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(54) **Electro-magnetic device comprising a cooling arrangement including a specifically arranged thermosyphon**

(57) A cooled electro-magnetic device (1) such as a medium frequency transformer or an inductor having improved cooling characteristics is proposed. The electro-magnetic device comprises a core (3), an electrically conductive winding (5) and a cooling arrangement (7). The cooling arrangement (7) comprises at least one thermosyphon (9, 21) and a blower (11). The thermosyphon (9, 21) comprises an evaporator (13), a condenser (15) and connection piping (17). The thermosyphon (9, 21) and the blower (11) are arranged such that the evaporator (13) is in thermal conductive contact with the core (3) and the condenser and the electrically conductive winding (5) are arranged in relation to the blower (11) such that cooling gas of a gas flow (19) generated by the blower (11) cools both the condenser (15) and the winding (5). Accordingly, particularly in electro-magnetic devices such as medium frequency transformers where thermal losses are not limited to occur in a single component but are typically distributed and partly occur in the core (3) and in the winding (5), the proposed cooling arrangement (7) enables to fulfill cooling requirements of both components by providing a single airflow (19) directly cooling the winding (5) and indirectly cooling the core (3) via the thermosyphon (9, 21).

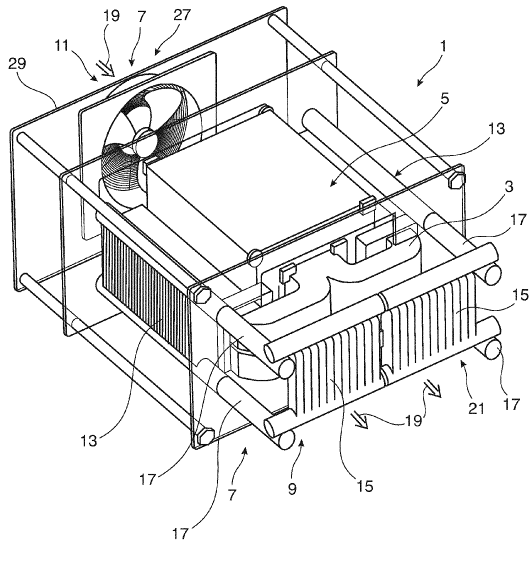

Fig. 1



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## Description

**[0001]** Electro-magnetic device comprising a cooling arrangement including a specifically arranged thermosyphon

### Field of the invention

**[0002]** The present invention relates to a cooled electro-magnetic device such as a dry medium frequency transformer or an inductor, the device having a cooling arrangement which is specifically adapted to cooling requirements of the device.

### Technical background

**[0003]** Electro-magnetic devices such as transformers or inductors typically comprise a core made from a magnetically permeable material and one or more electrically conductive windings arranged at the core. Therein, when winding coils are wound around the core, for example a transformer comprising such arrangement is termed as being of core form design whereas, when winding coils are surrounded by the core, the respective transformer is termed as being of shell form design.

**[0004]** Typically, when an electro-magnetic device is operated, heat is generated at least in one of the core and the electrically conductive windings. Cooling is one of the critical aspects of e.g. transformers as both the core and the windings dissipate heat. A power density of a transformer is generally limited, inter alia, by a maximum operating temperature which may be influenced by ambient temperature, core and windings transformer losses and thermal resistances.

**[0005]** Many electro-magnetic devices comprise one dominant heat generating component. For example, for low frequency transformers, losses are mainly located in the windings such that such low frequency transformers are conventionally simply cooled by air or oil convection through the windings.

**[0006]** However, there are electro-magnetic devices comprising two or more different heat generating components to be cooled during operation of the device.

### Summary of the invention

**[0007]** It may be an object of the present invention to provide an electro-magnetic device in which a cooling arrangement is adapted for satisfying cooling requirements of various device components.

**[0008]** According to an aspect of the present invention, a cooled electro-magnetic device is provided with a core, at least one electrically conductive winding and a cooling arrangement. The core comprises magnetically permeable material. The electrically conductive winding is arranged at the core in accordance with a core form design or a shell form design. The cooling arrangement comprises a thermosyphon and a blower arranged at a gas inlet of the electro-magnetic device. The thermosyphon comprises an evaporator, a condenser and connection piping connecting the evaporator and the condenser. The thermosyphon and the blower are arranged such that the evaporator is in thermally conductive contact with the core and the condenser and the electrically conductive winding are arranged in relation to the blower such that cooling gas of a gas flow generated by the blower in an operating state of the electro-magnetic device cools both the condenser and the electrically conductive winding before leaving the electro-magnetic device through a gas outlet of the electro-magnetic device.

