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(54) Wound transformer core with support structure

(57) The invention is related to a wound transformer core (10, 66, 82) with at least one core loop (12, 14) made of magnetic material, comprising multiple thin amorphous band-like iron sheets (16) which are concentrically stacked around at least one center axis (18, 20). A lower yoke section (24), an upper yoke section (22) and at least two limb sections (26, 28, 30) are developed, comprising a modular plate-like support structure (40, 74, 76) which is glued upright to the center axis (18, 20) on both face sides (70, 72) of the lower yoke section (24) and on both face sides (70, 72) of each limb section (26, 28, 30) in that way, that neighboured iron sheets are glued together at their outer edge. Elongated through holes (52, 54, 78) are foreseen within the plate-like structure (40, 74, 76), which are arranged at least in part crosswise to the longitudinal extension of the stacked iron sheets.

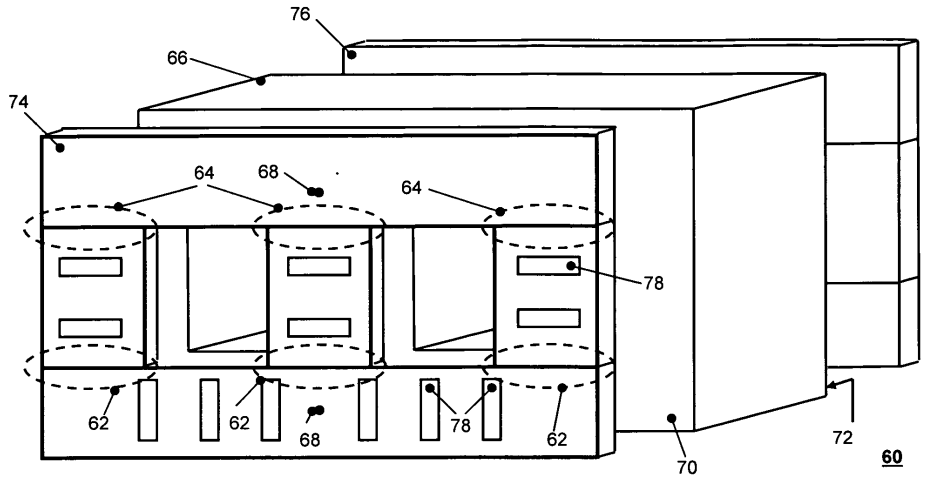

Fig. 3

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Description

[0001] The invention relates to a wound transformer core with at least one core loop made of magnetic material, comprising multiple thin amorphous band-like iron sheets which are concentrically stacked around at least one center axis, whereas a lower yoke section, an upper yoke section and at least two limb sections are developed, comprising a modular plate-like support structure which is glued upright to the center axis on both face sides of the lower yoke section and on both face sides of each limb section in that way, that neighboured iron sheets are glued together at their outer edge.

[0002] It is known, that transformers with an amorphous core provide in an advantageous way lower electrical losses than transformers with a conventional core. On the other side, amorphous transformer cores are rather difficult for manufacturing, since a suitable amorphous core material is only available in thin band-like sheets of a thickness of approximately a few 10μm and a width of some 10cm. Thus a typical amorphous core for a transformer with some few MW rated power requires some few 1000 layers of such concentrically stacked material. The characteristics of this material are sensitive to mechanical stress, so that such a core without any stabilizing arrangement or support structure is not stable enough to bear the weight of some coils or not even its own weight.

[0003] Stabilizing arrangements are known for example from the utility model CN201112062. Here so far called E-plates are suggested to be mounted and glued on both sides of major parts of the concentrically stacked transformer core. Especially the upper yoke of the transformer core is not foreseen to be stabilized by an E-plate, since the core has to be re-opened for mounting the coils on the limbs of the transformer core.

[0004] Disadvantageously within the state of the art is that on one side the gluing process during manufacturing is rather complex. On the other side the cut-off respectively scrap for manufacturing such an E-plate is rather high.

[0005] Based on this state of the art it is the objective of the invention to provide an amorphous wound core with improved support structure, which avoids the disadvantages mentioned above.

[0006] This problem is solved by a wound transformer core with a plate-like support structure of the aforementioned kind. It is characterized in that elongated through holes are foreseen within the plate-like structure, which are arranged at least in part crosswise to the longitudinal extension of the stacked iron sheets.

