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(54) **High-voltage-transformer**

Hochspannungstransformator

Transformateur haute tension

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(56) References cited:
US-A1- 2004 137 247
US-A1- 2007 247 266
US-B1- 6 411 188

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Description

[0001] The invention relates to a high-voltage-transformer comprising at least one transformer-core wound from an amorphous band-like material around at least one inner hollow, wherein two opposed laminated front sides are formed by the edges of the wound band-like material, wherein at least two opposed limb areas and an upper and lower yoke area are formed and wherein at least one hollow-cylindrical transformer coil is arranged around a limb area of the at least one transformer-core.

[0002] It is known, that high-voltage-transformers for power transmission are rated for voltage levels of for example 10kV, 60kV 110kV or above, whereas the rated power amounts for example 1MVA, 10MVA or even 100MVA. Transformer-cores for such transformers are typically based on stacked metal sheets. Due to a permanent magnetic re-orientation during operation of such transformer-core magnetic losses are produced, which cause also a heating effect on the transformer-core. A standard transformer-core of stacked metal sheets might be operated up to a temperature of several 100°C, whereas in this case the temperature resistance of the belonging coils of for example 180°C - 200°C is the limiting temperature factor for the whole transformer.

[0003] It is also known, that a transformer-core made from an amorphous material provides reduced core-losses in comparison to a standard transformer-core. Amorphous material is available typically as refractory band-like material, which is extremely sensitive against any mechanical stress. Thus an amorphous transformer-core has to be wound from such a band-like material, whereas the width of such band might amount for example 30cm and whereas several thousand layers have to be wound. Also a wound amorphous transformer-core is sensitive to any mechanical stress produced for example also by mechanical collisions. But also wearing the weight of the transformer as such has considered being mechanical stress. A dry type power distribution transformer in which the core is made of amorphous material ribbons or strips, is disclosed in US-6,411,188.

[0004] Due to the high fragility of an amorphous transformer-core and due to the limitation of the available width of the band-like amorphous material the maximum rated power of a transformer with amorphous transformer-core is limited to roughly 5 - 10MVA considering actual frame conditions. Transformer-cores of an amorphous material have to be cooled during operation, since the effect of reduced core losses is gained only in a temperature range of lower than 100°C - 140° for example, otherwise the core losses will increase disadvantageously. Thus the maximum rated power of an amorphous high-voltage transformer is also limited by the cooling system respectively by the cooling equipment of such a transformer. Due to its arrangement in an oil filled vessel an amorphous oil transformer already has a rather effective oil-based cooling system so that in most cases no additional cooling effort is required. On the other side amorphous dry transformers are subject to a limitation of the maximum rated power of for example 2 - 4MVA without enforced cooling system.

[0005] Based on this state of the art it is the objective of the invention to provide a dry high-voltage-transformer with a transformer-core wound from an amorphous band-like material with improved cooling characteristic.

[0006] This problem is solved by a high-voltage transformer of the aforementioned kind. This is characterized in that cooling means are connected with at least a section of at least one of the laminated front sides.

[0007] The basic idea of the invention consists in connecting cooling means such as a cooling element or a heat exchanger to the amorphous transformer-core on one or both of the laminated front sides. On the one hand, cooling means are suitable for the heat transportation from the area of contact with the amorphous transformer-core, so that a cooling effect for the amorphous transformer-core is gained. On the other side, the arrangement on one or both of the laminated front sides enables a significant higher cooling effect respectively heat transportation within the amorphous transformer-core itself.

[0008] The heat conductivity within the transformer-core wound from an amorphous band-like material is not the same in all geometrical directions. Moreover heat conductivity is highest within the same layer of amorphous band material whereas the heat conductivity perpendicular thereto through adjacent layers is significant lower. Due to the mechanical sensitiveness of the amorphous band-like material, adjacent layers are not pressed together with such a pressure force than the stacked metal sheets of a conventional transformer-core, so that the heat transmission inbetween adjacent layers might be reduced by the existence of possible infinitesimal small gaps. Furthermore the number of wound layers of an amorphous transformer-core is significant higher - for example 5000 - than the number of stacked metal sheets of a conventional comparable transformer-core - which comprises for example only a few 100 layers. Thus the number of heat passages through all layers is significant higher for a transformer-core wound from an amorphous band-like material than for a conventional stacked transformer-core of comparable size.

