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(54) Magnetic shielding for transformers

(57) The present invention relates to magnetic shielding of transformers (100), and particularly to a transformer (100) with at least one magnetic shielding arrangement (101).

A transformer (100) with at least one magnetic shielding arrangement (101) is provided, comprising a first magnetic shielding component (102). The first magnetic shielding component (102) is arranged in a first end region (104) of windings (106) of the transformer (100) such that a magnetic stray field and/or stray losses caused by the windings (106) of the transformer (100) during operation of the transformer (100) is reduced. The first magnetic shielding component (102) comprises at least one recess (201, 901, 904, 304) for a better cooling of the transformer (100).

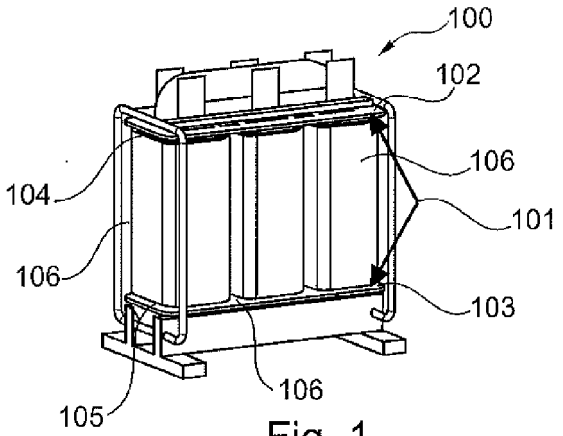

Fig. 1

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Description

FIELD OF THE INVENTION

[0001] The invention relates to magnetic shielding of transformers. In particular, the invention relates to a transformer with at least one magnetic shielding arrangement and to a magnetic shielding component adapted for the transformer with at least one magnetic shielding arrangement.

BACKGROUND OF THE INVENTION

[0002] In the field of medium and high voltage applications, the problem of stray magnetic fields and the corresponding induced power losses in electrical devices becomes significant as unit power increases. It is both a technical and an economic problem, since capitalization amounts for load losses represent an important part in the costs of a transformer. Furthermore, a material reduction due to high prices of raw materials in the construction of power units may lead to an increase in load losses.

[0003] In large power devices, such as power transformers, the existence of the stray magnetic flux may be inevitable and cannot be completely prevented just by means of careful and inventive design. Although the windings are placed around the core limbs, there is a considerable stray flux that finds a path in the space between the limbs and windings as well as in the space between windings and structural components. The stray magnetic field produced by the windings may have strongest values in the region around the ends of the windings which are very close to the clamps used to press the core laminations. This yields a high level of eddy current losses in the clamps and consequently their overheating. The losses in the clamps reduce the efficiency of the transformer, increase the cost of the transformer over its entire lifetime, create potential hazardous local overheating, and contribute to increasing the oil temperature of the transformer which reduces its cooling capabilities.

[0004] Dry transformers are environment-friendly, low maintenance transformers, which provide a very low flammability risk, and therefore are often used as distribution transformers, e.g. in public, industrial and residential buildings, power plants or on board of ships. Because of possible influences to humans or technical devices, the magnetic stray field emitted during operation of such dry transformers may have to be very low. A few countries have legal restrictions for the maximum values of the magnetic flux density at work places, living/sleeping rooms, hospitals, schools, etc. In Switzerland for example, this value is 1 μT.

[0005] The patent application JP-11283848-A describes a magnetic shielding arrangement in a transformer, wherein a magnetic shield is distributed along the yoke of the transformer.

[0006] The patent DE 44 32 739 B4 depicts an inductive electrical component with a cover of ferromagnetic material.

SUMMARY OF THE INVENTION

[0007] It may be seen as an object of the invention to provide an improved flexible and efficient magnetic shielding for a transformer.

[0008] This obj ect is achieved by a transformer with at least one magnetic shielding arrangement, and by a magnetic shielding component adapted for the transformer according to the independent claims. Further embodiments are evident from the dependent claims.

[0009] According to an embodiment of the invention, a transformer with at least one magnetic shielding arrangement for shielding the magnetic stray field of the transformer is provided. A first magnetic shielding component is arranged at a first end region of windings of the transformer such that a magnetic stray field and/or stray losses caused by the windings of the transformer during operation of the transformer are reduced. The first magnetic shielding component comprises at least one recess adapted for cooling the transformer.

[0010] In other words the first magnetic shielding component, which may be a separate component, for example a plate with a recess, may be arranged between one of more than one windings of the transformer and the yoke or shielding clamp of the transformer. The winding (s) may have corresponding duct(s).

[0011] Such a magnetic shielding arrangement may protect the clamps from the stray field produced by transformer windings and may prevent a magnetic stray field from emitting to the surrounding environment. Humans may be protected from the magnetic stray field emitted during operation of the transformer, for example. The at least one magnetic shielding arrangement may provide a (passive) magnetic shielding for dry-type transformers reducing the magnetic stray field emitted by the dry-type transformer to the environment.

[0012] Such a transformer with at least one magnetic shielding arrangement may provide for a minimum value of induced eddy current losses in core clamps of a transformer such as a power transformer, for example, a minimum hindrance of oil circulation in vertical direction of a transformer and at the bottom and top of the windings of the transformer, for a reduction of material, and thus for minimum material costs. The clamps of the transformers may be protected by the magnetic shielding arrangement with magnetic shields form the stray fields produced by the transformer windings.

[0013] For a better cooling or to reduce eddy currents, the recess may be a slot and the magnetic shielding arrangement and/or first component may of grating or net type. A transformer with such a magnetic shielding arrangement may provide that electrical fields remain below critical values and allow safe operation of the transformer.

[0014] According to an embodiment of the invention, the first magnetic shielding component may be made of a non-conductive but highly magnetic permeable material which may be relatively easy produced by rolling and pressing tiny oxidized films of highly permeable iron. The oxidized layers may prevent the conduction of electrical current in the desired direction, for example, the direction of induces eddy currents, achieving the required non-conductive property. After pressing the magnetic rolls, long magnetic shunts with an arbitrary shape of their cross-section may be produced that can be afterwards combined in a shunt system of a suitable shape. The magnetic shields may operate far from the saturation regime, such that the stray magnetic fields may be directed through them towards the core and hence bypassing the clamps.

