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(54) **Transformer with shielded yoke**

(57) The invention relates to the electric shielding of yokes of a transformer, and in particular to a yoke and electric shielding arrangement for a transformer and a transformer with the arrangement.

An electric shielding arrangement for a transformer is provided with a yoke (109, 301) for connecting limbs (113) of the transformer (101) and an electric shielding device (112, 301). The electric shielding device (112, 302) is arranged at the yoke (109, 301) between the yoke (109, 301) and a winding (103) of the transformer (101). The first electric shielding device (112, 302) may be a rounded cover (112, 302) and is adapted for shielding the yoke (109, 301) from an electric field of the winding (103) thus smoothing an electric field.

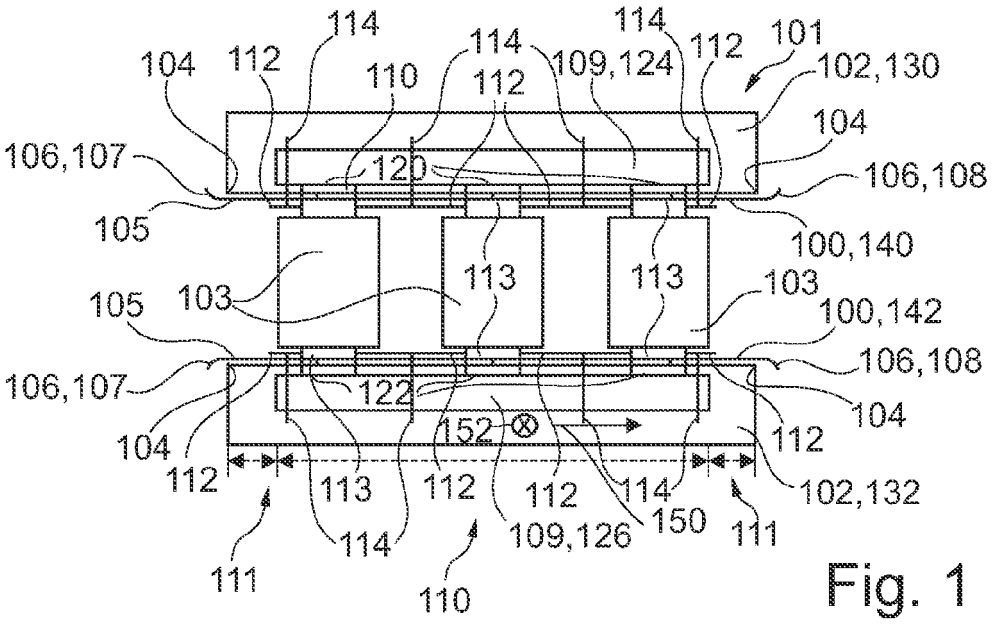

Fig. 1

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Description

FIELD OF THE INVENTION

[0001] The invention relates to electric shielding of yokes of transformers. In particular, the invention relates to an electric shielding arrangement for a transformer and a transformer comprising the arrangement.

BACKGROUND OF THE INVENTION

[0002] Transformers may be widely used for low, medium, and high voltage applications.

[0003] Typically, in dry type transformers, the insulation of yokes is made by an insulation film on the yoke without static shielding. A high voltage to yoke insulation is achieved by an airspace between the high voltage surrounded by solid insulation (e.g. casted) and the yoke surface being bare or insulated by some films.

[0004] The patent application CN-20132312-Y shows a transformer having an iron core provided with a transformer coil at the outer side, and shielded layers arranged between a secondary coil and the iron core and between a secondary coil and a primary coil.

SUMMARY OF THE INVENTION

[0005] It may be seen as an object of the invention to increase the dielectric strength of a transformer.

[0006] This object is achieved by an electric shielding device arrangement and by a transformer comprising the arrangement according to the independent claims. Further embodiments are evident from the dependent claims.

[0007] According to one embodiment of the invention an electric shielding arrangement for a transformer is provided with a yoke for connecting limbs of the transformer and an electric shielding device. The electric shielding device is arranged at the yoke between the yoke and a winding of the transformer. The electric shielding device is adapted for shielding the yoke from an electric field of the winding.

[0008] In other words, a cover may be arranged at the yoke facing the windings of the transformer and thereby shielding the yoke from an electric field of the windings. The electric shielding device may act as an electrostatic shield or as a protective shield in order to shield the sharp edges of the yoke itself and all other edges related to the yoke such as edges of yoke laminations, so smoothing the electric field of the transformer with respect to the yoke. This shielding cover is kept bare, not covered by any insulation film. The shielding cover may be insulated according to another embodiment of the invention. The yoke is adapted for connecting at least two limbs. More than one yoke may be provided. The winding may be arranged around at least one of the at least two limbs. The above and below mentioned electric shielding arrangement is applicable to dry transformers with a voltage level above 70kV effectively shielding the yoke of the dry transformer from the electric field generated by the winding of the dry transformer. Thus a dry transformer with HV winding designed as HV disc winding with a voltage level of 70kV and above may be built as compact as a dry transformer with a lower voltage level. There may be higher field strength in the critical region between the HV winding and the yoke and particularly higher field peaks at the HV disc winding and the edges of the yoke compared to a dry transformer with a voltage level below 70 kV requiring a higher dielectric strength. This required higher dielectric strength may be provided by the electric shielding device or electric shielding devices which may homogenize the electric field to the ground by a multipart shielding of the yoke. Thus the yoke is prevented from overheating or losing its required mechanical strength due to discharges of the electric field to the edges of the yoke by the electric shielding device.

[0009] The electric shielding device may increase the breakdown voltage and may lead to an improvement of shielding between winding of the transformer coil and the yoke compared to a yoke without an electric shielding device.

[0010] According to another embodiment of the invention the electric shielding device is adapted to shield the yoke from a winding of the transformer, when the arrangement is mounted to the transformer, thus smoothing an electric field between the winding and the yoke of the transformer.

[0011] According to another embodiment of the invention the electric shielding device has a shape corresponding to the shape of the yoke such that the yoke is covered by the electric shielding device. The shape may be partly cylindrical or oval layer like or may be any shape which is adjusted to the edges.

[0012] According to another embodiment of the invention the electric shielding device comprises a layer shape adapted to avoid sharp edges.

[0013] According to another embodiment of the invention the electric shielding device comprises a conductive material.

