031] In an embodiment of the invention, adjacent fins of the tube system are arranged at different heights, the height difference between two adjacent fins e.g. being in between 0,5 cm and 2 cm. This is another feature that may minimize condense retainment. In such an embodiment, even if in top view the fins may seem relatively close together, in reality the distance between two (lowermost) fins is then relatively large. For example, there may be two height levels until which the fins extend, or there may be more height levels. For example, the fins may alternately be arranged at different height levels, or in any other random or non-random way.

[0032] In an embodiment of the invention, when seen from the side, the tubes of the tube system comprise a left portion and a right portion, wherein the left and the right portions are each inclined with respect to the base area on which the housing is arranged with an angle of between 1 and 15 degrees, and wherein the centre of both portions is arranged lower than the sides of the respective portion. In such an embodiment the condense water forming on the tubes and the fins flows towards the middle of the housing, where it gathers into relatively large drops and falls of the tubes. This is yet another feature that can be implemented to reduce the amount of condense formed in between the tubes and fins of the tube system.

[0033] In an embodiment of the present invention, the distance between the base area on which the heat pump is arranged and the recessed portion of the housing bottom, is between 4 and 30 cm, preferably between 5 and 25 cm.

[0034] A second aspect of the present invention relates to a heating system, e.g. for a building or a pool, comprising the heat pump as described in the above

[0035] These and other aspects of the present invention are further elucidated with reference to the attached figures. In these figures:

Figure 1 schematically shows in an isometric view an embodiment of the heat pump including its housing and other components, in a partially de-assembled state;

Figure 2 schematically shows the heat pump of figure 1 from the side;

Figure 3 schematically shows the heat pump of figure 1 from below;

Figure 4 schematically shows a portion of the heat

pump of figure 1 in a cross-sectional view;
Figure 5 highly schematically shows a detailed view of the fins and the tubes of the heat pump; and
Figure 6 schematically shows an installation diagram of an embodiment of a heating system including heat pump.

[0036] With reference to Figure 1 initially, one possible embodiment of the heat pump 1 according to the present invention is shown. As shown here, the heat pump 1 comprises a housing 11. The housing 11 comprises two portions; a top portion and a bottom portion. The housing 11 advantageously is made of an expanded plastic material, in particular an EPP material. This material can easily be processed, into virtually any shape. Whereas the outer shape of the housing 11 will be discussed further in the below, noticeable in the upper portion of the housing 11, on top in the figure, are cut-outs. Similar cut-outs in the housing 11 are also arranged in the lower portion of the housing 11. Control components including a compressor 116, and a condenser 101 as well as a filter element 141 are arranged in these cut-outs and visible in Figure 1.

[0037] As the housing 11 can principally be made in any shape, the cut-outs are made in a size that allows the different components 101, 116 to be clamp-fitted in the housing 11, making the final assembly of the heat pump highly convenient and cheap. It is noted that the condenser 101 and the compressor 116 are oriented upwards and extend in the vertical orientation. It is noted that in alternative embodiments these may be oriented in the horizontal orientation, i.e. they may "lie down". This is expected to reduce further the height of the heat pump 1. As the condenser 101 is integrated in the housing 11, advantageously all components of the heat pump 1 are arranged in the housing 11 and the heat pump 1 is of the monoblock type, such that no inner unit is needed. The housing 11 e.g. receives (only) two tubes through which an object to be heated enters the condenser 101. For example the object to be heated is water of a central heating system with which a house is to be heated. For example, one inlet tube of the condenser provides the object to be heated in a relatively cold state, to be heated by the circulation fluid of the heat pump. The other tube of the condenser 101, the outlet tube, carries the object just heated, in its heated state, heated by the heat pump 1.

[0038] The housing 11 further comprises support elements 112, with which it rests on a base area BA (see figure 2). In this case the support elements 112 are arranged near the edges of the bottom and the centre portion of the bottom is recessed with respect to the support elements 112, but it may also be possible to arrange the support elements 112 near the centre of the bottom, and to have the edges recessed with respect to the centre. In any case there is a recessed portion 113, elevated with respect to the support elements 112, and defining a free space in between the base area and the bottom of the housing 11. Through this free space, air can flow

towards and away from the bottom of the housing 11 when the housing 11 is closed, which in this case leads to the fan 12 being arranged on top of the tubes 132 (as shown in Figures 2 and 3).

[0039] The housing 11 further comprises a number of parallel tubes 132, which tubes 132 in reality are fluidly connected to each other such that a fluid can flow through them. The tubes 132 define a tube system 13 in which a circulation fluid (not visible) is circulated. The tubes 132 are arranged in a horizontal plane and are surrounded by the housing 11 in the circumferential direction of the housing 11. By allowing the tubes 132, with the circulation fluid inside, to get into contact with the air, heat exchange of the air with the circulation fluid is facilitated.

[0040] For efficient heat exchange between the circulation fluid and the air, a stream of air is ideally generated, such that there is a constantly renewed influx of heat into the housing 11. Therefore the heat pump 1 includes a fan 12, the fan having blades 121.