[0015] Such a transformer with at least one magnetic shielding arrangement may advantageously improve the circulation of oil for a high bar transformer along with the cooling of the cores.

[0016] According to an embodiment of the invention, a rounding of the edges of the first magnetic shielding component may help to decrease distances and place the first magnetic shielding component as close as possible to the windings.

[0017] According to an embodiment of the invention, the first magnetic shielding component may be arranged below one or more of windings and corresponding ducts.

[0018] According to an embodiment of the invention, the magnetic shielding arrangement of the transformer may further comprise a second magnetic shielding component that is arranged at a second end region of the windings of the transformer.

[0019] The second magnetic shielding component may be arranged above one or more of windings and corresponding ducts.

[0020] According to an embodiment of the invention, the magnetic shielding arrangement may have the form of a shielding box surrounding the whole transformer. The shields/walls of the box may comprise a highly permeable plate alongside the transformer. For installing the shielding box, a number of plates may be positioned at all or some sides of the transformer. The shielding box can be formed by a frame built of electrically high-conducting but not magnetic material such as copper or aluminium. The frame may have one or more traverses that may be arranged horizontally and/or vertically in a frame built.

[0021] The frame built may combined, wherein the interstices of the frame are filled with one of the materials selected from the group comprising high-permeable and electrically low-conductive material, laminated core steel such as silicon core steel and amorphous core steel, and ferrite material. The frame may be suitable to mechanically clamp the laminated material together.

[0022] Layer plates may be used to build the box comprising material comprising high-permeable and electrically low-conductive material, laminated core steel such as silicon core steel and amorphous core steel, ferrite material, and electrically high-conductive and non-magnetic material. The layers with laminated material may have different lamination directions. In a most, there may be either high-permeable or electrically high-conductive material. There may be either high-permeable or electrically high-conductive material. There may be air-filled gaps in-between the individual layers.

[0023] The shields/walls may be integrated in an enclosure of the transformer.

[0024] According to an embodiment of the invention, the magnetic shielding components may be arranged in such a way, that they are at least partly surrounding the busbars of the transformer.

[0025] According to an embodiment of the invention, the first magnetic shielding component is arranged between the windings and a core clamp supporting a yoke of the transformer for protecting the core clamp from a magnetic stray field caused by windings of the transformer during operation.

[0026] According to an embodiment of the invention, the first magnetic shielding component comprises a first recess to fit the first magnetic shielding component to a core limb of the transformer such that part of a cross-sectional area of a winding of the transformer perpendicular to the axis of the core limb is not covered by the first magnetic shielding component such that a cooling flow in an axial direction through the first magnetic shielding component is provided.

[0027] According to an embodiment of the invention, the first recess may be in the middle of the first magnetic shielding component surrounded by magnetic shielding material which may built a frame form.

[0028] According to an embodiment of the invention, the first recess may on the side of the first magnetic shielding component that faces the core of the transformer.

[0029] According to an embodiment of the invention, the first recess may have a circular, a rectangular, and a polygonal form, or a combination thereof.

[0030] According to an embodiment of the invention, there may be extensions of the first recess to improve the oil circulation, the cooling of the windings, and the fitting of the first magnetic shielding component to the core of the transformer.

[0031] According to an embodiment of the invention, the first magnetic shielding component comprises a second recess in a direction parallel to a yoke of the transformer such that a cooling flow in an axial direction through the first magnetic shielding component in an area of the outer windings of the transformer is provided.

[0032] Such a second recess may provide for a better oil circulation, a better cooling of the clamp and the oil, and a shield material reduction.

[0033] According to an embodiment of the invention, there may be extensions at the second recess to improve the oil circulation and the cooling of the windings.

[0034] According to an embodiment of the invention,

the second recess may have a circular, a rectangular, and a polygonal form, or a combination thereof.

[0035] According to an embodiment of the invention, the first magnetic shielding component comprises a third recess in a direction away from the core of the transformer in the direction opposite of the first recess such that a cooling flow in an axial direction through the first magnetic shielding component in an area outside of the windings of the transformer is provided.

[0036] According to an embodiment of the invention, there may be extensions at the third recess to improve the oil circulation and the cooling of the windings.

[0037] According to an embodiment of the invention, the third recess may have a circular, a rectangular, or a polygonal form, or a combination thereof.

[0038] According to an embodiment of the invention, the first magnetic shielding component is essentially planar.

[0039] According to an embodiment of the invention, a planar first magnetic shielding component may have a form of a plate.

[0040] According to an embodiment of the invention, the plates may have a shape selected from the group comprising a rectangular, a polygonal, a circular, and a semi-circular shape, or a combination thereof.

[0041] According to an embodiment of the invention, the first magnetic shielding component further comprises an extension that is arranged at the first magnetic shielding component at the frame of the first recess in a direction towards the core of the transformer for arranging the first magnetic shielding component at the core of the transformer.

[0042] According to an embodiment of the invention, the extension extends at least partly in a first recess.

[0043] According to an embodiment of the invention, there may be more than one extension.

[0044] There may be four extensions arranged at the frame of the first recess of the first magnetic shielding component extending in a direction of the first recess at a blunt angle compared to the plane of the first magnetic shielding component or at a sharp angle to the core axis of the transformer.

[0045] According to an embodiment of the invention, the at least one recess is adapted for reducing eddy currents in the clamps that occur during operation of the transformer.

[0046] According to an embodiment of the invention, the first magnetic shielding component comprises extensions in a direction parallel to a core of the transformer covering at least a part of the windings of the transformer such that the first magnetic shielding component has a trough-like form for redirecting the magnetic stray flux caused by the windings of the transformer during operation of the transformer.

[0047] According to another embodiment of the invention, the first magnetic shielding component is formed by a plurality of separate magnetic shielding elements such that a ring shaped first magnetic shielding component is provided.