[0009] Thus the connection of cooling means to one or both of the laminated front sides of the transformer-core wound from an amorphous band-like material provides a significant increased cooling effect on the amorphous transformer-core and enables the construction of dry transformers with amorphous transformer-core with increased rated power above 2 - 4MVA. Also bigger transformer-cores can be cooled therewith in a way that the critical material temperature of for example 100°C - 140°C is not exceeded within the inner transformer-core during its operation.

[0010] In a variant of the invention the cooling means comprise at least one cooling element with a flat side, which is mounted adjacently face to face on a front side

of the transformer-core. The heat transfer inbetween transformer-core and cooling element is advantageously improved if both components have a common boundary surface. The cooling means might comprise several components and be based on several kinds of cooling principals. It is for example possible to use an air based cooling system where a cooling element is surrounded in part by environmental air, which moves up when heated, so that a natural air flow is given. Airflow can be improved by a blower or fan or such for example, so that the efficiency of such a cooling system is improved in an advantageous way. But also cooling systems with heat exchanger respectively evaporator and condenser and closed cooling circuit are within the scope of the invention. The closed cooling circuit might be filled in an advantageous way with a cooling liquid, so that the efficiency of the cooling system is once more increased.

[0011] According to a preferred embodiment of the invention at least one laminated front side of the transformer-core is rib shaped at least in part and the cooling means comprise at least one cooling element with a flat side and corresponding notches therein, which is mounted adjacently face to face and toothed on a belonging section of a front side of the transformer-core. The common boundary surface of cooling means respectively cooling element and amorphous transformer-core is enlarged therewith, so that the heat transfer between both components is once more increased. A rib shape on the laminated front sides of the transformer-cores might become realized by a belonging variation of the width of the band-like amorphous material. It is for example an option to alternate packages of layers of the band-like material with the same width in their position for example packages of 250 layers each. In this case ribs are formed on both laminated face sides of the transformer-core as well in the limb- as in the yoke-areas. Typically a hollow-cylindrical coil is arranged around each limb area, so that nearly no space for a cooling element is available around the limb areas. Nevertheless the notches inbetween the ribs in the limb-areas can be used as cooling channels for example. Thus it is possible to arrange a pipe with a cooling liquid therein through the limb areas, which has to be seen as cooling means. But it is also possible to alternate the width of the amorphous band-like material winding-wise, so that ribs are only formed in the yoke areas, which provide sufficient space to connect cooling elements therewith.

[0012] According to a further embodiment of the invention at least one stripe of a solid heat-conducting material is wound inbetween adjacent layers of the band-like material and thermally connected to at least one of the cooling elements. Such stripe respectively bar provides an improved heat transfer from the inner transformer-core to one or both of the laminated front sides of the amorphous transformer-core, where the cooling means are foreseen. Thus a more homogenous temperature distribution within the amorphous transformer-core is gained, which improves once more its magnetic behaviour concerning reduced losses.

[0013] According to a further embodiment of the invention at least one cooling element comprises cooling ribs averted from the belonging laminated front side of the transformer-core. Thus the outer surface of the cooling element is once more enlarged, providing an improved cooling effect for heat exchange with the surrounding air for example.

[0014] According to a further embodiment of the invention the cooling means are connected with the at least one section of the laminated front sides by a glued bond at least in part. Preferably the glue is applied in a liquid form, so that all cavities which might be present inbetween the adjacent components to be glued together are filled with glue. Preferably the glue has good heat conducting characteristics, which might be enhanced for example by adding some Bornitrid. Thus the heat transfer inbetween transformer-core and cooling means is improved.

[0015] By the same reason also the connection of the cooling means with the at least one section of the laminated front sides comprises a heat conducting substance such as Bornitrid, for example 1% of weight, especially if it is applied in the liquid state.

