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(54) **FLOW GUIDING APPARATUS**

(57) Flow guiding apparatus (1) for a heating device (2), in particular an air-source heat pump water heater using a flammable refrigerant, the heating device (2) including at least a heat exchanger (8), a compressor element (15), an expansion valve (28) and a temperature sensor (29) connectable to the expansion valve (28) for monitoring the temperature of the refrigerant flowing out the heat exchanger (8), the apparatus (1) comprising a housing (3) couplable to a casing of the heating device (2) and comprising an air inlet (4) and an air outlet (5), the housing (3) defining an air flow region (7), wherein the housing (3) is configured so that the heat exchanger

(8) is arranged inside the air flow region (7) for exchanging heat in said air flow region (7), and so that air is guided to flow from the air inlet (4) to the heat exchanger (8) and from the heat exchanger (8) to the air outlet (5), the air being confined in the air flow region (7) and being prevented from being in contact with the compressor element (15) and the expansion valve (28) that are arranged outside the air flow region (7), and wherein the housing (3) is shaped to place in the air flow region (7) the temperature sensor (29) connectable to the expansion valve (29).

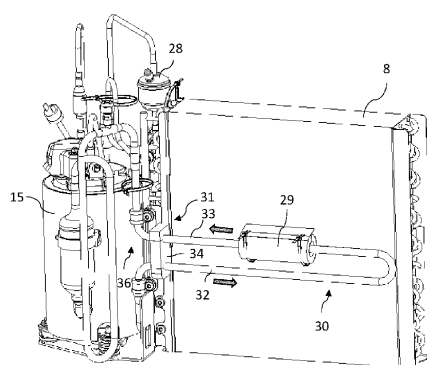


FIG. 4A

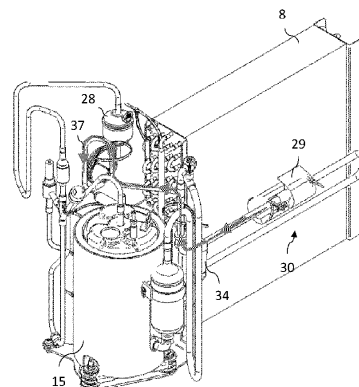


FIG. 4B

Description

[0001] The invention relates to a flow guiding apparatus for a heating device and to a heating device comprising said apparatus. Also, the invention relates to a use of said flow guiding apparatus in a heating device, in particular an air-source heat pump water heater using a flammable refrigerant.

[0002] A heating device like a heat pump is a device able to warm a closed space of a building or to warm domestic hot water by transferring thermal energy from a source to another. An air-source heat pump water heater is a device using the heat pump technology to use energy from air to heat the domestic water contained in a tank. This is obtained using a refrigeration cycle carried out in the opposite direction of the heat transfer. Among the different refrigeration cycles, the most widely used is the vapor compression refrigeration, in which a refrigerant undergoes phase changes.

[0003] For a heat pump water heater, vapor-compression refrigeration uses a circulating liquid refrigerant as the medium which absorbs heat from one source, compresses it, thereby increasing its temperature before releasing it in another source. A vapor-compression refrigeration system usually comprises at least a compressor, an expansion valve and, two heat exchangers and a network of pipes connecting these elements and in which the refrigerant circulates. In a heating mode the external heat exchanger is the evaporator and the internal one being the condenser. In particular, the thermodynamic circuit of a heat pump water heater comprises a first stage, or hot stage, including the condenser, and a second stage, or cold stage, including the evaporator. A heat transfer fluid circulates in a closed circuit, wherein this fluid flows in the evaporator at low pressure. At the evaporator outlet, the fluid is compressed by the compressor and flows in the condenser before passing through an expansion valve. The valve lowers the fluid's pressure so that the fluid can return to the evaporator. The condenser is usually arranged in, or around, a water tank in order to determine a heat transfer, whereas the evaporator is crossed by an air circulation path and is coupled to a fan element.

[0004] Through the evaporator circulate fluids such as R410A, R-32, R134a, to evaporate/vaporize from liquid to gas within the system while absorbing heat from a source in the process. However, environmental constraints prevent the use of historical refrigerants and lead to the use of new so-called natural fluids. These fluids are highly flammable and can therefore generate risks of explosion in the event of a leak in an electrical appliance that has not been designed to control this risk. For example, the presence of the compressor and more generally of a source of ignition close to the evaporator can strongly affect the safety of the heating device. An ignition source is an item or substance capable of an energy release sufficient to ignite a flammable fluid. It can be of several natures including hot source and electrical, me-

chanical or chemical activation energy.

[0005] As mentioned above, to operate, the heat pump circuit needs an expansion valve. The function of the expansion valve is to expand the refrigerant from high pressure to low pressure. This serves also to control the amount of refrigerant released into the evaporator and regulate the superheat of the refrigerant that flows out of the evaporator to a constant and defined value. To do it so, the expansion valve needs a thermal bulb/sensor to regulate the superheat by influencing the flow rate. To absolve this function, the sensor is positioned on the frigorific piping between the evaporator outlet and the compressor inlet. It is isolated from the air flow thanks to insulating means (mainly foam) and is fixed to the piping with a temperature-conducting solution. As this probe cannot be immersed in the refrigerant, it is placed in contact with the conductive tube in which circulates the refrigerant. This can be achieved for example by using a copper (for high thermal conductivity) housing soldered, screwed or clipped onto the refrigerant circuit, by using an adhesive with a temperature-conducting aluminium surface or by using a thermally conductive adhesive paste.

[0006] However, based on the arrangement of the components of the heating device, the expansion valve could not function correctly. For example, in designs where the evaporator is confined in a region where airflow is prevented from cooling more elements than necessary, especially the compressor and the refrigerant pipes going from the compressor to the condenser (useful heat), it would be reasonable to place the temperature sensor of the expansion valve on the piping located outside the air flow in order to not have any deviation due to the air temperature. However, this would lead to a malfunctioning of the expansion valve. As a matter of fact, the temperature read by the temperature sensor is biased because the compressor will heat the piping and therefore the probe by conduction. Moreover, as there is no air circulation allowing thermal convection around all the components of the heat pump (and in particular the compressor and frigorific piping associated), the whole environment increases in temperature. It is therefore necessary to position the temperature sensor in a place where the temperature read by the probe will not be biased by external behaviours that would distort the read temperature value of the refrigerant (as the heating of the compressor). Indeed, if the sensor overheats, it would act like if there is not enough fluid in the evaporator and open the expansion valve.

[0007] When opening the hot gas valve, there is no overheat identified so the expansion valve would act like if there is too much fluid in the evaporator and close the expansion valve.

[0008] It is therefore desirable to obtain an apparatus or system able to control the situation of leakage of flammable fluid at the evaporator and at the same time able to correctly monitor the temperature of the refrigerant fluid for a correct functioning of the expansion valve.

[0009] The object is solved by a flow guiding apparatus for a heating device, in particular an air-source heat pump water heater using a flammable refrigerant, the heating device including at least a heat exchanger, a compressor element, an expansion valve and a temperature sensor connectable to the expansion valve for monitoring the temperature of the refrigerant flowing out the heat exchanger, the apparatus comprising: a housing couplable to a casing of the heating device and comprising an air inlet and an air outlet, the housing defining an air flow region, wherein the housing is configured so that the heat exchanger is arranged inside the air flow region for exchanging heat in said air flow region, and so that air is guided to flow from the air inlet to the heat exchanger and from the heat exchanger to the air outlet, the air being confined in the air flow region and being prevented from being in contact with the compressor element and the expansion valve that are arranged outside the air flow region, and wherein the housing is shaped to place in the air flow region the temperature sensor connectable to the expansion valve.