[0041] Turning to Figure 2, the heat pump 1 is shown in a closed position, wherein the top half of the housing 11 is placed on top of the bottom half of the housing 11 and wherein the heat pump 1 is shown from the side. The heat pump 1 is placed on a base area BA, which base area BA is aligned with the horizontal direction. Clearly recognizable in figure 2 is the bottom profile 111 of the housing 11, with the supporting elements 112 that are arranged on the base area BA and the recessed portion 113 that is positioned away from the base area BA. A distance between the base area BA and the recessed portion 113 of the housing 11 is indicated with d_3 , and preferably is between 4 and 30 cm.

[0042] The maximum height H, measured in the vertical direction V, is indicated in figure 2 as well. Preferably the maximum height H of the heat pump does not exceed 50 cm, preferably 45 cm, more preferably 40 cm. As shown here the height of the housing 11 is lower than the maximum height of the heat pump 1, in other words as shown here the fan 12 sticks out with respect to the housing 11. It is however also possible that the fan 12 is integrated in the housing 11, and that the height of the housing 11 defines the maximum height H of the heat pump 1.

[0043] Shown on the left side of Figure 2 is a slanted edge 119. This edge 119 is slanted downwards with respect to the middle part of the housing 11, where the fan 12 is mounted, and the edge of that side 119 has a lower height H1 than the maximum height H of the heat pump 1 - and, for that matter, also a lower height H1 than the other side of the housing 11.

[0044] As may be recognized from a comparison of Figures 2 and 3, which are both drawn on the same scale, the height dimension H is the lowest dimension of the length dimension L, width dimension W and height dimension H. That is, the heat pump 1 advantageously is lower than it is wide and the heat pump 1 is also lower than it is long.

[0045] The fan 12, when the heat pump 1 is active,

rotates about a rotation axis R. In the shown embodiment the rotation axis R does not coincide precisely with the vertical axis V, but is inclined at an angle α of between 10 and 15 degrees. In other embodiments however this angle may be smaller, e.g. 0 or negative, or larger, e.g. up to 30 degrees. As explained, the rotation axis R of the fan 12 may also substantially coincide with the horizontal axis H.

[0046] Turning now to Figure 3, the heat pump 1 is shown from below. The bottom of the housing 11 is open, to allow air to flow into the housing and exchange heat with the circulation fluid in the tubes 132 of the tube system 13. The fan 12 in operation rotates to extract air from below the housing 11, and to blow it away from the housing 11 at the top where it is positioned. However, in embodiments the fan 12 might also be mounted below the tubes 132 and blow air through the housing 11 in the same way. Therefore, also near the top of the housing 11 the housing 11 is preferably open, as is also visible from Figure 4, which shows a cross-sectional view of housing 11. However, in embodiments, the fan 12 may also be operated to rotate in the opposite direction, to extract air from above the housing 11, blow it through the housing 11, and have it leave the housing 11 at the bottom.

[0047] The tubes 132, here shown as individual tubes 132 but in reality fluidly connected to each other such that the circulation fluid can flow from the condenser 101 to the compressor 116 through the evaporator, are arranged parallel to each other. The individual tubes 132 may be divided over one or more flow circuits. Adjacent tubes 132 are positioned at a distance d1 of between 10 and 50 mm from each other, when measured from the central axis of one tube 132 to the central axis of the adjacent tube 132.

[0048] Figure 4 shows in a cross sectional view the relative position of some of the components of the heat pump 1 with respect to the vertical direction. As shown, the tubes 132 of the tube system 13 are arranged in three layers above each other. Alternatively, there may be a single layer of tubes 132, a double layer of tubes 132, or more than three layers of tubes 132. Each of the layers is arranged substantially horizontally, with a small inclination α with respect to the horizontal, e.g. in between ± 1 and ± 10 degrees. However, the layers may also be arranged horizontally, e.g. in between +1 degrees and -1 degrees with respect to the horizon, including at an angle of 0 degrees with respect to the horizon. The tubes 132 are lower near the "front" of the housing 11, the side having the slanted edge, than near the back of the housing 11.

[0049] Although it is not visible in Figure 4, also in the direction towards the centre of the housing 11 the tubes may be inclined. For example there may be a "left" and a "right" portion, each of the portions being inclined towards the centre of the housing at an angle of between 1 and 10 degrees, the tubes 132 of the left and right portion being higher near the edge of the housing 11 than

near the centre of the housing 11.

[0050] Further visible in Figure 4 are the supporting elements 112 and the housing 12, wherein the housing has a recessed portion that is free from the base area on which the housing 11 rests. The distance between the bottom of the recessed portion of the housing 11 and the base area on which the supporting elements 112 rest is indicated here with d3. As shown, the height d3 approximately equals the distance of the fins 133 to the base area, so that the fins 133 and tubes 132 are fully covered by the housing 11 when looking at the heat pump from the side. However, this is by no means necessary and in embodiments it may even be preferred if the housing 11 exposes some of the tubes 132 and/or a portion of the fins 133 when looking from the side. That is, in some embodiments d3 may be larger than illustrated here. In terms of absolute numbers, d3 may e.g. be between 4 and 30 cm.