[0014] According to another embodiment of the invention the electric shielding device comprises a thin rectangular piece of one of aluminium and copper and may be ground connected. According to another embodiment of the invention the electric shielding device is connected to the metallic structure of the transformer (the clamps).

[0015] The electric shielding device may comprise a mixture of aluminium and copper. The electric shielding device may comprise any other conductive material such as carbon steel or non-magnetic steel, and/or may comprise semiconductive material, since semiconductive material would also smooth the electric field.

[0016] According to another embodiment of the invention the electric shielding device covers edges of the transformer yoke which are caused by yoke laminations. The yoke laminations may be steel plates and may have a rectangular form or cross section or generally a polyg-

onal form or cross section. The electric shielding device may act as an electrostatic shield or as a protective shield in order to shield the (sharp) edges of yoke laminations, so smoothing the electric field of the transformer with respect to the yoke.

[0017] According to another embodiment of the invention a ground connecting device is provided which is adapted to ground connect the electric shielding device to ground potential. The ground connection device may comprise a first and a second ground connecting part as mentioned below.

[0018] Such a grounding of the electric shielding device by a ground connecting device to ground potential may provide for the yoke being free of an electric field of the windings with essentially no electric potential. The electric shielding device has the electric potential and is affected by the electric field of the winding and not the yoke. The ground connecting device may be a copper strip.

[0019] According to another embodiment of the invention the ground connecting device is covered or shielded by the electric shielding device.

[0020] According to another embodiment of the invention an insulation material is provided, the insulation material covering the electric shielding device for increasing the dielectric stability of the transformer.

[0021] Due to the insulation material a short circuit between the yoke steel plate that would lead to higher core losses may be avoided. The cover of the electric shielding device with an insulation material such as an insulating film may increase the electrical field that the electric shielding device may withstand without the development of a discharge. The insulating film may be a semitransparent insulating film. The insulating film may be one of a polyester film and a fiberglass film.

[0022] According to another embodiment of the invention a dielectric shielding of the yoke from an electric field of the winding is provided by the electric shielding device, which may be a copper sheet or copper foil, and/or an insulating layer applied at the yoke, the insulating layer possibly having a high epsilon, for example an epsilon of 10. Thus the electric field at the yoke may be smoothed.

[0023] According to another embodiment of the invention the yoke is a split yoke, comprising a first yoke part and a second yoke part, wherein the electric shielding device comprises a first electric shielding element and a second electric shielding element. The first electric shielding element is arranged at the first yoke part between the first yoke part and the winding of the transformer. The second electric shielding element is arranged at the second yoke part between the second yoke part and the winding of the transformer. The first electric shielding element is adapted for shielding the first yoke part from an electric field of the winding, and the second electric shielding element is adapted for shielding the second yoke part from an electric field of the winding.

[0024] In other words a yoke may be split in two halves, a first yoke part, and a second yoke part. A first and second electric shielding element, possibly in form of covers, may be arranged at the first and second yoke parts facing the windings of the transformer and thereby shielding the first and second yoke parts from an electric field of the windings. The first and second electric shielding elements may act as electrostatic shields or as protective shields in order to shield the sharp edges of the first and second yoke parts themselves and all other edges related to the first and second yoke parts such as edges of first and second yoke laminations, so smoothing the electric field of the transformer with respect to the first and second yoke parts. This shielding covers may be kept bare, not covered by any insulation film. The shielding covers may be insulated according to another embodiment of the invention. The first and second yoke parts are adapted for connecting at least two limbs. More than one first and second yoke parts may be provided. The winding may be arranged around at least one of the at least two limbs.

[0025] The above and below mentioned electric shielding arrangement is adapted to effectively shield the first and second yoke parts of a dry transformer (possibly a dry transformer with a voltage level above 70 kV) from the electric field generated by the winding of the dry transformer. Thus a dry transformer with HV winding designed as HV disc winding with a voltage level of 70kV and above may be built as compact as a dry transformer with a lower voltage level. There may be higher field strength in the critical region between the HV winding and the first and second yoke part and particularly higher field peaks at the HV disc winding and the edges of the first and second yoke parts compared to a dry transformer with a voltage level below 70 kV requiring a higher dielectric strength. This required higher dielectric strength may be provided by the first and second electric shielding elements which may homogenize the electric field to the ground by a multi-part shielding of the first and second yoke parts and may at the same time provide for an efficient cooling by cooling ducts in between the two halves of the split yoke. Thus the first and second yoke part is prevented from overheating or losing its required mechanical strength due to discharges of the electric field to the edges of the first and second yoke parts by the electric shielding elements.

[0026] The first and/or second electric shielding elements may comprise a mixture of aluminium and copper. The first and/or second electric shielding elements may comprise any other conductive material such as carbon steel or non-magnetic steel, and/or may comprise semiconductive material, since semiconductive material would also smooth the electric field.

[0027] The first and second electric shielding elements may increase the breakdown voltage and may lead to an improvement of shielding between winding of the transformer coil and the first and second yoke parts compared to first and second yoke parts without electric shielding elements.

[0028] According to another embodiment of the inven-

tion the first and/or second electric shielding elements are adapted to shield the first and/or second yoke parts from a winding of the transformer, when the arrangement is mounted to the transformer, thus smoothing an electric field between the winding and the first and/or second yoke parts of the transformer.

[0029] According to another embodiment of the invention the first and/or second electric shielding elements have a shape corresponding to the shape of the first and/or second yoke parts such that the first and/or second yoke parts are covered by the first and/or second electric shielding elements. The shape may be partly cylindrical or oval layer like or may be any shape which is adjusted to the first and/or second edges.

[0030] According to another embodiment of the invention the first and/ or second electric shielding elements comprise a layer shape adapted to avoid sharp edges.

[0031] According to another embodiment of the invention the first and/or second electric shielding elements comprise a conductive material.

[0032] According to another embodiment of the invention the first and/or second electric shielding elements comprise a thin rectangular piece of one of aluminum and copper and may be ground connected. According to another embodiment of the invention the first and/or second electric shielding elements are connected to the metallic structure of the transformer (the clamps).

[0033] The first and/or second electric shielding elements may comprise a mixture of aluminium and copper. The first and/or second electric shielding elements may comprise any other conductive material such as carbon steel or non-magnetic steel, and/or may comprise semiconductive material, since semiconductive material would also smooth the electric field.