**[0009]** An idea to the present invention may be seen as based on the following observations and perceptions:

> In some modem electro-magnetic devices such as medium frequency transformers having an optimized design, the designer may choose where to distribute the thermal losses among the components of the device. For example, in such medium frequency transformers, both the core and the windings may be designed and adapted such that a significant portion of the overall thermal losses of the transformer is generated in each of the core and the windings, respectively, such that each of both components of the core and the windings generates more than e.g. 20% of the overall thermal losses of the electro-magnetic device. Accordingly, for such device, it may not be sufficient to cool only one of the components, core or windings.

**[0010]** Therefore, an idea underlying the present invention is to provide a dual core and winding cooling solution. With such novel cooling approach, the device designer may allocate the losses in either the core or the windings leading to more freedom in shape, size and generally in the design.

**[0011]** In order to establish the dual core and winding cooling solution, it is proposed to provide the electro-magnetic device with both a thermosyphon and a blower. Therein, the core of the electro-magnetic device may be mainly cooled by an evaporator of the thermosyphon being in thermal conductive contact with this core. The blower is arranged and adapted such that a cooling gas of a gas flow generated by the blower may serve for cooling the windings of the electro-magnetic device. Additionally, the blower is arranged and adapted such that the gas flow also cools the condenser of the thermosyphon. Accordingly, all heat generating components of the electro-magnetic device are directly or indirectly cooled by the gas flow generated by the blower as the gas flow directly cools the heat generating windings and, furthermore, the gas flow is used for cooling the condenser of the thermosyphon, the evaporator of which is in thermal contact with the core and allows thereby indirectly cooling the core.

**[0012]** According to an embodiment of the invention, a heat transfer rate applied to the windings is adjustable by the gas flow generated by the blower whereas a heat transfer rate applied to the core is adjustable by both the gas flow generated by the blower and a design of the thermosyphon. Therein, the two heat transfer rates may be adjusted depending on actual cooling requirements of the core and the windings, respectively, such that thermal loss of the windings is increasable in favor to a decreased thermal loss of the core, and vice versa, in an operating state of the electro-magnetic device. Therein, the device is adapted for partitioning an overall power density substantially to both the core and the electrically conductive windings, thereby influencing actual cooling requirements of the core and the windings, respectively.

**[0013]** In order to fulfill the actual cooling requirements of the core and of the windings, respectively, structural and/or functional features and properties of the thermosyphon and the blower comprised in the devices cooling arrangement may be specifically adapted for partitioning portions of the overall cooling capacity for cooling the core, on the one hand, and for cooling the windings, on the other hand.

**[0014]** For example, for adapting properties of the gas flow generated by the blower, at least one of the type, size and revolution speed of the blower may be suitably selected. For the thermosyphon, at least one of a working medium, a size of the condenser, a geometry of the condenser, an orientation of the condenser in the gas flow, a size of the evaporator and a geometry of the evaporator may be suitably selected. A condenser of a thermosyphon may be placed to match a gas flow distribution inside an enclosure of the electro-magnetic device. For example, a gas exhaust may be in line or on a side of the enclosure, the condenser may be arranged orthogonal to the gas flow or inclined thereto, and so on. Depending on whether one blower or two or more blowers are used for generating the gas flow symmetrical or asymmetrical cooling at the components of the electro-magnetic device, particularly at the components of the cooling arrangement, may be achieved and, for example, a cooling capacity of a thermosyphon may be specifically adapted to cooling requirements of device components thermally connected thereto. Furthermore, for example a size, geometry and type of fins used for example in the condenser of the thermosyphon may be chosen to, on the one hand, optimize cooling capacity of the thermosyphon and, on the other hand, optimize pressure loss and/or minimize clogging issues.

**[0015]** Possible features and advantages of embodiments of the present invention shall be explained in more detail in the following.

**[0016]** The proposed cooled electro-magnetic device may be any device comprising at least one core of magnetically permeable material and at least one electrically conductive winding. The core may comprise any type of magnetically permeable materials such as iron or other ferromagnetical materials. The core may have any suitable shape and size. The core may be provided with a core form design or may be part of a shell form design. The at least one electrically conductive winding may be provided with any electrically conductive material, for example in the form of a wire or litzs. The winding may be arranged around the core or adjacent to the core such that an electro-magnetic field generated by an electric current flowing through the winding at least partially enters the core.

**[0017]** The cooling arrangement of the proposed electro-magnetic device comprises at least two components, a thermosyphon and blower.

**[0018]** A thermosyphon is a device which is adapted for passive heat exchange based on natural convection. Therein, a liquid coolant agent may circulate within the thermosyphon without the necessity of any pump. A principle underlying the thermosyphon uses the fact that convective movement of a coolant liquid starts when the liquid in a loop is heated, causing it to expand and become less dense, and thus more buoyant than the cooler surrounding liquid at a bottom of the loop. Convection moves heated liquid upwards in the system as it is simultaneously replaced by cooler liquid returning by gravity. Ideally, the coolant liquid flows easily because a good thermosyphon should have very little hydraulic resistance. An example of a thermosyphon is described in EP 2 031 332 A1.

