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

(11) EP 4 428 457 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
11.09.2024 Bulletin 2024/37

(21) Application number: **23160623.7**

(22) Date of filing: **08.03.2023**

(51) International Patent Classification (IPC):
F24F 1/24 *(2011.01)* ***F24F 13/20*** *(2006.01)*
F24F 1/46 *(2011.01)* ***F24F 1/48*** *(2011.01)*
F24F 1/56 *(2011.01)*

(52) Cooperative Patent Classification (CPC):
F24F 1/24; F24F 1/48; F24F 1/56

(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 ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
KH MA MD TN

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(54) **HEAT PUMP SYSTEM**

(57) The invention relates to a heat pump system (1) comprising a housing (4), heat pump components, which are configured to carry a flammable refrigerant, in particular a refrigerant heavier than air, and electronic components (8) configured to control the heat pump system (1), wherein
the heat pump components are arranged in a first compartment (2) of the housing (4) and the electronic components (8) are arranged in a second compartment (3) of the housing (4), wherein
the first compartment (2) is separated from the second compartment (3) to prevent leaked refrigerant to spread from the first compartment (2) through the housing (4) to the second compartment (3) and wherein
the second compartment (2) comprises an air-cooling channel (5) going from a first opening (6) in the housing (4) to a second opening (7) in the housing (4), the air-cooling channel (5) being configured to guide a cooling air flow from the first opening (6) to the second opening (7) to cool the electronic components (8).

Fig. 1a

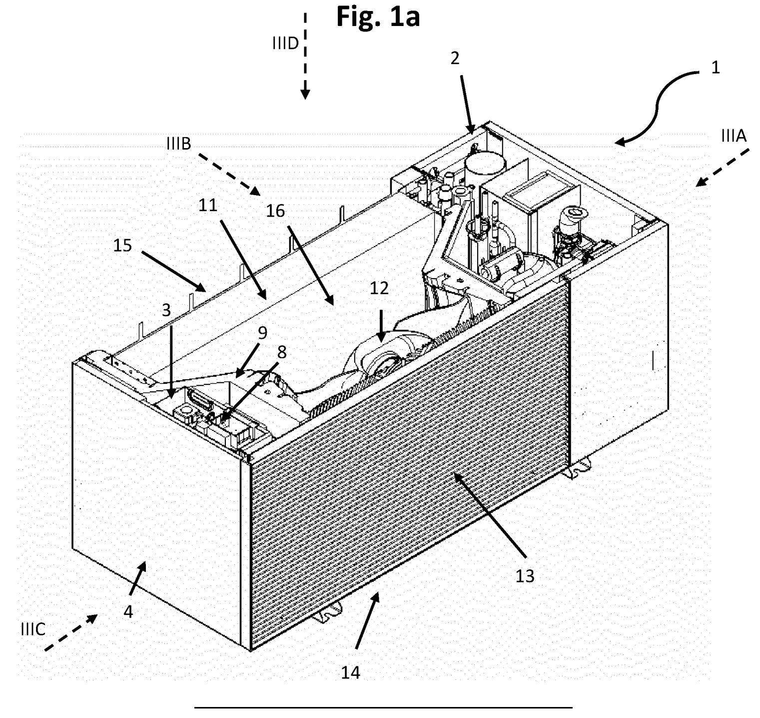

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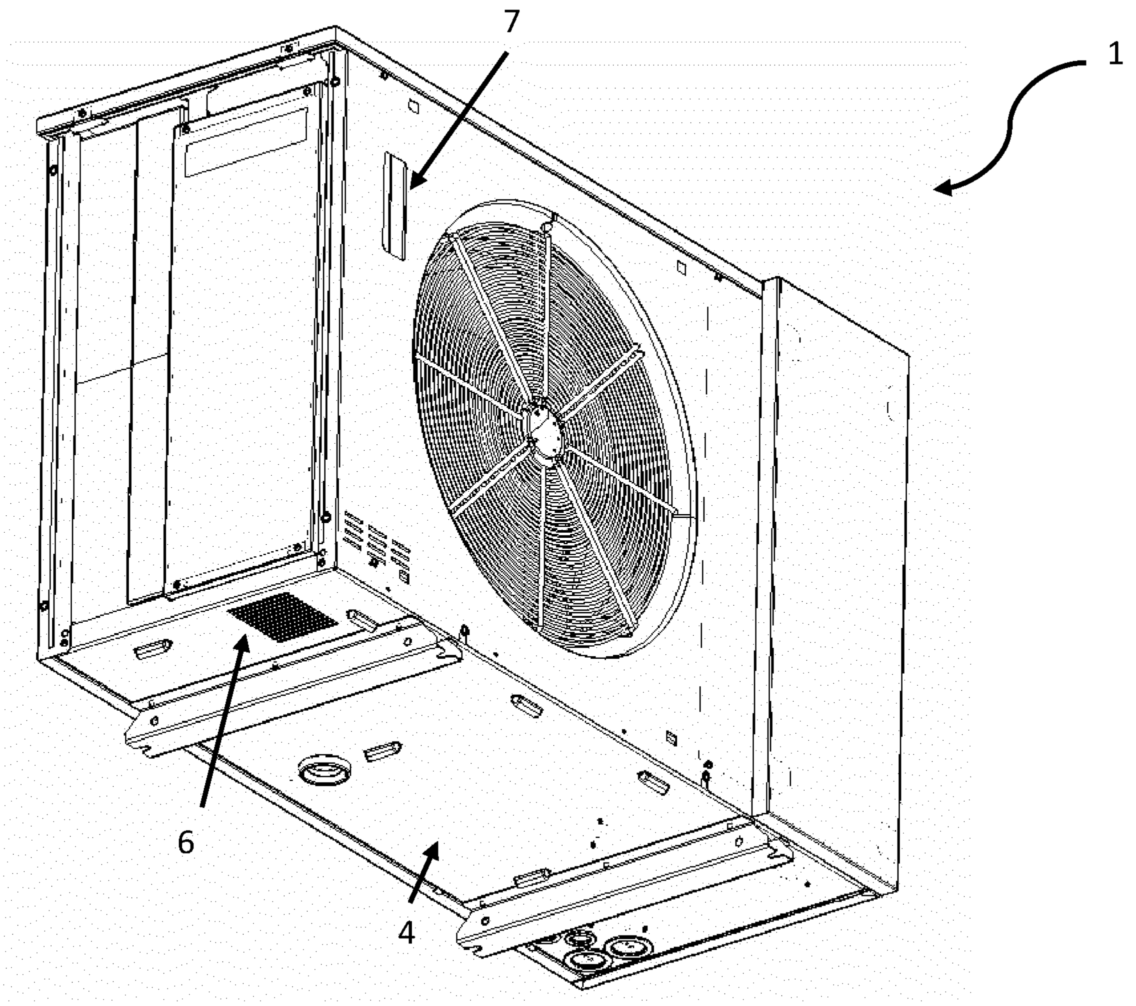
Fig. 1b



Description

[0001] The invention relates to a heat pump system comprising heat pump components configured to carry a refrigerant and comprises electronic components configured to control the heat pump system.