[0007] An amorphous concentrically wound transformer core has not to become glued with its total surface on a support structure. It is sufficient to foresee in certain distances some areas of the surface inbetween core and support structure with such a glue connection. Thus, the idea of the invention consists in applying the glue during the manufacturing process mainly through some elongated holes which are cut in the plate-like support structure in that way, that they are arranged at least in part crosswise to the longitudinal extension of the stacked iron sheets. Nearly all layers of the concentrically wound amorphous material are reachable at their outer edges by sections through the elongated holes. Therefore the manufacturing process is simplified since the glue is easy to apply while the transformer core and the support structure are laid each on each other. A pre-applying of the glue is avoided or at least reduced, so that the relative position inbetween the fragile core and the support structure can become optimized in an easier way before applying the glue into the elongated holes. Furthermore a needless movement or flapping of the fragile transformer core during the gluing process is avoided. Another aspect is that the weight of the support structure is reduced by those holes.

[0008] In a variant of the invention the modular plate-like support structure comprises for each face side of the belonging core sections at least two plate-like modules, which are connected each to each other by a first or second plug-in connection.

[0009] Hence it is possible to mount a support structure in several steps by using separate modules. This simplifies the manufacturing process. The plug-in connections have to be shaped in that way, that one module is connectable with an adjacent module by a simple sliding or hooking movement, while the concentrically wound core is in the preferred horizontal position. Even the plug-in connection as such might be stiff enough to support the transformer core it could be useful to strengthen the connection with some amount of glue or some screws or such.

[0010] According to another embodiment of the invention the plate-like support structure comprises for each face side of the belonging core sections a first plate-like module adapted to the size of the belonging side of the lower yoke section and further plate-like modules adapted to the size of the belonging side of each limb section, which each are connected to the belonging first plate-like module by a first or second plug-in connection.

[0011] The advantages of this special modular solution are similar to those mentioned above but in this case the plug-in connections have their maximum stability in vertical direction if the ready mounted transformer is in its upright working position. This is required for the lifting of the transformer since the transformer core itself has no own stiffness. Thus such a transformer core is normally lifted by using lifting lugs in the upper part of the upright standing transformer, whereas the major weight load is accumulated at its bottom. The upper yoke section is normally not glued together with a module of the support structure, since the transformer core has to be openable for mounting or de-mounting its coils. In addition, those I - shaped parts are producible without a major cut-off.

[0012] In a preferred form of the invention the plate-like support structure comprises for each face side a second plate-like module adapted to the size of the belonging side of the upper yoke section, which each are connected

to the further plate-like modules on the belonging sides by a first plug-in connection. To keep the upper yoke openable, it normally has not to be glued together with a module of the support structure. Furthermore a second plate-like module - if foreseen - has to be removable for the same purpose, thus those plug-in connections have to be openable.

[0013] According to the invention a first plug-in connection comprises at least one barbed nozzle of at least one plate-like module which is adapted to fit into a belonging hole in an adjacent plate-like module to be connected, so that a puzzle-piece like connection is realized. The hole might be developed as through hole, but also a milled non-through hole is thinkable for example. Such a connection enables an easy and robust merging together of the belonging module parts, while the transformer core is in a horizontal manufacturing position. It only has to be ensured, that the connected parts are fixed within the same plane, for example by gluing them on the transformer. If this kind of plug-in connection is not glued additionally with the transformer core, for example in the case of the upper yoke, it is also easily openable.

[0014] Following a further embodiment of the invention at least one first or one second plate-like module comprises two plates of similar size, which are mounted together on top of each other, whereas only the plate contacting one of the face sides of the transformer core comprises the holes respectively the barbed nozzles which are required for the connection to the adjacent modules. This is helpful to prevent a slipping of a barbed nozzle out of the belonging hole, especially in the case of the upper yoke, where this plug-in connection has to be openable and no glue is foreseen. In addition, the second module part gets strengthened, what is important for example for lifting lugs to be mounted thereon.

[0015] According to the invention a second plug-in connection comprises a bent section of at least one of the plate-like modules which is hooked into a matching slit within another adjacent plate-like module to be connected. This is also a stable kind of connection, which on the other side is not as suitable for re-opening. Thus, a second plug-in connection is only foreseen for the lower yoke area, since it is not required to be re-opened.

[0016] In another embodiment of the invention the plate-like support structure comprises an upper U-shaped beam-like module which is adapted to the size of the upper side of the upper yoke section and which is arranged thereon, whereas those plate-like modules, which are covering both sides of the limb sections are elongated over the upper side of the upper yoke section so that the elongated parts are at least in part adjacent to the sides of the U-shaped module whereas a mechanical connection inbetween the adjacent parts is foreseen.

[0017] This kind of solution enables a reduction of the weight of the support structure, since the U-shaped module can be built from a rather thin material. While the ready mounted transformer stands in its upright working position, no major forces are applied on the U-like module or the preferably alternately used second plate-like modules. Only in case of a lifting of the transformer using some lifting lugs - which are preferably attached or part of the plate-like module related to the upper yoke - forces are applied on this module. According to this variant, the lifting lugs are attachable to the elongated further plate-like modules, which are adapted to the size of the sides of the limbs. The U-like module has only the purpose to fix the elongated further plate-like modules.