[0048] According to an embodiment of the invention, the magnetic shielding elements forming the first magnetic shielding component have a form selected from the group consisting of a rectangular frame, a circular frame, a polygonal frame, a semi-circular frame with an inner first radius and an outer second radius, a rectangular form, a circular form, a polygonal form, an L-form, a U-form, or may have the form of a shielding box surrounding the transformer.

[0049] According to an embodiment of the invention, the first magnetic shielding component comprises a magnetically high-permeable and electrically low-conductive material.

[0050] Such a first magnetic shielding component may be constructed from rolled and pressed oxidized films of high-permeable iron, whose laminations are pressed parallel to the magnetic stray flux of the core of the transformer.

[0051] The oxidation layers may prevent the conduction of electric currents in the direction of the induced eddy currents achieving the required non-conductive property.

[0052] According to an embodiment of the invention, the first magnetic shielding component comprises an electrically high-conducting and non-magnetic material such as copper or aluminium, a laminated core steel such as silicon core steel and amorphous core steel, and ferrite material.

[0053] According to an embodiment of the invention, the transformer is a power transformer. Such a magnetic shielding arrangement of a power transformer may provide for a protection of the clamps, reduce the eddy current losses in the clamps, and leave enough space for the flow of oil, thereby providing the necessary cooling.

[0054] According to an embodiment of the invention, the transformer is a dry transformer.

[0055] According to an embodiment of the invention, the magnetic shielding component is adapted for a transformer according to any one of the preceding exemplary embodiments.

[0056] According to an embodiment of the invention, a method of reducing the magnetic stray field caused by windings of a transformer during operation is provided with the step of shielding the magnetic stray field by a magnetic shielding arrangement. The first magnetic shielding component of the magnetic shielding arrangement is arranged in a first end region of the windings of the transformer.

[0057] According to an embodiment of the invention, the use of a magnetic shielding arrangement for reducing the magnetic stray field of a transformer and/or a power transformer caused by the windings of a dry transformer and/or the power transformer during operation is provided.

[0058] These and other aspects of the present invention will become apparent from and elucidated with reference to the embodiments described hereafter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0059] 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. 1 schematically shows a perspective view of a dry transformer with a magnetic shielding arrangement for magnetic shielding of the transformer according to one embodiment of the invention.

Fig. 2A schematically shows a perspective view of a magnetic shielding component for magnetic shielding of a transformer according to another embodiment of the invention.

Fig. 2B schematically shows a perspective view of a magnetic shielding component with extensions for magnetic shielding of a transformer according to another embodiment of the invention.

Fig. 3A schematically shows a perspective view of a magnetic shielding component composed of several bodies with extensions for magnetic shielding of a transformer according to another embodiment of the invention.

Fig. 3B schematically shows a perspective view of a magnetic shielding component with an extension composed of several bodies with extensions for magnetic shielding of a transformer according to another embodiment of the invention.

Fig. 3C schematically shows a perspective view of a magnetic shielding component with an extension composed of several bodies with extensions and slots for magnetic shielding of a transformer according to another embodiment of the invention.

Fig. 4 schematically shows a perspective view of a transformer with a magnetic shielding arrangement comprising a plate alongside the transformer for magnetic shielding according to another embodiment of the invention.

Fig. 5A schematically shows a cross-sectional view of a shielding wall with two layers for magnetic shielding of a transformer according to another embodiment of the invention.

Fig. 5B schematically shows a cross-sectional view of a shielding wall with several layers for magnetic shielding of a transformer according to another embodiment of the invention.

Fig. 6A schematically shows a cross-sectional view of a frame concept of a magnetic shielding arrangement for magnetic shielding of a transformer according to another embodiment of the invention.

Fig. 6B schematically shows a cross-sectional view of a frame concept with a horizontal traverse of a magnetic shielding arrangement for magnetic shielding of a transformer according to another embodiment of the invention.

Fig. 6C schematically shows a cross-sectional view of a frame concept with a horizontal and a vertical traverse of a magnetic shielding arrangement for magnetic shielding of a transformer according to another embodiment of the invention.

Fig. 6D schematically shows a cross-sectional view of a frame concept with three horizontal and three vertical traverses of a magnetic shielding arrangement for magnetic shielding of a transformer according to another embodiment of the invention.

Fig. 7 schematically shows a perspective view of a part of a three-phase transformer.

Fig. 8A schematically shows a perspective view of the part of a three-phase transformer of Fig. 7 with a magnetic shielding arrangement according to an embodiment of the invention.

Fig. 8B schematically shows a cross-sectional view of one core of the transformer according to Fig. 8A.

Fig. 9A schematically shows a perspective view of the part of a three-phase transformer of Fig. 7 with a magnetic shielding arrangement according to an embodiment of the invention.

Fig. 9B schematically shows a cross-sectional view of one core of the transformer according to Fig. 9A.

Fig. 10A schematically shows a perspective view of the part of a three-phase transformer of Fig. 7 with a magnetic shielding arrangement according to an embodiment of the invention.

Fig. 10B schematically shows a cross-sectional view of one core of the transformer according to Fig. 10A.

Fig. 11A schematically shows a perspective view of the part of a three-phase transformer of Fig. 7 with a magnetic shielding arrangement according to an embodiment of the invention.

Fig. 11B schematically shows a cross-sectional view of one core of the transformer according to Fig. 11A.

Fig. 12A schematically shows a perspective view of the part of a three-phase transformer of Fig. 7 with

a magnetic shielding arrangement according to an embodiment of the invention.

Fig. 12B schematically shows a cross-sectional view of one core of the transformer according to Fig. 12A.

[0060] The reference signs used in the drawings, and their meanings, are listed in summary form and a list of reference signs. In principle, identical parts are provided with the same reference signs in the figures.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0061] Fig. 1 depicts a transformer 100 comprising a magnetic shielding arrangement 101 with a first magnetic shielding component 102 and a second magnetic shielding component 103.