[0002] Heating of water or air in buildings, such as heating water of a central heating system or heating of water for domestic use, may be accomplished by means of a heat pump system. In general, heat pump systems use refrigerants to transport heat from a source medium (typically air, ground or ground water) to a destination medium (typically water). Such a heat pump system may either be a ground source heat pump (GSHP) system or an air source heat pump (ASHP) system. In a GSHP system, calories are exchanged between the ground or ground water, and a fluid, the fluid in particular being air or water. The calories in the ground may be extracted by capturing calories in a water table or by circulating a water-based circuit in the ground. In an ASHP system calories are exchanged between the air and a fluid, in particular air or water.

[0003] The refrigerant is circulated through a refrigeration circuit. The refrigeration circuit comprises heat pump components configured to carry a refrigerant, such as at least a first heat exchanger (evaporator), a compressor, a second heat exchanger (condenser), an expansion valve and refrigerant piping. In the first heat exchanger (evaporator) heat is transferred from the source medium to the refrigerant. In the second heat exchanger, heat is transferred from the refrigerant to the destination medium.

[0004] With the development of environmental requirements, the refrigerants used in the past are being replaced by refrigerants that are cleaner for the environment. The replacement fluids are mostly natural flammable fluids. Examples of a flammable heat transfer fluid is propane, butane and isobutane.

[0005] The term flammable is used in this text with reference to the ASHRAE standards for refrigerants and EN 378-2, defining the following classes: 1, 2L, 2, or 3, ranging from no flame propagation to high flame propagation and high heat of combustion.

[0006] The term flammable is used to refer to refrigerants that are highly flammable, class 3, such as R290 (propane), R600 (butane) and R600a (isobutane). Class 3 refrigerants, when tested, exhibit flame propagation at 140°F (60°C) and 14.7 psi (101.3 kPa) and that either has a heat of combustion of 19,000 kJ/kg (8,174 BTU/lb) or greater or an LFL of 0.10 kg/m3 or lower. The term LFL means lower flammable limit. The flammability range is delineated by the upper and lower flammability limits. Outside this range of air/vapor mixtures, the mixture cannot be ignited. Outside this range there is not enough flammable refrigerant or too much (so not enough combustive such as oxygen) to burn.

[0007] The term flammable may also be used here to refer to refrigerants from class 2 (less flammable), such as R-152a or class 2L (mildly flammable) such as R-32, R-1234yf, R-1234ze.

[0008] The integration of these flammable refrigerants leads to new risks and the implementation of associated means of protection.

[0009] To operate, a heat pump system comprises an electronic control system, comprising electronic components to operate the product according to various parameters: power requirements, available power, temperature and pressure of certain components, customer requirements, operating mode, etc.

[0010] The electronic components may comprise various elements, such as transistors, coils, capacitors, electronic chips etc. During operation electric current flows through these electronic components causing them to heat up. This heating up can lead to a reduction in the life of the electronic components, a shutdown of the heat pump system and generate safety risks (heating, fire, etc.). These electronic components must therefore be cooled to ensure optimal operation of the heat pump system.

[0011] A known solution is to ventilate the electronic components to improve the thermal convection around the electronic components and thus enhance cooling. Cooling by convection may be done by natural convection, i.e. convection caused by environmental air movements and temperature differences, or by forced convection, i.e. convection generated by a dedicated fan or by the air flow from the fan of an air-to-air or air-to-water heat pump.

[0012] Cooling can be carried out directly on the electronic components or can be enhanced by the presence of fins acting as heat sinks to increase the heat exchange surface and therefore the cooling surface.

[0013] In the event of a failure or leakage in the refrigeration circuit, refrigerant may leak and spread to its surroundings. Common causes of leaks are corrosion, shock and faulty brazing. When the refrigerant is flammable, the leaked refrigerant may catch fire if activation energy is present. The activation energy can be a high temperature or the presence of an electric arc. Both types of activation energy are potentially present in the electronic control system.

[0014] When cooling by convection is applied leaked refrigerant may easily be conveyed towards the electronic components, increasing the chance of the leaked refrigerant being ignited.

[0015] The object of the invention is therefore to provide a heat pump system with a reduced risk of explosions or fire because of leaked refrigerant.

[0016] The object is solved by a heat pump system comprising a housing, heat pump components, which are configured to carry a flammable refrigerant, in particular a refrigerant heavier than air, and electronic components configured to control the heat pump system, wherein the heat pump components are arranged in a first compartment of the housing and at least part of the electronic components are arranged in a second compartment of the housing, wherein the first compartment is separated from the second compartment to prevent leaked refrigerant to spread from the first compartment through the housing to the second compartment and wherein the second compartment comprises an air-cooling channel going from a first opening in the housing to a second opening in the housing, the air-cooling channel being configured to guide a cooling air flow from the first opening to the second opening to cool the electronic components.

[0017] The electronic components arranged in the second compartment are preferably at least all the electronic components being a potential ignition source, i.e. the electronic components capable of reaching or generating the ignition temperature required to ignite the flammable refrigerant (e.g. 470°C in the case of propane) and igniting leaked refrigerant. These electronic components in the second compartment comprise all components that may create arcs or sparks, especially switches, where arcs are formed when opening and closing the switch with an energy greater than the activation energy of the flammable fluid. Electronic components that are not capable of reaching the ignition temperature, e.g. by creating arcs, may be present in the first compartment, such as wires (with a protective sheath). Wires are also not considered electronic components that are configured to control the heat pump system, as being passive elements. Another example of an electronic component not being a potential ignition source is an electronic board bathed in a resin bath to avoid direct contact between a powered electronic component and the air.

[0018] Also, components that merely use electricity as power source, such as compressors and fans may be present in the first compartment. Such elements are not considered electronic components that are configured to control the heat pump system and also have their own protection against reaching high temperatures and/or creating sparks or arcs (e.g. sealing).