**[0019]** Specifically, a thermosyphon may use 2-phase cooling principles in which phase transition from a liquid phase to a gaseous phase, and vice versa, occurs and serves for absorbing energy from a heat source and releasing energy to a heat sink, respectively.

**[0020]** According to an embodiment of the present invention, the thermosyphon is a loop-type thermosyphon. In such loop type thermosyphon, connection piping is provided between an evaporator and a condenser such that coolant evaporated at the evaporator may flow through a part of the piping towards the condenser where it condenses before flowing back to another part of the connection piping towards the evaporator, thereby closing the loop. As the evaporator is in thermally conductive contact with the core, heat losses dissipated in the core are conducted to the evaporator. At this location, the coolant fluid contained in the thermosyphon will evaporate. The vapor will move to the condenser where the heat may be dumped to the gas flow generated by the blower. At this location, the vapor will condense back to the liquid state and return to the evaporator.

**[0021]** In an alternative embodiment of the present invention, the thermosyphon of the proposed electro-magnetic device is a heat pipe. In such specific type of thermosyphon, heat may be transferred by evaporation and condensation of vapor, i.e. by phase transition between liquid phase and gaseous phase and vice versa.

**[0022]** According to an embodiment of the present invention, the cooled electro-magnetic device further comprises at least one second thermosyphon being in thermal conductive contact with the core, wherein the first and second thermosyphons are arranged in parallel within the gas flow generated by the blower. In such embodiment comprising at least two thermosyphons, the evaporators of each of the thermosyphons may be in thermal contact to the core at different locations. For example, a first evaporator may be attached to a first surface of the core and a second evaporator may be attached to a second surface of the core opposite to the first surface. Therein, the two condensers of the two thermosyphons may be arranged next to each other such that different portions of an overall gas flow generated by the blower cool the respective condensers.

**[0023]** According to an alternative embodiment of the present invention, the cooled electro-magnetic device further comprises at least one third thermosyphon being in thermal conductive contact with the core, wherein the first and third thermosyphons are arranged in series within the gas flow generated by the blower. In such arrangement, again at least two thermosyphons are provided for the cooling arrangement of the electro-magnetic device. However, in contrast to the previous embodiment, condensers of the thermosyphons are not arranged next to each other but one behind the other such that a gas flow serially first cools one of the condensers before cooling the other one of the condensers.

**[0024]** While a parallel arrangement of a plurality of thermosyphons may increase the overall heat transfer rate of the cooling arrangement, a serial arrangement of thermosyphons may provide for reduced space requirements for the cooling arrangement.

**[0025]** In the embodiments described before, the condenser of the first thermosyphon and the condenser of one of the second thermosyphon and the third thermosyphon may be arranged at opposite ends of the core with respect to the gas flow. In such arrangement, the gas flow may first cool a condenser of one of the thermosyphons before cooling the windings arranged at the core and before finally cooling another condenser of the respective other thermosyphon. In such serial arrangement, the positioning of the first thermosyphon, on the one hand, and at least one of the second and third thermosyphon, on the other hand, may be specifically adapted to the specific cooling requirements of the electro-magnetic device.

**[0026]** For example, different portions of the core may generate different amounts of heat during operation of the electro-magnetic device thereby resulting in locally different cooling requirements. Accordingly, for example a first thermosyphon having an evaporator thermally contacting a portion of the core showing increased thermal losses could be arranged such that its condenser is arranged at an end of the core where the gas flow provided by the blower first enters the electro-magnetic device and therefore has the best cooling capacity. Another thermosyphon having an evaporator in contact with a less heat-generating portion of the core may be arranged such that its condenser is arranged at an opposite end of the core such that the gas flow cools this condenser only after previously cooling the heat-generating windings and, possibly, the condenser arranged at the opposite end, the gas flow therefore having increased temperature and reduced cooling capacity at this stage.

**[0027]** According to a specific embodiment of the present invention, the core of the electro-magnetic device comprises a non-isotropic heat conductance. For example, a core material or an arrangement of core building components may have a non-isotropic heat conductance, i.e. the heat conductance in one direction along the core may differ from the heat conductance along another direction. When using such specific core, the evaporator may be beneficially arranged perpendicular to a plane of maximum heat conductance of the core.

**[0028]** Lacking isotropy of the heat conductance may occur for example in cores which are assembled from a plurality of sheet-like components in order to, inter alia, suppress eddy currents. In such core comprising a stack of sheet-like components, heat conductance in a direction along a plane of a sheet-like component may differ from heat conductance in a direction orthogonal to this plane. Accordingly, by arranging the evaporator in thermal contact with a side surface of a stack of sheets forming the core and therefore perpendicular to a plane of the maximum heat conductance which coincides with the plane of the core sheets, optimum thermal conduction of heat from the core to the evaporator may be achieved.