[0034] A yoke cooling duct may be present between the first and the second yoke part for cooling the transformer by cooling agents such as oil or air or water. According to an exemplary embodiment of the invention the cooling agent is air.

[0035] According to another embodiment of the invention the arrangement may comprise more than one yoke cooling duct, more than one yoke, and more than one electric shielding device each being arranged at a yoke between the yoke and the winding of the transformer.

[0036] According to another embodiment of the invention the first yoke part comprises first yoke laminations which form first edges of the first yoke part, wherein the first electric shielding element is covering the first edges. The second yoke part comprises second yoke laminations which form second edges of the second yoke part, wherein the second electric shielding element is covering the second edges

[0037] The first and second yoke laminations may be steel plates and may have a rectangular form or cross section or generally a polygonal form or cross section. The first and second electric shielding elements may act as electrostatic shields or as protective shields in order to shield the (sharp) edges of first and second yoke laminations, so smoothing the electric field of the transformer with respect to the first and second yoke parts.

[0038] According to another embodiment of the invention the arrangement further comprises a first ground connecting part, which is adapted to ground connect the first electric shielding element to ground potential. According to another embodiment of the invention the first electric shielding element is connected to the transformer metallic structure, which is ground connected.

[0039] According to another embodiment of the invention the arrangement further comprises a second ground connecting part, which is adapted to ground connect the second electric shielding element to ground potential. According to another embodiment of the invention the second electric shielding element is connected to the transformer metallic structure, which is ground connected.

[0040] Such a grounding of the first and/or second electric shielding elements by a first and/or second ground connecting part of a ground connecting device to ground potential may provide for the first and/or second yoke part being free of an electric field of the windings with essentially no electric potential. The first and/or second electric shielding parts have the electric potential and are affected by the electric field of the winding and not the first and/or second yoke parts.

[0041] According to another embodiment of the invention the first and/or second ground connecting parts may be copper strips.

[0042] According to another embodiment of the invention the first and/or second ground connecting parts are covered or shielded by the first and/or second electric shielding elements.

[0043] According to another embodiment of the invention one of the first, second, or both electric shielding elements comprises an insulating material covering the first, second, or both electric shielding elements for increasing the dielectric stability of the transformer.

[0044] Due to the insulation material a short circuit between the first and/or second yoke part steel plate that would lead to higher core losses may be avoided. The cover of the first and/or second electric shielding element with a first and/or second insulation material such as an insulating film may increase the electrical field that the first and/or second electric shielding element may withstand without the development of a discharge. The insulating film may be a semitransparent insulating film. The insulating film may be one of a polyester film and a fiberglass film.

[0045] According to another embodiment of the invention a dielectric shielding of the first and/or second yoke part from an electric field of the winding is provided by the first and/or second electric shielding element, which may be a copper sheet or copper foil, and/or an insulating layer applied at the first and/or second yoke part, the insulating layer possibly having a high epsilon, for example an epsilon of 10. Thus the electric field at the first and/or second yoke part may be smoothed.

[0046] According to another embodiment of the inven-

tion a third electric shielding element is provided with a clamp attached at the yoke and stabilizing the yoke. The third electric shielding element is arranged at the clamp between the clamp and the winding of the transformer and is adapted for shielding the clamp from an electric field of the winding.

[0047] In other words, a cover may be placed on a clamp facing the winding, and the cover may act as an electrostatic shield or as a protective shield in order to shield the sharp edges of the clamp itself and all other metallic edges related to the clamp, so smoothing the electric field of the transformer with respect to the clamps. This shielding cover is kept bare, not covered by any insulation film. The shielding cover may be insulated according to another embodiment of the invention. The clamp is adapted for holding together or mechanically fixing or stabilizing a yoke of the transformer to the coil (s) of the transformer. The third electric shielding element may cover the clamp and/or may have a vat- or trough-like form covering the clamp.

[0048] The above mentioned third electric shielding element is applicable to dry transformers with a voltage level above 70kV effectively shielding the clamp of the dry transformer from the electric field generated by the winding of the dry transformer. Thus a dry transformer with HV winding designed as HV disc winding with a voltage level of 70kV and above may be built as compact as a dry transformer with a lower voltage level. There may be higher field strength in the critical region between the HV winding and the clamp and particularly higher field peaks at the HV disc winding and the edges of the clamp compared to a dry transformer with a voltage level below 70 kV requiring a higher dielectric strength. This required higher dielectric strength may be provided by the third electric shielding element which may homogenize the electric field to the ground such that the clamp is prevented from overheating or losing its required mechanical strength due to discharges of the electric field to the edges of the clamp by the third electric shielding element.

[0049] The third electric shielding element may comprise a material selected from the group consisting of steel, and aluminium, and generally any conducting material with stabilizing mechanical properties.

[0050] The third electric shielding element may increase the breakdown voltage and may lead to a 25% improvement of shielding between winding of the transformer coil and the clamps compared to clamps without a third electric shielding element according to impulse voltage tests.

[0051] The clamp may have rounded edges forming a rounded clamp that may have the function of the third electric shielding element, shielding the clamp from an electric field generated by the winding or windings of the transformer.

[0052] According to another embodiment of the invention the third electric shielding element comprises rounded edges.

[0053] Such a third electric shielding element with rounded edges may smooth an electric field of the winding of a transformer with respect to the transformer clamp by avoiding field peaks or discharges at edges of the clamp, thus preventing the clamp from overheating or losing its required mechanical strength.

[0054] According to another embodiment of the invention the first and/or second electric shielding element comprises a first electric shielding element part and a second electric shielding element part which are separate from each other.

[0055] According to another embodiment of the invention a transformer is provided comprising an arrangement of anyone of the above-mentioned embodiments, at least two limbs, a winding arranged around at least one of the at least two limbs, and a yoke connecting the at least two limbs.

