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(54) **Dry transformer cooled by means of a compact thermosyphon air to air heat exchanger**

(57) The present invention is concerned with the cooling of electrical heat sources, in particular for improving the cooling of a transformer.

A power unit (200) with a heat producing unit (203) comprising at least one heat source (202) and with a cooling unit comprising at least one heat exchanger device (100) and at least a portion of a secondary chamber (209) is provided. The at least one heat source (202) is thermally connected to the at least one heat exchanger

device (100). The heat producing unit (203) and the cooling unit (201) are attached to one another such that a substantially closed primary chamber (211) with at least one heat source (202) is formed. The primary chamber (211) is structurally separated from the secondary chamber (209), and the primary chamber (211) and the secondary chamber (209) are thermally connected to one another by the at least one heat exchanger device (100) in an operating state of the power unit (200).

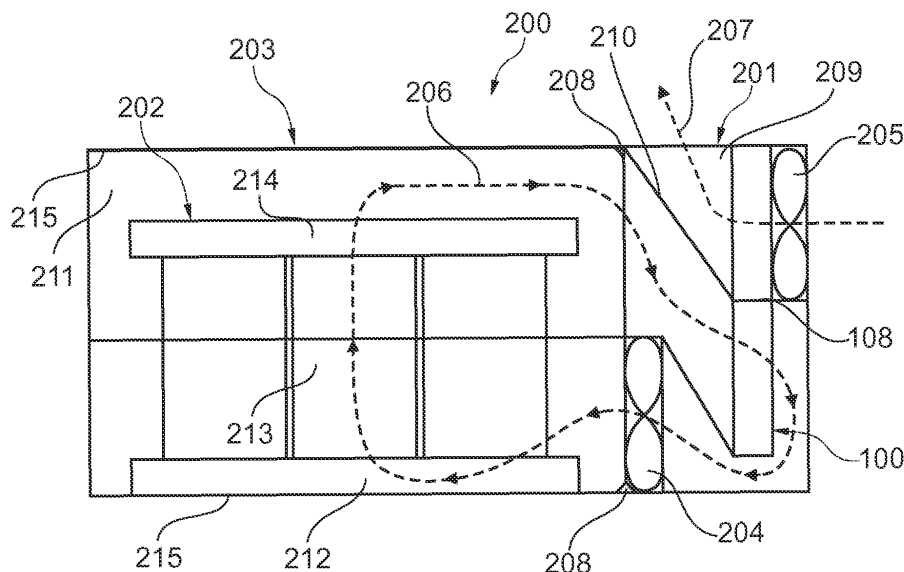


Fig. 2

Description

FIELD OF THE INVENTION

[0001] The invention relates to the field of heat exchangers. In particular, the invention relates to a power unit for cooling a heat source, such as a dry transformer arranged in a heat producing unit with a cooling unit attached to said heat producing unit, and to the use of such a power unit for transferring heat from the heat source to ambient air surrounding the power unit, and to a method for assembling a power unit.

BACKGROUND OF THE INVENTION

[0002] The market for dry transformers and for example low voltage drive systems is competitive with many global players. This may impose a strict low-cost condition to the design. In a typical system, transformers or power electronics components such as discrete or integrated (i.e. module type) semiconductor devices, inductors, resistors, capacitors, copper bus bars and also transformers are assembled in close proximity. Printed circuit board (PCB) panels and control electronics are also present in many designs. During operation, these components dissipate heat of varying quantities.

[0003] In addition, these components are tolerant to temperature of varying levels. The environmental conditions surrounding the driving system also vary in terms of air temperature, humidity, dust and chemical content. The thermal management and integration concept of a drive system and a transformer has to consider all these underlying factors in addition to the electrical performance of this system.

[0004] Heat pipe heat exchangers are used to cool transformers or any other electronic components by fluid evaporation and condensation inside the heat pipe to transport the heat of the transformers or electronic components, respectively. However this technology is often bulky and expensive because the air side heat transfer may not be optimal.

[0005] Using the plate heat exchanger technology for cooling a transformer or other electronic components implies using hot and cold airstreams that simply flow next to the heat source between parallel plates, without mixing. The large pressure loss generated by an assembly using this technology often makes the overall cooling unit bulky and expensive.

[0006] US 3,887,759 A shows the cooling of a dry transformer using an evaporating and condensing fluid, wherein the fluid is directly in contact with the coils of the transformer but is not used to cool air inside the vaporization chamber which houses the transformer.

SUMMARY OF THE INVENTION

[0007] It may be seen as an object of the invention to provide for an efficient cooling of an electronic device.

[0008] This object is achieved by a power unit with a heat producing unit comprising at least one heat source, and with a cooling unit attached to the power unit for cooling the heat source, a use of a power unit for transferring a heat load originating from a transformer to ambient air, and a method for assembling a power unit according to the independent claims. Further embodiments are evident from the dependent claims.

[0009] According to an embodiment of the invention, a power unit comprises a heat producing unit with at least one heat source and a cooling unit with at least one heat exchanger device and at least a portion of a secondary chamber. The at least one heat source is thermally connected to the at least one heat exchanger device. The heat producing unit and the cooling unit are attached to one another such that a substantially closed primary chamber with the at least one heat source is formed. The primary chamber is structurally separated from the secondary chamber, for example by a wall, a thermal insulation, a plate, a sheet or any other device suitable for structurally separating the primary chamber from the secondary chamber. The primary chamber and the secondary chamber are thermally connected to one another by the at least one heat exchanger device in an operating state of the power unit.

[0010] The heat producing unit and the cooling unit may be open before being attached to each other as described above. The forming of a substantially closed primary chamber at the attachment of the heat producing unit and the cooling unit to one another means, that the primary chamber is for example closed with respect to ambient air. Substantially closed may be seen as an equivalent to completely closed, i.e. airtight, or almost closed, where practically no air exchange to ambient air is possible.

[0011] Such a cooling unit with a heat exchanger device may provide an air-to-air heat exchange and may use the external air as a secondary coolant. The transferring of heat from the heat source to ambient air by the heat exchanger device may be managed by a separation of two airstreams which enables a low pressure drop and a low volume of the cooling unit.