[0019] This heat pump system has a low risk of explosions or fire to occur because of leaked refrigerant, as any leaked refrigerant is prevented from spreading to the electronic components being ignition source. At the same time, the electronic components are efficiently cooled, which helps to keep the electronic components within a temperature range in which they function most efficiently. Furthermore, the likelihood of the electronic components from providing the activation energy for causing an explosion or fire is reduced.

[0020] The heat pump components configured to carry a flammable refrigerant heavier than air may comprise a first heat exchanger, a compressor, an expansion valve, a second heat exchanger and refrigerant piping to fluidly connect the aforementioned heat pump components to create a refrigerant circuit. The second compartment does not comprise any components configured to carry refrigerant.

[0021] The first and second openings are in fact holes provided in the housing forming an entrance and an exit respectively of the air-cooling channel.

[0022] The air duct may comprise a cooling fan to generate an air flow from the first opening to the second opening.

[0023] According to an embodiment, the second compartment comprises a gas-tight electrical box, comprising the electronic components configured to control the heat pump system.

[0024] According to this embodiment, the second compartment may comprise a sub-compartment comprising the electronic components which are a potential ignition source. The sub-compartment may be referred to as an electrical box. The electrical box is preferably gas-tight, providing further protection against leaked refrigerant. The electrical box may be made gas-tight by sealing.

[0025] The electronic box may comprise fins, protruding outwardly and/or inwardly (into the inner space of the electronic box) to enhance cooling of the electronic components contained in the electronic box.

[0026] The air-cooling channel may run through the interior of the second compartment, for instance along the electrical box or through a gas-tight channel provided through the electrical box.

[0027] Generally, the first and/or second compartment may be divided in two or more subcompartments.

[0028] According to the invention a heat pump system is provided that comprises a specific air-cooling channel for cooling the electronic components of a heat pump system using a flammable fluid heavier than air. For this purpose, the heat pump system is separated into at least two blocks or compartments that are separated by a wall preventing the transfer of refrigerant from the first to the second compartment. In case of a leak, the refrigerant will spread in the most natural way, the wall preventing the refrigerant from naturally flowing directly into the second compartment via convection. Refrigerant may reach the second compartment via a different route or via the mechanism of diffusion, but this will only result in refrigerant reaching the second compartment in low, diluted, concentrations. As explained in this document, the heat pump system is designed such that such different, indirect routes preferably comprise at least one angle of less than 90°. The first block or compartment accommodates all the heat pump components configured to carry a flammable refrigerant. The second block or compartment has no elements configured to carry the flammable refrigerant and houses the electronic components which are potential ignition sources.

[0029] The two blocks or compartments are made such that no refrigerant can flow directly from the first to the second block or compartment, either by the realization of tight separation walls, or by the fact of having an open area between these two walls only at heights higher than the heat pump components configured to carry a flammable refrigerant. The refrigerant, being heavier than air, will not rise and will not be able to pass to the second compartment.

[0030] By providing the air-cooling channel in the second compartment, which is separated from the first compartment, the risk of leaked refrigerant getting into contact with the electronic components is minimized.

[0031] According to a further embodiment the first opening is positioned in a no-refrigerant extraction surface area of the housing and/or the second opening is positioned in a no-refrigerant extraction surface area of the housing.

[0032] Preferably, at least the first opening is positioned in a no-refrigerant extraction surface area of the housing, as this reduces the risk of leaked refrigerant from entering the air-cooling unit. A cooling fan may be arranged in the air-cooling channel, configured to generate the cooling air flow through the air-cooling channel from the first to the second opening. More preferably, both the first and second openings are positioned in a no-refrigerant extraction surface area of the housing, as this reduces the risk of leaked refrigerant from entering the air-cooling unit even in case the cooling fan is malfunctioning or not working.

[0033] It is noted that the term surface area refers to parts of the outside area of the housing and may refer to an entire panel (front, side, top, bottom panel) or side face of the housing or to a part of a panel or side face of the housing.

[0034] This embodiment provides the advantage that the risk of leaked refrigerant penetrating the air-cooling channel via the outer space of the housing is reduced as the openings are positioned in surface areas of the housing where leaked refrigerant will not be present or only in small quantities, when spreading via the outer space of the housing. The term no-refrigerant zones is used to refer to surface areas along the outer surface of the housing where leaked refrigerant will not be present or only in quantities much smaller than other surface areas of the housing. The no-refrigerant extraction surface areas may be located on sides of the housing directed away from the first compartment, at altitudes higher than the heat pump components configured to carry a flammable refrigerant heavier than air and/or on surface areas of the housing not comprising an air outlet side of the housing, where a heat-exchanger air flow exits the housing.

[0035] According to an embodiment the first and/or second openings are positioned on surface areas of the housing which are facing away from the first compartment, and/or which are above the heat pump components and/or which are above any point configured to carry a flammable refrigerant, and/or which are part of the second compartment and/or which are separated by a wall or barrier creating a flow path between the heat pump components configured to carry a flammable refrigerant and the first and/or second openings with at least one angle of 90° or less.

[0036] The phrase facing away from the first compartment is used to indicate that a normal vector to such a surface area of the housing, the normal vector being directed away from the inner space of the housing, is pointing in a direction away from the first compartment. Such a normal vector does not have a component being directed towards the first compartment. Additionally or alternatively, such a normal vector is pointing in a direction which is 90° degrees or more away from an imaginary straight line running from such a surface area of the housing to the first compartment.

[0037] The term above is used in reference to a normal operating orientation of the heat pump system. The openings may be located at a height or vertical level above any heat pump components configured to carry a flammable refrigerant or at least above the channels and chambers in which flammable refrigerant may be present in the heat pump components configured to carry a flammable refrigerant.

[0038] By providing the first and second openings on surfaces belonging to the second compartment, these openings are not on walls adjacent to the first compartment. Thus, in case of leakage of refrigerant, the refrigerant will not enter air-cooling.

[0039] According to an embodiment the first and/or second opening is/are concealed, and/or protected by a mesh structure.

[0040] The openings can be concealed so that they are not visible to the user. The openings can also be protected by a mesh structure to prevent penetration by foreign objects. Preferably, the mesh structure has mesh openings in line with the standard IEC 60335-1 : 2020. The mesh openings may have a diameter of less than 12 mm. The mesh may be provided by mesh openings in a steel plate.