[0056] Such a transformer with an electric shielding arrangement may effectively shield the yoke or the first and/or second yoke parts of a transformer from the electric field generated by the winding of the transformer. Thus for example a dry transformer with HV winding designed as HV disc winding with a voltage level of 70kV and above may be built as compact as a dry transformer with a lower voltage level. There may be higher field strength in the critical region between the HV winding and the yoke or first and/or second yoke parts and particularly higher field peaks at the HV disc winding and the edges of the yoke or first and/or yoke parts compared to a dry transformer with a voltage level below 70 kV requiring a higher dielectric strength. This required higher dielectric strength may be provided by the electric shielding device or the first and/or second electric shielding element which may homogenize the electric field to the ground such that the yoke or the first and/or second yoke part is prevented from overheating or losing its required mechanical strength due to discharges of the electric field to the edges of the yoke or first and/or second yoke part by the electric shielding device or first and/or second electric shielding element. The following embodiments may all have the above mentioned advantages compared to a transformer without the above and below mentioned electric shielding arrangement.

[0057] According to another embodiment of the invention a transformer is provided with the yoke being a split yoke with a first yoke part and a second yoke part as mentioned according to embodiments above. The transformer further comprises at least one cooling duct and at least one spacer. The at least one spacer is adapted for defining a space between the first yoke part and the second yoke part. The at least one cooling duct is defined by the space between the first yoke part and the second yoke part. The at least one spacer is adapted for pressing the first electric shielding element and the second electric shielding element both partly extending in the cooling duct to the first yoke part and to the second yoke part thus fastening the first and second electric shielding elements.

[0058] According to another embodiment of the inven-

tion the transformer may be a dry type transformer.

[0059] According to another embodiment of the invention the windings of the transformer are high voltage windings or low voltage windings. The transformer is adapted for electrically shielding the high voltage and/or low voltage windings from the yoke.

[0060] According to another embodiment of the invention the transformer is applicable at a 72.5 kV level and at a level above and/or below 72.5 kV level.

[0061] 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

[0062] 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 cross-sectional view of a transformer with an electric shielding arrangement for a transformer according to an embodiment of the invention.

Fig. 2 schematically shows a cross-sectional view of an electric shielding arrangement according to another embodiment of the invention.

Fig. 3 schematically shows a cross-sectional view of an electric shielding arrangement with a first yoke part and a second yoke part according to another embodiment of the invention.

Fig. 4 schematically shows a perspective view of part of a bottom yoke of a transformer with an electric shielding device arrangement and two yoke parts according to another embodiment of the invention.

Fig. 5 schematically shows a perspective view of a bottom yoke of a transformer with an electric shielding arrangement and two yoke parts according to another embodiment of the invention.

Fig. 6 schematically shows a perspective view of a part of an electric shielding arrangement for a transformer according to another embodiment of the invention.

[0063] The reference signs used in the drawings, and their meanings, are listed in summary form in a list of reference signs. In principle, identical parts are provided with the same reference signs in the figures.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0064] Fig. 1 schematically shows a cross-sectional view of an electric shielding arrangement for a transformer 101 with a yoke 109, 124, 126 connecting limbs 113 and an electric shielding device 112. The electric shielding device 112 is arranged at the yoke 109, 124, 126 covering the yoke 109 between the yoke 109 and a winding 103 of the transformer 101. The electric shielding device 112 is adapted for shielding the yoke 109, 124, 126 from an electric field of the winding 103.

[0065] The electric shielding device 112 may be a rounded cover or an electrostatic shield being placed onto the yoke 109, 124, 126 in an area facing the winding 103 of the transformer 101 and is adapted to shield the sharp edges of the yoke 109, 124, 126 and thus smoothing the electric field of the transformer 101. The electric shielding device 112 may be covered with an insulation film.

[0066] The electric shielding device 112 may be adapted to shield the yoke 109, 124, 126 from a winding 103 of the transformer 101, when the arrangement is mounted to the transformer 101, thus smoothing an electric field between the windings 103 and the yoke 109, 124, 126 of the transformer 101.

[0067] The electric shielding device 112 may have a cylindrical or an oval layer shape or a shape corresponding to the shape of the yoke 109, 124, 126 such that the yoke 109, 124, 126 is covered by the electric shielding device 112. The electric shielding device 112 may further comprise a layer shape adapted to avoid sharp edges.

[0068] The electric shielding device may have a conductive material and may be a thin rectangular piece of aluminium or copper or a mixture thereof or may have a semiconductive material, and may be ground connected by a ground connecting device 114.

[0069] The ground connecting device 114 is adapted to ground connect the electric shielding device 112 to ground potential.

[0070] The electric shielding device 112 may comprise an insulating film covering the electric shielding device 112 in order to avoid a short circuit between yoke steel plates that would lead to higher limb 113 losses.

[0071] The cover with an insulating material or film of the electric shielding device 112 may increase the electric field that the electric shielding device 112 can withstand without the development of a discharge. The insulating film may be a semitransparent insulating film.

[0072] The electric shielding device 112 may comprise a first electric shielding element part and a second electric shielding element part which are separate from each other, meaning that the electric shielding device 112 may be separated in several parts.

[0073] The transformer 101 is adapted for electrically shielding the windings 103, which may be high voltage or low voltage windings 103, from the yoke 109, 124, 126.

[0074] The transformer 101 of Fig. 1 may be applicable at a 72.5 kV level or at a level lower or higher than a 72.5 kV level.

[0075] A clamp 102, 130, 132 is attached at the yoke 109, 124, 126, and stabilizes the yoke 109, 124, 126 of

the transformer 101, and a third electric shielding element 100, 140, 142 is arranged at the clamp 102, 130, 132 between the yoke 109, 124, 126 and a winding 103 of the transformer 101. The third electric shielding element 100, 140, 142 is adapted for shielding the clamp 102, 130, 132 from an electric field of the winding 103. The clamp 102, 130, 132 is adapted for holding together or mechanically fixing the yoke 109, 124, 126 of the transformer 101. The yoke 109, 124, 126 connects at least two limbs 113 of the transformer 101. The third electric shielding element 100, 140, 142 may comprise rounded edges 105, 106.

[0076] The third electric shielding element 100, 140, 142 may project over the clamp edges 104.

[0077] The transformer 101 comprises the above mentioned arrangement and at least two limbs 113, in particular three limbs 113, each comprising a first limb end 120 and a second limb end 122. A winding 103 is arranged around at least one of the at least two limbs 113, in particular a winding 103 is arranged at three limbs 113. A first yoke 109, 124 connects the three limbs 113 at the first limb ends 120. A second yoke 109, 126 connects the three limbs 113 at the second limb ends 122. The electric shielding arrangement comprises first clamps 102, 130 attached at the first yoke 109, 124 to stabilize the first yoke 109, 124, and second clamps 102, 132 attached at the second yoke 109, 124 to stabilize the second yoke 109, 126. First third electric shielding elements 100, 140 are arranged at the first clamps 102, 130 between the first yoke 109, 126 and three windings 103 each of the windings 103 arranged around each of the three limbs 113. Second third electric shielding elements 100, 142 are arranged at the second clamps 102, 132 between the second yoke 109, 126 and the three windings 103.