[0051] Also illustrated in Figure 4 is the height d between the blades 121 of the fan 12 and the fins 133. This distance can e.g. be less than 20 cm. The total height of the heat pump 1, i.e. sum of the distance between the base area and the bottom of the recessed portion d3, the height of the tube system 13 (not indicated), the height between the tube system 13 and the fan 12, and the height of the fan itself, including the fan guard, (not indicated) preferably does not exceed 50 cm.

[0052] Turning now to Figure 5, highly schematically is shown a detailed view of the tubes 132, arranged in three layers on top of each other and extending in a substantially horizontal orientation, and the fins 133 connected the tubes 132 and extending in the generally vertical direction. Indicated at CW is a drop of condense water, stuck in between the fins 133. Preferably, any such condense water is minimized as generally speaking the efficiency of the heat pump decreases when there is condense water CW. Several measures, besides those already explained in the above, can be taken to minimize the occurrence of condense water CW. For example, at HF, the height of the fins 133 can alter, two adjacent fins 133 having different heights and one protruding with respect to the other. Condense water CW will naturally stick to the longest fin and compared to the top of the fins 133, having different heights at the bottom effectively increases the distance between the fins in a horizontal direction. A more simple measure to effectively increase the distance between the fins 133 in the horizontal direction is to simply spread the fins 133 further apart, as is indicated at d2a where the distance between two fins 133 is larger than at d2b.

[0053] A yet further solution to minimize the amount of condense water CW in between the fins 133 is the application of a drainage element 134, and extending downwards with respect to fin 133. Helped by the gravity, condense water forming in between the fins 133 will move downwards, to the end of the fin 133. There the condense water CW moves onto the drainage element 134, which is preferably formed to drain any water on it. The leakage

element 134 may be connected to fin 133 or may be connected to the fin-tube system at any other place and extend downwards with respect to fin 133.

[0054] Turning now to figure 6, the heat pump 1 is shown with the evaporator E on the lower left. In the evaporator E the circulation fluid of the heat pump 1 extracts heat from the outside air, leading the circulation fluid to evaporate and increase in temperature. More centrally, the condenser C is shown. At condenser C the heated circulation fluid gives off its heat to an object to be heated, e.g. as here shown a fluid in a central heating system 102 of a house. At the condenser C the circulation fluid cools and water of the central heating system 102 is heated. The water of the central heating system is a circulation fluid in its own right, heated at the condenser C of the heat pump, and cooled in e.g. a living room of a house to increase the temperature in said living room. The heat pump 1 comprises a tube system 13 for the circulation of a circulation fluid. As indicated, when the circulation fluid flows in the one direction the heat pump acts in a heating mode, heating the object to be heated 102 and extracting heat from the outside air at the evaporator E. When the circulation fluid flows in the opposite direction, at the portion of the heat pump where the circulation fluid is in (indirect) contact with the outside air the circulation fluid condenses to give off heat to the outside air, and at the portion where it is in (indirect) contact with the object to be "heated", the circulation fluid evaporates and extracts heat from the object to be "heated", cooling said object to be "heated" so that said object can extract heat from e.g. a living room of a house. That is, compared to the heating mode, in the cooling mode the condenser becomes an evaporator and vice versa. In the figure, the heating mode is explained and indicated.

[0055] A portion 131 of the tube system 13 is arranged in the housing 11 of the heat pump 1, for the exchange of heat with air, e.g. the outside air. Arranged near the housing, e.g. on top of it, is a fan 12 driven by motor M. In the embodiment where the heat pump 1 operates as an evaporator, a relatively cold circulation fluid, colder than the outside air, enters the evaporator E in a substantially liquid state. By the indirect contact with the outside air, the liquid is heated and eventually it evaporates. The circulation fluid leaves the evaporator E in a substantially gaseous state. It is then compressed by a compressor 116, the compressor 116 increasing the density and the temperature of the gas. The compressor 116 is typically driven by an electric motor (not indicated). A 4-way valve 143 is added to allow the flow direction in the fluid circuit 13 to be reversed, as described. Another reason to reverse the flow may be to defrost the evaporator when using the heat pump 1 in the heating mode.

[0056] If operation of the heat pump 1 as a heating system is considered, reference numeral 101 refers to the element of the heat pump 1 where the circulation fluid, having extracted energy from the outside air, the condenser exchanges its heat with the object to be heated 102. For example, this object to be heated may be a

swimming pool, the water of a central heating system of a building, or any other object to be heated. In this condenser 101 the hot gas condenses to a liquid and in that process gives off its thermal energy, i.e. its latent and sensible heat, to a medium that is then used to e.g. heat a volume of a building. Of course, by reversing the flow of the circulation fluid in the heat pump 1, the object to be heated can be cooled. Condenser 101 may be arranged inside the housing 1, so that a monoblock heat pump 1 is obtained, but in other embodiments condenser 101 may be an inner unit of a heat pump system, so that a split type heat pump is obtained.

[0057] Further visible in Figure 6 are a liquid receiver 117, a filter element 141 and an electronic expansion valve 142. The filter element 141 filters the circulation fluid and removes impurities. The liquid receiver 117, in combination with the electronic expansion valve 142, controls the amount of liquid that enters the evaporator, and ensures that an optimal efficiency is obtained.