[0041] According to an embodiment the heat pump system comprising an air-refrigerant heat-exchanger and a heat-exchanger fan positioned inside the housing, wherein the heat-exchanger fan is configured to generate a heat-exchanger air flow through the air-refrigerant heat-exchanger, and the housing comprises an air inlet configured to allow the heat-exchanger air flow to enter the housing and an air outlet configured to allow the heat-exchanger air flow to exit the housing, the air outlet being on an air outlet side of the housing, wherein the first and/or second openings are positioned on sides of the housing other than the air inlet side of the housing.

[0042] The air-refrigerant heat-exchanger may be positioned in the housing, in the first compartment.

[0043] Leaked refrigerant present outside the housing of the heat pump system is likely to be sucked towards the air inlet, while it is effectively blown away from the heat pump system at the air outlet side of the housing. It is therefore advantageous not to provide first and/or second openings on the air inlet side of the housing to prevent leaked refrigerant from ending up in the second compartment.

[0044] More generally, the first and/or second openings may not be on the whole frontage arranged on the side of the air inlet side of the air-refrigerant heat-exchanger. Indeed, the heat-exchanger fan generates a heat-exchanger air flow through the air-refrigerant heat-exchanger, so it can convey and put in movement air loaded with leaked refrigerant. It is therefore to be avoided to put a first and/or second opening on the whole side where this air is sucked towards.

[0045] According to an embodiment the inner space of the housing comprises at least one separation wall separating the first compartment from the second compartment, the separation wall being impermeable to the refrigerant.

[0046] Such a separation wall prevents leaked refrigerant to spread through the inner space to the second compartment. The separation wall may run from one side panel of the housing to another side panel of the housing and may be positioned on a base panel of the housing. The separation wall may be formed by an air guider of the air-refrigerant heat-exchanger.

[0047] According to an embodiment a top edge of the separation wall is at a higher gravitational level than all the heat pump components configured to carry the flammable refrigerant heavier than air and/or than any point in the heat pump system configured to carry the flammable refrigerant.

[0048] Such points include all the channels, conduits, tanks and vessel where the refrigerant may flow through or is stored. This may also be referred to as the the refrigerant circuit. Such a separation wall will be sufficient to prevent leaked refrigerant from spreading from the first compartment, through the inner space of the housing, to the second compartment. The refrigerant, being heavier than air, will not be able rise above the top edge of the separation wall to pass the separation wall.

[0049] According to an embodiment

- the first opening and the second opening are provided on the same side of the housing, or
- the first opening and the second opening are provided on different sides of the housing, or
- the first opening and/or second opening are provided on a horizontal side of the housing, and/or
- the first opening and/or second opening are provided on a vertical side of the housing.

[0050] The housing may be formed by a plurality of connected panels. The first and second opening may be provided on the same panel or different panels. The sides or panels may be horizontal or vertical.

[0051] According to an embodiment a cooling fan is arranged in the air-cooling channel, configured to generate the cooling air flow through the air-cooling channel. A cooling fan is an efficient device for generating an air flow.

[0052] According to an embodiment fins are arranged in the air-cooling channel, which fins are in thermal connection with the electronic components to enhance cooling of the electronic components by the cooling air flow.

[0053] According to an embodiment one or more electronic components are positioned in the air-cooling channel.

[0054] Cooling can be carried out directly on the electronic components by positioning electronic components in the air-cooling channel. Cooling can be enhanced by the presence of fins in the air-cooling channel, acting as heat sinks to increase the heat exchange surface and therefore the cooling surface. The air-cooling channel may comprise a combination of electronic components and fins.

[0055] According to an embodiment the first compartment comprises a first sub-compartment comprising an air-refrigerant heat-exchanger and a heat exchanger fan, and a second sub-compartment comprising a compressor, a water-refrigerant heat-exchanger and an expansion valve.

[0056] According to an embodiment the first compartment and second compartment are connected by means of connection channels comprising electrical cables.

[0057] The connection channels allow the first compartment and the second compartment to communicate. The electronic components can send control signals to the heat pump components, transmit power, and/or receive diagnostic and/or sensor data from the heat pump components and sensors. The connection channels may comprise wires, such as power cables.

[0058] According to an embodiment the heat pump system is a reversible heat pump system. A reversible heat pump system can be used for heating and cooling purposes.. The air-refrigerant heat-exchanger may function as an evaporator when the heat pump is used for heating purposes and as condenser when the heat pump is used for cooling purposes.

[0059] 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 1a-b	schematically shows perspective views of a heat pump system according to an embodiment,
Figures 2	schematically shows a top view of a heat pump system according to an embodiment,
Figures 3a-3d	schematically shows different side views of a heat pump system according to an embodiment,
Figure 4	schematically shows a perspective view of an embodiment wherein the second compartment comprises a gastight electrical box.

[0060] With reference to Figure 1a a heat pump system 1 is provided with a housing 4. In the housing 4 heat pump components configured to carry a flammable refrigerant, in particular a refrigerant heavier than air, are arranged. These heat pump components form a refrigeration circuit, comprising a first heat exchanger (evaporator), a compressor, a second heat exchanger (condenser), an expansion valve and refrigerant piping.

[0061] The first heat exchanger may be an air-refrigerant heat-exchanger 11. In the air-refrigerant heat-exchanger 11 heat is transferred from the source medium (air) to the refrigerant. The air-refrigerant heat-exchanger 11 may also be referred to as evaporator or a condenser depending on whether the heat pump system is used for heating or cooling purposes. The heat pump system may be a reversible heat pump system allowing both cooling and heating.

[0062] The heat pump components configured to carry a flammable refrigerant are all provided in a first compartment 2 of the housing 4. The first compartment may further comprise a heat exchanger fan 12. The first compartment may be divided in a first sub-compartment comprising the air-refrigerant heat-exchanger 11 and the heat exchanger fan 12, where the second sub-compartment comprises the remaining heat pump components configured to carry a flammable refrigerant. Further provided may be a air guide wall to guide air from the air-refrigerant heat-exchanger 11 to the heat exchanger fan 12. The first and second sub-compartment may be divided by a wall formed by part of the air guide wall of the heat exchanger fan. Electronic components 8 being a potential ignition source and configured to control the heat pump system 1 are arranged in a second compartment 3 of the housing 4. The electronic components 8 may be provided on one or more electronic boards. The electronic components 8 are schematically depicted in Fig. 1. The first and second compartment 2, 3 may be divided by a separation wall 9 formed by another part of the air guide wall. The separation wall is sufficient high to prevent leaked refrigerant from directy flowing into the second compartment. The separation wall 9 may be higher than the heat pump components configured to carry refrigerant.