[0016] According to a further embodiment of the invention the cooling means are connected with the laminated sides of the yoke areas. The yoke areas provide the best accessibility and space for the attachment of for example a cooling element. Optional cooling ribs of the cooling element are preferably perpendicular orientated, so that the ribs might become cooled by a natural air-flow. But also the limb areas are suitable for mounting cooling channels therein, for example within a free space inbetween limb and a transformer coil.

[0017] According to a further embodiment of the invention at least one area of the laminated front side is slanted and cooling means are connected thereto. A slanted area provides on one hand an enlarged contact area inbetween transformer-core and cooling means for an improved heat transfer, on the other side the cross section of a limb might become shaped in a polygonal respectively round-like manner, so that the cross section of the limb is adapted to the cross section of the inner opening of a hollow cylindrical transformer-coil arranged around the limb. A slanted area is realized by a belonging variation of the width of the band-like amorphous material.

[0018] According to a further embodiment of the invention the transformer-core wound from an amorphous band-like material comprises two inner hollows and three limb areas. Such a transformer-core is suitable for arranging three coils thereon, so that a three-phase transformer is build.

[0019] Further advantageous embodiments of the invention are mentioned in the dependent claims.

[0020] The invention will now be further explained by means of an exemplary embodiment and with reference to the accompanying drawings, in which:

Figure 1 shows a high-voltage-transformer,
Figure 2 shows a second transformer-core wound from amorphous band-like material,
Figure 3 shows a cross-section of third transformer-core with cooling means,
Figure 4 shows a cross-section of fourth transformer-core with cooling means,
Figure 5 shows a cross-section of fifth transformer-core with cooling means and
Figure 6 shows a cross-section of sixth transformer-core with cooling means.

[0021] Fig. 1 shows a high-voltage-transformer 10 from a side view. Three hollow-cylindrical transformer-coils 18, 20, 22 are arranged around belonging limbs of a transformer-core 12 wound from an amorphous band-like material. The transformer-core 12 comprises two hollows 14, 16 inbetween the limbs. On a laminated front side in the upper yoke area a cooling element 24 is foreseen, which comprises ribs with perpendicular orientation. The cooling element 24 is glued on the belonging laminated front side of the transformer-core 12. This improves on the one hand the heat transfer inbetween both components 12 <-> 24 and on the other side the mechanical stability of the wound transformer-core 12 is improved therewith.

[0022] Fig. 2 shows a second transformer-core wound from amorphous band-like material in a view on one of its laminated front sides. Around two inner hollows 44, 46 an amorphous band-like material is wound layer-wise 32, so that three limb areas 34, 36, 38 and an upper 40 and lower 42 yoke area are formed. In total three loops of the band-like amorphous material are foreseen: one inner loop each around each hollow 44, 46 and a third outer loop around both inner loops. Each loop might comprise a few thousand layers.

[0023] Fig. 3 shows a cross-section 50 of a third transformer-core through an inner hollow 60 and adjacent yokes 64 of the transformer-core. The center axis of the hollow 60 is indicated with reference number 62. In this case the cooling means are cooling elements 54, 58 with cooling ribs 56, which are attached on both laminated face sides of the transformer-core in the upper and lower 64 yoke area. In this figure only a few winding layers 52 of amorphous band-like material are indicated, whereas in a real amorphous transformer-core some thousand of those layers are foreseen.

[0024] Fig. 4 shows a cross-section 70 of a fourth transformer-core through an inner hollow and adjacent yokes of the transformer-core. In this example the cross section of the yoke-areas comprise ribs and notches 76 whereas the belonging side of cooling elements 72 connected therewith comprise corresponding ribs and notches. Thus a toothed 78 connection of the laminated front sides of the transformer-core with belonging cooling elements 72 is built. The heat transfer is increased therewith. For an additionally increased cooling effect the cooling elements 72 comprise cooling ribs 74.

[0025] Fig. 5 shows a cross-section 80 of a fifth transformer comparable to Fig. 3. In addition the fifth transformer-core comprises a stripe respectively bar 84 from a solid heat-conducting material, which is wound inbetween adjacent layers of amorphous band-like material and which is thermally connected to cooling elements 82 which are mounted on both laminated face sides of the transformer-core. A suitable heat-material is for example steel.