[0058] Not shown but preferred is the use of a buffer vessel of e.g. a few hundred litres, in which additional hot water may be stored that is produced as a buffer, e.g. for when a large volume of hot water is desired by the residents of the building to be heated.

[0059] Preferably, as shown here, the heat pump is of the monoblock type. This eases installation as only the tubes carrying the object to be heated need to extend from the inside of the building to the heat pump 1, and from the heat pump 1 back into the inside of the building. Possibly, along with the tubes carrying the object to be heated also a communication line extends inwards, to control the components inside the housing 11.

LIST OF REFERENCE NUMERALS

[0060]

1	heat pump
	11 housing
40	111 bottom profile
	112 supporting element
	113 recessed portion
	114 tube inlet
	115 tube outlet
45	116 compressor
	117 expansion vessel
	119 slanted side
	12 fan
	121 blade
50	13 tube system
	131 portion inside housing
	132 individual tube
	133 fin
	134 drainage element
55	14 control components
	141 filter
	142 expansion valve
	143 4 way valve

	144 pressure and/or temperature sensor	
	145 switch	
100	heating system	
101	inner unit	
102	external heating system	5
BA	base area	
CW	condense water	
d	(vertical) distance between fan blades and tube system	
d1	(horizontal) distance between adjacent parallel tubes of the tube system	10
d2	(horizontal) distance between adjacent fins of the tube system	
d3	(vertical) distance between recessed portion and base area	15
H	horizontal orientation height	
H1	height at slanted side	
HF	height fin	
L	length	
M	motor	20
R	rotation axis fan	
V	vertical orientation	
W	width	
α	angle between orientation tubes and horizontal direction	25

Claims

1. A heat pump (1) for exchanging heat between the air and a circulation fluid, the heat pump comprising a housing (11), a fan (12), and a tube system (13) for circulating the circulation fluid, wherein:
 - the housing (11) is adapted to be arranged on a substantially horizontal base area (BA) such as a flat roof portion or a ground surface, the housing (11) having a bottom profile (111) that includes at least one supporting element (112) with which the housing (11), when installed, rests on the base area (BA) and a portion (113) that is recessed with respect to the supporting element (112), so that the recessed portion (113) is spaced apart from the base area (BA) and so that air can flow into the housing (11) from below;
 - at least a portion (131) of the tube system (13) is surrounded by the housing (11), said portion (131) substantially arranged in a horizontal plane (H), the circulation fluid in use flowing through the tube system (13); and
 - the fan (12) operable to generate an air flow through the housing (11) and across the tube system (13), for the exchange of heat between the air and the circulation fluid inside the tube system (13).
2. The heat pump according to claim 1, wherein the housing (11) further comprises a compressor (116).
3. The heat pump according to claim 1 or 2, wherein the housing (11) further comprises an buffer vessel (117).
4. The heat pump according to any one of the preceding claims, wherein the housing (11) is made of an expanded plastic material, such as EPS, XPS, PIR, preferably EPP.
5. The heat pump according to claim 4, wherein control components (14) of the heat pump, e.g. the compressor (116), the buffer vessel (117), expansion valve, pressure sensor, temperature sensor, and/or a controller, are clamp-fitted in the EPP material.
6. The heat pump according to any one of the preceding claims, wherein at least one side (119) of the housing is slanted downwards, the edge of said side (119) having a lower height (H1) than the middle of the housing (11).
7. The heat pump according to any one of the preceding claims, wherein the fan (12) is operable to generate an air flow in two directions: upwards with respect to recessed bottom portion (113) as well as downwards with respect to the recessed bottom portion (113).
8. The heat pump according to any one of the preceding claims, wherein a maximum height (H) of the heat pump (1) does not exceed 50 cm, preferably does not exceed 45 cm, more preferably does not exceed 40 cm.
9. The heat pump according to any one of the preceding claims, wherein a height dimension (H) of the heat pump (1) is less than its width dimension (W) and less than its length dimension (L).
10. The heat pump according to any one of the preceding claims, wherein the portion (131) of the tube system (13) that is positioned inside the housing (11) is arranged in a meandering shape, wherein when seen in a top view the distance (d1) between two adjacent parallel tubes (132) is between 10 and 50 mm.
11. The heat pump according to any one of the preceding claims, wherein the portion (131) of the tube system (13) that is positioned in the housing (11) is arranged in a meandering shape, the tubes (132) connected to a plurality of spaced-apart fins (133), the distance (d2) between two adjacent fins (133) being more than 3 mm, preferably more than 3.5 mm, ideally more than 4 mm and less than 6 mm.
12. The heat pump according to any one of the preceding claims, wherein the distance (d3) between the base

area (BA) on which the heat pump (1) is arranged and the recessed portion (113) of the housing (11) bottom, is between 4 and 30 cm.