[0010] Advantageously, the apparatus can be integrated in a heat pump water heater and the heat exchanger is an evaporator operating with a flammable refrigerant heavier than air. That means, the heat exchanger, in particular evaporator, exchanges heat from the air to the refrigerant. The housing is shaped such that it accommodates the evaporator and guides the air flow passing through the evaporator in a closed air flow region thereby preventing any possible leakage of flammable refrigerant fluid present in the evaporator, thereby preventing any possible contact with other components of the heating device (hot source or with activation energy), e.g. the compressor, that could trigger an explosion.

[0011] Moreover, this apparatus allows a more accurate reading of the refrigerant temperature, thereby allowing the expansion valve to close faster and avoid fluid migration when the system is off. Moving the temperature sensor away from the compressor avoids overheating of the sensor when the compressor is off, which would open the expansion valve and encourage the migration of the fluid (rising from the condenser). In particular, this reduces the pump down time of the compressor.

[0012] In addition, thanks to this apparatus, the heat from the compressor that is lost during this circuit cooling is recycled and used to warm the air entering the evaporator. This improves the exchange performance of the evaporator as more energy is available.

[0013] In one example, the temperature sensor is attached to a piping portion containing the refrigerant flowing from the heat exchanger to the compressor element, and the housing comprises a piping port for the passage of said piping portion inside the air flow region. In other words, a portion of the piping containing the refrigerant is deviated in order to enter and exit the air flow region.

[0014] By circulating part of the refrigerant circuit between the evaporator and the compressor in the air flow region, the tubes of this piping portion are cooled by con-

vection and are therefore not affected by the operating temperature of the compressor. Thus, the temperature read by the sensor in contact with the refrigerant tube of said piping portion is the temperature of the fluid and is not biased by the temperature relayed by the compressor. This accurate reading of the refrigerant temperature allows the heat pump system to operate correctly. Indeed, having the temperature sensor in a cooler environment prevents the expansion valve to open and to close too frequently and irrelevantly due to misinterpretation of the state of the system.

[0015] The piping port can be located in a zone delimiting the air flow region, i.e. can be located between a zone inside the air flow region and a zone outside said air flow region.

[0016] In another example, the piping portion comprises an inlet piping and an outlet piping, the temperature sensor being located between the inlet piping and the outlet piping and the piping port comprises a gasket element for supporting the inlet piping and the outlet piping. The inlet piping is a section of the piping portion entering the air flow region, whereas the outlet piping is a section of the piping portion exiting the air flow region. The piping portion can have a coil shape, wherein the inlet point of the inlet piping and the outlet point of the outlet piping are close to each other, in particular are both located to the piping port at the gasket element. Advantageously, the gasket element comprises two through holes for the passage of the inlet piping and the outlet piping. It is noted that the gasket element can also serve to seal the pipe. In that case it is configured to avoid the transmission of vibrations from the piping. In other words, as the compressor vibrates, the compressor can transmit vibration to the piping. In this case, abrasion between the piping and the gasket is preferably to be reduced, in particular avoided. Advantageously, the gasket can therefore be made of a soft or flexible material. A soft or flexible material in accordance with the present invention is preferably defined as a material that has a tensile elongation in elastic behavior of at least 10%. In other words, for the determination of such an elastic behavior, a tensile stress is applied to the material until it is elongated by at least 10% and then it has to return to its original length without deformation. The tensile elongation value is determined according to ISO 1798 and DIN 53571. A suitable material is for example polyethylene foam. A suitable material, in particular polyethylene foam, preferably has a Young Modulus between 0 MPa and 100MPa, in particular between 1 MPa and 100 MPa, in particular 5 MPa to 20 MPa. The values in MPa refer to the Young Modulus determined at 3% compression in dependence of g/l (gram per liter). The Young Modulus is determined according to ISO 844. Alternatively or additionally, the interface points between the gasket and the piping can be vibration-damped. Suitable means for vibration damping can be for example elastomeric rings.

[0017] In an additional example, the housing is shaped to place the temperature sensor in the air flow region,

wherein the air is guided to flow from the air inlet to the heat exchanger. In this way, overheating of the temperature sensor is avoided.

[0018] In an example, the temperature sensor can be an electronic sensor or a mechanical sensor. The sensor can be electronically connected to the expansion valve for monitoring at least one temperature dependent value. The temperature sensor can be a so called sensing bulb containing a liquid which expands depending on the temperature of the piping. This bulb is fluidly connected to the expansion valve so that when the temperature of the bulb rises, the liquid expands and this expansion pushes a part directly into the expansion valve to close or to open it.

[0019] According to an example, the housing comprises a first component for holding the heat exchanger and the compressor element connectable to the heating device and a second component connectable to the heating device to form the air flow region. Advantageously, the two components are configured to physically separate the heat exchanger and the temperature sensor located in the air flow region from the compressor element. For example, the first component can surround, at least partially, the compressor element and the second component can surround, at least partially, the heat exchanger and the temperature sensor. It is noted that the both the first component and the second component can be directly connected to a portion of the heating device or indirectly connected to a portion of the heating device, i.e., by means of an interposed element.

[0020] In one example, the second component is at least in part fixable to, and removable from, the first component, the first component and the second component being both shaped to guide air to flow from the air inlet to the heat exchanger and from the heat exchanger to the air outlet. Specifically, the first component can be the bottom component of the housing and the second component can be the top component of the housing, wherein the first component represents a base on which several elements of the heating device can be accommodated and/or fixed. For example, the evaporator, the compressor, the expansion valve and the fan element can be accommodated on the second component of the housing. The second component is configured to be coupled to the first component and acts as a sort of cap and is used to separate the evaporator (and the fan element) from other elements present and arranged on the first component, such as the compressor. In addition to isolating the evaporator (and the fan element) from other elements of the heating device, by coupling the first component to the second component an air flow region is built in order to guide the air flow from the air inlet to the evaporator and from the evaporator to the air outlet. The first and second component are specifically shaped to confine air in the air flow region and to form a preferred path from the air inlet to the air outlet passing through the evaporator.

[0021] To fluidically isolate the evaporator and the tem-

perature sensor from other elements of the heating device that could trigger an explosion in case of leakage of the flammable refrigerant fluid and that could determine an overheating of the sensor, the first component is connected to the second component to form a connecting region that is airtight and/or watertight. In this way, the apparatus ensures a good seal between the evaporator and the heating device, thereby improving the overall performance of the device. Indeed, if the heating device stops, the outside air penetrates into the apparatus but is confined in the housing. This apparatus is positioned within the overall heating device casing, providing two layers of thermal insulation.

[0022] In one example, the first component and the second component are one-piece parts. This facilitates the manufacturing of these components and strongly reduces the risk of fluid passage from inside the housing in the air flow region and to outside the housing (of course with the exception of the air flowing through the air inlet and air outlet).