[0012] Due to the transfer of heat from the heat source to ambient air a two phase heat transfer is achieved providing scalability, wherein efficiency does not depend on size, as the two-phase fluid inside the heat exchanger devices transports the heat from the hot side to the cold side by natural convection. Thus a plurality of heat exchanger devices may be combined with each other enabling the cooling unit to meet different heat load requirements of one or more heat sources, such as transformers, for example.

[0013] Such a cooling unit with a heat exchanger device being attached to a heat producing unit with a heat source allows the use of two phase heat transfer principle in order to efficiently remove the input heat without the need for a pumping unit. This results in cost reduction and reliability improvement. The heat exchanger device

may be a thermosyphon-type heat exchanger, which may be employed in the cooling unit for cooling electric circuit components, for example for cooling low voltage AC drive systems and transformers.

[0014] Another advantage of the cooling unit for cooling a heat source with a heat exchanger device is that within the heat exchanger device a loop-thermosyphon configuration may be provided, by separating the up-going and down-coming fluid streams in separate channels of multiport conduits. Different numbers and sizes of channels may be used for the up-going and down-coming streams in order to optimize the boiling and condensation performance of the heat exchanger device.

[0015] As mentioned above the heat exchanger device may be a compact thermosyphon air to air heat exchanger, which is designed to transfer the heat from a high Ingress Protection index enclosure housing a transformer to ambient air.

[0016] The use of the cooling unit with a thermosyphon heat exchanger device as mentioned above may result in cost reduction and increased efficiency.

[0017] According to another embodiment of the invention the attachment of the cooling unit the heat producing unit with the heat source is realized by a force-fit fastening, such as a flange-screw fastening, for example. The cooling unit may also be attached to the heat producing unit with heat source by welding.

[0018] According to an embodiment of the invention, the heat producing unit comprises a housing with the at least one heat source being arranged in the housing. The housing and the cooling unit are attached to one another. The above mentioned attachment means and methods may be also applied to the attachment of the housing and the cooling unit to one another.

[0019] According to an embodiment of the invention the cooling unit may be integrated in the housing of the heat source that may be a transformer.

[0020] According to an embodiment of the invention the heat exchanger device is a compact heat exchanger device.

[0021] According to an embodiment of the invention, the cooling unit is a cooling cabinet or a cooling apparatus. The cooling cabinet may comprise a plurality of compact thermosyphon air-to-air heat exchangers with a plurality of blowers to blow air transferring the heat from the heat source to the heat exchanger device and to blow the ambient air. Two blowers may be used for each heat exchanger device.

[0022] According to an embodiment of the invention, the at least one heat source comprises at least one dry transformer, for example a high ingress protection index dry transformer.

[0023] Due to the use of a thermosyphon air-to-air heat exchanger device for the dry transformer an increase cooling performance may be achieved while the weight and the volume and the required air pressure drop may be decreased. A totally enclosed dry transformer may be provided which is cooled by using only air by the use of

a compact thermosyphon air-to-air heat exchanger with advantageously lower costs and a lower volume compared to conventional heat exchanger technologies, which are comparatively very bulky and expensive.

[0024] The use of a cooling cabinet with a heat exchanger device for cooling a dry transformer or a general heat source (in car industry, for example) may provide an optimization of this technology concerning cost and efficiency. The cooling cabinet with the heat exchanger device provides a compact and low cost thermosyphon air-to-air heat exchanger system which may optimize heat exchanger automotive technology with respect to volume optimization and cost efficiency.

[0025] In addition or as an alternative, the cooling unit is detachable from the heat producing unit. A plurality of heat producing units may be attachable to the heat producing unit and a plurality of cooling units may be attachable to the heat producing unit.

[0026] According to an embodiment of the invention, the power unit further comprises a first blower and a second blower. The first blower is designed for blowing primary air of a primary air circuit to the heat source for transferring heat from the heat source to the primary air in an operating state of the power unit. The second blower is designed for blowing secondary air of a secondary air circuit for transferring the transferred heat of the heat source to the secondary air in an operating state of the power unit.

[0027] According to an embodiment of the invention, the first blower and the second blower are selected from the group comprising a centrifugal fan and an axial fan.

[0028] According to an embodiment of the invention, the first blower is a centrifugal fan, and the second blower is an axial fan.

[0029] According to an embodiment of the invention, the first and the second blower are selected from the group comprising a pump, a fan, a propeller, and any other devices suitable for blowing out or sucking in air.

[0030] Such a cooling unit with two blowers may advantageously enable the usage of an axial fan at the upper side or cold side of the heat exchanger devices, which may be compact thermosyphon air-to-air heat exchangers, for example, because the pressure losses through the heat exchangers are low, thus bringing the additional advantage of lower noise level.

[0031] The lower part or hot side of the heat exchanger devices may use a centrifugal fan as a blower because the pressure losses through the heat sources, which may be transformers, for example, are high.

[0032] Such a cooling unit with blowers for blowing air for transferring heat from the heat source may comprise two blowers per heat exchanger device, or may comprise two blowers for a plurality of heat exchanger devices which may be arranged next to each other in the cooling cabinet.

[0033] According to an embodiment of the invention, the primary air circuit is a closed circuit and the secondary air circuit is an open circuit. The primary air circuit and

the secondary air circuit are separated from each other.

[0034] According to an embodiment of the invention, the power unit further comprises a plurality of stackable heat exchanger devices being stacked in one heat exchanger unit.

[0035] The heat exchanger devices may be stacked next to each other and/ or behind each other and/ or above each other. Eight heat exchanger devices may be arranged next to each other, for example.

[0036] A stacking of the heat exchanger devices may be advantageous for the following reasons:

- it may reduce the cooler costs since only one heat exchanger design may be used for different heat losses.
- according to simulations using for example twelve independent heat exchangers stacked on one another the overall cooling performance was increased by more than 70% compared to a single thermosyphon heat exchanger of the same size as the whole stack, due to the fact that each stacked thermosyphon has its own internal fluid temperature.
- it improves the reliability of the cooler because if one thermosyphon of the stack fails, due to a leak of fluid for example, the other ones will still have a cooling action.
- it improves the safety because the amount of pressurized fluid in each thermosyphon is much less than in a single thermosyphon heat exchanger of the same size as the stack.
- it improves the logistics because each thermosyphon is much lighter than in a single thermosyphon heat exchanger of the same size as the stack. Thus they can be assembled or removed from the cooler more easily.
- Also in case of dirty air, most of the fouling will occur on the first thermosyphon of the stack, which can be easily removed to be cleaned or changed.