[0018] In a further variant of the invention lifting lugs are foreseen at both sides and both ends of the U-shaped module, whereas those lifting lugs are strengthened by congruent holes of belonging once more elongated module parts. This enables an easy possibility to gain stable lifting lugs.

[0019] According to another variant three core loops are foreseen, whereas the transformer core comprises a first, a second and a third toroidal rectangular amorphous iron sheet package, whereas the basically round toroidal shape is developed more in a rectangular manner comprising also a rather rectangular shaped inner hole each. The first and second iron sheet packages are arranged side by side within the inner hole of the third package. Hence a three phase transformer core is realized, what is for high relevance of distribution networks for electrical energy. Of course also variants with more or less core loops are thinkable, so that e.g. a five limb transformer core is realized.

[0020] In a preferred embodiment of the invention the corners of the toroidal rectangular developed amorphous iron packages are shaped as soft, that two approximately triangular hollows are built inbetween the three sheet packages, whereas at least one through bolt is arranged there through, which connects the opposing module parts of the support structure.

[0021] Even a connection inbetween the opposing modules of the support structure on both face sides of the transformer core has not to apply any pressure on the fragile core, it has to be foreseen to give the support structure as such a certain stiffness. This can be gained for example by the U-shaped module mentioned above, but also by through bolts with a screw thread. Normally those through bolts have to be arranged near the core, which makes it necessary, to enlarge the support structure respectively to reduce the size of the coil. Both are disadvantageously. The use of this triangular hollow as a through hole for through bolts enables the placing of a through bolt or such at exactly these points of the support structure, where it is most useful for stabilization purposes.

[0022] A transformer comprising a transformer core of the aforementioned kind and at least an electrically primary and secondary winding takes advantage of the easier mounting process of such a transformer core and provides in addition lower electrical losses.

[0023] Further advantageous embodiments of the invention are mentioned in the dependent claims.

[0024] The invention will now be further explained by

means of an exemplary embodiment and with reference to the accompanying drawings, in which:

Fig. 1 shows an example for a wound transformer core,
Fig. 2 shows an example for a modular plate-like structure for one face side,
Fig. 3 shows a 1 st example for wound transformer core with plate-like support structure,
Fig. 4 shows a 2nd example for wound transformer core with plate-like support structure,
Fig. 5 shows an example for first plug-in connection and
Fig. 6 shows an example for a for second plug-in connection

[0025] Fig. 1 shows an example 10 for a wound transformer core with several layers of concentrically stacked thin amorphous band like iron sheets 16. In the fig, only 8 layers of the stacked sheets are indicated, whereas a realistic number is some thousand layers, dependent on the size of the transformer core. A first and a second iron sheet package are concentrically stacked around the first center axis 18 respectively the second center axis 20, whereas each package is indicated with four layers. Both packages are surrounded by a common third package with further four indicated layers. Due to the softly shaped corners of each package - otherwise the iron sheets would brake in a sharply edged corner - two nearly triangular through 32 hollows are developed within the core. Those hollows are suitable to arrange a connection element inbetween the plate-like modules on both sides of the belonging core section, for example a screw or a bolt.

[0026] Totally two single core loops 12 and 14 and one common core loop over the outer limbs are developed so that this transformer core is suitable to be used for a three-phase transformer. Due to the basically rectangular shape of the thin iron sheet packages - except the softly shaped corners - an upper yoke section 22, a lower yoke section 24 and three limb sections 26, 28, 30 are developed, which is indicated with a belonging dotted rectangle. Typically the length of one sheet of the amorphous material corresponds to the length of belonging layer of 360°, whereas the cutting side usually is arranged within the upper yoke section. Hence, the whole core can be opened in the upper yoke section so that a belonging coil can be positioned on the opened limbs.

[0027] Fig. 2 shows an example 40 for a modular plate-like structure which is foreseen to be mounted respectively glued on one face side of such a transformer core described before. A plate-like module adapted to each section of a transformer core of the aforementioned kind is foreseen, so that a first plate-like module 42 for the upper yoke section, a second plate like module 44 for the lower yoke section and three plate-like modules 46, 48, 50 are foreseen for the limb sections. The material of those modules is preferably a steel plate that's thickness might be inbetween some few millimetres up to more than one centimetre. Of course, also other materials such as other metals or fibre strengthened composite materials are thinkable. Those module and adjacent arranged plates are an example for the major parts of a support structure for one side of the transformer core, whereas on the other side a symmetrical arrangement should be foreseen. The total size of such a support structure might amount 0,5m - 2,5m in two dimensions, corresponding to the size of the transformer core.