[0023] In another example, the first component and the second component are both shaped to form a first seat, in particular for the placement of the heat exchanger. The first component comprises a recess where to fix, e.g. to slot in, the base of the evaporator and the second component comprises an internal concave region to accommodate, at least in part, the top of the evaporator.

[0024] In an additional example, the first component and the second component are both shaped to form a second seat, in particular for the placement of a fan element. Similar to the case of the first seat, the first component can comprise a recess where to fix, e.g. to slot in, the base of the fan element and the second component can comprise an internal concave region to accommodate, at least in part, the top of the fan element.

[0025] In a further example, the housing can comprise a base component interposed between at least the first component and the heating device to fix said first component to the heating device. In addition or in alternative, the housing can comprise a base component interposed between at least the second component and the heating device to fix said second component to the heating device.

[0026] In another example, the first component and the second component form a one-piece structure.

[0027] In one example, the air inlet and the air outlet are located on the second component and the heat exchanger and the compressor element are fixable to the first component. Advantageously, the connection of the first component with the second component produces a physical separation between the compressor and the evaporator, although they are both located on the same supporting base, i.e., the first component. Alternatively, the heat exchanger and the compressor element can be fixable to a base element interposed between at least the first component and/or the second component, and the heating device.

[0028] In an example, the apparatus further comprises

a condensate drain outlet coupled to the heat exchanger to evacuate condensate resulting from heat exchange at the heat exchanger. In this way, the condensate resulting from the heat exchange at the evaporator can be safely evacuated.

[0029] In case the condensate drain is not properly functioning, i.e., it is obstructed, the apparatus can further comprise a safety drain outlet located in a bottom region of the housing to evacuate a fluid from the air flow region to the outside. For example, the safety drain outlet can be located in the first component of the housing. Accordingly, even if the condensate drain outlet is blocked by water, the, in particular flammable, refrigerant fluid will be able to escape through the safety drain outlet. This outlet is positioned at a low point and far from electronic devices, which ensures that the fluid will never fill the housing and risk entering the rest of the heating device environment or go to electronic devices.

[0030] In another example, the air inlet and the air outlet are both located in a top or lateral region of the housing. In a different configuration, the air inlet can be located in the top region, whereas the air outlet in the lateral region, or vice versa. The different location of the air inlet and outlet affects the shape of the housing, i.e. the shape of the first and second components of the housing in order to form the air flow region able to efficiently guide the air from the air inlet to the evaporator and from the evaporator to the air outlet.

[0031] In a further example, in order to make the apparatus compatible with the environment of the heating device, the housing is made of a polymeric material, in particular of foam plastic, more particularly of polypropylene expanded (PPE). Specifically, both the first and the second component are made of polymeric material, in particular of foam plastic, more particularly of polypropylene expanded (PPE).

[0032] In an additional example, in order to optimize air flow and limit aerodynamic disturbances, an air duct connecting the air inlet to the air outlet comprises a variable cross-section. In particular, the cross-section of the air duct at the air inlet and at the air outlet can be different from the cross-section at the heat exchanger, wherein in particular the cross-section of the air duct at the air inlet and at the air outlet can be circular or cylindrical and the cross-section at the heat exchanger can be polygonal or angular shaped. Specifically, the air duct can have a progressive cross-section, for example increasing from the air inlet to the evaporator and decreasing from the evaporator to the air outlet.

[0033] In another example, the heating device further comprises at least a fan element, in particular a brushless fan, arranged inside the air flow region and coupled to the heat exchanger. In this way, the fan element is accommodated in the housing and, similarly to the heat exchanger, separated from the other elements of the heating device. The fan element serves to optimize the flowing of the air in the air flow region. Advantageously, the fan element can be placed downstream of the evaporator

in the air flow region due to a lower air mass volume of the air. However, the fan element can also be placed upstream of the evaporator. In this way, it is possible to manage refrigerant leaks at the evaporator regardless of the state of the heating device. If the fan element is running, the leak will be extracted from the air duct through the air outlet. If the fan element is off, since the refrigerant fluid is heavier than air, this fluid can escape through the condensate drain outlet and/or the safety drain outlet.

[0034] In an example, the air flow region comprises an air flow sub-region located between the fan element and the heat exchanger, the housing in said air flow sub-region being shaped to guide air from the heat exchanger to the air outlet. In the air flow sub-region the first and second components are shaped to form a volute structure to improve the fan element performances. Also, in this air flow sub-region the first and second components are shaped to form a conduit to improve the air flow guiding from the evaporator to the fan element.

[0035] According to another example, to increase the safety of the heating device, any ignition source is arranged outside the air flow circulating region, i.e. outside the housing.

[0036] In an example, at least a portion of the housing is part of the heating device. The apparatus can be composed of specific parts or can be integrated with parts that are also used for the structure of the heating device, such as a heat pump base or the outer casing of the heat pump. In particular, the apparatus can therefore be located inside the heating device and covered by the casing parts or be part of the casing itself.

[0037] In another aspect of the invention, a heating device, in particular a heat pump water heater using a flammable refrigerant, is provided, the heating device comprising the inventive apparatus. In particular, the heating device comprises at least a heat exchanger, a compressor element and an expansion valve and a temperature sensor connectable to the expansion valve for monitoring the temperature of the refrigerant flowing out the heat exchanger, wherein the heat exchanger and the temperature sensor are located inside the air flow region in the housing of the apparatus and the compressor element and the expansion valve are located outside said air flow region in the housing of the apparatus.

[0038] In one example, the temperature sensor is attached to a piping portion with a material having a thermal conductivity higher than $1 \text{ W/(m}^{\circ}\text{K)}$. Also, the temperature sensor can be covered by a thermal insulation material, in particular an insulation foam, wherein in particular the thermal insulation material has a thermal conductivity lower than $0.1 \text{ W/(m}^{\circ}\text{K)}$. In addition, a piping portion on which the temperature sensor is attached can have a length of at least 5 cm.

[0039] According to a further example, the heating device comprises a capping element configured to be coupled to a top region of the heating device and covering the housing of the apparatus, the capping element comprising a first opening coupled to the air inlet of the hous-

ing and a second opening coupled to the air outlet of the housing, wherein between the first opening and the air inlet and between the second opening and the air outlet are provided sealing means.

[0040] In a further aspect of the invention, a use of the inventive flow guiding apparatus is provided. The inventive flow guiding apparatus is used in a heating device, in particular a heat pump water heater using a flammable refrigerant.

[0041] In the figures, the subject-matter of the invention is schematically shown, wherein identical or similarly acting elements are usually provided with the same reference signs.

Figure 1 shows a schematic representation of the flow guiding apparatus according to an example.

Figures 2A-B show a perspective view of the apparatus with and without the second component according to an example.

Figures 3A-B show a perspective view of the apparatus with and without the second component according to an example.

Figure 4A-B show two perspective views of the temperature sensor attached to the piping portion according to an example.

Figures 5A-B figure 5A shows a cross-section view and figure 5B shows a perspective view of the heating device and the capping element according to an example.