[0062] The first magnetic shielding component 102 is arranged in a first end region 104 of windings 106 of the transformer 100 and the second magnetic shielding component 103 is arranged at a second end region 105 of windings 106 of the transformer 100 such that a magnetic stray field and/or stray losses caused by the windings 106 of the transformer 100 during operation of the transformer 100 is reduced. The edges of the first magnetic shielding component 102 and the second magnetic shielding component 103 are rounded.

[0063] Fig. 2A schematically depicts a first magnetic shielding component 102 or a second magnetic shielding component 103 with rounded edges being essentially planar, with a recess 201 essentially in the middle of the planar first or second magnetic shielding component 102, 103.

[0064] Fig. 2B depicts the first or second magnetic shielding component 102, 103 of Fig. 2A with extensions 202, 203 being arranged at the first or second magnetic shielding component 102, 103 at a frame of the first recess 201 in an upright position, possibly in a direction towards the core of a transformer, when the first or second magnetic shielding component 102, 103 is installed.

[0065] The extensions 202, 203 may extend in a direction of the first recess 201 at a blunt angle compared to the plane of the first or second magnetic shielding component 102, 103 or at a sharp angle to a core axis of a transformer. The recess 201 of the first or second magnetic shielding component 102, 103 may fit to a core of a transformer.

[0066] Fig. 3A schematically depicts the first or second magnetic shielding component 102, 103 with extensions 202, 203 according to Fig. 2B, with the difference that the first or second magnetic shielding component 102, 103 is splitted into several magnetic shielding elements 301, 302, 303 forming the first or second magnetic shielding component 102, 103. In this way the circulation of the cooling fluid between the shielding elements 301, 302, 303 is provided and the cooling flux in axial direction of the the core limbs 402 is improved.

[0067] Fig. 3B schematically shows the first or second magnetic shielding component 102, 103 according to Fig. 3A with the difference, that each magnetic shielding element 301, 302, 303 comprises an extension 305 in a direction parallel to a core limb axis of a transformer fitting through the recess 201. The extensions 305 are adapted to cover at least a part of the windings of the transformer such that the first or second magnetic shielding component 102, 103 has a trough-like form for deflecting magnetic stray flux caused by the windings of the transformer during operation of the transformer.

[0068] Fig. 3C schematically shows the first or second magnetic shielding component 102, 103 of Fig. 3B, with the difference each magnetic shielding element 301, 302, 303 comprises a slot-like second recess 304 in parallel to the first recess 201.

[0069] Fig. 4 schematically shows a perspective view of a transformer 100 with a magnetic shielding arrangement 101 comprising a first magnetic shielding component 102 being arranged at a first end region 104 of the windings 106 of the transformer and a shield/wall 401 arranged at one side of the transformer 100 parallel to the core limbs 402 of the transformer. The magnetic shielding component 102 and the shield/wall 401 which may comprise a high-permeable plate 401 reducing a magnetic stray field and/or stray losses caused by the windings 106 of the transformer 100 during operation of the transformer 100. The magnetic shielding arrangement 101 may also have the form of a shielding box comprising a plurality of shields/walls 401 surrounding the whole transformer 100. There may be up to six shields/walls 401 positioned at all sides of the transformer 100.

[0070] Fig. 5A schematically shows a cross-sectional view of the shield 401 of Fig. 4 comprising a layered plate 501 comprising layers 502, 503 which may comprise laminated material possibly having different lamination directions. The layered plate 501 may comprise materials selected from the group comprising high-permeable and electrically low-conductive material, laminated core steel, such as silicon core steel and amorphous core steel, and ferrite material, and electrically high-conductive and non-magnetic material.

[0071] The first layer 502 can comprise high-permeable material. The second layer 503 can comprise electrically high-conductive material. There may be gaps which may be air-filled in-between the first and the second layers 502, 503.

[0072] Fig. 5B schematically shows several layered plates 501 according to Fig. 5A forming a shield 401.

[0073] Fig. 6A schematically shows a frame build 601 of shields according to Fig. 5A or Fig. 5B for magnetic shielding of a transformer, comprising one frame.

[0074] Fig. 6B shows the frame build 601 of Fig. 6A with a horizontal traverse 602 in the middle of the frame.

[0075] Fig. 6C shows the frame build 601 of Fig. 6B added by a vertical traverse 602.

[0076] Fig. 6D schematically shows the frame build of Fig. 6A with three vertical traverses 602 and three hori-

zontal traverses 602 in equi-spaced distances arranged inside the frame build 601.

[0077] Fig. 7 schematically shows a perspective view of a part of a transformer 100 with three phases with three core limbs 402 possibly surrounded by regulation windings 800, low-voltage windings 801 and high-voltage windings 802 in order to efficiently energize the core limbs 402 and establish the magnetic coupling essential for the transformer's functioning. Due to imperfections in the interaction between the windings 800, 801, 802 and the core limbs 402 a certain level of stray flux is always present penetrating the structural components of the transformer such as the core clamps 701 which press the core laminations in order to ensure the core's stability. A yoke 702 is connecting the core limbs 402.

[0078] Fig. 8A shows the transformer of Fig. 7 with the difference, that a first or second magnetic shielding component 102, 103 is provided comprising three separate magnetic shielding elements 301, 302, 303, wherein the magnetic shielding elements 301, 302, 303 are arranged between the windings 800, 801, 802 and the clamp 701.

[0079] Fig. 8B schematically shows a cross-section of one core limb 402 of the transformer 100 of Fig. 8A with windings 800, 801, 802 surrounding the core limb 402. The first or second magnetic shielding component 102, 103 comprises of a first magnetic shielding element 804 and a second magnetic shielding elements 805, each magnetic shielding element 804, 805 comprising a recess 201 with an extension 803.

[0080] Fig. 9A schematically shows a perspective view of the transformer 100 of Fig. 8A, with the difference, that the first or second magnetic shielding component 102, 103 comprises three separate magnetic shielding elements 301, 302, 303, each comprising a first magnetic shielding element 804 and a second magnetic shielding element 805 and a first, second and third recess 201, 901, 904 with extensions 803, 902. The second and the third recess 901, 904 of the neighbouring shielding components 102, 103 provide a cooling flux between neighbouring coils of the transformer 100 in axial direction of the core limb 402.