**[0029]** According to an embodiment of the present invention, the core and the electrically conductive windings are part of a dry medium frequency transformer. While it is known that in low frequency transformers, thermal losses are mainly located in the windings such that such low frequency transformers may be simply cooled by air or oil convection through these windings, medium frequency transformers exhibit thermal losses in both, the windings and the core. In other words, while medium frequency transformers allow for a higher power density compared to low frequency transformers, cooling requirements in such medium frequency transformers are more complex. The cooling arrangement defined for the electro-magnetic device proposed herein is specifically adapted for fulfilling such complex cooling requirements.

**[0030]** According to an alternative embodiment, the core and the at least one electrically conductive winding is part of an inductor. Therein, the inductor may have a single set of windings and may benefit from the simultaneous core and winding cooling in a similar manner as a transformer.

**[0031]** According to another aspect of the present invention, a power unit is proposed to comprise a cooled electro-magnetic device according to an embodiment of the present invention as for example described further above. Such power unit may be for example an electric machine for example in the form of an electric generator or an electric motor that converts mechanical energy to electrical energy, or vice versa, respectively.

**[0032]** Therein, the blower of the cooling arrangement may be provided inside a housing of the electro-magnetic device. Alternatively, the blower may be provided outside such housing thereby allowing for example several electrical phases to be cooled by a common blower.

**[0033]** It shall be noted that possible features and advantages of the invention are described herein with respect to various embodiments of the invention. A person skilled in the art will notice that the features may be suitably combined or replaced in order to create alternative embodiments and possibly achieve synergy effects.

Brief description of the drawings

**[0034]** Embodiments of the invention will be described with reference to the attached drawings. However, neither the description nor the drawings shall be interpreted as limiting the invention.

Fig. 1 shows a perspective view of an electro-magnetic device according to an embodiment of the present invention.

Fig. 2 shows a perspective view of main components of an electro-magnetic device according to the embodiment shown in Fig. 1.

Fig. 3 shows a perspective view of an electro-magnetic device according to an alternative embodiment of the present invention.

**[0035]** The figures are only schematic and not to scale. Same reference signs refer to same or similar features throughout the figures.

Detailed description of embodiments

**[0036]** Fig. 1 shows a medium frequency transformer provided with the features and components of a cooled electro-magnetic device 1 according to a first embodiment of the present invention.

**[0037]** The electro-magnetic device 1 comprises a core 3 and electrically conductive windings 5. The core 3 is provided as a dual core but could also be provided as a single core. The windings 5 are wound around a middle beam of the core 3.

**[0038]** The core 3 and the windings 5 are enclosed by a housing 29, only a rear portion of which is shown in Fig. 1 for clarity reasons.

**[0039]** A cooling arrangement 7 is provided for cooling all heat-generating components of the electro-magnetic device 1. The cooling arrangement 7 comprises a blower 11 arranged at a gas inlet 27 of the housing 29. The blower 11 is adapted for blowing or sucking a gas flow 19 through the housing 29 enclosing the electro-magnetic device 1. Therein, the gas flow 19 may enter the housing 29 at the gas inlet 27, flow through at least some of the components of the electro-magnetic device 1 and exit the housing 29 at a gas outlet (not shown in Fig. 1).

**[0040]** The electro-magnetic device 1 further comprises two thermosyphons 9, 21. As also shown in Fig. 2 in clearer details, each of the thermosyphons 9, 21 comprises an evaporator 13 and a condenser 15. The evaporator 13 of a thermosyphon 9, 21 is in fluid communication with the associated condenser 15 via tubes of a connection piping 17. The evaporator 13 is arranged at a lateral surface of the core 3 and in thermal conductive contact therewith. Accordingly, heat generated in the core 3 during operation of the electro-magnetic device 1 may be transferred to the evaporator 13. The heat increase at the evaporator 13 resulting from such heat absorption may result in evaporating a coolant fluid comprised within the evaporator 13. The evaporating fluid may move through one of the tubes of the connection piping 17 acting as a riser pipe and may finally reach the condenser 15. In the condenser 15, the at least partly evaporated fluid may move through pipes being in thermal contact with fins or lamellae through which at least a portion of the gas flow 19 generated by the blower 11 flows. As heat is transferred to the gas flow 19, the evaporated fluid condenses back to the liquid phase. The condensed liquid may then flow back through a second tube of the connection piping 17 towards the evaporator 13 in order to close the loop.

**[0041]** In the embodiment shown in Figs. 1 and 2, the electro-magnetic device 1 is provided with a first thermosyphon 9 and a second thermosyphon 21 arranged in parallel to each other. The evaporators 13 of these two thermosyphons 9, 21 are arranged at opposite side surfaces of the core 3. The condensers 15 of the thermosyphons 9, 21 are arranged at a downstream end of the core 3 with respect to the gas flow 19. The two condensers 19 are arranged next to each other such that one portion of the gas flow 19 flows through the condenser 15 of the first thermosyphon 9 and a separate portion of the gas flow 19 flows through the condenser 15 of the second thermosyphon 21.