Figure 1 illustrates the apparatus 1 for guiding the airflow in a schematic representation. The apparatus 1 can be coupled to a heating device 2, for example a heat pump water heater. The heating device 2 comprises at least one heat exchanger such as an evaporator 8 to absorb heat from the air and transfer it to the refrigerant fluid circulating in said evaporator 8. Thus, the fluid will be able to change from an at least partially liquid to a gaseous state. The evaporator 8 is crossed by an air circulating path receiving air from outside. The air can be ambient air or stale air from domestic rooms via ventilation ducts. The fluid at low pressure is conducted to a compressor 15 coupled to the evaporator 8 and is then directed to another heat exchanger, such as a condenser (not shown in the figure) for a heat transfer with a water tank 21. The device 2 comprises also an expansion valve 28 to expand the refrigerant from high pressure to low pressure, the expansion valve 28 being connected to the evaporator 8 through a piping (not shown in the figure). The expansion valve 28 is electronically connected to a temperature sensor 29 for monitoring the refrigerant temperature, the temperature sensor 29 being attached to a portion of the piping connecting the evaporator 8 to the

compressor 15 (not shown in the figure). The evaporator 8, the expansion valve 28, and the compressor 15 are located on a top region of the heating device 2 and the water tank 21 is located in a bottom region of the heating device 2 inside a casing 22. Alternatively, the connection between the expansion valve 28 and the temperature sensor 29 is not electronic. For example, the connection can be provided by a capillary piping with fluid which expand inside it depending on the temperature of the sensor/bulb.

[0042] The apparatus 1 comprises a housing 3 having a first component 10 and a second component 11. It is noted that the first component 10 represents a base element on which several elements of the heating device are arranged. The first component 10 can be fixed to the top of the casing 22 of the heating device 2. The second component 11 is, on the other hand, a capping structure that can be fixed to, and removed from, the first component 10. Alternatively, the first component 10 and the second component 11 could form a single part. The second component 11 is schematically illustrated in figure 1 with a grey border. It is noted that according to the figure, when the second component 11 is coupled to the first component 10, the second component 11 is not configured to completely cover/cap the entire surface of the first component 10. As a matter of fact, when the second component 11 is coupled to the first component 10, an air flow region 7 is formed and some of the elements arranged on the first component 10, such as the compressor 15 and the expansion valve 28, are located outside said region 7, whereas other elements, such as the evaporator 8 and the temperature sensor 29 are located inside the air flow region 7. Alternatively, the second component 11 can completely cover the surface of the first component 10. In this case, the second component 11 could also function as a capping of the heat pump compartment and could comprise at least two separated closed regions containing the air flow region 7 and the compressor 15 and expansion valve 28, respectively.

[0043] The housing 3 comprises an air inlet 4, an air outlet 5 and an air duct 6 connecting the air inlet 4 to the air outlet 5. It is noted that the air duct 6 comprises a first sub-duct comprised between the air inlet 4 and the evaporator 8 and a second sub-duct comprised between the evaporator 8 and the air outlet 5. Environmental air at a certain temperature enters the air inlet 4, crosses the evaporator 8, and exits the air outlet 5 at a lower temperature. To improve the air conduction to the air outlet 5, a fan element 9 is located downstream of the evaporator 8 in the portion of the air duct 6 between the evaporator 8 and the air outlet 5.

[0044] The use of the apparatus 1 in a heating device 2, like a heat pump unit of a thermodynamic water heater operating with a flammable refrigerant heavier than air, is very useful. As a matter of fact, the apparatus 1 does not incorporate any ignition source (hot source or with activation energy). This apparatus 1 has a housing 3 allowing an air flow to enter and exit the apparatus 1 pass-

ing through the evaporator. Since the apparatus 1 is sealed from the rest of the heat pump compartment, it prevents the transfer of fluids (flammable gas in the event of a leak, water from condensate, air flow, etc.) to other element that are not in the housing 3. This avoids the risk of ignition in the event of a gas leak in the circuit contained in housing 3 or rather in the air flow region 7. It also improves the acoustics of the product thanks to an efficient and leakage-free airflow control since the noise waves from the operating compressor 15 must pass through surfaces before propagating to the outside of the product, either through the said compartment to reach the vents, or through the casing of the compressor 15. This also avoids water stagnation and corrosion. As a matter of fact, trenches and openings are included in the room to allow for fluid flow. This also improves the performance of the compressor 15 and the product in general as the compressor 15 is not cooled by air from the air vents. In particular, a condensate drain outlet 12 is located between the bottom of the fan space and the evaporator space to allow for water flow (splash, condensation, etc.). In order to cope with the possibility of an obstruction of the condensate drain outlet 12, an additional opening, i.e., a safety drain outlet 13, is present at a lower level than air outlet 5 and air inlet 4.

[0045] In addition, the position of the temperature sensor 29 in the air flow region 7 prevents the overheating of said sensor, for example due to the proximity of hot elements, which may cause convection or heating due to the conductive nature of the copper piping connected to hot elements, such as the compressor 15.

[0046] The housing 3, i.e., the first component 10 and the second component 11, is made of a material compatible with this environment and is preferably made of foamed plastic such as expanded polypropylene.

[0047] Figures 2A-2B and 3A-3B illustrate a perspective view of the apparatus 1 coupled to a heating device 2, in particular coupled to the top portion of the casing 22 of the heating device 2. Figures 2A and 2B show a first configuration, wherein the second component 11 is coupled to the first component 10 (Fig. 2A) and a second configuration, wherein the second component 11 is removed from the first component 11 (Fig. 2B). Also in combination with figure 1, it is noted that the second component 11 is a sort of convex cap suitably shaped to allow the arrangement of elements, such as the evaporator 8, the temperature sensor 29 and fan element 9 (only the corresponding fan seat 24 is shown in the figure) inside the housing 3, and to form an air duct 6 from the air inlet 4 to the air outlet 5 passing through the evaporator 8. For example, the second component 11 has an air flow portion 25 at the air inlet 4 and air outlet 5, the air flow portion 25 having a cylindrical shape. Also, the second component 11 has an evaporator portion 26 at the evaporator 8, the evaporator portion 26 having a polygonal outline to allow the arrangement of the upper part of the evaporator 8 that usually has a parallelepiped form (see figure 2B). Additionally, the second component 11 has a fan

portion 27, having a curved shape to allow the arrangement of the upper part of the fan 9 that usually has a circular form. In a similar way, the first component 10 is suitably shaped to allow the arrangement of elements, such as the evaporator 8, the temperature sensor 29, and fan element 9 inside the housing 3, and to form an air duct 6 from the air inlet 4 to the air outlet 5 passing through the evaporator 8. Figure 2B shows for example that the first component 10 is provided with a dedicated seat (or second seat) 24 for the fan element 9 having a curved shape. An analogous dedicated seat (or first seat) 23 for the evaporator 8 is also provided in the first component 10, this seat 23 having a rectangular, polygonal shape (not shown in the figure). The first seat 23 is a rectangular slot for inserting the lower part of the evaporator 8. This can be clearly derived for example from figure 3B.

[0048] By comparing figures 2A and 2B, it is noted that when the second component 11 is removed from the first component 10, different elements of the heating device 2, such as the evaporator 8, the temperature sensor 29, the expansion valve 28, and the compressor 15 are located in the same environment. In other words, air flowing through the evaporator 8 could also pass close to the compressor 15. This is basically the standard situation described in prior art. On the other hand, when the second component 11 is coupled to the first component 10, the evaporator 8 and the temperature sensor 29 are separated from the compressor 15 and the expansion valve 28. The walls of the second component 11 prevent air flowing in the air duct 6 from the air inlet 4 to the air outlet 5 to be in contact with the compressor 15 and to prevent the temperature sensor 29 to be in a overheating environment.