[0081] Fig. 9B schematically shows a cross-sectional view of one of the core limbs 402 of Fig. 9A, wherein each of the first and second magnetic shielding elements 804, 805 comprises a first recess 201 and three extensions 803 to fit the first and second magnetic shielding elements 804, 805 to the core limb 402 of the transformer. The magnetic shielding component, respectively the magnetic shielding elements 804, 805 further comprise a second recess 901 in a direction parallel to the yoke 702 comprising three extensions 902.

[0082] The first or second magnetic shielding component 102, 103 and respectively each magnetic shielding elements 804, 805, further comprises a third recess 904 in a direction away from the core limb 402 of the transformer 100 in a direction opposite to the first recess 201.

[0083] Fig. 10A schematically shows a perspective view of the transformer 100 of Fig. 9A with a different geometric form of the first and second magnetic shielding elements 804, 805.

[0084] Fig. 10B schematically shows a cross-section of one core limb 402 of the transformer according to Fig. 10A, each magnetic shielding element 804, 805 having a first recess 201 with an extension 803, and a second recess 901 with three extensions 902 in the same directions as depicted in Fig. 9B but with a different geometry concerning the recesses 201, 901 and the extensions 803, 902.

[0085] Fig. 11A schematically shows a perspective view of the transformer 100 of Fig. 9A with a different geometric form of the first and second magnetic shielding elements 804, 805.

[0086] Fig. 11B schematically shows a cross-section of one core limb 402 of the transformer according to Fig. 11A, each magnetic shielding element 804, 805 comprising a first recess 201 with an extension 803 and a second recess 901 with three extensions 902 according to Fig. 10B, but with a different geometry concerning the first recess 201 and the second recess 901 compared to the geometry of Fig. 10B.

[0087] Fig. 12A schematically shows a perspective view of the transformer 100 of Fig. 7, with the difference, that a first or second magnetic shielding component 102, 103 with separate magnetic shielding elements 301, 302, 303 is provided, wherein each magnetic shielding element 301, 302, 303 is arranged between the clamps 701 and the windings 801, 802, 803 surrounding the core limbs 402 of the transformer. Each of the plurality of magnetic shielding elements 301 has a semi-circular shape, being arranged between the regulation windings 800 and part of the high-voltage windings 802 of each core limb 402 of a transformer 100.

[0088] Fig. 12B schematically shows a cross-section of one core limb 402 of the transformer 100 with one magnetic shielding element 301, 302, 303 according to Fig. 12A.

[0089] While the invention has been illustrated and described in detail in the drawings in the foregoing description, such illustration and description are to be considered illustrative or exemplary and not restrictive; the invention is not limited to the disclosed embodiments.

[0090] Other variations of the disclosed embodiments may be understood and effected by those skilled in the art and practicing the claimed invention, from a study of the drawings, the disclosure, and the appended claims.

[0091] In the claims, the words "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" do not exclude a plurality. A single transformer or a single magnetic shielding component may fulfil the function 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

[0092]

100	transformer
101	magnetic shielding arrangement, at least one magnetic shielding arrangement
102	first magnetic shielding component
103	second magnetic shielding component
104	first end region
105	second end region
106	winding(s)
201	first recess, at least one recess
202	extension
203	extension
301	magnetic shielding element
302	magnetic shielding element
303	magnetic shielding element
304	second recess, at least one recess, slot(s)
401	shield/wall/high-permeable plate
402	core limb of a transformer, core limb
501	layered plate
502	first layer
503	second layer
601	frame build
602	traverse, vertical traverse, horizontal traverse
701	core clamp, clamp
702	yoke
800	regulation winding
801	low-voltage winding
802	high-voltage winding
803	extension
804	first magnetic shielding element
805	second magnetic shielding element
901	second recess, at least one recess
902	extension
904	third recess, at least one recess

Claims

1. A transformer (100) comprising at least one magnetic shielding arrangement (101), the shielding arrangement (101)comprising:

a first magnetic shielding component (102);
wherein the first magnetic shielding component (102) is arranged at a first end region (104) of windings (106) of the transformer (100) such that a magnetic stray field caused by the windings (106) of the transformer (100) during operation of the transformer (100) is reduced;
wherein the first magnetic shielding component (102) comprises at least one recess (201, 901, 904, 304) adapted for cooling the transformer.

2. The transformer (100) of claim 1, wherein the magnetic shielding arrangement (101) further comprises:

a second magnetic shielding component (103);
wherein the second magnetic shielding component (103) is arranged at a second end region (105) of the windings (106) of the transformer (100).

3. The transformer (100) of anyone of the preceding claims,
wherein the first magnetic shielding component (102) is arranged between the windings (106) and a core clamp (701) supporting a yoke (702) of the transformer (100) for protecting the core clamp (701) from a magnetic stray field caused by windings (106) of the transformer (100) during operation.

4. The transformer (100) of anyone of the preceding claims,
wherein the first magnetic shielding component (102) comprises a first recess (201) to fit the first magnetic shielding component (102) to a core limb (402) of the transformer (100) such that part of a cross-sectional area of a winding of the transformer (100) perpendicular to an axial direction of the core limb (402) is not covered by the first magnetic shielding component (102) such that a cooling flow in the axial direction and through the first magnetic shielding component (102) is provided.

5. The transformer (100) of anyone of the preceding claims,
wherein the first magnetic shielding component (102) comprises a second recess (901, 304) in a direction parallel to a yoke (702) of the transformer (100) such that a cooling flow in an axial direction through the first magnetic shielding component (102) in an area of the outer windings of the transformer (100) is provided.

6. The transformer (100) of anyone of the preceding claims,
wherein the first magnetic shielding component (102) comprises a third recess (904) in a direction away from the core of the transformer (100) in a direction opposite of the first recess (201) such that a cooling flow in an axial direction through the first magnetic shielding component (102) in an area outside of the windings of the transformer (100) is provided.