[0026] Fig. 6 shows a cross-section of sixth transformer-core with cooling means respectively cooling elements 94, 96. The cross section of the upper 98 lower limb comprises slanted areas 92. Cooling elements 94 are attached also to the slanted areas.

List of reference signs

[0027]

10 High-voltage-transformer
12 first transformer-core wound from amorphous band-like material
14 first inner hollow of first transformer-core
16 second inner hollow of first transformer-core
18 first hollow-cylindrical transformer coil
20 second hollow-cylindrical transformer coil
22 third hollow-cylindrical transformer coil
24 first cooling element
30 second transformer-core wound from amorphous band-like material
32 winding layers of amorphous band-like material
34 first limb area
36 second limb area
38 third limb area
40 upper yoke area
42 lower yoke area
44 first inner hollow of second transformer-core
46 second inner hollow of second transformer-core
50 cross-section of third transformer-core with cooling means
52 winding layers of amorphous band-like material
54 first cooling element of third transformer-core
56 cooling ribs averted from front side of third transformer-core
58 second cooling element of third transformer-core
60 inner hollow of third transformer-core
62 virtual center axis
64 cross section of lower yoke area of third transformer-core
70 cross-section of fourth transformer-core with cooling means
72 cooling element of fourth transformer-core
74 cooling ribs averted from front side of fourth transformer-core
76 notch of cooling element of fourth transformer-core
78 toothed area
80 cross-section of fifth transformer-core with cooling means

82 cooling element of fifth transformer-core
84 stripe of solid heat-conducting material
90 cross-section of sixth transformer-core with cooling means
92 slanted area of laminated front side
94 cooling element mounted on slanted area of laminated front side
96 cooling element mounted on non slanted area of laminated front side
98 cross section of upper yoke area of sixth transformer-core

Claims

1. High-voltage-transformer (10) comprising

- at least one transformer-core (12, 30) wound from an amorphous band-like material (32, 52) around at least one inner hollow (14, 16, 44, 46), wherein two opposed laminated front sides are formed by the edges of the wound band-like material (32, 52) and wherein at least two opposed limb areas (34, 36, 38) and an upper (40, 98) and lower (42, 64) yoke area are formed,
- at least one hollow-cylindrical transformer coil (18, 20, 22) arranged around a limb area (34, 36, 38) of the at least one transformer-core (12, 30),

characterized in that,
cooling means (54, 58, 72, 94, 96) are connected with at least a section of at least one of the laminated front sides.

2. High-voltage-transformer according to claim 1, **characterized in that** the cooling means (54, 58, 72, 94, 96) comprise at least one cooling element (54, 58) with a flat side, which is mounted adjacently face to face on a front side of the transformer-core (12, 30).

3. High-voltage-transformer according to claim 1 or 2, **characterized in that** at least one laminated front side of the transformer-core (12, 30) is at least in part rib shaped and **in that** the cooling means (54, 58, 72, 94, 96) comprise at least one cooling element (72) with a flat side and corresponding notches (76) therein, which is mounted adjacently face to face and toothed (78) on a belonging section of a front side of the transformer-core (12, 30).

4. High-voltage-transformer according to claim 2 or 3, **characterized in that** at least one stripe of a solid heat-conducting material (84) is wound inbetween adjacent layers of the band-like material (32, 52) and thermally connected to one of the cooling elements (54, 58, 72, 94, 96).

5. High-voltage-transformer according to any of the claims 2 to 4, **characterized in that** the at least one cooling element (54, 58, 72, 94, 96) comprises cooling ribs (56, 74) averted from the belonging laminated front side of the transformer-core (12, 30).

6. High-voltage-transformer according to any of the previous claims, **characterized in that** the cooling means (54, 58, 72, 94, 96) are connected with the at least one section of the laminated front sides by a glued bond at least in part.

7. High-voltage-transformer according to any of the previous claims, **characterized in that** the connection of the cooling means (54, 58, 72, 94, 96) with the at least one section of the laminated front sides comprises a heat conducting substance.

8. High-voltage-transformer according to any of the previous claims, **characterized in that** the cooling means (54, 58, 72, 94, 96) are connected with the laminated sides of the yoke areas (40, 42, 64, 98).