[0063] The first compartment 2 is separated from the second compartment 3 to prevent leaked refrigerant to spread from the first compartment 2 through the housing 4 to the second compartment 3.

[0064] Fig. 1b shows a different perspective view of the heat pump system 1 than Fig. 1a, showing a first opening 6 in the housing 4 and a second opening 7 in the housing. An air-cooling channel 5 (not shown) is provided to generate an air flow through the air-cooling channel 5 to cool the electronic components 8, for instance by means of a cooling fan.

[0065] Fig. 2 shows a top view of the heat pump system 1 and shows an air-cooling channel 5 going from a first opening 6 in the housing 4 to a second opening 7 in the housing 4. The air-cooling channel 5 is provided to generate an air flow through the air-cooling channel 5 to cool the electronic components 8, for instance by means of a cooling fan. The air-cooling channel 5 and the air channel between the heat-exchanger 11 and its associated fan 12 are separated and closed from each other to prevent the risk of having refrigerant going from the first compartment 2 to the second compartment 3 and especially in the air-cooling channel 5.

[0066] The air-refrigerant heat-exchanger 11 is positioned in a mid-section of the heat pump system 1. An air-duct 16 is provided to guide air through the housing 4 and through the air-refrigerant heat-exchanger 11 to allow the air to exchange heat with the refrigerant in the air-refrigerant heat-exchanger 11. The air leaves the housing via an air outlet 13. Heat-exchanger fan 12 is provided to generate the heat-exchanger air flow. The heat pump system 1 has an air outlet side 14 and an air inlet side 15, the air outlet 13 being arranged on the air outlet side 14.

[0067] Fig. 3a schematically shows a side view of the heat pump system 1 in a direction shown by arrow IIIA in Fig. 1. Fig. 3b schematically shows a side view of the heat pump system 1 in a direction shown by arrow IIIB in Fig. 1. Fig. 3c schematically shows a side view of the heat pump system 1 in a direction shown by arrow IIIC in Fig. 1. Fig. 3d schematically shows a top view of the heat pump system 1 in a direction shown by arrow IIID in Fig. 1.

[0068] In Figures 3a-3d the shaded areas indicate so called refrigerant extraction surface areas of the housing 4, i.e. areas which are likely to be exposed to leaked refrigerant and where no openings (first and/or second openings 6, 7) of the air cooling channel 5 are to be positioned. The non-shaded areas are referred to as no-refrigerant extraction surface areas of the housing. According to an embodiment, the first opening 6 is positioned in a no-refrigerant extraction surface area of the housing 4 and/or the second opening 7 is positioned in a no-refrigerant extraction surface area of the housing 4.

[0069] The surface areas of the housing 4 in which first and/or second openings 6, 7 are positioned are facing away from the first compartment.

[0070] As shown in Fig.'s 3a and 3b, the openings 6, 7 may be provided in the second compartment 3 on the air inlet side 15. The openings 6, 7 may also be provided in the first compartment 2 but then above the heat pump components.

[0071] Fig. 3c shows that a side of the heat pump system 1 which is in the second compartment 3 and is facing away from the first compartment. This side of the heat pump system 1 completely is a no-refrigerant extraction surface of the housing and first and/or second opening 6, 7 may be positioned anywhere on this side of the housing 4.

[0072] Fig. 3d schematically depicts a top view of the heat pump system 1. It is shown that the air-refrigerant heat exchanger air inlet side 15 is a refrigerant extraction surface area and the air outlet side 14 is a refrigerant extraction surface area to the extent it is part of the first compartment 2, however, with the exception of the surface areas above the heat pump components.

[0073] Fig. 4 schematically shows a perspective view of an embodiment wherein the second compartment comprises a gas-tight electrical box 31, comprising the electronic components 8 configured to control the heat pump system 1, in particular the electronic components 8 being a potential ignition source.

[0074] Further shown is the air-cooling channel 5 which runs through the second compartment and along the electrical box 31 to enable heat exchange therewith. The embodiment may comprise fins, which may protrude out from the electrical box 31 and/or into the electrical box 31 (not shown) to enhance the heat exchange.

Reference Signs

[0075]

1. Heat pump system
2. First compartment
3. Second compartment
4. Housing
5. Air-cooling channel
6. First opening
7. Second opening
8. Electronic box containing the electronic components
9. Separation wall
11. Air-refrigerant heat-exchanger
12. Heat-exchanger fan
13. Air outlet
14. Air outlet side
15. Air inlet side
16. Air duct
31. Electrical box

Claims

1. Heat pump system (1) comprising a housing (4), heat pump components, which are configured to carry a flammable refrigerant, in particular a refrigerant heavier than air, and electronic components (8) configured to control the heat pump system (1), wherein

   the heat pump components are arranged in a first compartment (2) of the housing (4) and at least part of the electronic components (8) are arranged in a second compartment (3) of the housing (4), wherein
   the first compartment (2) is separated from the second compartment (3) to prevent leaked refrigerant to spread from the first compartment (2) through the housing (4) to the second compartment (3) and wherein
   the second compartment (2) comprises an air-cooling channel (5) going from a first opening (6) in the housing (4) to a second opening (7) in the housing (4), the air-cooling channel (5) being configured to guide a cooling air flow from the first opening (6) to the second opening (7) to cool the electronic components (8).

2. Heat pump system (1) according to claim 1, wherein the second compartment comprises a gas-tight electrical box, comprising the electronic components (8) configured to control the heat pump system (1).

3. Heat pump system (1) according to any one of the preceding claims, wherein

   - the first opening (6) is positioned in a no-refrigerant extraction surface area of the housing (4) and/or
   - the second opening (7) is positioned in a no-refrigerant extraction surface area of the housing (4).

4. Heat pump system (1) according to any one of the preceding claims, wherein the first and/or second openings (6, 7) are positioned on surface areas of the housing (4) which are

   - facing away from the first compartment (2), and/or
   - above the heat pump components and/or
   - above any point configured to carry the flammable refrigerant,
   - part of the second compartment and/or
   - separated by a wall or barrier creating a flow path between the heat pump components configured to carry a flammable refrigerant and the first and/or second openings with at least one angle of 90° or less.

5. Heat pump system (1) according to any one of the preceding claims, wherein the first and/or second opening (6, 7) is/are

   - concealed, and/or
   - protected by a mesh structure.