**[0042]** In such parallel arrangement of the thermosyphons 9, 21, the direction of the airflow 19 may be altered to flow in one direction or in the opposite direction depending on whether the greater portion of the overall thermal losses are dissipated in either the core 3, or the windings 5.

**[0043]** For example, when flowing in the direction as indicated for the gas flow 19 shown in Fig. 2, the gas flow 19 first flows through the windings 5, thereby cooling the windings as well as partially heating the gas flow 19, before being transmitted through the condensers 15 of the thermosyphons 9, 21, thereby indirectly cooling the associated evaporators 13 and the surfaces of the core 3 being in thermal contact with these evaporators 13. With such gas flow direction, more cooling capacity is provided to the windings 5 than with a gas flow 19 being directed in the opposite direction and therefore being pre-heated when flowing through the condensers 15 before reaching the windings 5.

**[0044]** However, independent of the selected gas flow direction, both, the windings 5 and the core 3 being in contact with the evaporators 13 of the thermosyphons 9, 21 are cooled by the same gas flow 19. The gas flow 19 therefore acts as a common coolant for both, the windings 5 and the core 3. For example, the gas flow may be an airflow.

**[0045]** In the specific embodiment shown in Fig. 2, the core 3 is provided as a stack of multiple sheet-components 31. Providing the core 3 with such sheet-components 31 may prevent excessive eddy currents occurring within the core 3 upon operation of the electro-magnetic device 1. However, heat exchange between the individual sheet-components 31 may be limited. In other words, the core 3 has a non-isotropic core structure having a significantly higher heat conductance in a direction along a plane of a sheet-component 31 compared to the heat conductance in a direction orthogonal thereto. In order to beneficially dissipate heat from such non-isotropic core 3, the evaporator 13 is arranged perpendicular to the plane of maximum thermal conductivity of the core 3, i.e. at a lateral surface of the stacked core 3.

**[0046]** Fig. 3 shows an alternative embodiment of an electro-magnetic device 1. Again, two thermosyphons 9, 23 are provided with their evaporators 13 being arranged in thermal contact to the core 3. However, the thermosyphons are not arranged in parallel, as in the embodiments of Figs. 1 and 2, but are arranged in series such that a gas flow 25 first cools one of the condensers 15 and only subsequently cools a second one of the condensers 15 of the respective other one thermosyphon.

**[0047]** In the embodiment shown in Fig. 3, a first thermosyphon 9 is arranged at a downstream end of the electro-magnetic device 1 with respect to gas flow 25 whereas a third thermosyphon 23 is arranged at an upstream side thereof. Accordingly, as shown in Fig. 3, the gas flow 25 first cools the condenser 15 of the third thermosyphon 23 thereby indirectly cooling the region of the core 3 being in thermal contact with its evaporator 13. The gas flow 25 continues flowing through the device 1 and thereby cools the windings 5. Finally, the already substantially heated gas flow 25 flows through the condenser 15 of the first thermosyphon 9 before exiting at a gas outlet. In such arrangement, reversing the direction of the gas flow 25 may result in other portions of the core being predominantly cooled thereby allowing simply adapting of the cooling capacity of the cooling arrangement 7 to actual cooling requirements of the core 3 and/or the windings 5. Thereby, the cooling arrangement 7 may for example cope with unbalanced heat losses within the electro-magnetic device 1.

**[0048]** Finally, it shall be noted that the wording such as "comprising", "including" or similar shall not exclude other elements or components to be part of the defined structure and that the term "a" or "an" does not exclude the presence of a plurality of elements. It should also be noted that reference signs in the claims should not be construed as limiting the scope of the claims.

List of reference signs

**[0049]**

1 : cooled electro-magnetic device
3 : core
5 : windings
7 : cooling arrangement
9 : first thermosyphon
11: blower
13: evaporator
15: condenser
17: connection piping
19: gas flow
21: second thermosyphon in parallel series arrangement
23: third thermosyphon in series arrangement
25: gas flow
27: gas inlet
29: housing
31: sheet-component of the core

## Claims

1. A cooled electro-magnetic device (1), comprising:

   a core (3) comprising magnetically permeable material,
   an electrically conductive winding (5) arranged at the core (3), and
   a cooling arrangement (7);

   wherein the cooling arrangement (7) comprises:

   a thermosyphon (9, 21, 23), and
   a blower (11) that is arranged at a gas inlet (27) of the electro-magnetic device (1);

   wherein the thermosyphon (9, 21, 23) comprises
   an evaporator (13),
   a condenser (15), and
   connection piping (17) connecting the evaporator (13) and the condenser (15);
   wherein the thermosyphon (9, 21, 23) and the blower (11) are arranged such that the evaporator (13) is in thermal conductive contact with the core (3), and the condenser (15) and the electrically conductive winding (5) are arranged in relation to the blower (11) such that cooling gas of a gas flow (19, 25) generated by the blower (11) in an operating state of the electro-magnetic device (1) cools both the condenser (15) and the electrically conductive winding (5) before leaving the electro-magnetic device (1) through a gas outlet of the electro-magnetic device (1).