9. High-voltage-transformer according to any of the previous claims, **characterized in that** at least one area of the laminated front side is slanted (92) and cooling means (54, 58, 72, 94, 96) are connected thereto.

10. High-voltage-transformer according to any of the previous claims, **characterized in that** the transformer-core (12, 30) wound from an amorphous band-like material (32, 52) comprises two inner hollows (14, 16, 44, 46) and three limb areas (34, 36, 38).

Patentansprüche

1. Hochspannungstransformator (10), umfassend

- mindestens einen Transformatorkern (12, 30), der aus einem amorphen bandartigen Material (32, 52) um mindestens einen inneren Hohlraum (14, 16, 44, 46) gewickelt ist, wobei die beiden einander gegenüberliegenden lamellierten Vorderseiten von den Kanten des gewickelten bandartigen Materials (32, 52) gebildet werden und wobei mindestens zwei einander gegenüberliegende Schenkelbereiche (34, 36, 38) und ein oberer (40, 98) und unterer (42, 64) Jochbereich gebildet werden,
- mindestens eine hohlzylindrische Transformatorspule (18, 20, 22), die um einen Schenkelbereich (34, 36, 38) des mindestens einen Transformatorkerns (12, 30) angeordnet ist,

dadurch gekennzeichnet, dass

Kühlmittel (54, 58, 72, 94, 96) mit mindestens einem Abschnitt mindestens einer der lamellierten Vorderseiten verbunden sind.

2. Hochspannungstransformator nach Anspruch 1, **dadurch gekennzeichnet, dass** die Kühlmittel (54, 58, 72, 94, 96) mindestens ein Kühlelement (54, 58) mit einer flachen Seite, das mit der Stirnfläche an eine Vorderseite des Transformatorkerns (12, 30) anliegend montiert ist, umfassen.

3. Hochspannungstransformator nach Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** mindestens eine lamellierte Vorderseite des Transformatorkerns (12, 30) mindestens teilweise rippenförmig ist und dass die Kühlmittel (54, 58, 72, 94, 96) mindestens ein Kühlelement (72) mit einer flachen Seite und entsprechenden Kerben (76) darin, das mit der Stirnfläche an einem zugehörigen Abschnitt einer Vorderseite des Transformatorkerns (12, 30) anliegend montiert und verzahnt (78) ist, umfassen.

4. Hochspannungstransformator nach Anspruch 2 oder 3, **dadurch gekennzeichnet, dass** mindestens ein Streifen eines festen wärmeleitenden Materials (84) zwischen die angrenzenden Schichten des bandartigen Materials (32, 52) gewickelt und thermisch mit einem der Kühlelemente (54, 58, 72, 94, 96) verbunden ist.

5. Hochspannungstransformator nach einem der Ansprüche 2 bis 4, **dadurch gekennzeichnet, dass** das mindestens eine Kühlelement (54, 58, 72, 94, 96) Kühlrippen (56, 74) umfasst, die von der zugehörigen lamellierten Vorderseite des Transformatorkerns (12, 30) abgewandt sind.

6. Hochspannungstransformator nach einem der vorherigen Ansprüche, **dadurch gekennzeichnet, dass** die Kühlmittel (54, 58, 72, 94, 96) mindestens teilweise durch eine Klebeverbindung mit dem mindestens einen Abschnitt der lamellierten Vorderseiten verbunden sind.

7. Hochspannungstransformator nach einem der vorherigen Ansprüche, **dadurch gekennzeichnet, dass** die Verbindung der Kühlmittel (54, 58, 72, 94, 96) mit dem mindestens einen Abschnitt der lamellierten Vorderseiten einen wärmeleitenden Stoff umfasst.

8. Hochspannungstransformator nach einem der vorherigen Ansprüche, **dadurch gekennzeichnet, dass** die Kühlmittel (54, 58, 72, 94, 96) mit den lamellierten Seiten der Jochbereiche (40, 42, 64, 98) verbunden sind.

9. Hochspannungstransformator nach einem der vorherigen Ansprüche, **dadurch gekennzeichnet, dass** mindestens ein Bereich der lamellierten Vorderseiten abgeschrägt ist (92) und Kühlmittel (54, 58, 72, 94, 96) mit ihm verbunden sind.