7. The transformer (100) of anyone of the preceding claims,
wherein the first magnetic shielding component (102) is essentially planar.

8. The transformer (100) of anyone of claims 4 to 7,
wherein the first magnetic shielding component (102) further comprises an extension (202, 203) that is arranged at the first magnetic shielding component (102) at the frame of the first recess (201) in a direction towards the core limb (402) of the transformer (100) for arranging the first magnetic shielding component (102) at the core of the transformer (100).

9. The transformer (100) of anyone of the preceding claims,
wherein the at least one recess (201, 901, 904, 304) is adapted for reducing eddy currents in the clamps that occur during operation of the transformer (100).

10. The transformer (100) of anyone of the preceding claims,
wherein the first magnetic shielding component (102) comprises extensions (305) in a direction parallel to a core axis of the transformer (100) covering at least a part of the windings (106) of the transformer (100) such that the first magnetic shielding component (102) has a trough-like form for deflecting the magnetic stray flux caused by the windings (106) of the transformer (100) during operation of the transformer (100).

11. The transformer (100) of anyone of the preceding claims,
wherein the first magnetic shielding component (102) is formed by a plurality of separate magnetic shielding elements (301, 302, 303) such that a ring shaped first magnetic shielding component (102) is provided.

12. The transformer (100) of anyone of the preceding claims,
wherein the first magnetic shielding component (102) comprises a magnetically high-permeable and a electrically low-conductive material.