[0078] First rounded edges 105 are arranged at a longitudinal side 150 of the clamp 102, 130, 132 facing the windings 103 of the transformer 101, wherein the windings 103 may be high voltage or low voltage windings. The longitudinal side 150 may be horizontal, and parallel to the yoke 109, 124, 126 limb 113 connecting side and perpendicular to the limbs 113 as indicated in Fig. 1. The first rounded edges 105 may arranged at clamp edges 104 which may be metallic clamp edges 104 related to the clamp 102, 130, 132.

[0079] The third electric shielding element 100, 140, 142 may act as an electrostatic shield to shield the sharp clamp edges 104 itself and all other metallic clamp edges 104 related to the clamp 102, 130, 132, thus smoothing the electric field of the transformer 101.

[0080] Second rounded edges 106 are arranged at the first end 107 and at the second end 108 of the third electric shielding element 100, 140, 142 at a transverse side 152 of the clamp 102, 130, 132. The transverse side 152 may be horizontal, perpendicular to the longitudinal side 150 and to a vertical side parallel to the limbs 113.

[0081] The first or second rounded edges 105, 106 may have a radius of 10-45 mm, in particular 30 mm.

[0082] The first rounded edges 105 have a different radius at a first region 110 at a yoke 109, 109, 124, 126 of the transformer 101 then at a second region 111 that is not at the yoke 109, 124, 126. The third electric shielding element 100, 140, 142 may be grounded by being connected to the clamp 102, 130, 132, for example by being welded to the clamp 102, 130, 132.

[0083] The first rounded edges 105 may have a length of 1/8 of a circumference of a sphere defined by the radius of the first rounded edges 105 or in other words the first rounded edges 105 may have a length of 1/8 of a sphere.

[0084] The transformer 101 may be a dry type transformer 101.

[0085] The third electric shielding element 100, 140, 142 is arranged on all clamps 102, 130, 132 of the transformer 101, wherein the transformer 101 is adapted for electrically shielding the windings 103 which may be high voltage windings 103 or low voltage windings 103, or both, to the clamp 102, 130, 132.

[0086] Fig. 2 schematically shows a cross-sectional view of the yoke 109 of Fig. 1 with two clamps 102 being arranged at the yoke 109.

[0087] The yoke 109 comprises yoke laminations 202 which form edges 201 of the yoke 109. The electric shielding device 112 is covering the edges 201.

[0088] Fig. 3 schematically shows a cross-sectional view of an electric shielding arrangement for a transformer 101 with a first yoke part 109 and a first electric shielding element 112 and a second yoke part 301 and a second electric shielding element 302. Fig. 3 thus shows a split yoke 109, 301 with two halves, a first yoke part 109, and a second yoke part 301.

[0089] The first electric shielding element 112 is arranged at the first yoke part 109 between the first yoke part 109 and a winding of the transformer (not shown, see Fig. 1). The first electric shielding element 112 is adapted for shielding the first yoke part 109 from an electric field of the winding.

[0090] The second electric shielding element 302 is arranged at the second yoke part 301 between the second yoke part 301 and a winding of the transformer (not shown, see Fig. 1). The second electric shielding element 302 is adapted for shielding the second yoke 301 from an electric field of the winding.

[0091] A yoke cooling duct 312 may be present between the first yoke part 109 and the second yoke part 301 for cooling the transformer 101 by a cooling agent such as oil, water or air. Any suitable cooling agent may be used which is adapted for cooling the transformer 101 via a yoke cooling duct 312.

[0092] The first yoke part 109 comprises first yoke laminations 202 which form first edges 201 of the first yoke part 109, wherein the first electric shielding element 112 is covering the first edges 201.

[0093] The second yoke part 301 comprises second yoke laminations 303 which form second edges 303 of the second yoke part 301, wherein the second electric shielding element 302 is covering the second edges 303.

[0094] The first and second yoke laminations 202, 304 may be steel plates and may have a rectangular form or cross-section or generally a polygonal form or cross-section.

[0095] The first electric shielding element 112 is adapted to shield the first yoke part 109 from a winding of a transformer, when the arrangement is mounted to the transformer, thus smoothing an electric field between the winding and the first yoke part 109 of the transformer.

[0096] The second electric shielding element 302 is adapted to shield the second yoke part 301 from a winding of the transformer, when the arrangement is mounted to the transformer, thus smoothing an electric field between the winding and the second yoke part 301 of the transformer 101.

[0097] The first and the second electric shielding elements 112, 302 may have a cylindrical-like oval layer shape. The form of the first and second electric shielding elements 112, 302 may comprise a layer shape adapted to avoid sharp edges.

[0098] The first and second electric shielding elements 112, 302 extend for a distance D, which may be 100 mm, and possibly 15 mm in a bottom yoke (see 109, 126 of Fig. 1) and 50 mm in an upper yoke (see 109, 124 of Fig. 1), in a direction inside the cooling duct 312. The first and the second electric shielding elements 112, 302 may comprise a conductive material such as aluminium or copper, or a mixture of both, and may be ground connected. The yoke 109, 301 is split in two halves by means of placing some insulating strips or spacers 314, with a strip width of typically 14-18mm. The strips or spacers 314 may be placed vertically every 70 mm along the length of the yoke 109, 301. The strips or spacers 314 may have the same height as the yoke 109, 301. The insulating films of the electric shielding elements 112, 302 and the electric shielding elements 112, 302 itself may be introduced partially into the duct 312 (for the distance D of possibly 15, 50, 100 mm). The strips or spacers 314 may be fibre-glass rods 314 providing a defined space between the two halves of the yoke 109, 301, the first yoke part 109, and the second yoke part 301, respectively, and providing cooling ducts 312. The fibre-glass rods 314 may press first electric shielding element 112 and the second shielding element 302, which may both be copper sheets, and/or the insulating films of the electric shielding elements 112, 302 to the first and second yoke parts 109, 301 in the region of the cooling duct 312. Thus the fibre-glass rods 314 may be fastening means for the electric shielding elements 112, 302.