[0037] According to an embodiment of the invention, the heat exchanger device of the cooling unit further comprises a distribution manifold that may be connected to each end of a conduit of the heat exchanger device being designed for transferring heat from the heat source to ambient air. At the side of the heat exchanger device, where the heat of the heat source is blown via air to the heat exchanger device the working fluid essence within an evaporator channel of the heat exchanger device to the upper distribution manifold and from there to a plurality of condenser channels, where the fluid condenses and drops to the lower distribution manifold.

[0038] According to an embodiment of the invention, the at least one heat exchanger device comprises at least

one thermosyphon air-to-air heat exchanger. The thermosyphon air-to-air heat exchanger device may have a compact design.

[0039] According to an embodiment of the invention, the heat exchanger device comprises at least one heat pipe for transferring heat from the heat source to ambient air in an operating state of the power unit.

[0040] According to another embodiment of the invention, the at least one heat pipe comprises a closed circuit with a cooling fluid that changes its phase depending on a temperature.

[0041] According to an embodiment of the invention, the at least one heat pipe comprises a multiport tube and wherein at least one port thereof is used as an evaporator channel and at least another port thereof is used as a condenser channel in an operating state of the power unit.

[0042] According to an embodiment of the invention, the heat exchange device comprises several heat pipes. An at least one heat pipe of the several heat pipes is at least partially thermally connected to another heat pipe of the several heat pipes by a second heat transfer element, in particular a fin-like second heat transfer element.

[0043] Further, the heat exchanger device of the cooling unit comprises at least one evaporator channel, at least one condenser channel, and a second heat transfer element. The second transfer element is designed for transferring heat out of the condenser channel.

[0044] According to an embodiment of the invention, the cooling unit further comprises a seal that is designed for providing an airtight attachment of the cooling unit to the housing of the heat source. Any type of seal enabling an airtight attachment of the cooling unit to the housing of the heat source may be used, such as a rubber seal, a silicone rubber seal, cellular rubber seal, foam rubber seal, for example.

[0045] According to an embodiment of the invention an airtight attachment of the cooling unit to the housing of the heat source may be provided by a paste-like hardening substance or material, such as silicone paste that is used for sanitary applications.

[0046] According to an embodiment of the invention an arrangement of a transformer (as described above and below) having a transformer enclosure and a heat exchanger device (as described above and below) having a heat exchanger enclosure is provided. The heat exchanger device enclosure is adapted for being mounted to the transformer enclosure, such that a closed air circuit and an open air circuit are provided for cooling the transformer.

[0047] According to an embodiment of the invention the use of a power unit according to any one of the above and below described embodiments for transferring a heat load originating from a transformer, in particular a dry transformer, that is arranged inside of a housing of a heat producing unit to ambient air is provided. The heat load is transmitted by a closed air circuit running within the housing to the at least one heat exchanger device in a

first step, and from there at least a portion of the heat load is transmitted to an open air circuit passing the cooling unit in a second step.

[0048] According to an embodiment of the invention, the use of a heat exchanger device (as described above and below) for transferring heat from a transformer inside of a housing to ambient air is provided. The heat exchanger device is adapted for using a closed air circuit and an open air circuit for transferring the heat.

[0049] According to an embodiment of the invention, a method for assembling a power unit is provided that comprises the steps of providing a heat producing unit with at least one heat source, providing a cooling unit with at least one heat exchanger device and at least a portion of a secondary chamber, and attaching the heat producing unit to the cooling unit such that a substantially closed primary chamber with the at least one heat source is formed, and such that the at least one heat source and the at least one heat exchanger device are thermally connected to one another, wherein the primary chamber is structurally separated from the secondary chamber, and wherein the primary chamber and the secondary chamber are thermally connected to one another by the at least one heat exchanger device in an operating state of the power unit.

[0050] According to an embodiment of the invention, the method further comprises the steps of providing of at least one evaporator channel, providing at least one condenser channel, providing a first blower for blowing first air through the closed circuit and for transferring heat into the evaporation channel, and providing a second blower for blowing second air through the open circuit and for transferring heat out of the condenser channel.

[0051] According to an embodiment of the invention, the method comprises the step of stacking a plurality of heat exchanger devices in one heat exchanger unit.

[0052] According to an embodiment of the invention, a conduit is arranged vertically to the heat exchanger device of the cooling unit. The at least one evaporator channel and the at least one condenser channel are arranged parallel to each other and are separated by an interior wall of the conduit.

[0053] According to an embodiment of the invention, the conduit of the heat exchanger device of the cooling unit is a flat tube having planar exterior sidewalls.

[0054] According to an embodiment of the invention, a conduit of the heat exchanger device of the cooling unit is made of aluminium.

[0055] According to an embodiment of the invention, the evaporator channel of the heat exchanger device of the cooling unit has a larger cross-sectional area than the condenser channel.

[0056] According to an embodiment of the invention, the condenser channel of the heat exchanger device of the cooling unit has a larger inner surface than the evaporator channel.

[0057] According to an embodiment of the invention, the second heat transfer element of the heat exchanger

device of the cooling unit comprises a plurality of cooling fins that are arranged on the at least one condenser channel, and designed for transferring heat out of the at least one condenser channel.

[0058] According to an embodiment of the invention, a distribution manifold of the heat exchanger device of the cooling unit is attached to at least one end of the conduit of the heat exchanger device.

[0059] According to an embodiment of the invention, the heat exchanger device further comprises a separation element, wherein the separation element is designed for separation of a first environment enclosing the transformer from a second environment. The temperature of the first environment is higher than the temperature of the second environment.