2. The device of claim 1, wherein a heat transfer rate applied to the windings (5) is adjustable by the gas flow (19, 25) generated by the blower (11), and wherein a heat transfer rate applied to the core (3) is adjustable by the gas flow (19, 25) generated by the blower (11) and by a design of the thermosyphon

(9) depending on actual cooling requirements of the core (3) and the winding (5), respectively, such that thermal loss of the windings (5) is increasable in favor to a decreased thermal loss of the core (3), and vice versa, in an operating state of the electro-magnetic device (1), and wherein the device (1) is adapted for partitioning an overall power density substantially to both the core (3) and the electrically conductive winding (5) thereby influencing actual cooling requirements of the core (3) and the winding (5), respectively.

3. The device of claim 1 or 2, wherein the core (3) and the
electrically conductive winding (5) are parts of a dry medium frequency transformer.

4. The device of claim 1 or 2, wherein the core (3) and the electrically conductive winding (5) are parts of an inductor.

5. The device of one of claims 1 to 4, further comprising a second thermosyphon (21) being in thermal conductive contact with the core (3), wherein the first and second thermosyphons (9, 21) are arranged in parallel within the gas flow (19) generated by the blower (11).

6. The device of one of claims 1 to 5, further comprising a third thermosyphon (23) being in thermal conductive contact with the core (3), wherein the first and third thermosyphons (9, 23) are arranged in series within the gas flow (25) generated by the blower (11).

7. The device of claim 5 or 6, wherein the condenser (15) of the first thermosyphon (9) and the condenser (15) of one of the second thermosyphon (21) and the third thermosyphon (23) are arranged at opposite ends of the core (3) with respect to the gas flow (19).

8. The device of one of claims 1 to 7, wherein the thermosyphon (9, 21, 23) is a loop-type thermosyphon.

9. The device of one of claims 1 to 8, wherein the thermosyphon (9, 21, 23) is a heat pipe.

10. The device of one of claims 1 to 9, wherein the core (3) comprises non-isotropic heat conductance and wherein the evaporator (13) is arranged perpendicular to a plane of maximum heat conductance of the core (3).

11. The device of one of claims 1 to 10, wherein the winding (5) and the condenser (15) are cooled by the same gas flow (19; 25), the gas flow being preferably an air flow.

12. Power unit comprising a cooled electro-magnetic device (1) according to one of claims 1 to 11.

13. Power unit of claim 12, wherein the blower (7) is provided outside a housing (29) of the electro-magnetic device (1).