[0049] Figure 3A illustrates in detail the coupling of the second component 11 to the first component 10 and the arrangement of elements, such as the evaporator 8, the temperature sensor 29, the piping portion 30 on which the temperature sensor 29 is attached, and the fan element 9, inside the housing 3 in the air flow region 7. To better appreciate the location of the evaporator 8, the temperature sensor 29, the piping portion 30, and the fan element 9, the second component 11 is sketched with a transparency grade.

[0050] Figure 3B shows in a top view the evaporator 8 with the temperature sensor 29 on the first component 10 and the second seat 24 dedicated for arranging the fan element 9. An air flow sub-region 16 is located between the evaporator, in particular the first seat 23, and the second seat 24. In this airflow sub-region 16, the housing 3, and in particular the first component 10 and second component 11 are shaped to guide air from the evaporator 8 to the air outlet 5. In the air flow sub-region 16 the first and second components 10, 11 are shaped to form a volute structure to improve the performances of the fan element 9. Also, in this air flow sub-region 16 the first and second components 10, 11 are shaped to form conduit to improve the air flow guiding from the evap-

orator 8 to the fan element 9.

[0051] Figure 3B also shows a connection region 14, represented with a dotted line in the figure, this region 14 being the contact portion between the first component 10 and the second component 11. In other words, the connection region 14 is the external border of the air flow region 7 and defines the outline inside which the elements (e.g. the evaporator 8, temperature sensor 29, piping portion 30, the fan element 9) are confined in the air flow region 7. At the connection region 14, the housing 3 is water-sealed and air-sealed from the rest of the heat pump compartment.

[0052] Figures 4A and 4B illustrate the arrangement of the temperature sensor 29 relative to the evaporator 8, the compressor 15 and the expansion valve 28, without the first component 10 and the second component 11 of the flow guiding apparatus 1. It is noted that the piping containing the refrigerant has a piping portion 30 that deviates from a linear path 36 in order to create an additional path close to a surface of the evaporator 8. As explained above and as shown in Fig. 3A, the deviation serves to place the piping portion 30 in the air flow region 7. A piping port 31 in the form of a gasket element 34 delimits the internal area from the external area of the air flow region 7. The gasket element 34 has two through holes for the passage of the inlet piping 32 (containing the refrigerant flowing out the evaporator 8) and the outlet piping 33 (containing the refrigerant flowing to the compressor element 15). To save space, the piping portion 30 has a curved section so that the inlet piping 32 and the outlet piping 33 are parallel and the inlet and outlet point are located in the same area at the piping port 31. The temperature sensor 29 is attached to the piping portion 30 between the inlet piping 32 and the outlet piping 33. In particular, the temperature sensor 29 is attached with a material having a high thermal conductivity (for example $> 1 \text{ W/(m}^2\text{K)}$). The assembly formed by temperature sensor 29 and the attaching material having a high thermal conductivity is covered with an insulation preventing direct impact of the air flow (for example with a thermal conductivity lower than $0.1 \text{ W/(m}^2\text{K)}$). The temperature sensor 29 is a sensing bulb containing a liquid which expands depending on the temperature of the piping. As shown in figure 4B, this bulb 29 is connected to the expansion valve 28 by a capillary piping 37 so that when the temperature of the bulb 29 rises, the liquid expands and this expansion pushes a part directly into the expansion valve 28 to close or to open it. The capillary piping 37 is illustrated in the figure with an arrowed path flowing out of the temperature sensor 29.

[0053] Figure 5A shows the presence of a capping element 17 that can be coupled to the upper portion of the casing 22 of the heating device 2. The capping element 17 basically covers the elements of the top of the casing 22, thereby also covering the apparatus 1, i.e., the first component 10 and the second component 11. The capping element 17 comprises a first opening 18 coupled to the air inlet 4 and a second opening 19 coupled to the

air outlet 5. Figure 5A shows a sliced cross-section of the heating device 2 including the apparatus 1. The figure basically shows the presence of the first and second components 10, 11 without the evaporator 8, temperature sensor 29 and the fan element 9. It is noted that the second component 11 is connected to the first component 10 through a joint mechanism made of recessing and protruding elements and that below the first component 10 there is a lower region 35 where to arrange the condenser and the water tank (not shown in the figure). Figure 5B shows a bottom view of the cap element 17. It is noted that the first and second openings 18, 19 are provided with sealing means 20 for determining a sealed coupling with the air inlet 4 and air outlet 5 of the flow guiding apparatus 1.

Reference Signs

[0054]

1	Flow guiding apparatus
2	Heating device
3	Housing
4	Air inlet
5	Air outlet
6	Air duct
7	Air flow region
8	Heat exchanger
9	Fan element
10	First component
11	Second component
12	Condensate drain outlet
13	Safety drain outlet
14	Connecting region
15	Compressor element
16	Air flow sub-region
17	Capping element
18	First opening
19	Second opening
20	Sealing means
21	Water tank
22	Casing
23	First seat
24	Second seat
25	Air flow portion
26	Evaporator portion
27	Fan portion
28	Expansion valve
29	Temperature sensor
30	Piping portion
31	Piping port
32	Inlet piping
33	Outlet piping
34	Gasket element
35	Lower portion
36	Linear path
37	Capillary piping