[0060] According to an embodiment of the invention, the first heat transfer element of the heat exchanger device of the cooling unit comprises a plurality of heating fins that are arranged on the at least one evaporator channel, and designed for transferring heat into the at least one evaporator channel.

[0061] According to an embodiment of the invention, a method of producing a heat exchanger device for a cooling unit is provided comprising steps of providing at least one conduit for a working fluid with an exterior wall and at least one interior wall for forming at least one evaporator channel and at least one condenser channel within the at least one conduit; connecting a second heat transfer element for transferring heat out of the condenser channel to the at least one conduit.

[0062] According to an embodiment of the invention, the method further comprises the steps of joining the components of the heat exchanger device together in a one-shot oven braising process and/or covering the components of the heat exchanger device with braising alloy, for example aluminium-siliceous (AlSi) braising alloy, before the braising process.

[0063] According to an embodiment of the invention, the method further comprises the steps of applying a flux material to the components of the heat exchanger device before the braising process and/or wherein the braising is conducted in non-oxidizing atmosphere; joining all components other than the mounting elements together in one-shot oven braising process, pressing the mounting element onto the exterior wall of the conduit with thermally conductive gap filling material in between.

[0064] These and other aspects of the present invention will become apparent from and elucidated with reference to the embodiments described hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0065] The subject-matter of the invention will be explained in more detail in the following text with reference to exemplary embodiments which are illustrated in the attached drawings.

Fig. 1a shows a schematic perspective view of a heat

exchanger device according to an embodiment of the invention.

Fig. 1b shows a schematic perspective view of a conduit of the heat exchanger device of Fig. 1a according to an embodiment of the invention.

Fig. 2 shows a schematic sectional view of an arrangement of a power unit with a heat producing unit comprising a heat source in a housing attached to a cooling unit for cooling a heat source according to an embodiment of the invention.

Fig. 3 shows a schematic perspective view of a cooling unit with an integrated heat producing unit comprising a heat source for cooling a heat source with two blowers and a plurality of heat exchanger devices according to another embodiment of the invention.

Fig. 4 shows a schematic perspective view of a heat exchanger unit with eight stacked heat exchanger devices according to an embodiment of the invention.

Fig. 5 shows a schematic perspective view of a heat exchanger device according to another embodiment of the invention.

Fig. 6 shows a flowchart of a method for assembling a power unit according to another embodiment of the invention.

[0066] The reference symbols used in the drawings, and their meanings, are listed in summary form and a list of reference symbols. In principle, identical parts are provided with the same reference symbols in the figures.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0067] Fig. 1a shows a heat exchanger device 100, which may be for example a thermosyphon air-to-air heat exchanger 100, comprising a plurality of conduits 110 for a working fluid, each having an exterior wall 112 and each having interior walls 114 (see Fig. 1b) for forming at least one evaporator channel 120 and at least one condenser channel 130 within the conduit 110. Furthermore the heat exchanger device 100 comprises a second heat transfer element 180 for transferring heat out of the condenser channel 130. A suitable heat exchanger is disclosed in EP2031332A1, for example.

[0068] The second heat transfer element 180 comprises cooling fins provided on exterior walls 112 of the conduits 110 (see Fig. 1b). Two header tubes, used as distribution manifolds 190, are connected to each end of the conduits 110. If heat comes from a heat source (not shown in Fig. 1a), the working fluid essence within the

evaporator channel 120 flows to the upper distribution manifold 190 and from there to the condenser channel 130, where the fluid condenses and drops to the lower distribution manifolds 190. The lower part of the heat exchanger device 100 forms a hot side 103 of the heat exchanger device 100 as indicated by the arrow 103, whereas the arrow 102 indicates the cold side 102 of the heat exchanger device 100 in the upper part of the heat exchanger device 100.

[0069] The second heat transfer element 180 comprises a support bar 195 which is connecting the lower distribution manifold 190 with the upper distribution manifold 190.

[0070] On top of the upper distribution manifold 190 there is arranged a fluid terminal 401 for filling the upper distribution manifold 190 with cooling fluid.

[0071] An air seal 108 impedes the air exchange between the lower part and the upper part of the heat exchanger device 100. The air seal 108 may be made of any suitable sealing material, for example, of rubber, or cellular rubber.

[0072] Fig. 1b shows a schematic perspective view of one conduit 110 comprising an exterior wall 112 and interior walls 114 that separate four evaporator channels 120 from four condenser channels 130.

[0073] The evaporator channels 120 receive the heat in form of hot air 104 indicated by the arrow 104. The evaporator channels are fully or partially filled with the working fluid, depending on the amount of initial charge. The fluid in the evaporator channels evaporates due to the heat and the vapour 106 rises up in the channel by the buoyancy effect. Some amount of liquid is also entrained in the vapour stream and will be pushed up in the channels.

[0074] The conduit in form of a flat tube 110 has air cooling fins 180 of the second heat transfer element 180 on both sides. These fins 180 are typically cooled by a convective air flow, commonly generated by a cooling fan or a blower (not shown) providing cold air 105 as indicated by the arrow 105. It is also possible to use natural convection currents to provide the cold air 105.

[0075] The mixture of vapour 106 and liquid 107 inside the evaporator channels 120 reaches a top side header tube 190 (see Fig. 1a) and then the liquid 107 and vapour 106 flows down the condenser channels 130. While going down the condenser channels 130, vapour 106 condenses back into liquid 107 since the channels 130 are cooled by the fins 180. The liquid condensate flows down to the bottom header tube 190 (not shown, see Fig. 1a) and flows back into the evaporator channels 120, closing the loop.

[0076] As with all thermosyphon type devices, which may be used as a heat exchanger device, all air in other non-condensable gases inside the heat exchanger device is preferably evacuated (i.e. this charge) and the system is partially filled (i.e. charged) with a working fluid. For this reason this charging and charging valves (not shown) are included in the assembly. The free ends of

the header tubes, or in other words the distribution manifolds 190 (not shown) are suitable locations for such valves. A single valve may also be utilized for both charging and discharging. Alternatively, the heat exchanger device 100 may be evacuated, charged and permanently sealed. In this case, a valve is not necessary.