13. The heat pump according to any one of the preceding claims, wherein a drainage element (134) is arranged in between fins (133) of the tube system (13), the drainage element (134) extending downwards with respect to the fins (133) of the tube system (13). 5
14. The heat pump according to any one of the preceding claims, wherein adjacent fins (133) of the tube system (13) are arranged at different heights (HF), the height difference between two adjacent fins (133) e.g. being in between 0,5 cm and 2 cm. 10 15
15. The heat pump according to any one of the preceding claims, wherein when seen from the side, the tubes (132) of the tube system (13) comprise a left portion and a right portion, the portions inclined with respect to the base area (BA) on which the housing (11) is arranged at an angle of between 1° and 15°, wherein the centre of both portions is arranged lower than the side of the respective portion. 20 25

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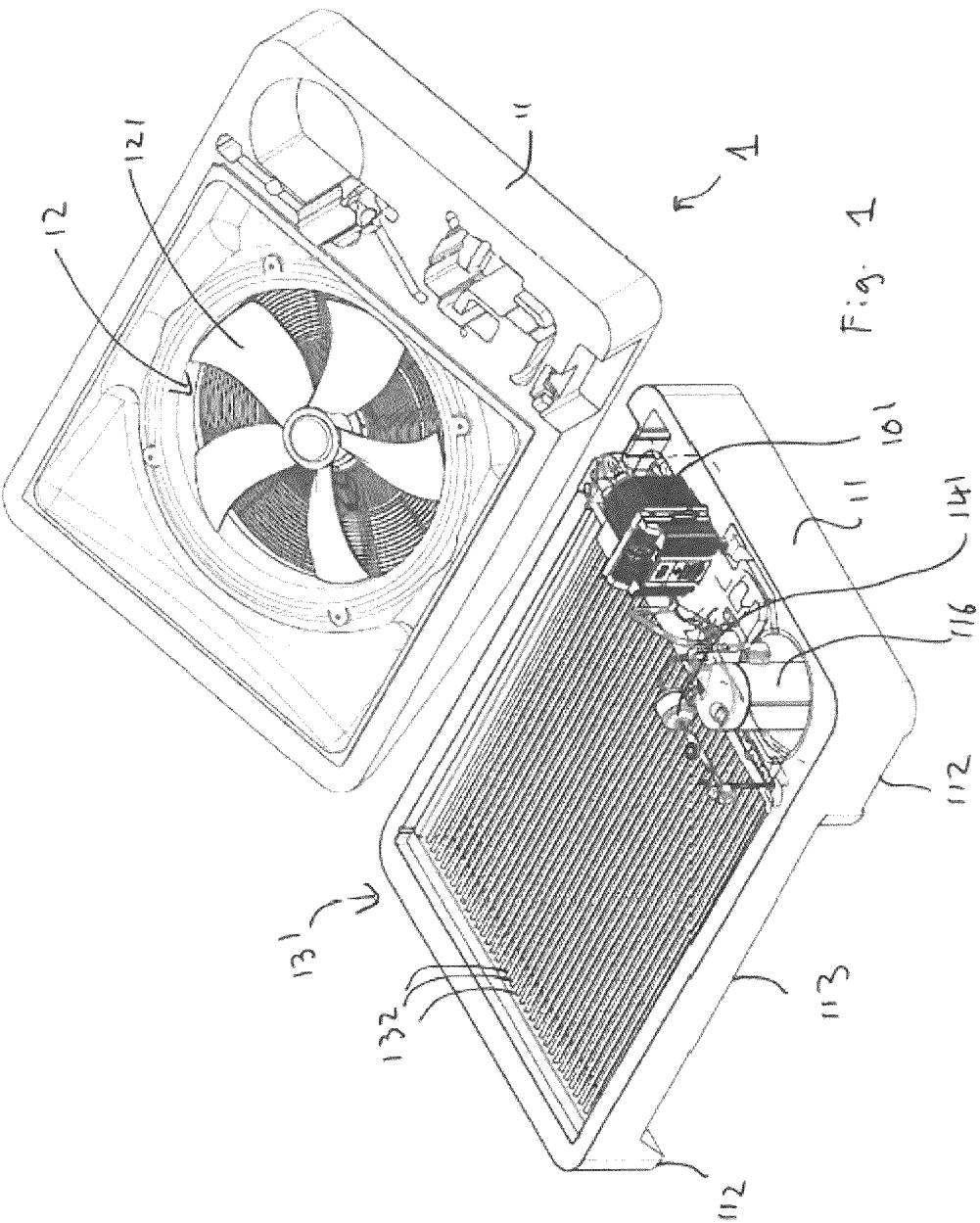
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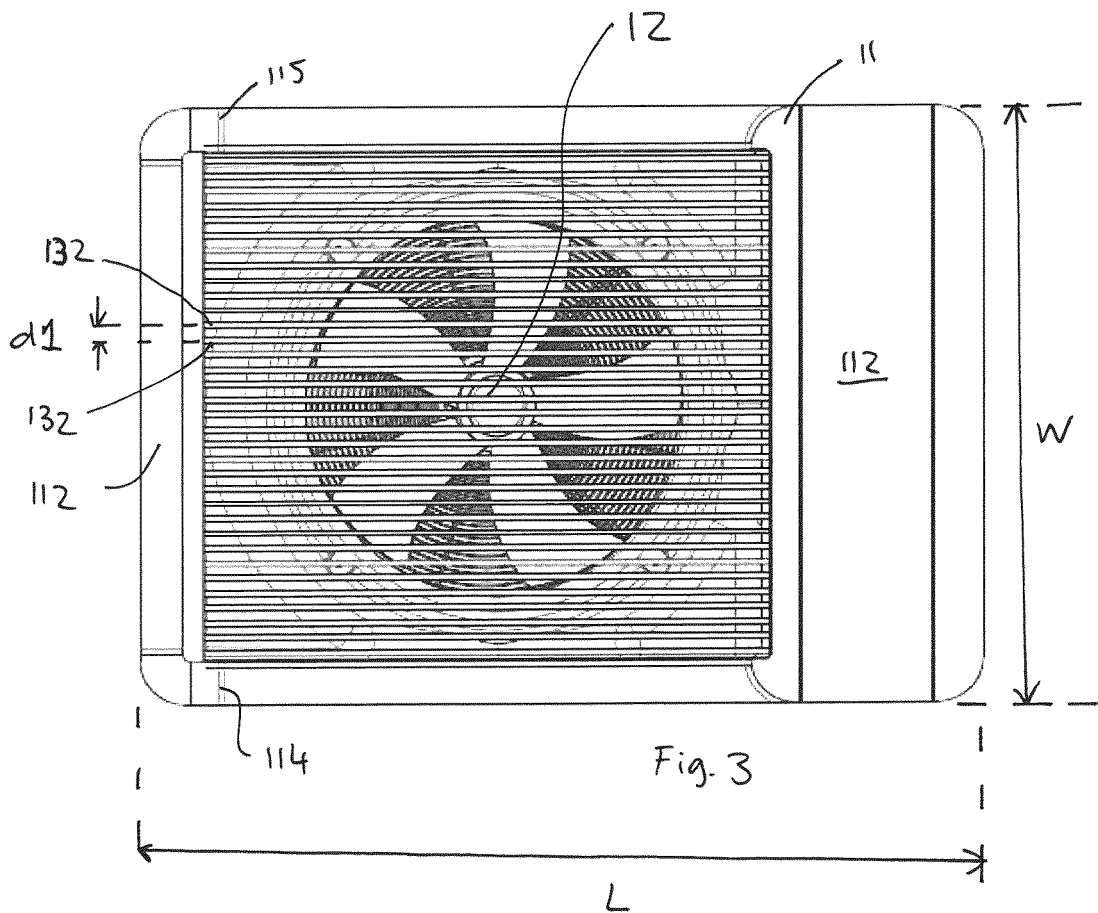
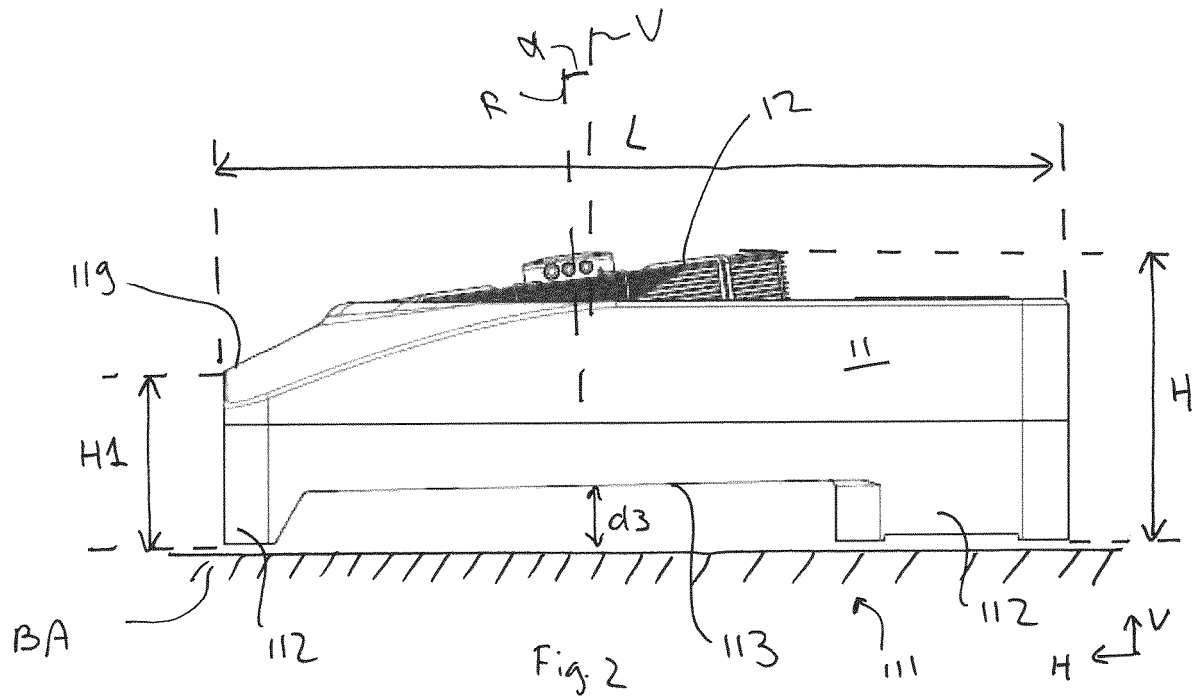
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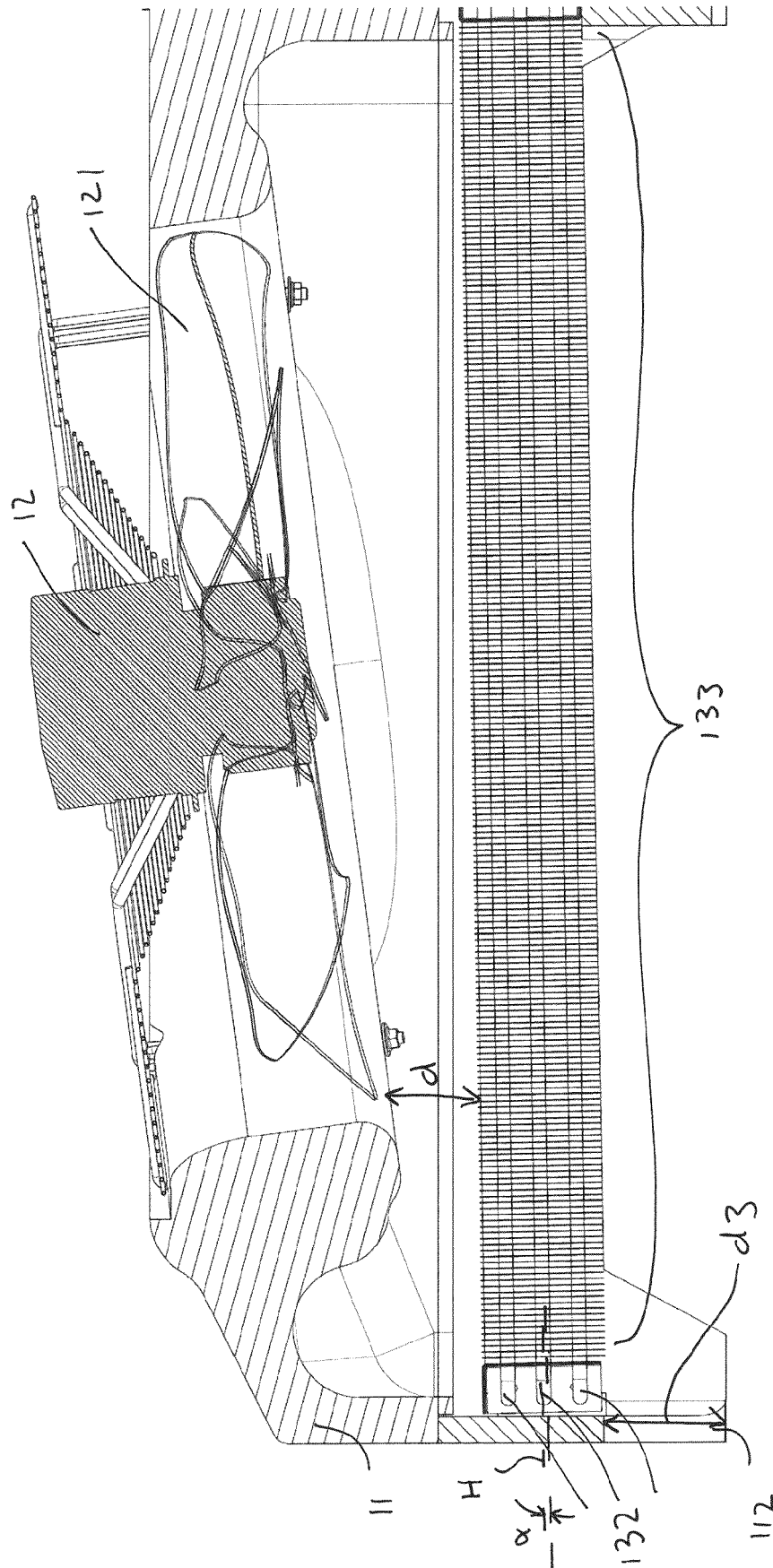