6. Heat pump system (1) according to any one of the preceding claims, the heat pump system (1) comprising an air-refrigerant heat-exchanger (11) and a heat-exchanger fan (12) positioned inside the housing (4), wherein the heat-exchanger fan (12) is configured to generate an heat-exchanger air flow through the air-refrigerant heat-exchanger (11), and the housing (4) comprises an air outlet (13) configured to allow the heat-exchanger air flow to exit the housing (4), the air outlet (13) being on an air outlet side of the housing (4), wherein the first and/or second openings (6, 7) are positioned on sides of the housing (4) other than the air-refrigerant heat exchanger side of the housing (4).

7. Heat pump system (1) according to any one of the preceding claims, wherein the inner space of the housing (4) comprises at least one separation wall (9) separating the first compartment (2) from the second compartment (3), the separation wall (9) being impermeable to the refrigerant.

8. Heat pump system (1) according to claim 7, wherein a top edge of the separation wall (9) is at a higher

gravitational level than all the heat pump components configured to carry the flammable refrigerant heavier than air and/or than any point in the heat pump system configured to carry the flammable refrigerant.

9. Heat pump system (1) according to any one of the preceding claims, wherein

- the first opening (6) and the second opening (7) are provided on the same side of the housing (4), or
- the first opening (6) and the second opening (7) are provided on different sides of the housing (4), or
- the first opening (6) and/or second opening (7) are provided on a horizontal side of the housing, and/or
- the first opening (6) and/or second opening (7) are provided on a vertical side of the housing.

10. Heat pump system (1) according to any one of the preceding claims, wherein a cooling fan is arranged in the air-cooling channel (5), configured to generate the cooling air flow through the air-cooling channel (5).

11. Heat pump system (1) according to any one of the preceding claims, wherein fins are arranged in the air-cooling channel (5), which fins are in thermal connection with the electronic components (8) for cooling of the electronic components (8) by the cooling air flow.

12. Heat pump system (1) according to any one of the preceding claims, wherein one or more electronic components (8) are positioned in the air-cooling channel (5).

13. Heat pump system (1) according to any one of the preceding claims, wherein the first compartment (2) comprises a first sub-compartment comprising an air-refrigerant heat-exchanger (11) and a heat-exchanger fan (12) and a second sub-compartment comprising a compressor, a water-refrigerant heat-exchanger and an expansion valve.

14. Heat pump system (1) according to any one of the preceding claims, wherein the first compartment (2) and second compartment (3) are connected by means of connection channels comprising electrical cables.

15. Heat pump system (1) according to any one of the preceding claims, wherein the heat pump system is a reversible heat pump system.