[0099] A first ground connecting part 114 is adapted to ground connect the first electric shielding element 112 to ground potential.

[0100] The first ground connecting part 114 may be connected to the first electric shielding element 112 and to a first earthing point 308 which is attached to the clamp 102.

[0101] A second ground connecting part 306 is adapted to ground connect the second electric shielding element 302 to ground potential.

[0102] The second ground connecting part 306 may be connected to the second electric shielding element 302 and to a second earthing point 310 which is attached to the clamp 102.

[0103] The yoke 109, 301 is a split yoke 109, 301 with a first yoke part 109 and a second yoke part 301. The transformer 101 further comprises at least one cooling duct 312 and at least one spacer 314, wherein the at least one spacer 314 is adapted for defining a space between the first yoke part 109 and the second yoke part 301, wherein the at least one cooling duct 312 is defined by the space between the first yoke part 109 and the second yoke part 301, wherein the at least one spacer 314 is adapted for pressing the first electric shielding element 112 and the second electric shielding element 302 both partly extending into the cooling duct 312 to the first yoke part 109 and to the second yoke part 301 thus fastening the first and second electric shielding elements 112, 301.

[0104] The first and second electric shielding elements 112, 302 may comprise an insulating film covering the first and second electric shielding elements 112, 302 in order to avoid a short circuit between first and second yoke steel plates or yoke laminations 202, 304 that would lead to higher core losses. The cover with an insulating film of the first and second electric shielding elements 112, 302 may increase the electrical field that the first and second electric shielding elements 112, 302 may withstand without the development of a discharge.

[0105] The insulating film may be a semitransparent insulating film.

[0106] Fig. 4 schematically shows a perspective view of a bottom part of a transformer 101 with an electric shielding arrangement for the transformer 101 comprising a first yoke part 109 and a second yoke part (not shown), and a first electric shielding element 112 and a second electric shielding element 302 as described in Fig. 3.

[0107] A yoke cooling duct 312 is present between the first yoke part 109 and the second yoke part 301 for cooling the transformer 101 by a cooling agent such as oil or air. Insulating strips or spacers 314 are placed vertically to the first and second yoke parts 109, 301 heights, possibly every 70 mm along the length of the first and second yoke parts 109, 301 as described in Fig. 3.

[0108] The first electric shielding element 112 is arranged at a first yoke part 109 covering the first yoke part 109 and facing a winding 103 of the transformer 101.

[0109] The second electric shielding element 302 is arranged at the second yoke part covering the second yoke part and facing a winding 103 of the transformer 101.

[0110] A first ground connecting part 114, which may be a copper strip 114, is ground connecting the first electric shielding element 112 to ground potential, and connected to the clamp 102.

[0111] A second ground connecting part 306, which

may be a copper strip 306, is ground connecting the second electric shielding element 302 to ground potential, and connected to the clamp 102.

[0112] The first and second electric shielding elements 109, 302 are covered by an insulating film, which may be a semitransparent insulating film increasing the electric field that the first and second electric shielding elements 112, 302 can withstand without the development of a discharge.

[0113] Fig. 5 shows in a different perspective view the bottom part of the transformer 101 as shown in Figure 4. In difference to figure 4 the third electric shielding elements 100 covering the clamp 102 and the ground connecting parts 114, 306 are shown.

[0114] Fig. 6 schematically shows a perspective view of a part of a transformer 101 depicting the third electric shielding element 100 which is covering in a vat like shape the clamp 102 and the first ground connecting part 114. The first ground connecting part 114 made of a copper strip is grounding the first electric shielding element 112 to the clamp 102 and may be fixed to the electric shielding element 112 by a screw (not shown). Above the third electric shielding element 100 insulators 601 supporting mechanically the coils of the transformer 101 are arranged.

[0115] 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.

[0116] Other variants of the disclosed embodiments may be understood and affected by those skilled in the art and practising the claimed invention, from a study of the drawings, the disclosure, and the appended claims.

[0117] 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 electric shielding arrangement, , or a single transformer, a single yoke or clamp, or a single electric shielding device, or a single first, second, or third electric shielding element 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

[0118]

100	Third electric shielding element
101	Transformer
102	Clamp
103	Winding
104	Clamp edge(s)
105	Rounded edges, first rounded edges
106	Second rounded edges
107	First end (of the third electric shielding device)
108	Second end (of the third electric shielding device)
109	Yoke, first yoke part
110	First region (at the yoke)
111	Second region (that is not at the yoke)
112	First electric shielding element
113	limb(s)
114	First ground connecting part
120	First limb end(s)
122	Second limb end(s)
124	First yoke
126	Second yoke
130	First clamp(s)
132	Second clamp(s)
140	First third electric shielding element(s)
142	Second third electric shielding element(s)
150	Longitudinal side (of the clamp)
152	Transverse side (of the clamp)
201	First edges
202	First yoke laminations
301	Yoke, second yoke part
302	Second electric shielding element
303	Second edges
304	Second yoke laminations
306	Second ground connecting part
308	First earthing point

310 Second earthing point

312 Yoke cooling duct(s)

314 Spacer, strip

601 Insulator

D Distance

Claims

1. An electric shielding arrangement for a transformer (101), the arrangement comprising:

a yoke (109, 301) for connecting limbs (113) of the transformer (101); and
an electric shielding device (112, 302);
wherein the electric shielding device (112, 302) is arranged at the yoke (109, 301) between the yoke (109, 301) and a winding (103) of the transformer (101) and is adapted for shielding the yoke (109, 301) from an electric field of the winding (103).

2. The arrangement of claim 1,
wherein the yoke (109, 301) comprises yoke laminations (202, 304) which form edges (201, 303) of the yoke (109, 301);
wherein the electric shielding device (112, 302) is covering the edges (201, 303).

3. The arrangement of anyone of the preceding claims, further comprising:

a ground connecting device (114, 306);
wherein the ground connecting device (114, 306) is adapted to ground-connect the electric shielding device (112, 302) to ground potential.

4. The arrangement of anyone of the preceding claims, further comprising:

an insulating material covering the electric shielding device (112, 302) for increasing the dielectric stability of the transformer (101).