[0028] The plate-like modules 46, 48, 50 which are adapted to the size of the limb section and the plate-like module 44, which is adapted to the size of the lower yoke, are foreseen to be glued on a transformer core of the aforementioned kind. To simplify the gluing process, horizontal elongated holes 54 are cut in the limb-related modules 46, 48, 50 and vertical elongated holes 52 are cut in the lower-yoke related module 44. Thus the elongated holes are always across to the longitudinal extension of the stacked iron sheets, so that a plate-like module can be placed in the right position on a horizontal transformer core whereas a major part of the required glue can be applied afterward through the elongated holes 52, 54. The upper yoke related module has not foreseen such elongated holes for, since it has to be re-openable as mentioned before and a glue connection is not useful.

[0029] Fig. 3 shows a 1st example 60 for wound transformer core with plate-like support structure. The plate like support structure for a transformer core 66 is divided in two major parts, one part 74 for the first face side 70 of the transformer core 66 and a symmetric part 76 for the second face side 72 of the transformer. Both parts 74, 76 are illustrated in a certain axial distance to the transformer core 66, whereas in the mounted state both parts 74, 76 are glued thereon, except in the area of the upper yoke. A through bolt 68 indicates an axial connection inbetween the first 74 and the second 76 part, whereas the connection is arranged through an approximately triangular hole of the transformer core. Elongated through holes 78 are foreseen within the modular plate-like support structure.

[0030] The symmetrical support structure parts 74, 76 comprise mainly two yoke-related and three limb-related plate-like module parts each, which are connected by first or second plug-in connections 62 in the lower yoke area or only by first plug-in connections 64 in the upper yoke area. The plug-in connections 62, 64 are explained more in detail in Fig. 5 and Fig. 6 with the reference signs 100 respectively 110. As explained thereafter, a first plug-in connection is easily re-openable, whereas a second plug-in connection is not as easy to re-open. Thus both kinds of plug-in connections 64 are suitable for the lower-yoke area, whereas plug-in connections in the upper-yoke area should be carried out as first plug-in connections.

[0031] Fig. 4 shows a 2nd example 80 for wound transformer core 82 with plate-like support structure, whereas the part of the support structure for the second face side of the transformer core is not illustrated. In comparison

to the 1st example in fig. 4 a plate-like module for the upper yoke section is not foreseen. This is possible, since the ready mounted transformer is - also during transport or operation - in an upright position. Thus, no significant forces are applied on the upper yoke section, except when lifting the transformer for example with a crane. Hence some contact points for example a load hook have to be foreseen in the upper yoke section. In this example this is realized by elongated outer limb-related plate-like modules 86, 90 with some lifting lugs at their upper ends. To ensure a certain stability of the hole structure, an U-shaped beam like module 92 is arranged on the upper side of the upper yoke and connected with the adjacent ends of the elongated limb-related plate like modules for example by screws or another re-openable connection.

[0032] Fig. 5 shows an example 100 for first plug-in connection, comprising a plate-like module 102 with barbed nozzle adapted to fit in hole of another plate like module 104. Theoretically it is as well thinkable, that the nozzles are part of the limb-modules, whereas the holes are cut in a matching yoke module as contrawise. Due to the puzzle-like functionality, this kind of plug-in connection is easy to re-open.

[0033] Fig. 6 shows an example for a second plug-in connection 110, based on a hook-functionality. A plate-like module with a bent section 112 and a matching plate like module with a slit 114 is illustrated from a top view perspective. A comparable plate-like module with bent section in a side view is showed with the reference number 116, whereas a side view of two connected parts is illustrated with the reference number 118.

List of reference signs

[0034]