[0077] Fig. 2 shows a schematic cross-sectional view of a cooling unit 200 with a cooling unit 201 being attached to a heat producing unit 203 that comprises a heat source 202 in form of a dry transformer 202. The cooling unit 201 comprises a heat exchanger device 100 that is designed for transferring heat from the heat source 202 to ambient air. The heat source 202 is arranged in a housing 215

[0078] The cooling unit 201, which may be a cooling cabinet 201, is attached to the housing 215 enclosing the heat source 202.

[0079] A seal 208 which is between the cooling unit 201 and the housing 215 of the heat source 202 is designed for providing an airtight attachment of the cooling unit 201 to the housing 215 of the heat producing unit 203. The seal 208 may be a rubber seal 208, for example, or any other type of seal suitable for the above mentioned airtight attachment.

[0080] The heat producing unit 203 comprises at least one heat source 202 and the cooling unit 201 comprises at least one heat exchanger device 100 and at least a portion of a secondary chamber 209. The at least one heat source is thermally connected to the at least one heat exchanger device 100. The heat producing unit 203, in particular the housing 215 of the heat producing unit 203, and the cooling unit 201 are attached to one another such that a substantially closed primary chamber 211 with the at least one heat source 202 is formed. The primary chamber 211 is structurally separated from the secondary chamber 209 by a separation 210. The separation 208 may be selected from the group comprising a sheet, a plate, a wall, and an insulation material. The primary chamber 211 and the secondary chamber 209 are thermally connected to one another by the at least one heat exchanger device 100 in an operating state of the power unit.

[0081] The heat exchanger device 100 is designed for transferring heat from the heat source 202 to ambient air. A first blower 204 is designed for blowing primary air of a primary air circuit 206 to the heat source 202 for transferring heat from the heat source 202 to the primary air in an operating state of the power unit 200. Directly after the first blower 204 the primary air may have a pressure of 720 Pa and at a 1st portion of the transformer 212 the primary air may have a temperature of 46°C. The air of the primary air circuit 206 flows through a 2nd portion of the transformer 213 and may warm up to a temperature of 75°C when it leaves the transformer 202 after flowing through a 3rd portion of the transformer 214. About 15.000 m³/h of primary air may be transferred in the primary air circuit 206.

[0082] A second blower 205 is designed for blowing

secondary air of a secondary air circuit 207 for transferring the transferred heat of the heat source 202 to the secondary air in an operating state of the power unit 200. The heat exchanger device 100 is separated by an air seal 108 and provides for the transfer of heat from the heat source 202 as the primary air flows through a lower part of the heat exchanger device 100 within the primary air circuit 206, and the secondary air flows through the upper part of the heat exchanger device 100 within the secondary air circuit 207. The heat exchanger device 100 is separated in a lower and upper part by the air seal 108.

[0083] The secondary air may have a temperature of 40° and a pressure of 30 Pa before it is blown by the second blower 205 to the heat exchanger device 100. After leaving the heat exchanger device 100 the secondary air may have a temperature of 61°C which may be transferred to ambient air.

[0084] The heat exchanger device 100 may run with a power of 97 kW. The amount of secondary air transported per hour in the secondary air circuit 207 may be 20.000 m³.

[0085] The cooling unit 201 may be attached to the housing 203 of the heat producing unit 203 by a flange screw connection. However, any other suitable connection is possible to attach the cooling unit 201 to the housing 203 of the heat producing unit 203.

[0086] The primary air circuit 206 may be a closed circuit 206, whereas the secondary air circuit 207 may be an open circuit. The primary air circuit 206 and the secondary air circuit 207 are separated from each other by the separation 210.

[0087] The cooling unit 201 is detachable from the heat producing unit 203. A plurality of heat producing units 203 may be attachable to the heat producing unit 201 and a plurality of cooling units 201 may be attachable to the heat producing unit 203.

[0088] Fig. 3 shows a schematic perspective view of a cooling unit 201, built as a cooling cabinet 201, with a first blower 204 which may be a centrifugal fan 204 compensating the high pressure losses through a heat source, possibly a dry transformer (not shown). The centrifugal fan 204 is designed for blowing primary air of a primary air circuit to a heat source which comprises two transformers 202 and is enclosed by a housing 215 of a heat producing unit 203 for transferring heat from the heat source to the primary air. The heat producing unit 203 is integrated in the cooling cabinet 201. The centrifugal fan 204 is arranged in the lower part of the cooling cabinet 201 partly next to the heat producing unit 203.

[0089] In the middle and upper part of the cooling cabinet 201 there is a plurality of eight stackable heat exchanger devices 100 being stacked in a heat exchanger unit 301. An air seal 108 is arranged in the middle of each heat exchanger device 100 separating a lower part of the heat exchanger device 100 with a hot side receiving the heat of a heat source (not shown) via air of a primary air circuit (see Fig. 2) from an upper part of the heat exchanger device 100 with a cold side for transferring the

heat to the ambient air by a secondary air circuit (see Fig. 2). The heat exchanger unit 301 is arranged partly next to the heat producing unit 203 within the cooling cabinet 201.

[0090] A blower 205 in form of an axial fan 205 blows secondary air of a secondary air circuit (see Fig. 2) for transferring the transferred heat of the heat source to the secondary air in an operating state of the power unit 200 which comprises the cooling cabinet 201 and the heat producing unit 203. An axial fan 205 may be used as a second blower 205 because the pressure losses through the heat exchanger devices 100 are low, thus bringing the advantage of a lower noise level.

[0091] Fig. 4 shows a schematic perspective view of a heat exchanger unit 301 with eight stackable heat exchanger devices 100 being stacked together and an air seal 108 impeding the air exchange between the upper and lower part of the stacked heat exchanger devices 100, or in other words between the cold and hot part of the heat exchanger devices 100. Each heat exchanger device 100 comprises a fluid terminal 101 for providing cooling fluid for each heat exchanger device 100. The fluid terminals 101 of the heat exchanger devices 100 are suitable for being coupled or interconnected to one another.

[0092] The cooling airflow 401 may be achieved in a direction orthogonal to the front of the heat exchange devices 100 as indicated by the arrow 401. However an inverse cooling direction may also be provided depending on the arrangement of the heat source to be cooled.