Fig. 1a

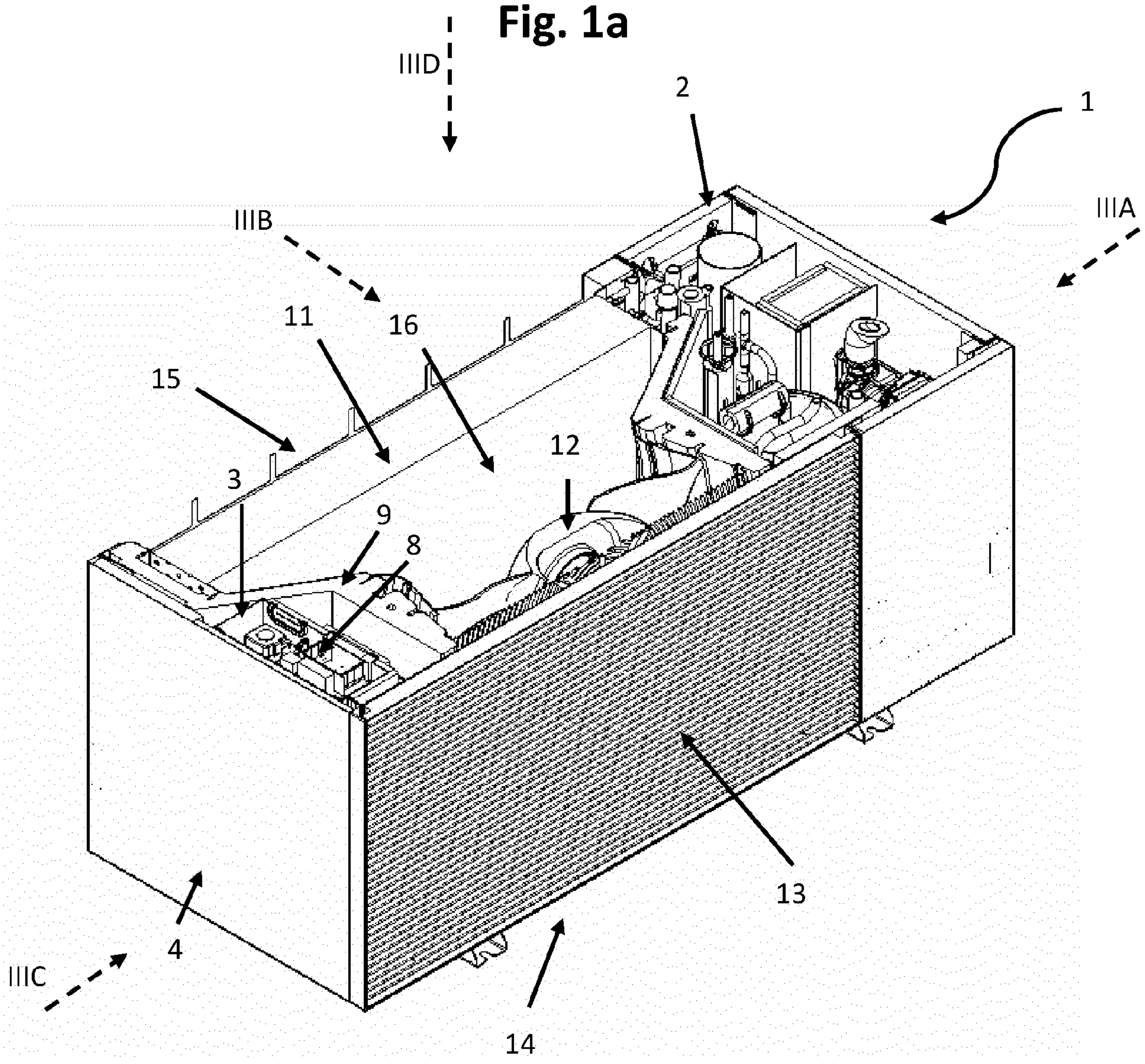


Fig. 1b

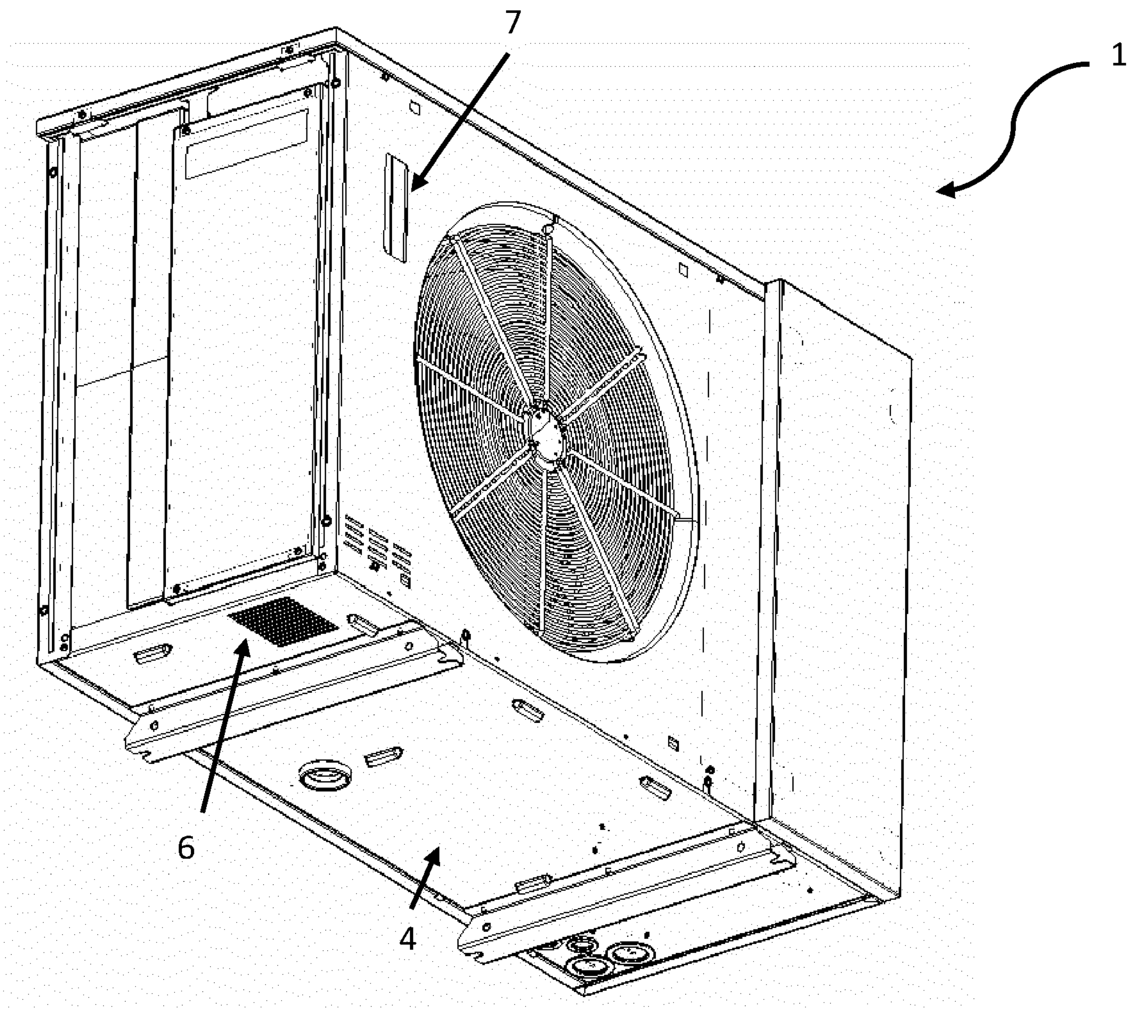


Fig. 2

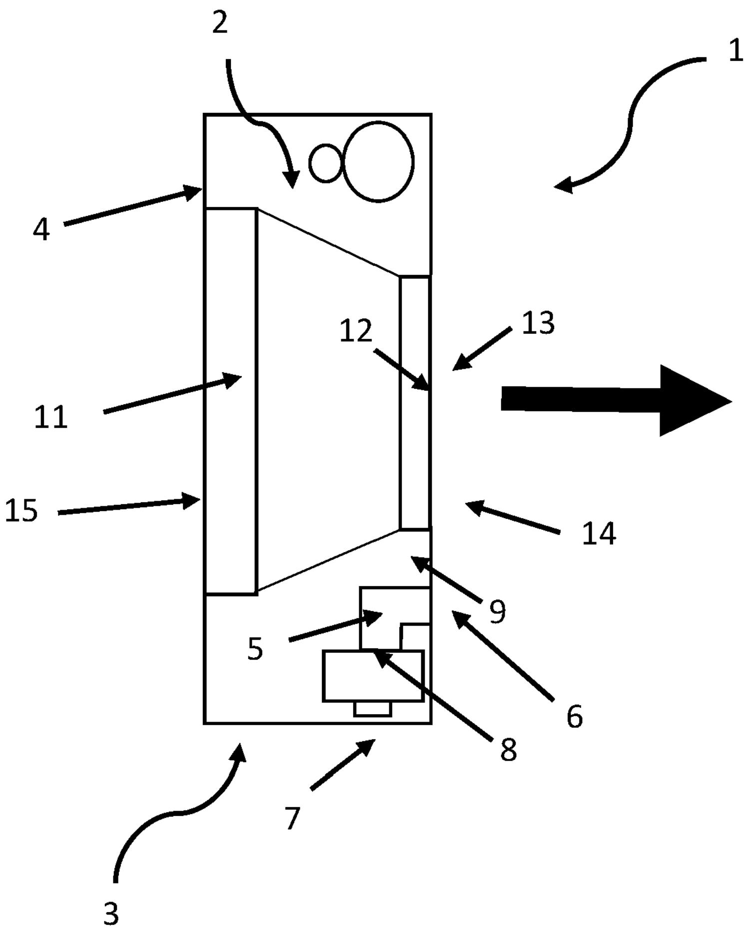


Fig. 3a

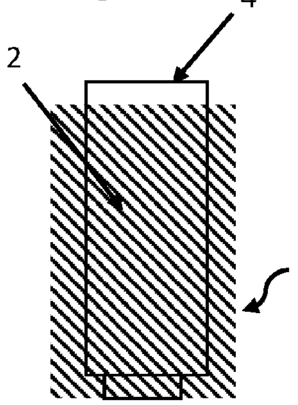


Fig. 3b

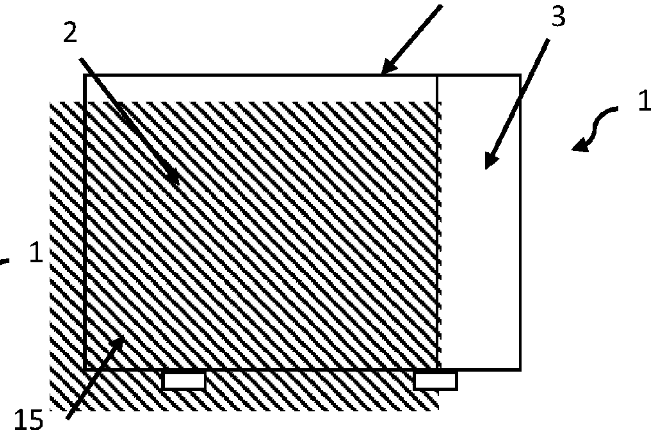


Fig. 3c

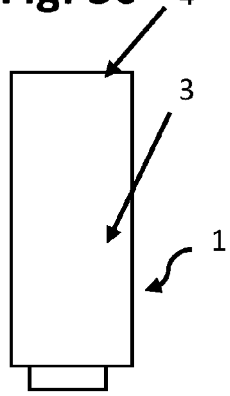