Claims

1. Flow guiding apparatus (1) for a heating device (2), in particular an air-source heat pump water heater using a flammable refrigerant, the heating device (2) including at least a heat exchanger (8), a compressor element (15), an expansion valve (28) and a temperature sensor (29) connectable to the expansion valve (28) for monitoring the temperature of the refrigerant flowing out the heat exchanger (8), the apparatus (1) comprising:
 - a housing (3) couplable to a casing of the heating device (2) and comprising an air inlet (4) and an air outlet (5), the housing (3) defining an airflow region (7), wherein the housing (3) is configured so that the heat exchanger (8) is arranged inside the air flow region (7) for exchanging heat in said air flow region (7), and so that air is guided to flow from the air inlet (4) to the heat exchanger (8) and from the heat exchanger (8) to the air outlet (5), the air being confined in the air flow region (7) and being prevented from being in contact with the compressor element (15) and the expansion valve (28) that are arranged outside the air flow region (7), and wherein the housing (3) is shaped to place in the air flow region (7) the temperature sensor (29) connectable to the expansion valve (29).
2. Apparatus (1) according to claim 1, **characterized in that** the temperature sensor (29) is attached to a piping portion (30) containing the refrigerant flowing from the heat exchanger (8) to the compressor element (15), and the housing (3) comprises a piping port (31) for the passage of said piping portion (30) inside the air flow region (7).
3. Apparatus (1) according to claim 2, **characterized in that** the piping portion (30) comprises an inlet piping (32) and an outlet piping (33), the temperature sensor (29) being located between the inlet piping (32) and the outlet piping (33) and the piping port (31) comprises a gasket element (34) for supporting the inlet piping (32) and the outlet piping (33).
4. Apparatus (1) according to any one of claims 1 to 3, **characterized in that**
 - a. the housing (3) is shaped to place the temperature sensor (29) in the air flow region (7) wherein the air is guided to flow from the air inlet (4) to the heat exchanger (8); and/or
 - b. the temperature sensor (29) is an electronic sensor or a mechanical sensor.
5. Apparatus (1) according to any one of claims 1 to 4, **characterized in that** the housing (3) comprises a first component (10) for holding the heat exchanger (8) and the compressor element (15) connectable to the heating device (2) and a second component (11) connectable to the heating device (2), to form the air flow region (7).
6. Apparatus (1) according to claim 5, **characterized in that**
 - a. the second component (11) is at least in part fixable to, and removable from, the first component (10), the first component (10) and the second component (11) being both shaped to guide air to flow from the air inlet (4) to the heat exchanger (8) and from the heat exchanger (8) to the air outlet (5); and/or
 - b. the first component (10) is connected to the second component (11) to form a connecting region (14) that is airtight and/or watertight; and/or
 - c. the first component (10) and the second component (11) are one-piece parts; and/or
 - d. the first component (10) and the second component (11) are both shaped to form a first seat (23), in particular for the placement of the heat exchanger (8); and/or
 - e. the first component (10) and the second component (11) are both shaped to form a second seat (24), in particular for the placement of a fan element (9); and/or
 - f. the housing (3) comprises a base component interposed between at least the first component (10) and the heating device (2) to fix said first component (10) to the heating device (2); and/or
 - g. the housing (3) comprises a base component interposed between at least the second component (11) and the heating device (2) to fix said second component (11) to the heating device (2); and/or
 - h. the first component (10) and the second component (11) form a one-piece structure.
7. Apparatus (1) according to any one of claims 5 to 6, **characterized in that** the air inlet (4) and the air outlet (5) are located on the second component (11) and/or the heat exchanger (8) and the compressor element (15) are fixable to the first component (10) or to a base element interposed between at least the first component (10) and/or the second component (11), and the heating device (2).
8. Apparatus (1) according to any one of claims 1 to 7, **characterized in that** a. the apparatus (1) further comprises a condensate drain outlet (12) coupled to the heat exchanger (8) to evacuate condensate resulting from heat exchange at the heat exchanger (8); and/or

- b. the apparatus (1) further comprises a safety drain outlet (13) located in a bottom region of the housing (3) to evacuate a fluid, in particular the flammable refrigerant, from the air flow region (7) to the outside; and/or
- c. the air inlet (4) and the air outlet (5) are both located in a top or lateral region of the housing (3); and/or
- d. the housing (3) is made of a polymeric material, in particular of foam plastic, more particularly of polypropylene expanded (PPE).
9. Apparatus (1) according to any one of claims 1 to 8, **characterized in that** an air duct (6) connecting the air inlet (4) to the air outlet (5) comprises a variable cross-section, wherein in particular the cross-section of the air duct (6) at the air inlet (4) and at the air outlet (5) is different from the cross-section at the heat exchanger (8), wherein in particular the cross-section of the air duct (6) at the air inlet (4) and at the air outlet (5) is circular and the cross-section at the heat exchanger (8) is polygonal.
10. Apparatus (1) according to any one of claims 1 to 9, **characterized in that** the heating device (2) further comprises at least a fan element (9), in particular a brushless fan, arranged inside the air flow region (7) and coupled to the heat exchanger (8), wherein in particular the air flow region (7) comprises an air flow sub-region (16) located between the fan element (9) and the heat exchanger (8), the housing (3) in said air flow sub-region (16) being shaped to guide air from the heat exchanger (8) to the air outlet (5).
11. Apparatus (1) according to any one of claims 1 to 10, **characterized in that**
- a. any ignition source is arranged outside the air flow region (7) and/or
- b. at least a portion of the housing (3) is part of the heating device (2).
12. Heating device (2), in particular a heat pump water heater using a flammable refrigerant, comprising the apparatus (1) according to any one of claims 1 to 11, the heating device (2) comprising at least a heat exchanger (8), a compressor element (15) and an expansion valve (28) and a temperature sensor (29) connectable to the expansion valve (28) for monitoring the temperature of the refrigerant flowing out the heat exchanger (8), wherein the heat exchanger (8) and the temperature sensor (29) are located inside the air flow region (7) in the housing (3) of the apparatus (1) and the compressor element (15) and the expansion valve (28) are located outside said air flow region (7) in the housing (3) of the apparatus (1).
13. Heating device (2) according to claim 12, **characterized in that**
- a. the temperature sensor (29) is attached to a piping portion (30) with a material having a thermal conductivity higher than $1 \text{ W/(m}^{\circ}\text{K)}$; and/or
- b. temperature sensor (29) is covered by a thermal insulation material, in particular an insulation foam, wherein in particular the thermal insulation material has a thermal conductivity lower than $0.1 \text{ W/(m}^{\circ}\text{K)}$; and/or
- c. a piping portion (30) on which the temperature sensor (29) is attached has a length of at least 5 cm.
14. Heating device (2) according to one of claims claim 12 to 13, further comprising a capping element (17) configured to be coupled to a top region of the heating device (2) and covering the housing (3) of the apparatus (1), the capping element (17) comprising a first opening (18) coupled to the air inlet (4) of the housing (3) and a second opening (19) coupled to the air outlet (5) of the housing (3), wherein between the first opening (18) and the air inlet (4) and between the second opening (19) and the air outlet (5) are provided sealing means (20).
15. Use of the flow guiding apparatus (1) according to one of claims 1 to 11 in a heating device (2), in particular an air-source heat pump water heater using a flammable refrigerant.