[0093] As may be seen from Fig. 5 cooling fins 180 are provided on a portion of the exterior wall 112 of the conduit 110 associated with the condenser channel 130, and heating fins 183 are provided on a portion of the exterior wall 112 of the conduit 110 associated with the evaporator channel 120. The heating fins 183 and the cooling fins 180 work as first and second heat transfer elements, respectively.

[0094] The heat exchanger device 100 shown in Fig. 5 functions according to the loop thermosyphon principle. The heat exchanger device 100 is charged with a working fluid. Any refrigerant fluid may be used, such as for example R134a, R245fa, R365mfc, R600a, carbon dioxide, methanol, and ammoniac.

[0095] The heating fins 183 conduct the heat from a heat producing unit (see Fig. 2) to the evaporator channels 120 of the heat exchanger device 100. The evaporator channels 120 are fully or partially filled with a working fluid, depending on the amount of initial charge. The fluid in the evaporator channels 120 evaporate due to the heat and the vapour rises up in the channel by the buoyancy effect. Some amount of liquid is also entrained in the vapour stream and will be pushed up in the channels.

[0096] The mixture of vapour and liquid inside the evaporator channels 120 reaches the top side header tube 190 and then flows down the condenser channels 130. While going through the condenser channels 130,

vapour condenses back into liquids since the channels 130 are cooled by the fins 180 situated in the secondary chamber (see Fig. 2). The liquid condensate flows down to the bottom header tube 190 and flows back into the evaporator channels 120, closing the loop.

[0097] Fig. 6 shows a flowchart of a method 600 for assembling a power unit that comprises the steps of providing a heat producing unit with at least one heat source 601, providing a cooling unit with at least one heat exchanger device and at least a portion of a secondary chamber 602, attaching the heat producing unit to the cooling unit such that a substantially closed primary chamber with the at least one heat source is formed, and such that the at least one heat source and the at least one heat exchanger device are thermally connected to one another 603, wherein the primary chamber is structurally separated from the secondary chamber, and wherein the primary chamber and the secondary chamber are thermally connected to one another by the at least one heat exchanger device in an operating state of the power unit, providing at least one evaporator channel 604, providing at least one condenser channel 605, providing a first blower for blowing first air through the closed circuit and for transferring heat into the evaporator channel 606, providing a second blower for blowing second air through the open circuit and for transferring heat out of this condenser channel 607, and stacking a plurality of heat exchanger devices in one heat exchanger unit 608.

[0098] While the invention has been illustrated and described in detail in the drawings and the foregoing description, such illustration and description are to be considered illustrative or exemplary and not restricted; the invention is not limited to the disclosed embodiments. Other variations of the disclosed embodiments may be understood and effected by those skilled in the art and practising the claimed invention, from a study of the drawings, the disclosure, and the appended claims.

[0099] In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality. A single cooling unit or heat exchanger device may fulfil the functions of several items recited in the claims. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures may not be used to advantage. Any reference signs in the claims should not be construed as limiting the scope.

LIST OF REFERENCE SYMBOLS

[0100]

100	Heat exchanger device
101	Fluid terminal
102	Cold side

103	Hot side		one heat source (202);
104	Hot air		a cooling unit (201) comprising at least one heat exchanger device (100) and at least a portion of a secondary chamber (209);
105	Cold air	5	wherein the at least one heat source (202) is thermally connected to the at least one heat exchanger device (100);
106	Vapour		wherein the heat producing unit (203) and the cooling unit (201) are attached to one another such that a substantially closed primary chamber (211) with the at least one heat source (202) is formed;
107	Liquid	10	wherein the primary chamber (211) is structurally separated from the secondary chamber (209); and
108	Air seal		wherein the primary chamber (211) and the secondary chamber (209) are thermally connected to one another by the at least one heat exchanger device (100) in an operating state of the power unit (200).
110	Conduit		
112	Exterior wall of conduit	15	
114	Interior wall of conduit		
120	Evaporator channel	20	
130	Condenser channel		
180	Second heat transfer element		2. The power unit (200) according to claim 1, wherein the heat producing unit (203) comprises a housing (215);
183	Heating fin	25	wherein the at least one heat source (202) is arranged in the housing (215);
190	Distribution manifold		wherein the housing (215) and the cooling unit (201) are attached to one another.
195	Support bar		
201	Cooling unit, cooling cabinet	30	3. The power unit (200) according to claim 1 or 2, wherein the at least one heat source (202) comprises at least one dry transformer (202).
202	Heat source, transformer, dry transformer		
203	Heat producing unit	35	4. The power unit (200) according to any one of the preceding claims, wherein the cooling unit (201) is detachable from the heat producing unit (203).
204	First blower, centrifugal fan		
205	Second blower, axial fan	40	5. The power unit (200) according to any one of the preceding claims, further comprising:
206	Primary air circuit, closed air circuit, closed circuit		a first blower (204);
207	Secondary air circuit, open air circuit, open circuit		a second blower (205);
208	Seal	45	wherein the first blower (204) is designed for blowing primary air of a primary air circuit (206) to the heat source (202) for transferring heat from the heat source (202) to the primary air in an operating state of the power unit (200);
210	Separation		wherein the second blower (205) is designed for blowing secondary air of a secondary air circuit (207) for transferring the transferred heat of the heat source (202) to the secondary air in an operating state of the power unit (200).
301	Heat exchanger unit	50	
401	Cooling air flow		

Claims

1. A power unit (200) comprising:
 - a heat producing unit (203) comprising at least
6. The power unit (200) according to claim 5, wherein the first blower (204) and the second blower (205) are selected from the group comprising a centrifugal fan and an axial fan.