Fig. 4

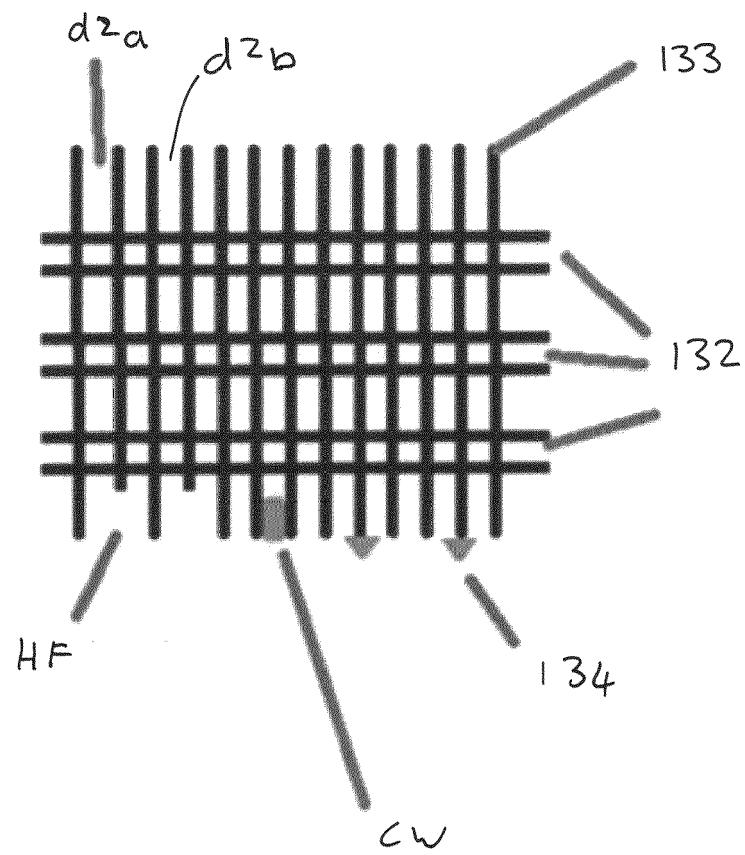


Fig. 5

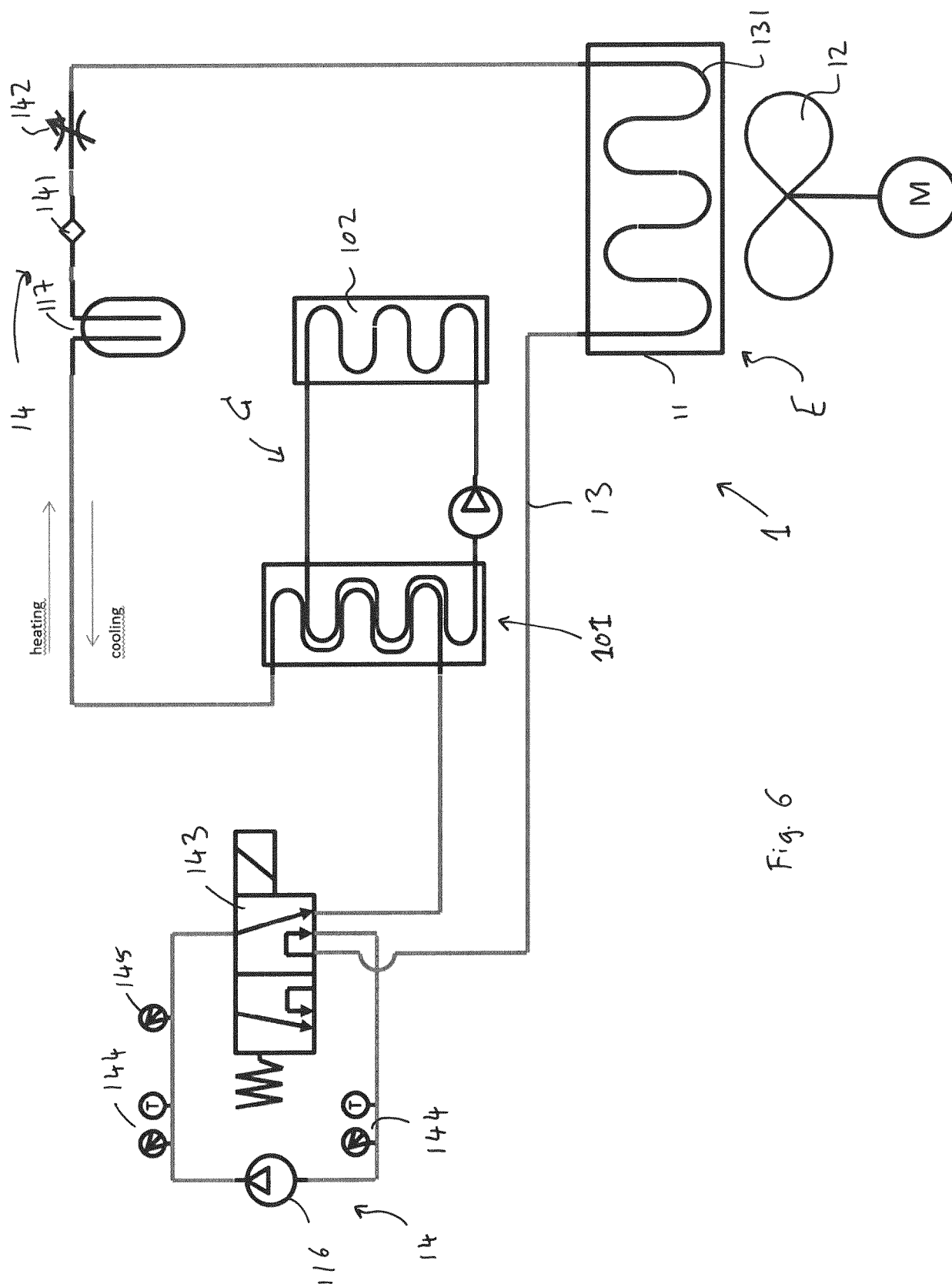


Fig. 6



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Application Number

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Y	* the whole document * -----	4, 5	F24F1/54 F24F1/56 F24F1/60
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Place of search Munich		Date of completion of the search 8 September 2022	Examiner Mattias Grenbäck
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