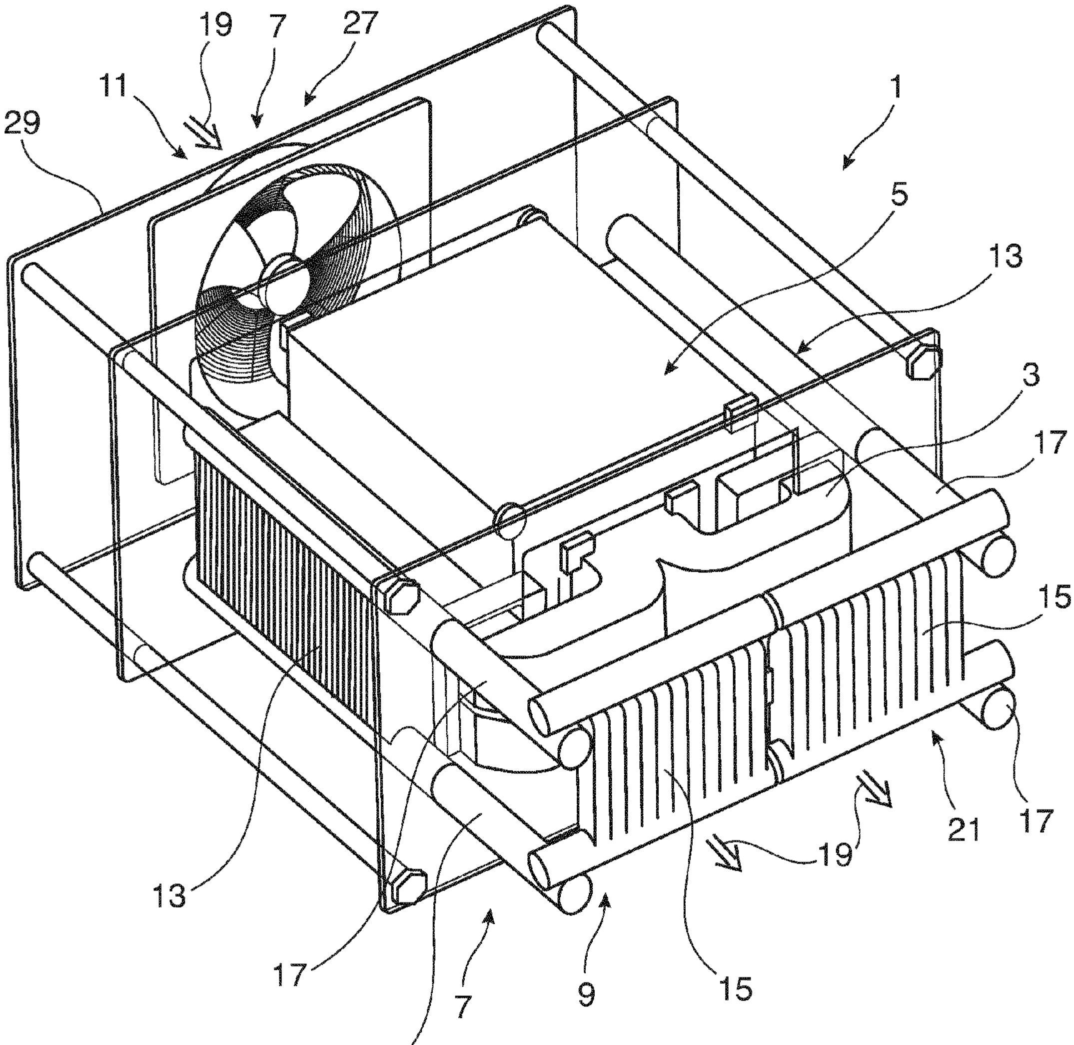


Fig. 1

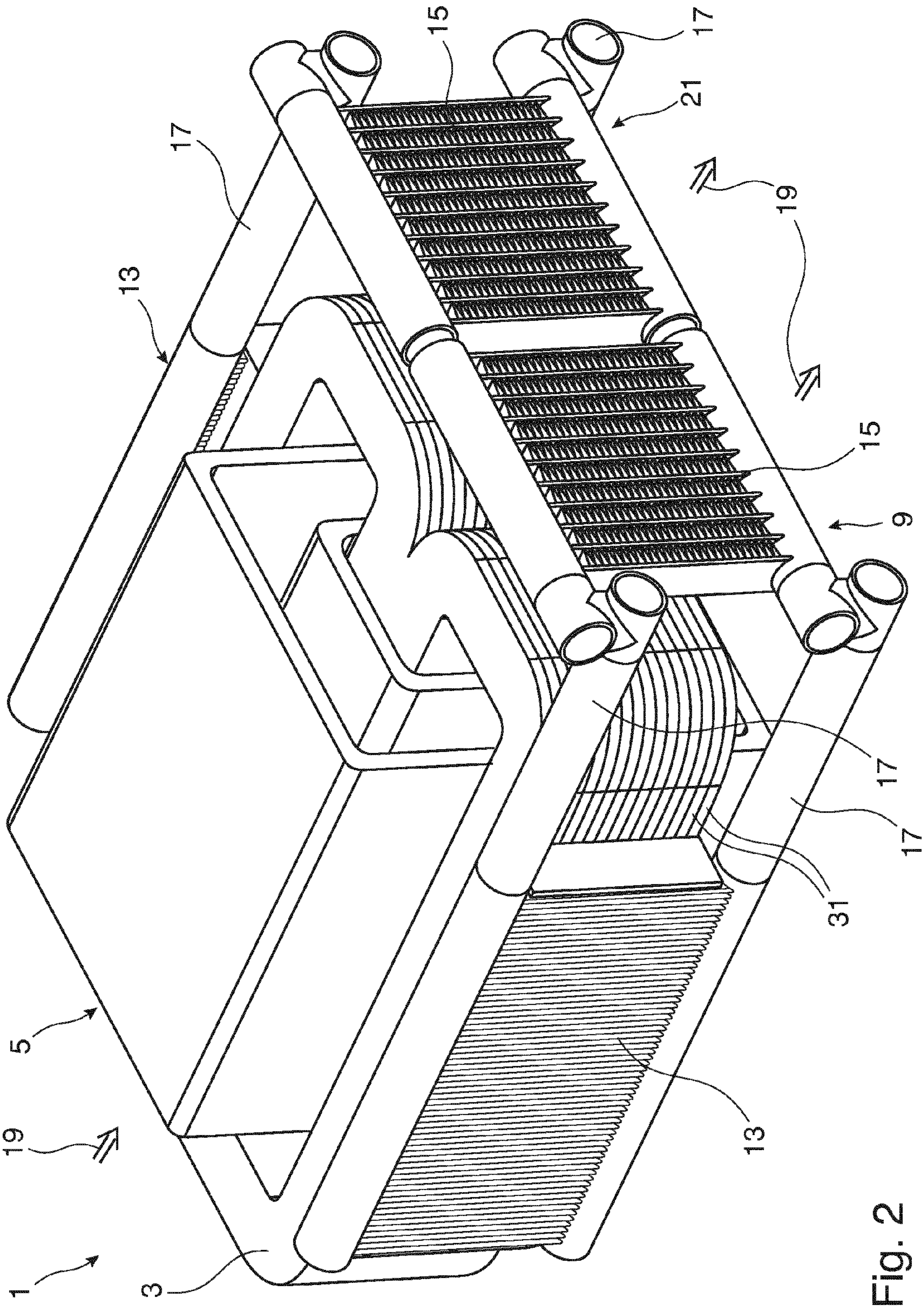


Fig. 2

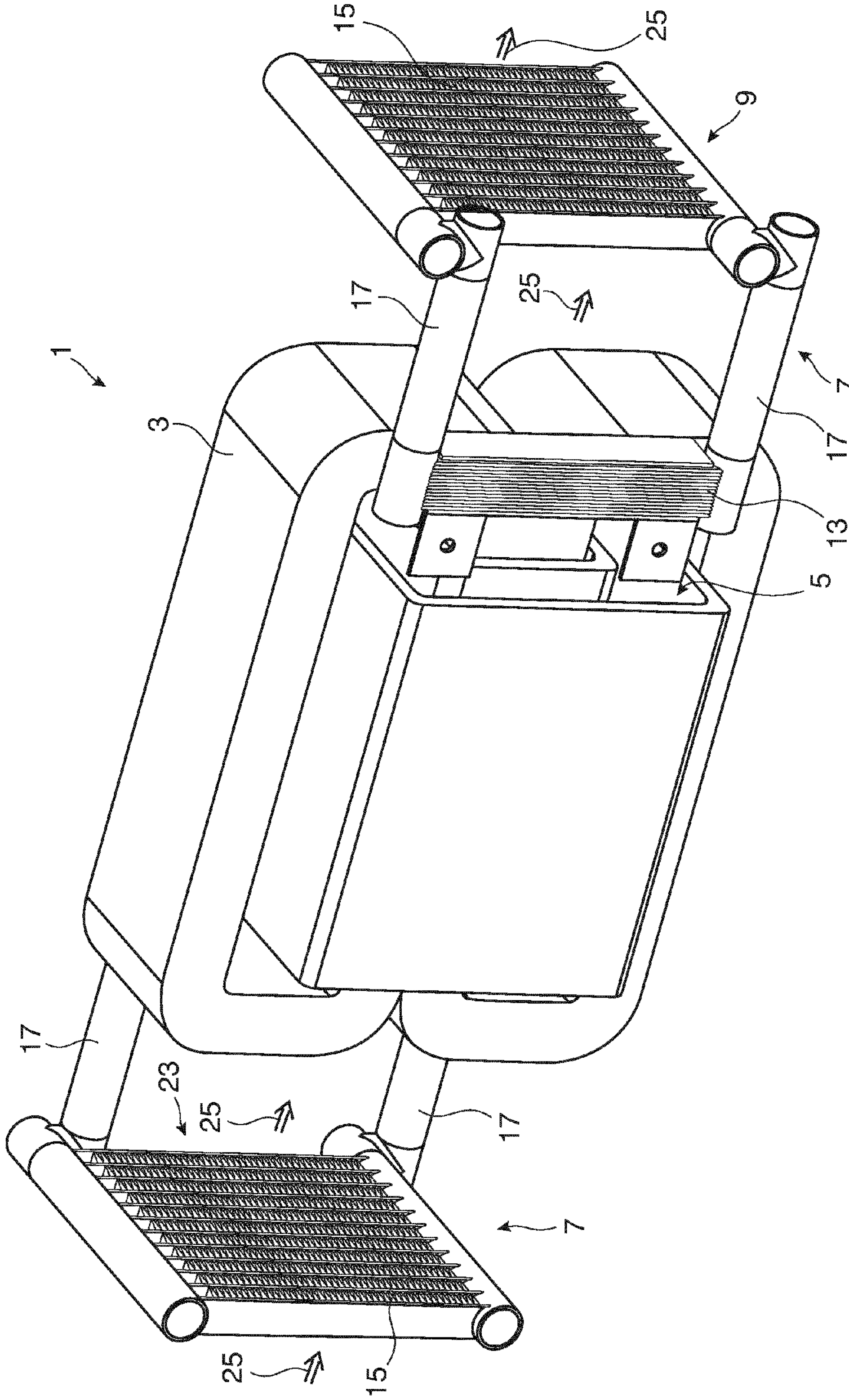


Fig. 3

Europäisches Patentamt
European Patent Office
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# EUROPEAN SEARCH REPORT

Application Number
EP 12 17 4974

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (IPC) |
|---|---|---|---|
| X | JP 52 062428 U (HITACHI CO LTD) 9 May 1977 (1977-05-09) * figures 6a,6b,8 * ----- | 1-5,9, 11-13 | INV. H01F27/18 H01F27/08 H01F27/24 |
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