7. The power unit (200) according to claim 5 or 6, wherein the primary air circuit (206) is a closed circuit (206); wherein the secondary air circuit (207) is an open circuit (207); and wherein the primary air circuit (206) and the secondary air circuit (207) are separated from each other.
8. The power unit (200) according to any one of the preceding claims, further comprising:
- a plurality of stackable heat exchanger devices (100) being stacked in one heat exchanger unit (301).
9. The power unit (200) according to any one of the preceding claims, wherein the at least one heat exchanger device (100) comprises at least one thermosyphon-type air to air heat exchanger (100).
10. The power unit (200) according to any one of the preceding claims, wherein the heat exchanger device (100) comprises at least one heat pipe for transferring heat from the heat source (202) to ambient air in an operating state of the power unit (200).
11. The power unit according to claim 10, wherein the at least one heat pipe comprises a closed circuit with a cooling fluid that changes its phase depending on a temperature.
12. The power unit according to claim 10 or 11, wherein the at least one heat pipe comprises a multiport tube and wherein at least one port thereof is used as an evaporator channel (120) and at least another port thereof is used as a condenser channel (130) in an operating state of the power unit (200).
13. The power unit according to any one of claims 10 to 12, wherein the heat exchange device (100) comprises several heat pipes; wherein at least one heat pipe of the several heat pipes is at least partially thermally connected to another heat pipe of the several heat pipes by a second heat transfer element (180), in particular a fin-like second heat transfer element (180).
14. Use of a power unit (200) according to any one of the preceding claims for transferring a heat load originating from a transformer (202), in particular a dry transformer (202), that is arranged inside of a housing (215) of a heat producing unit (203) to ambient air; wherein the heat load is transmitted by a closed air circuit (206) running within the housing (215) to the at least one heat exchanger device (100) in a

first step, and from where at least a portion of the heat load is transmitted to an open air circuit (207) passing the cooling unit (201) in a second step.

- 5 15. A method (600) for assembling a power unit, comprising the steps of:

Providing a heat producing unit with at least one heat source (601);
 Providing a cooling unit with at least one heat exchanger device and at least a portion of a secondary chamber (602);
 Attaching the heat producing unit to the cooling unit such that a substantially closed primary chamber with the at least one heat source is formed, and such that the at least one heat source and the at least one heat exchanger device are thermally connected to one another (603);
 wherein the primary chamber is structurally separated from the secondary chamber;
 wherein the primary chamber and the secondary chamber are thermally connected to one another by the at least one heat exchanger device in an operating state of the power unit.