13. The transformer (100) of anyone of the preceding claims,
wherein the transformer (100) is a power transformer (100).

14. The transformer (100) of anyone of the preceding claims,
wherein the transformer (100) is a dry transformer (100).

15. A magnetic shielding component (102, 103) adapted for a transformer (100) according to anyone of claims 1 to 14.

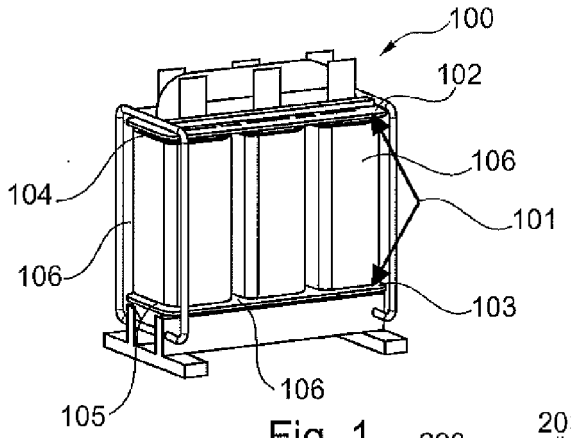

Fig. 1

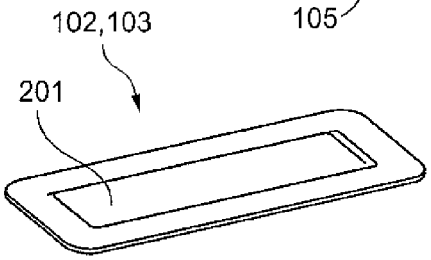

Fig. 2A

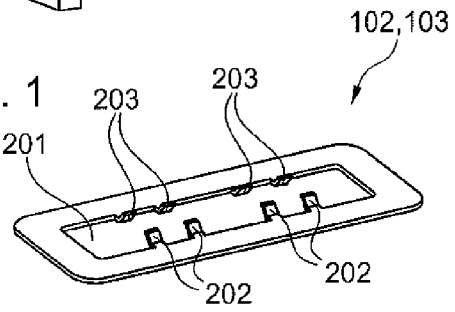

Fig. 2B

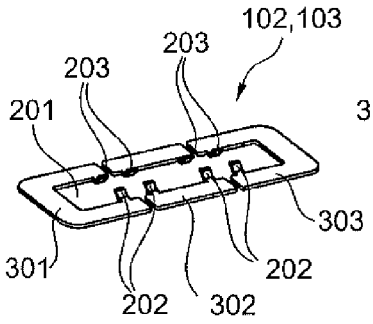

Fig. 3A

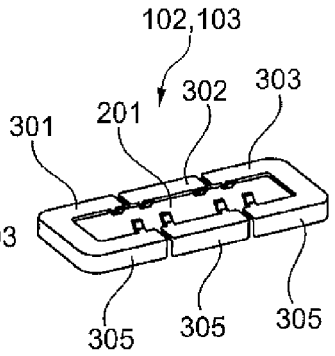

Fig. 3B

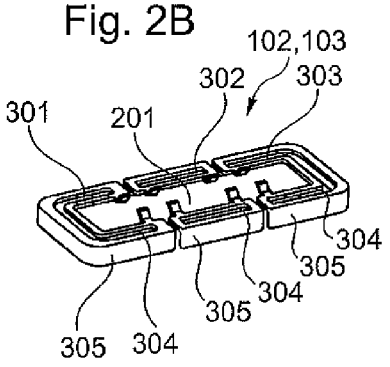

Fig. 3C

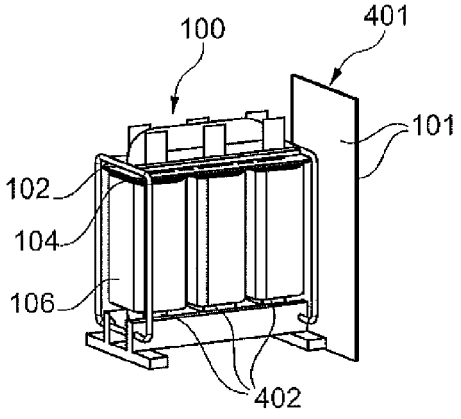

Fig. 4

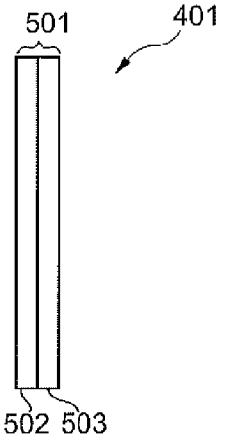

Fig. 5A

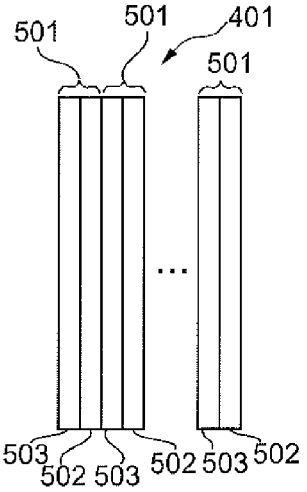

Fig. 5B

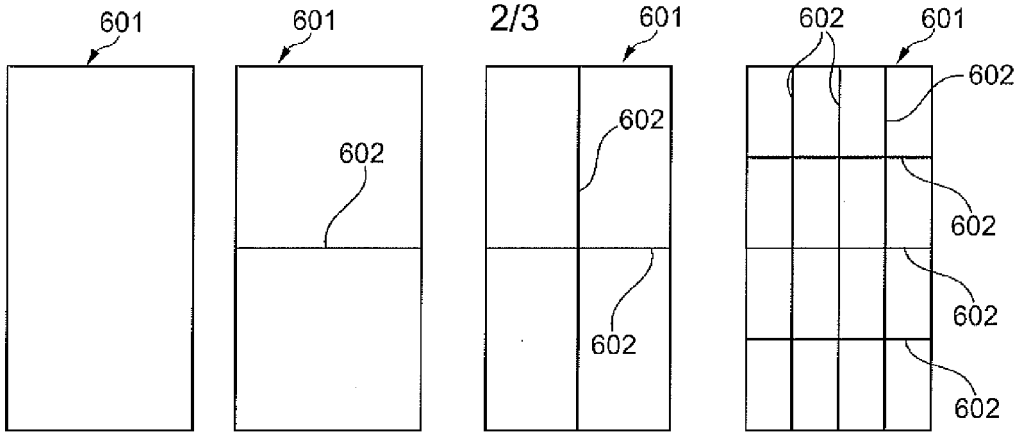

Fig. 6A Fig. 6B Fig. 6C Fig. 6D

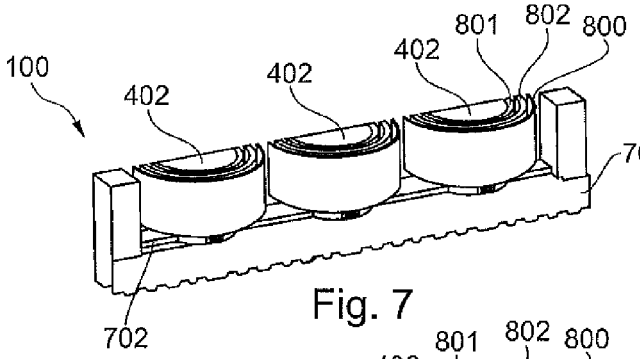

Fig. 7

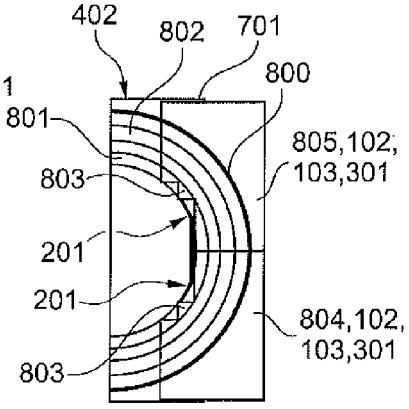

Fig. 8B

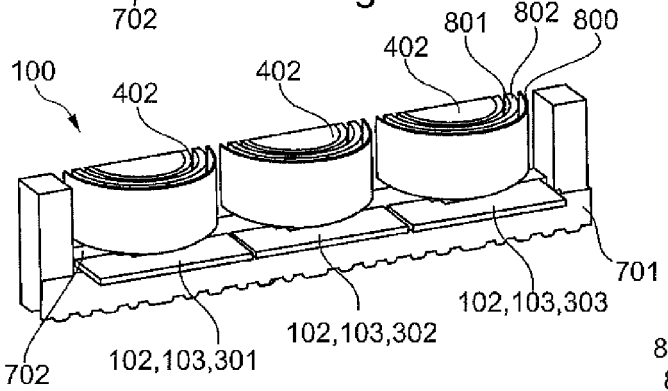

Fig. 8A

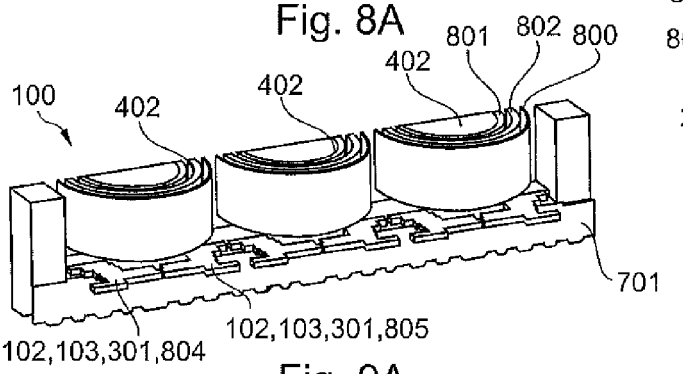

Fig. 9A

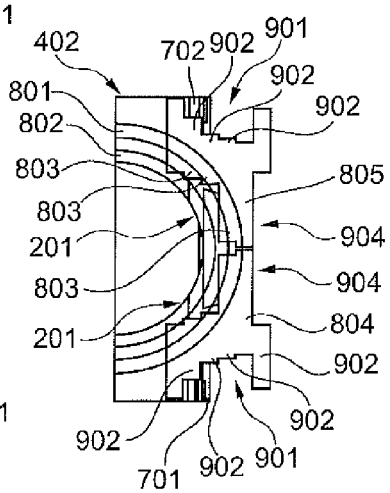

Fig. 9B

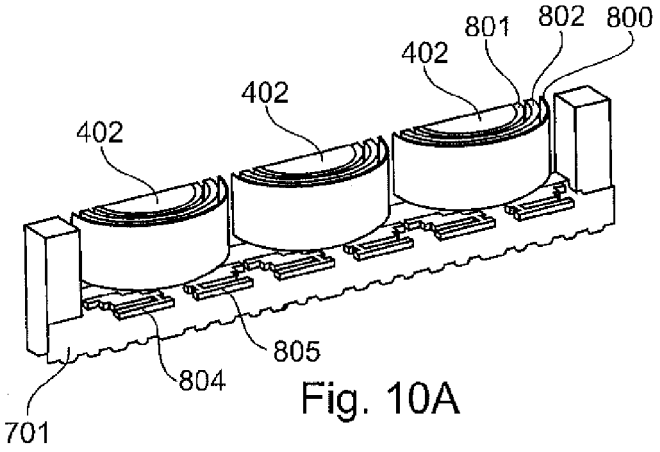