5. The arrangement of claim 1,
wherein the yoke (109, 301) is a split yoke (109, 301), comprising:

a first yoke part (109);
a second yoke part (301); and
wherein the electric shielding device (112, 302) comprises:

a first electric shielding element (112); and
a second electric shielding element (302);
wherein the first electric shielding element (112) is arranged at the first yoke part (109) between the first yoke part (109) and the winding (103) of the transformer (101);
wherein the second electric shielding element (302) is arranged at the second yoke part (301) between the second yoke part (301) and the winding (103) of the transformer (101);
wherein the first electric shielding element (112) is adapted for shielding the first yoke part (109) from an electric field of the winding (103);
wherein the second electric shielding element (302) is adapted for shielding the second yoke part (301) from an electric field of the winding (103).

6. The arrangement of claim 5,
wherein the first yoke part (109) comprises first yoke laminations (202) which form first edges (201) of the first yoke part (109);
wherein the first electric shielding element (112) is covering the first edges (201); wherein the second yoke part (301) comprises second yoke laminations (304) which form second edges (303) of the second yoke part (301);
wherein the second electric shielding element (302) is covering the second edges (303).

7. The arrangement of claim 5 or 6, further comprising:

a first ground connecting part (114), which is adapted to ground-connect the first electric shielding element (112) to ground potential;
a second ground connecting part (306), which is adapted to ground-connect the second electric shielding element (302) to ground potential.

8. The arrangement of anyone of claims 5 to 7,
wherein one of the first, second, or both electric shielding elements (112, 302) comprises an insulating material covering the first, second, or both electric shielding elements (112, 302) for increasing the dielectric stability of the transformer (101).

9. The arrangement of anyone of the preceding claims, further comprising
a third electric shielding element (100) and having
a clamp (102) attached at the yoke (109, 301) and stabilizes the yoke (109, 301);
the third electric shielding element (100) is arranged at the clamp (102) between the clamp (102) and the winding (103) of the transformer (101) and is adapted for shielding the clamp (102) from an electric field of the winding (103).

10. The arrangement of claim 9, wherein the third electric shielding element (100) comprises rounded edges (105, 106).

11. Transformer (101) comprising:

an arrangement of anyone of claims 1 to 10;
at least two limbs (113);
a winding (103) arranged around at least one of the at least two limbs (113); and
a yoke (109, 301) connecting the at least two limbs (113).

12. The transformer (101) of claim 11, wherein the yoke (109, 301) is a split yoke (109, 301) with a first yoke part (109) and a second yoke part (301) as claimed in any of the claims 5 to 10;
the transformer (101) further comprising:

at least one cooling duct (312);
at least one spacer (314);
wherein the at least one spacer (314) is adapted for defining a space between the first yoke part (109) and the second yoke part (301);
wherein the at least one cooling duct (312) is defined by the space between the first yoke part (109) and the second yoke part (301);
wherein the at least one spacer (314) is adapted for pressing the first electric shielding element (112) and the second electric shielding element (302) both partly extending in the cooling duct (312) to the first yoke part (109) and to the second yoke part (301) thus fastening the first and second electric shielding elements (112, 301).