10 example for a wound transformer core

12 first core loop made of magnetic material

14 second core loop made of magnetic material

16 concentrically stacked thin amorphous band-like iron sheets

18 first center axis

20 second center axis

22 upper yoke section of wound transformer core

24 lower yoke section of wound transformer core

26 first limb section of wound transformer core

28 second limb section of wound transformer core

30 third limb section of wound transformer core

32 approximately triangular hollow

40 example for a modular plate-like structure for one face side

42 plate-like module adapted to side of upper yoke section

44 plate-like module adapted to side of lower yoke section

46 plate-like module adapted to first limb section

48 plate-like module adapted to second limb section

50 plate-like module adapted to third limb section

52 vertical elongated through holes

54 horizontal elongated through holes

60 1 st example for wound transformer core with plate-like support structure

62 first or second plug-in connections

64 first plug-in connections

66 wound transformer core

68 through bolt

70 first face side of wound transformer core

72 second face side of wound transformer core

74 modular plate-like structure for first face side

76 modular plate-like structure for second face side

78 elongated through holes

80 2nd example for wound transformer core with plate-like support structure

82 wound transformer core

84 first or second plug-in connections

86 once more elongated plate-like module adapted to first limb section

88 elongated plate-like module adapted to second limb section

90 once more elongated plate-like module adapted to third limb section

92 U-shaped beam-like module

94 congruent holes of lifting lugs

100 example for first plug-in connection

102 plate-like module with barbed nozzle adapted to fit in hole

104 plate-like module with hole adapted to fit with barbed nozzle

110 example for second plug-in connection

112 plate-like module with bent section in a top view

114 plate-like module with matching slit section in a top view

116 plate-like module with bent section in a side view

118 hooked plate-like modules in a side view

Claims

1. Wound transformer core (10, 66, 82) with at least one core loop (12, 14) made of magnetic material, comprising multiple thin amorphous band-like iron sheets (16) which are concentrically stacked around at least one center axis (18, 20), whereof a lower yoke section (24), an upper yoke section (22) and at least two limb sections (26, 28, 30) are developed, comprising a modular plate-like support structure (40, 74, 76) which is glued upright to the center axis (18, 20) on both face sides (70, 72) of the lower yoke section (24) and on both face sides (70, 72) of each limb section (26, 28, 30) in that way, that neighboured iron sheets are glued together at their outer edge, **characterized in that**
elongated through holes (52, 54, 78) are foreseen within the plate-like structure (40, 74, 76), which are arranged at least in part crosswise to the longitudinal extension of the stacked iron sheets.

2. Wound transformer core according to claim 1, **characterized in that** the modular plate-like support structure (40, 74, 76) comprises for each face side (70, 72) of the belonging core sections (24, 26, 28, 30) at least two plate-like modules (42, 44, 46, 48, 50, 86, 88, 90), which are connected each to each other by a first (100) or second (110) plug-in connection.

3. Wound transformer core according to claim 1 or 2, **characterized in that** the plate-like support structure (40, 74, 76) comprises for each face side (70, 72) of the belonging core sections (24, 26, 28, 30) a first plate-like module (44) adapted to the size of the belonging side of the lower yoke section (24) and further plate-like modules (46, 48, 50) adapted to the size of the belonging side of each limb section (26, 28, 30), which each are connected to the belonging first plate-like module (44) by a first (100) or second (110) plug-in connection.

4. Wound transformer core according to claim 3, **characterized in that** the plate-like support structure (40, 74, 76) comprises for each face side (70, 72) a second plate-like module (42) adapted to the size of the belonging side of the upper yoke section (22), which each are connected to the further plate-like modules (46, 48, 50) on the belonging sides (70, 72) by a first (100) plug-in connection.

5. Wound transformer core according to claim 2 - 4, **characterized in that** a first plug-in connection (100) comprises at least one barbed nozzle of at least one plate-like module (102) which is adapted to fit into a belonging hole in an adjacent plate-like module (104) to be connected, so that a puzzle-piece like connection (100) is realized.

6. Wound transformer core according to claim 5, **characterized in that** at least one first (44) or one second (42) plate-like module comprises two plates of similar size, which are mounted together on top of each other, whereas only the plate contacting one of the face sides (70, 72) of the transformer core (10, 66, 82) comprises the holes (104) respectively the barbed nozzles (102) which are required for the connection to the adjacent modules.

7. Wound transformer core according to claim 2 - 6, **characterized in that** a second plug-in connection (110) comprises a bent section of at least one of the plate-like modules (112, 116), which is hooked into a matching slit within another adjacent plate-like module (114) to be connected (118).

8. Wound transformer core according to any of the previous claims, **characterized in that** the plate-like support structure (40, 74, 76) comprises an upper U-shaped beam-like module (92) which is adapted to the size of the upper side of the upper yoke section (22) and which is arranged thereon, whereas those plate-like modules, which are covering both sides of the limb sections (86, 88, 90), are elongated over the upper side of the upper yoke section (22), so that the elongated parts are at least in part adjacent to the sides of the U-shaped module (92), whereas a mechanical connection inbetween the adjacent parts (86, 88, 90 $\Leftrightarrow$ 92) is foreseen.

9. Wound transformer core according to claim 8, **characterized in that** lifting lugs are foreseen at both

sides and both ends of the U-shaped module, whereas those lifting lugs are strengthened by congruent holes (94) of belonging once more elongated module parts (86, 90).

10. Wound transformer core according to any of the previous claims, **characterized in that** three core loops (12, 14) are foreseen, whereas the transformer core (10, 66, 82) comprises a first, a second and a third toroidal rectangular amorphous iron sheet package with an inner hole each, whereas the first and second iron sheet package are arranged side by side within the inner hole of the third package.

11. Wound transformer core according to claim 10, **characterized in that** the corners of the toroidal rectangular amorphous iron packages are shaped as soft, that two approximately triangular hollows (32) are built inbetween the three sheet packages, whereas at least one through bolt (68) is arranged there through, which connects the opposing module parts of the support structure (40, 74, 76).