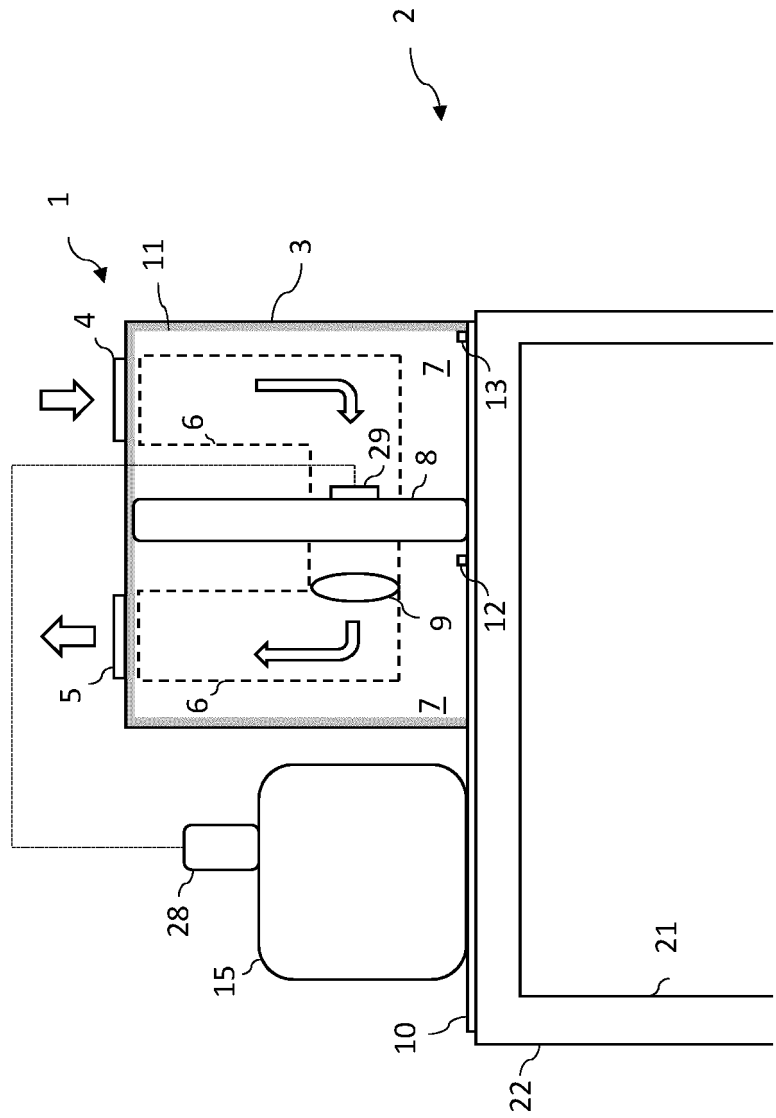


FIG. 1

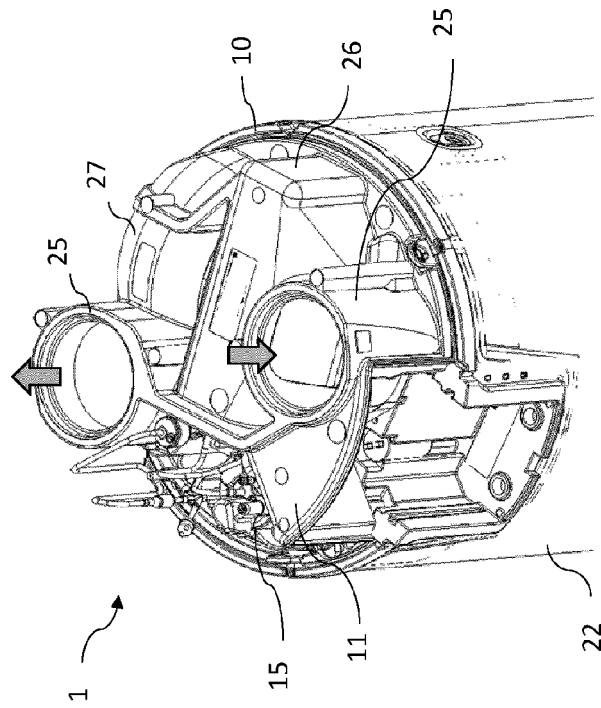


FIG. 2A

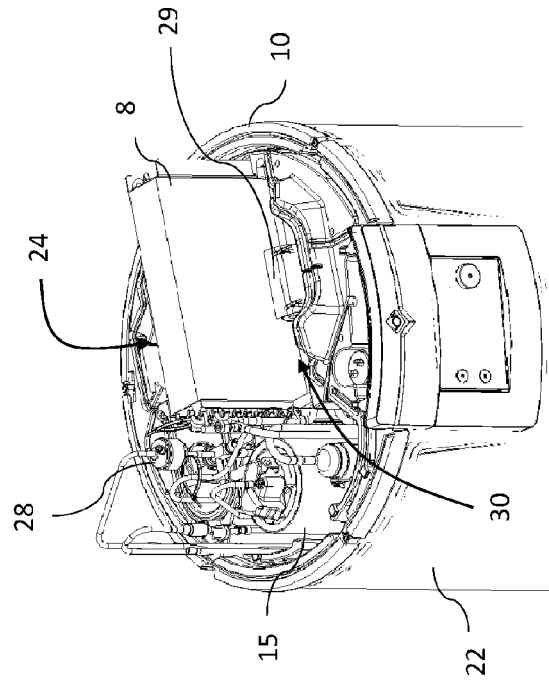


FIG. 2B

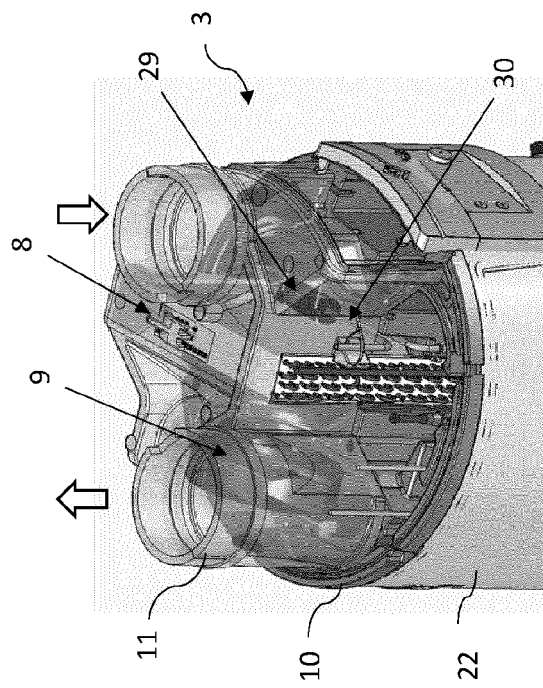


FIG. 3A

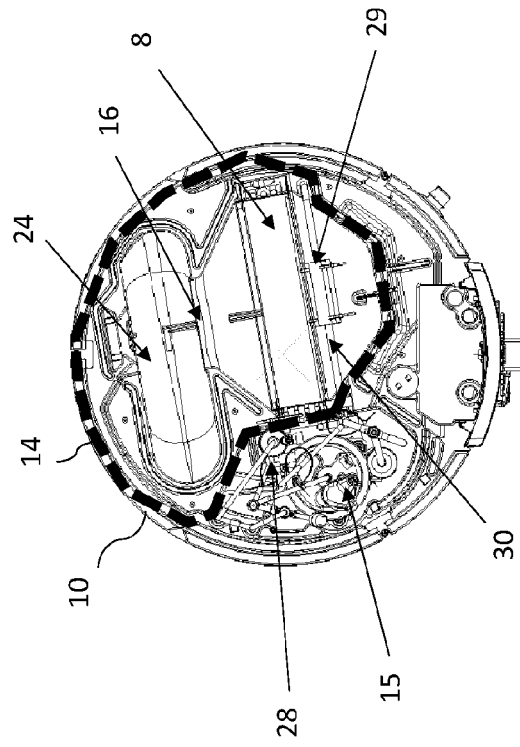


FIG. 3B

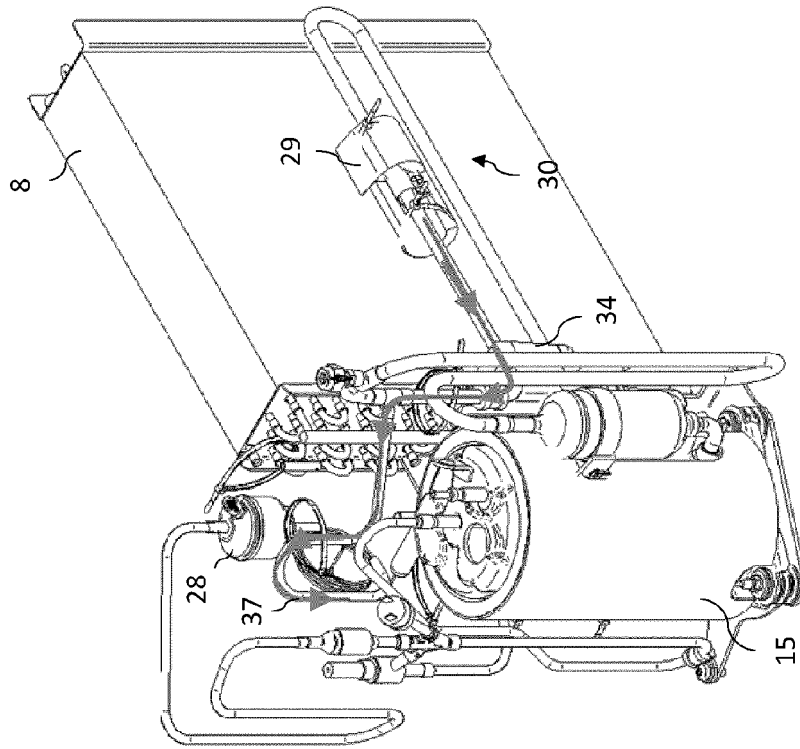


FIG. 4B

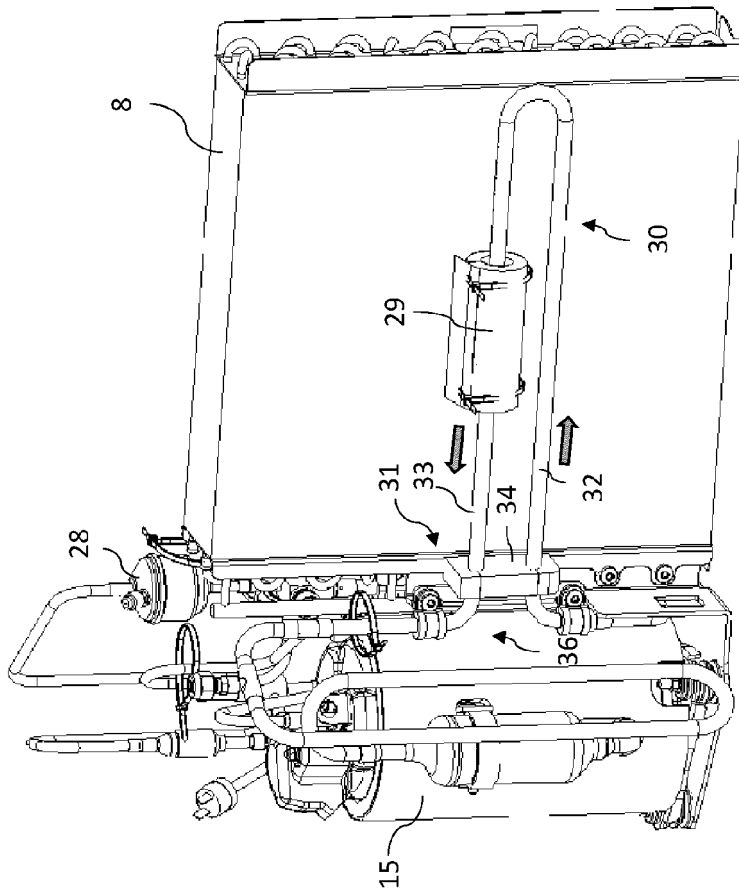


FIG. 4A

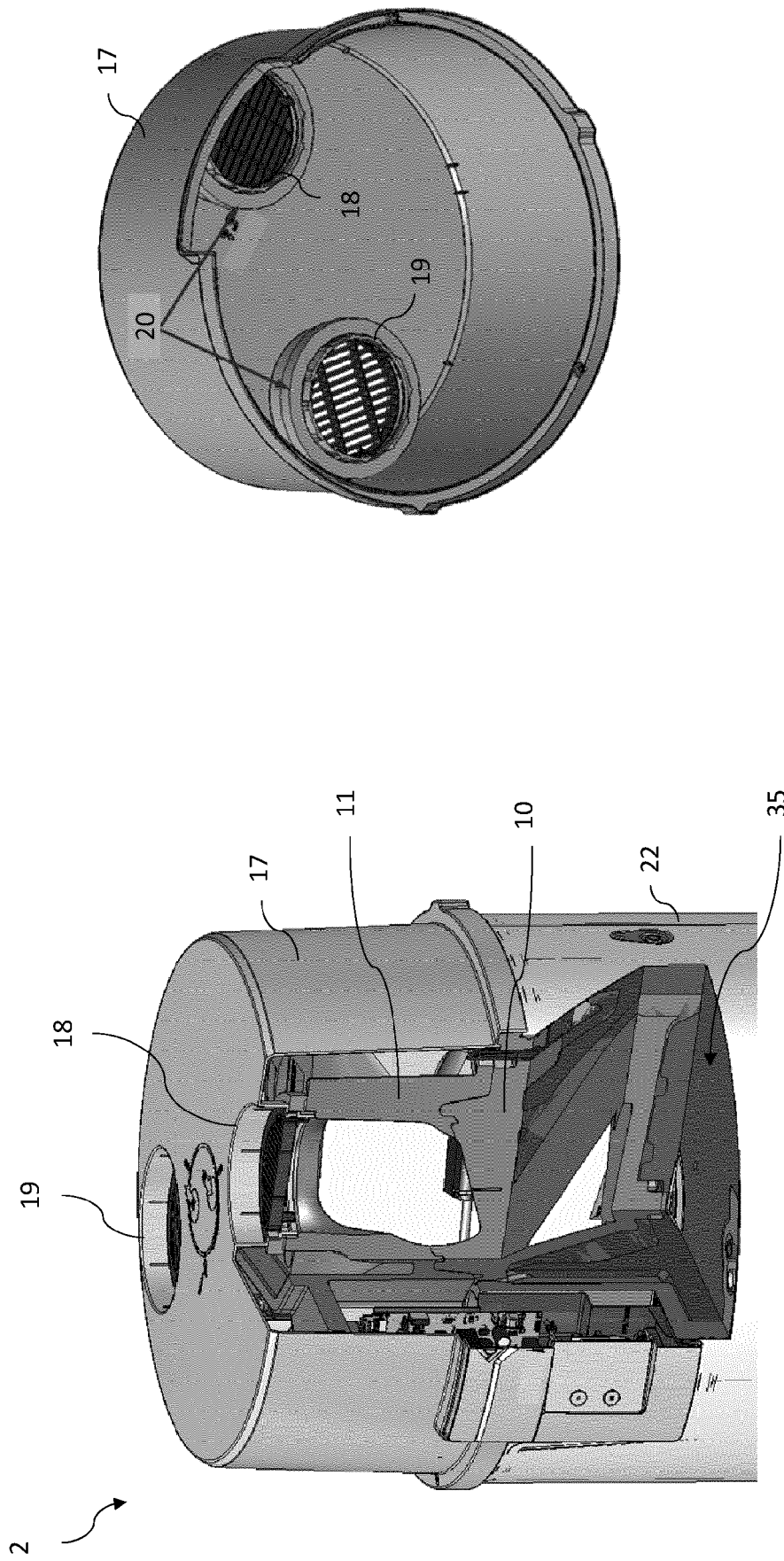


FIG. 5B

FIG. 5A



EUROPEAN SEARCH REPORT

Application Number

EP 22 16 6331

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			TECHNICAL FIELDS SEARCHED (IPC)
			F24H F25B
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 16 September 2022	Examiner Hoffmann, Stéphanie
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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