Fig. 3d

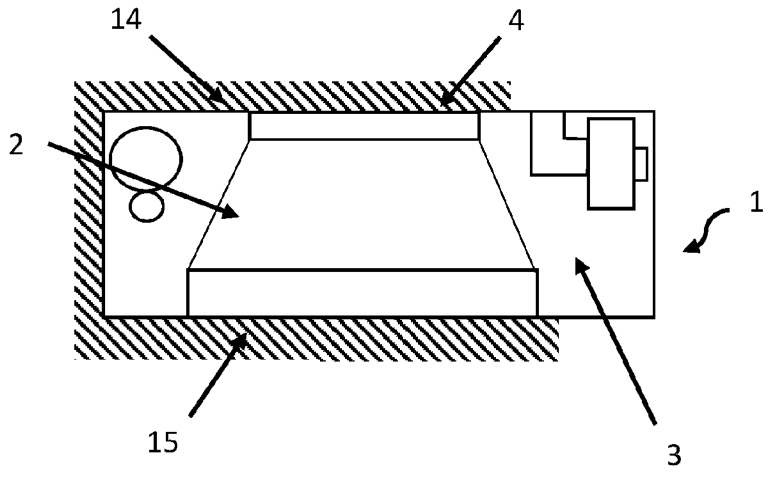
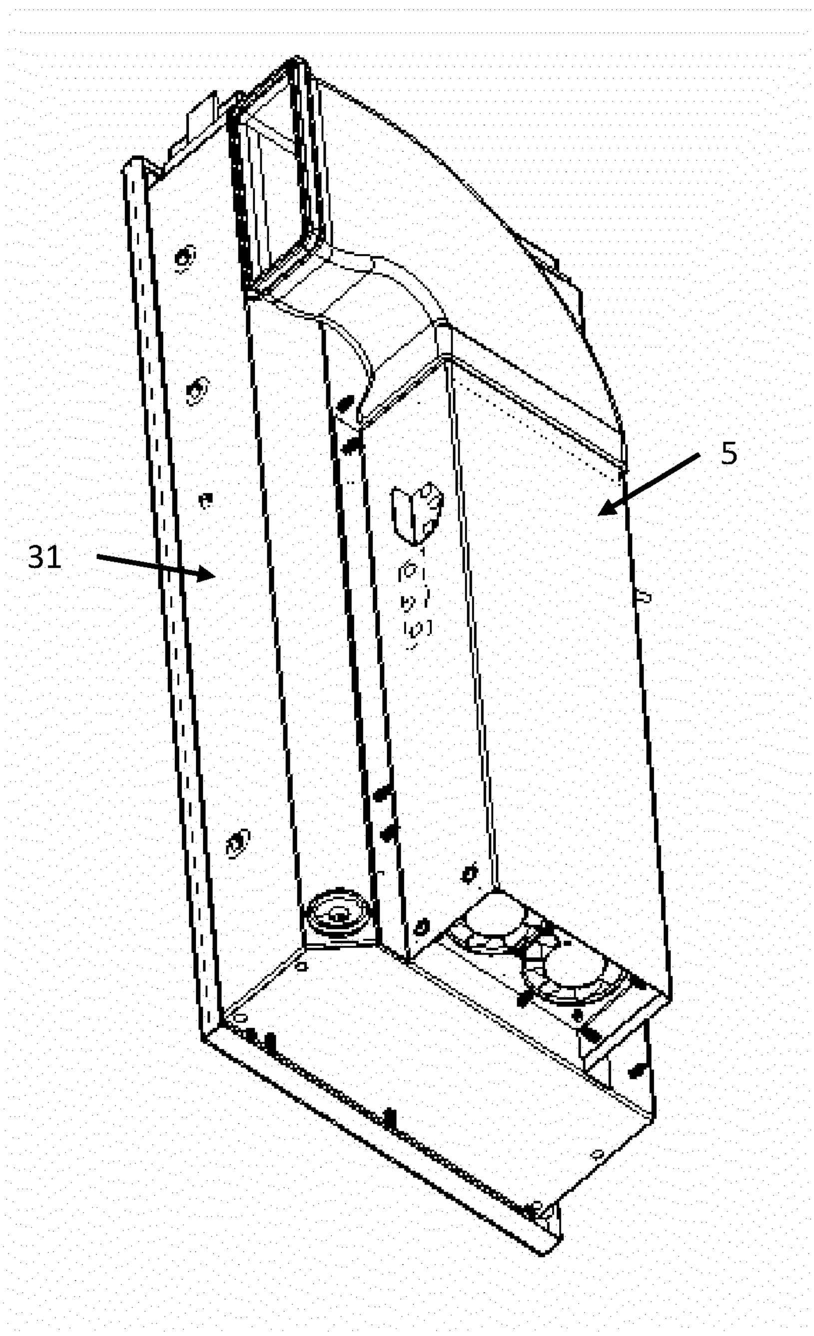


Fig. 4



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Place of search	Date of completion of the search	Examiner
Munich	18 August 2023	Anconetani, Mirco

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