12. Transformer, **characterized in that** it comprises a transformer core according to any of the previous claims and at least one primary and at least one secondary electrical winding.

13. Transformer according to claim 12, **characterized in that** it is a three-phase transformer.

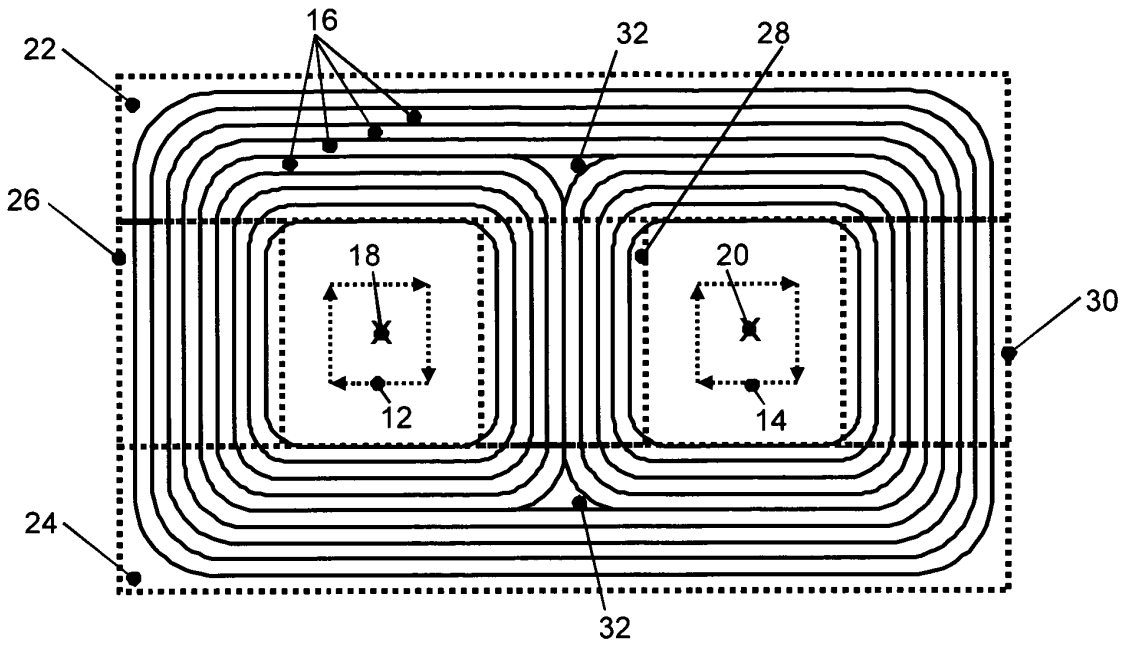

Fig. 1

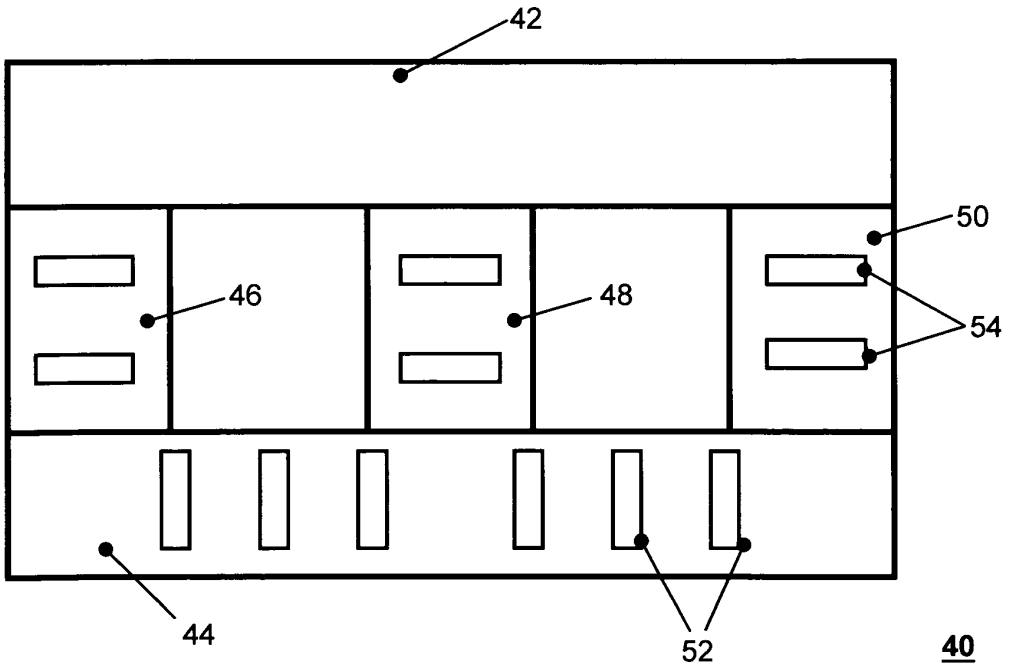

Fig. 2

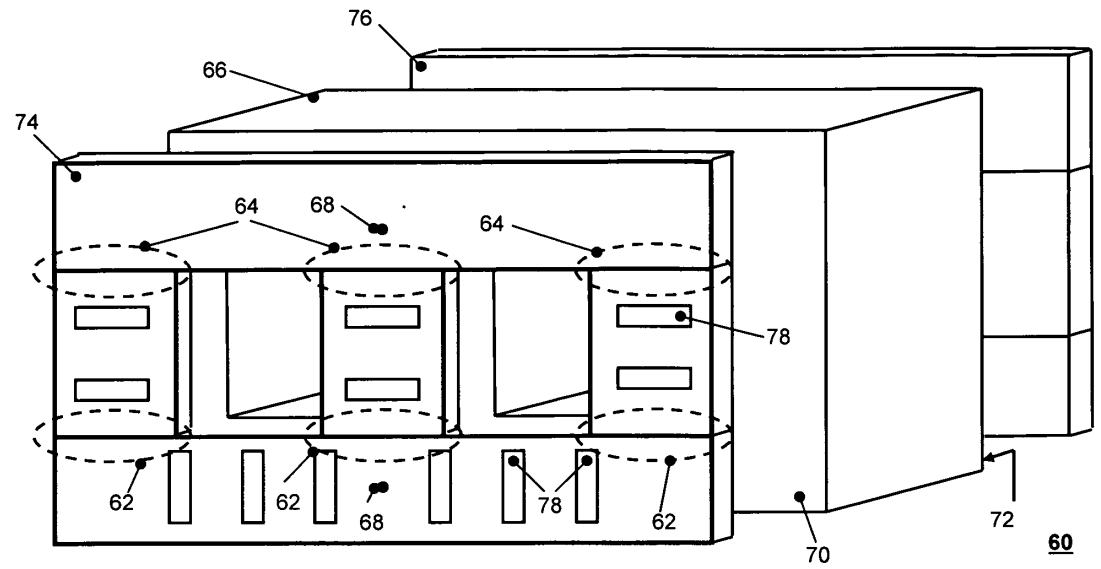

Fig. 3

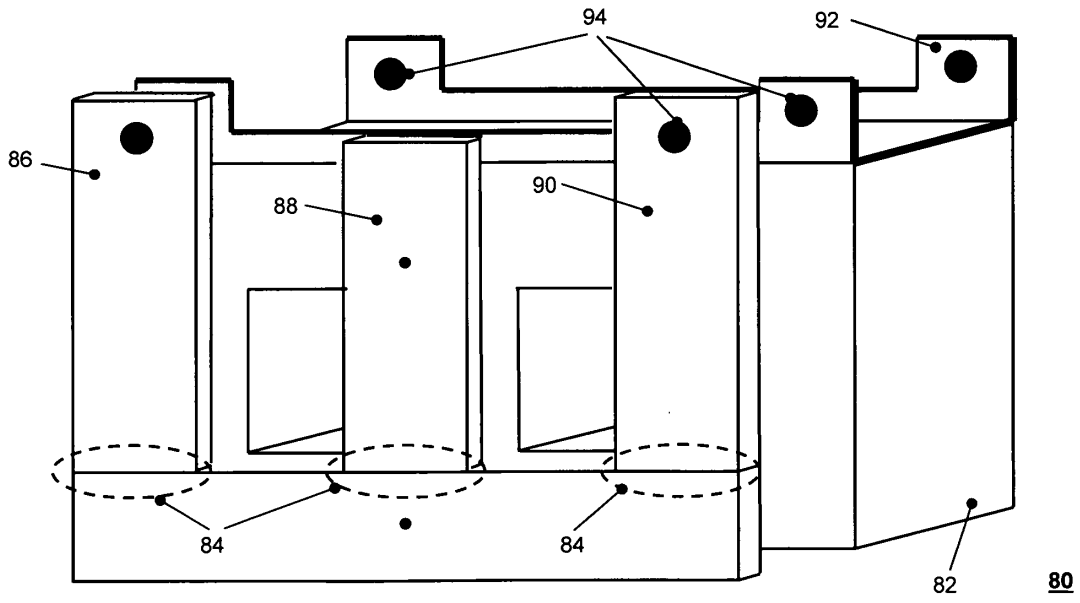

Fig. 4