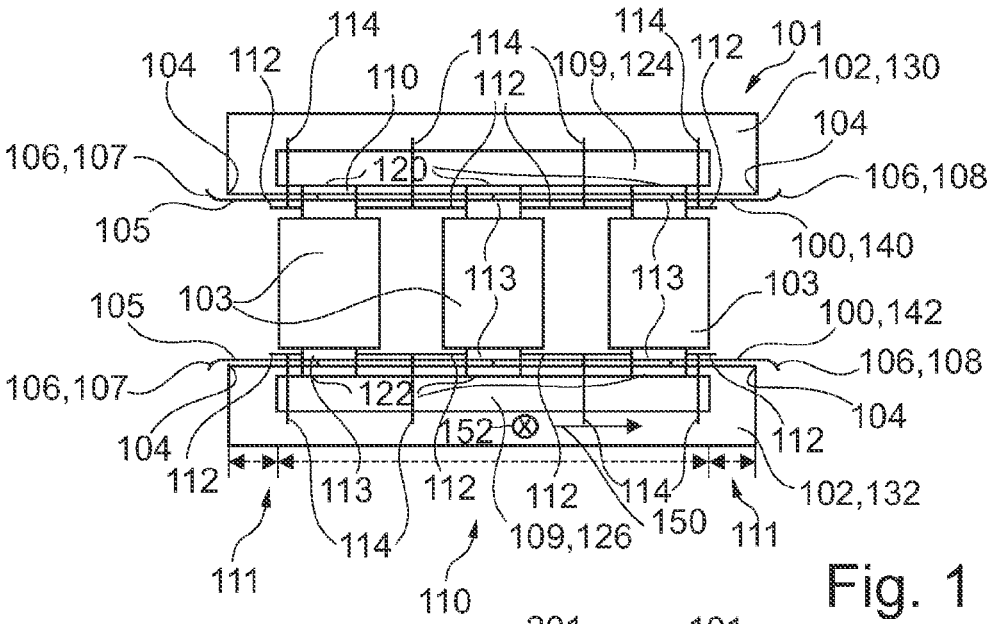

Fig. 1

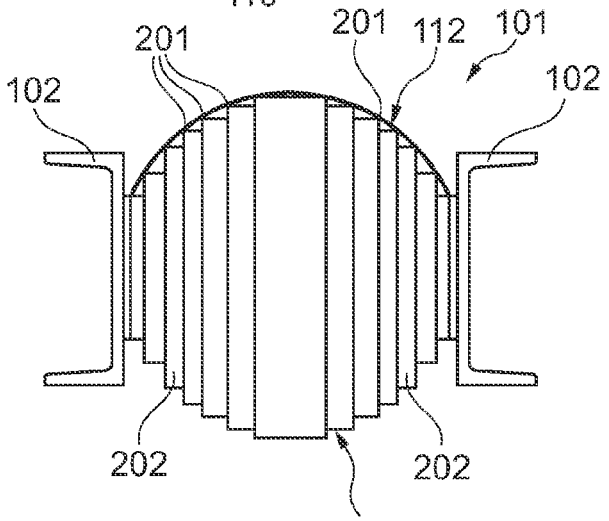

Fig. 2

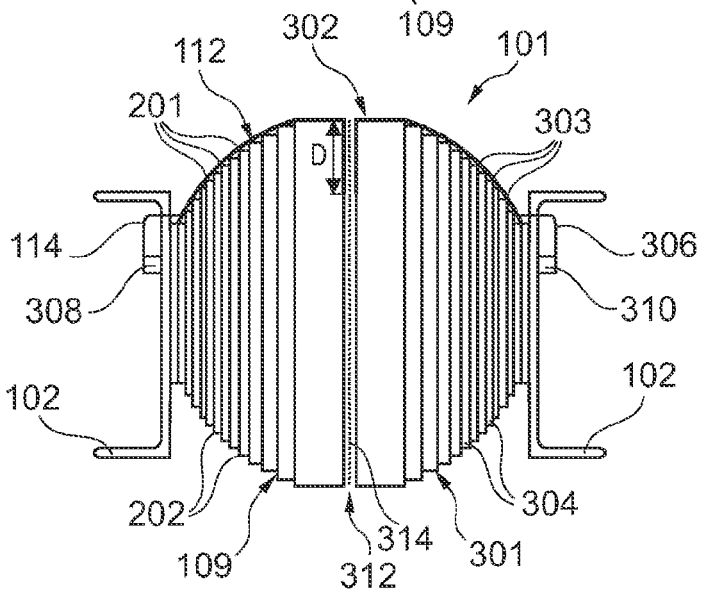

Fig. 3

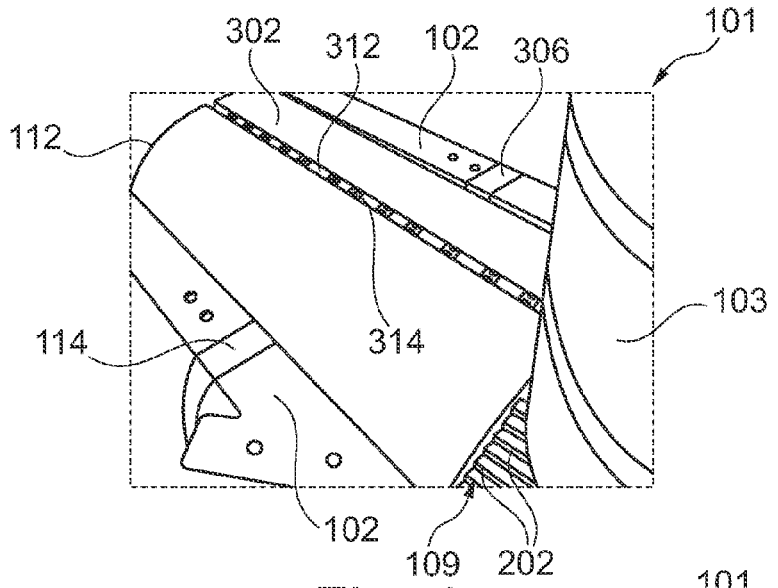

Fig. 4

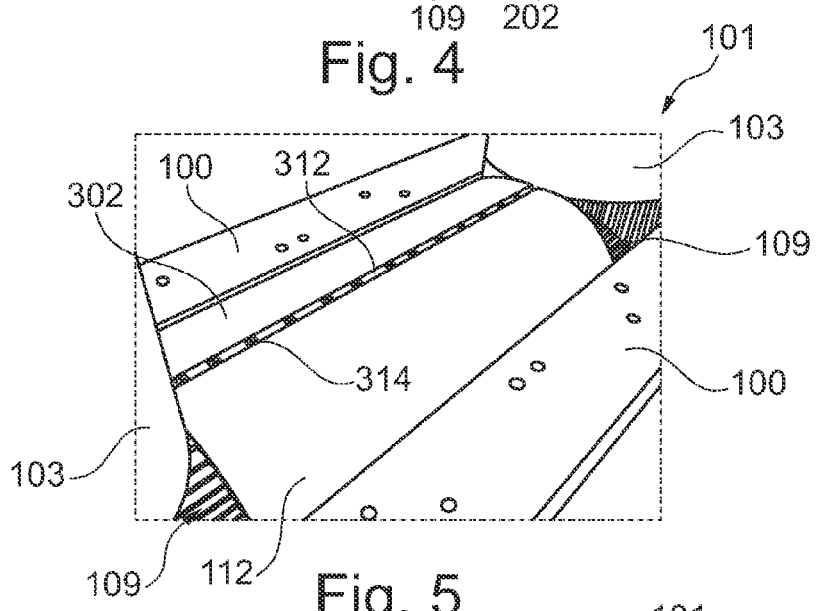

Fig. 5

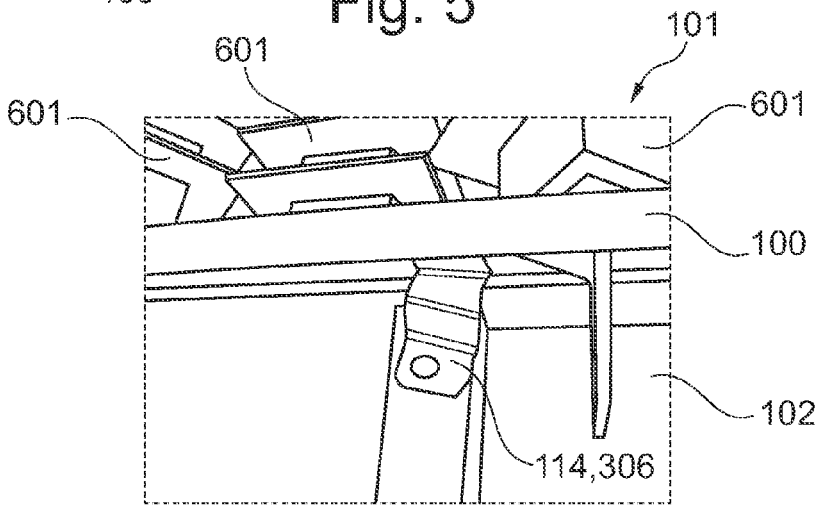

Fig. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 10 16 7486

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 4 725 804 A (YARPEZESHKAN HASSAN [US]) 16 February 1988 (1988-02-16) * column 2, line 61 - column 3, line 49; figure 1 * -----	1-4,11	INV. H01F27/36
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	29 September 2010	Van den Berg, G

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29-09-2010

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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