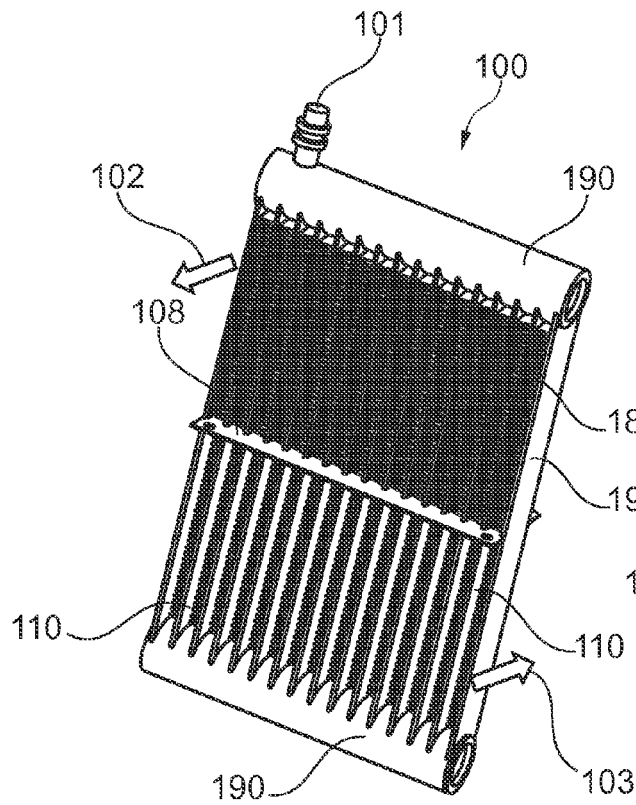


Fig. 1a

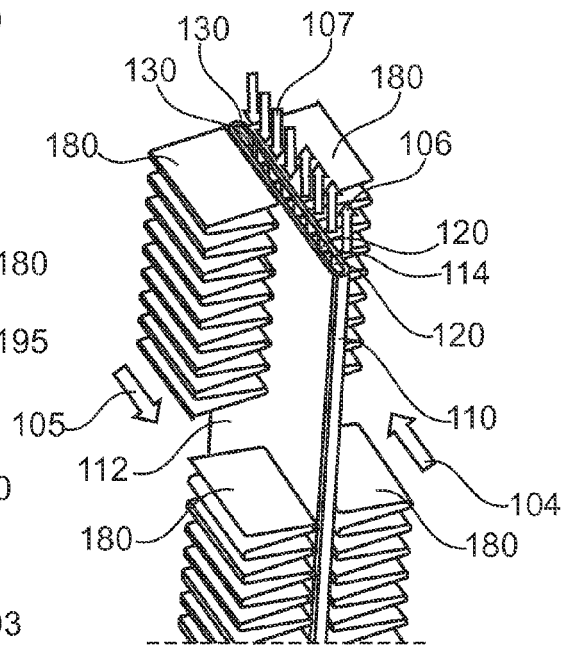


Fig. 1b

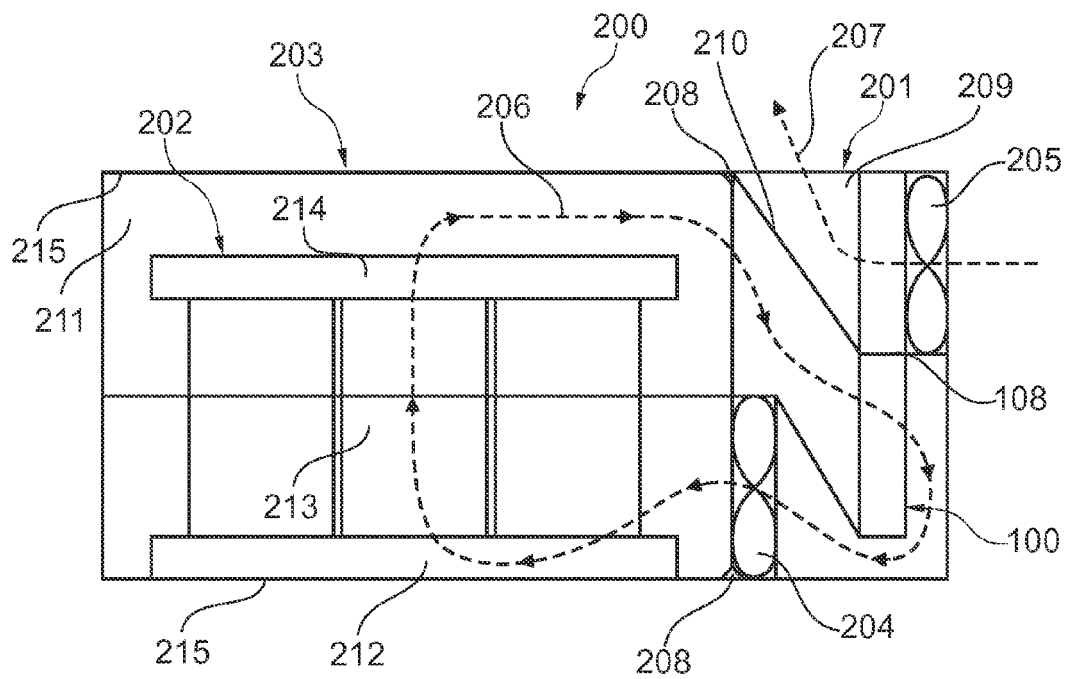


Fig. 2

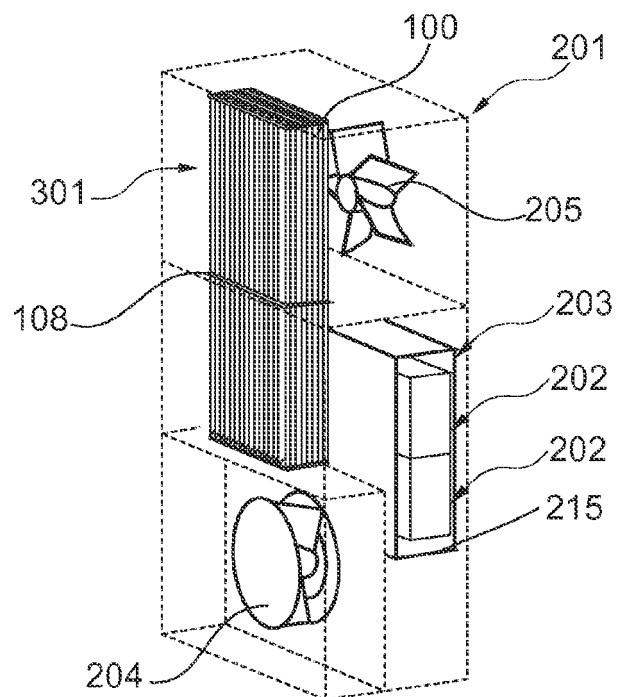


Fig. 3

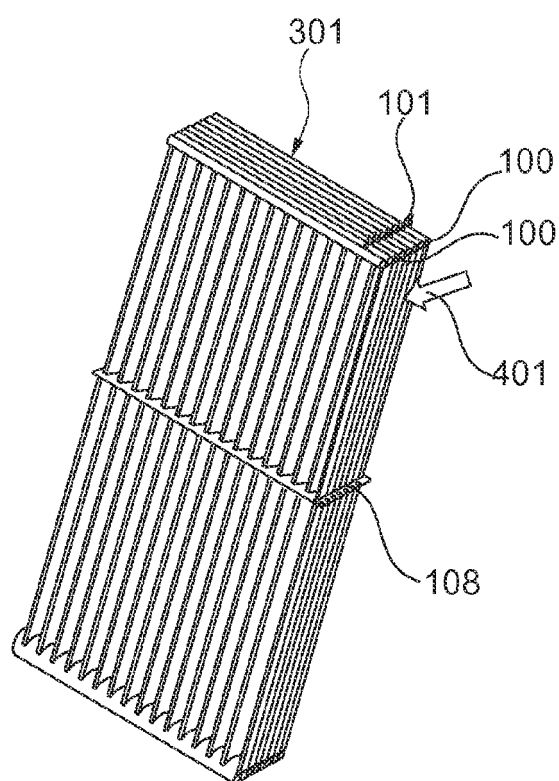


Fig. 4

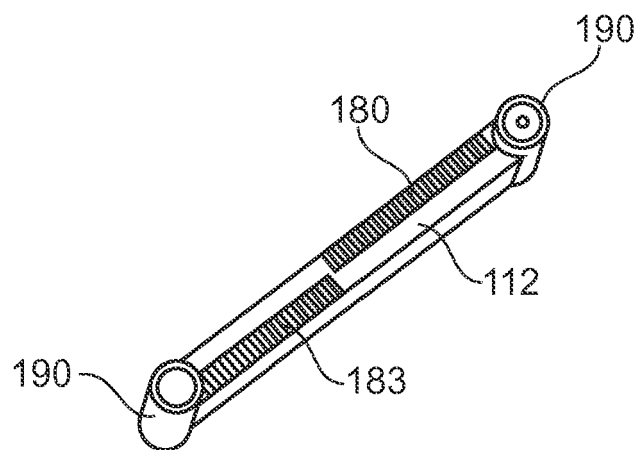


Fig. 5

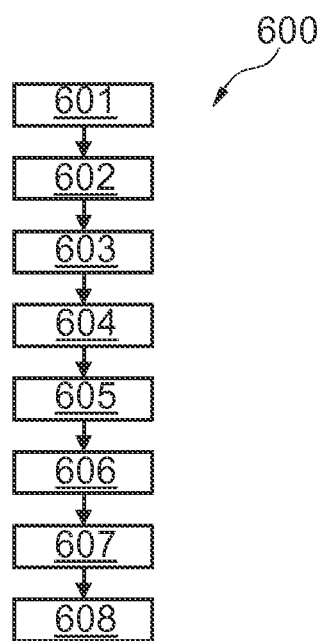


Fig. 6



EUROPEAN SEARCH REPORT

Application Number
EP 09 16 7770

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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 19 January 2010	Examiner Marti Almeda, Rafael
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