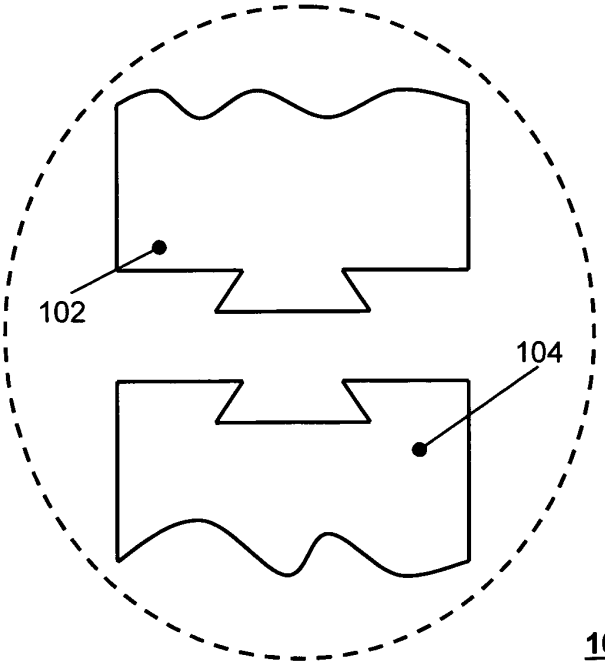

Fig. 5

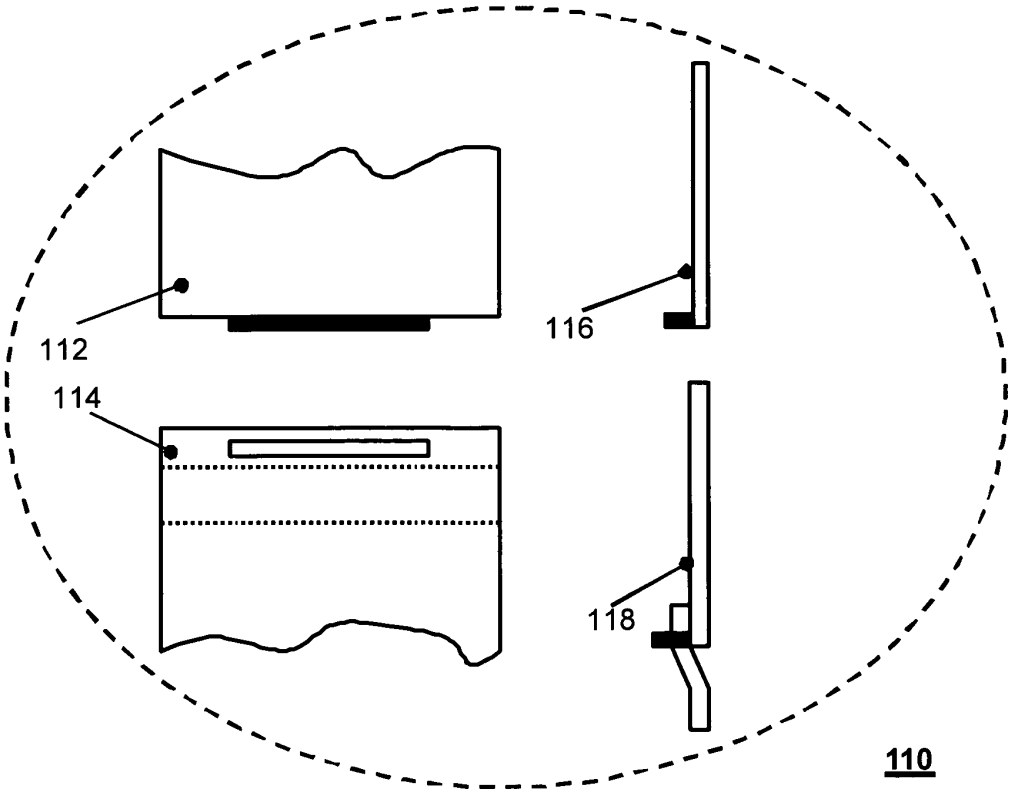

Fig. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 10 00 9105

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	US 2002/157239 A1 (NGO DUNG A [US] ET AL) 31 October 2002 (2002-10-31) * paragraphs [0023] - [0031]; figures 1-3 * * paragraphs [0041], [0042]; figure 7 * * paragraphs [0046] - [0050] * -----	1,10,12, 13	INV. H01F27/26
A,D	CN 201 112 062 Y (DATONG SHANGHAI CO LTD [CN]) 10 September 2008 (2008-09-10) * abstract; figures 1-11 * -----	1-13	

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
Munich	4 March 2011	Reder, Michael

CATEGORY OF CITED DOCUMENTS

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1

EPO FORM 1503 03.82 (P04C01)

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CN 201112062 Y	10-09-2008	NONE	

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Patent documents cited in the description

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