Fig. 10A

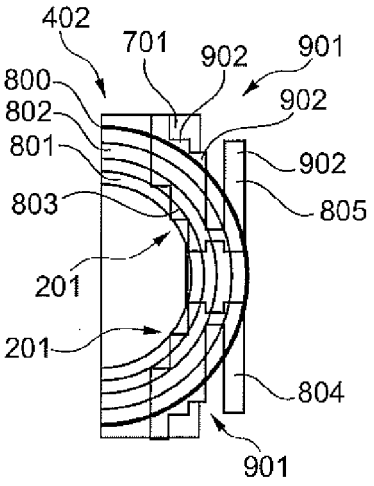

Fig. 10B

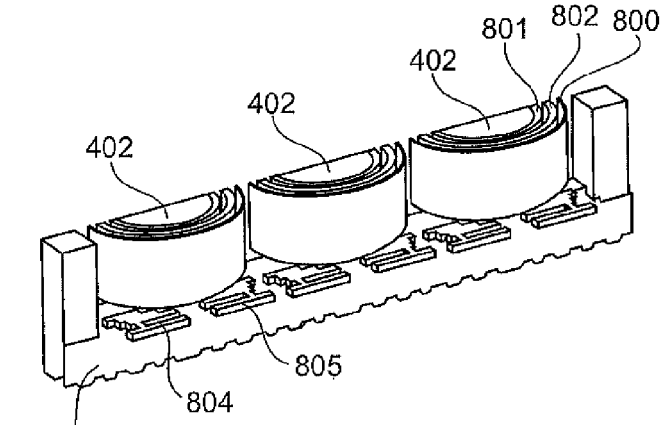

Fig. 11A

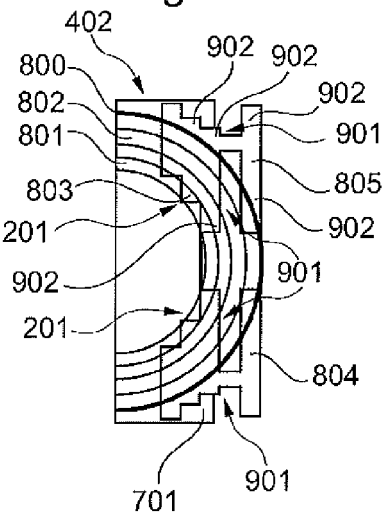

Fig. 11B

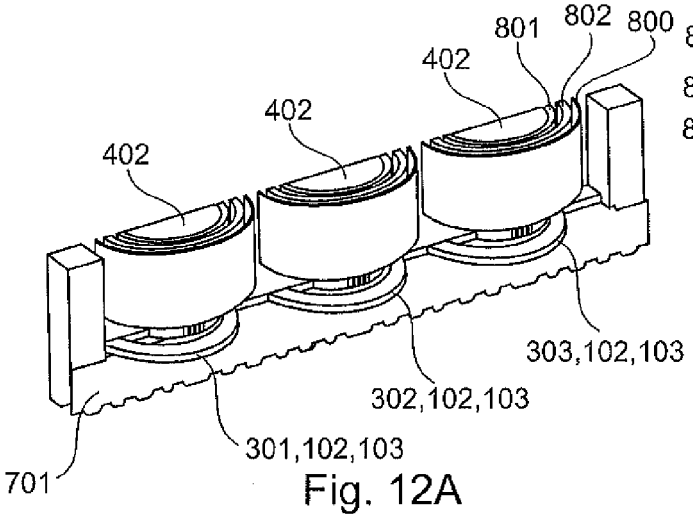

Fig. 12A

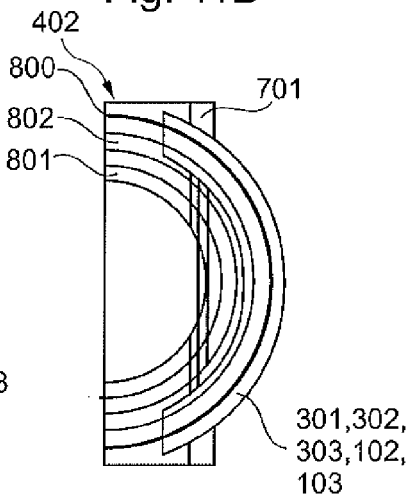

Fig. 12B

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EUROPEAN SEARCH REPORT

Application Number
EP 10 16 7494

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 57 152116 A (HITACHI LTD) 20 September 1982 (1982-09-20) * figures 1-5,8,9 * -----	1-15	INV. H01F27/36 H01F27/08
X	JP 56 032706 A (HITACHI LTD) 2 April 1981 (1981-04-02) * figures 1,2,4-6 * -----	1-15	
X	JP 60 098609 A (TOSHIBA KK) 1 June 1985 (1985-06-01) * figures 2-4 * -----	1-15	
X	JP 58 139415 A (HITACHI LTD) 18 August 1983 (1983-08-18) * figures 1,3,5,6 * -----	1-15	
			TECHNICAL FIELDS SEARCHED (IPC)
			H01F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	3 December 2010	Teske, Ekkehard

CATEGORY OF CITED DOCUMENTS

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EPO FORM 1503 03.82 (P04C01)

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03-12-2010

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- DE 4432739 B4 **[0006]**