10. Hochspannungstransformator nach einem der vorherigen Ansprüche, **dadurch gekennzeichnet, dass** der aus einem amorphen bandartigen Material (32, 52) gewickelte Transformatorkern (12, 30) zwei innere Hohlräume (14, 16, 44, 46) und drei Schenkelbereiche (34, 36, 38) umfasst.

Revendications

1. Transformateur haute tension (10) comprenant :

- au moins un noyau de transformateur (12, 30) enroulé à partir d'un matériau amorphe de type bande (32, 52) autour d'au moins une partie creuse interne (14, 16, 44, 46), deux côtés avant stratifiés opposés étant formés par les bords du matériau de type bande enroulé (32, 52) et au moins deux zones de branches opposées (34, 36, 38) et une zone de carcasse supérieure (40, 98) et inférieure (42, 64) étant formées,
- au moins une bobine de transformateur cylindrique creuse (18, 20, 22) agencée autour d'une zone de branche (34, 36, 38) de l'au moins un noyau de transformateur (12, 30),

caractérisé en ce que
des moyens de refroidissement (54, 58, 72, 94, 96) sont connectés à au moins une section d'au moins l'un des côtés avant stratifiés.

2. Transformateur haute tension selon la revendication 1, **caractérisé en ce que** les moyens de refroidissement (54, 58, 72, 94, 96) comprennent au moins un élément de refroidissement (54, 58) avec un côté plat, qui est monté en position adjacente face à face sur un côté avant du noyau de transformateur (12, 30).

3. Transformateur haute tension selon la revendication 1 ou 2, **caractérisé en ce qu'**au moins un côté avant stratifié du noyau de transformateur (12, 30) est au moins en partie en forme de nervure et **en ce que** les moyens de refroidissement (54, 58, 72, 94, 96) comprennent au moins un élément de refroidissement (72) avec un côté plat et des encoches correspondantes (76) dans celui-ci, lequel est monté en position adjacente face à face et présente des dents (78) sur une section associée d'un côté avant du noyau de transformateur (12, 30).

4. Transformateur haute tension selon la revendication 2 ou 3, **caractérisé en ce qu'**au moins un ruban

d'un matériau massif thermoconducteur (84) est enroulé entre des couches adjacentes du matériau de type bande (32, 52) et est connecté thermiquement à l'un des éléments de refroidissement (54, 58, 72, 94, 96).

5. Transformateur haute tension selon l'une quelconque des revendications 2 à 4, **caractérisé en ce que** l'au moins un élément de refroidissement (54, 58, 72, 94, 96) comprend des nervures de refroidissement (56, 74) détournées du côté avant stratifié associé du noyau de transformateur (12, 30).

6. Transformateur haute tension selon l'une quelconque des revendications précédentes, **caractérisé en ce que** les moyens de refroidissement (54, 58, 72, 94, 96) sont connectés au moins en partie à l'au moins une section des côtés avant stratifiés par une liaison collée.

7. Transformateur haute tension selon l'une quelconque des revendications précédentes, **caractérisé en ce que** la connexion des moyens de refroidissement (54, 58, 72, 94, 96) à l'au moins une section des côtés avant stratifiés comprend une substance thermoconductrice.

8. Transformateur haute tension selon l'une quelconque des revendications précédentes, **caractérisé en ce que** les moyens de refroidissement (54, 58, 72, 94, 96) sont connectés aux côtés stratifiés des zones de carcasse (40, 42, 64, 98).

9. Transformateur haute tension selon l'une quelconque des revendications précédentes, **caractérisé en ce qu'**au moins une zone du côté avant stratifié est inclinée (92) et des moyens de refroidissement (54, 58, 72, 94, 96) sont connectés à celle-ci.

10. Transformateur haute tension selon l'une quelconque des revendications précédentes, **caractérisé en ce que** le noyau de transformateur (12, 30) enroulé à partir d'un matériau amorphe de type bande (32, 52) comprend deux parties creuses internes (14, 16, 44, 46) et trois zones de branches (34, 36, 38).

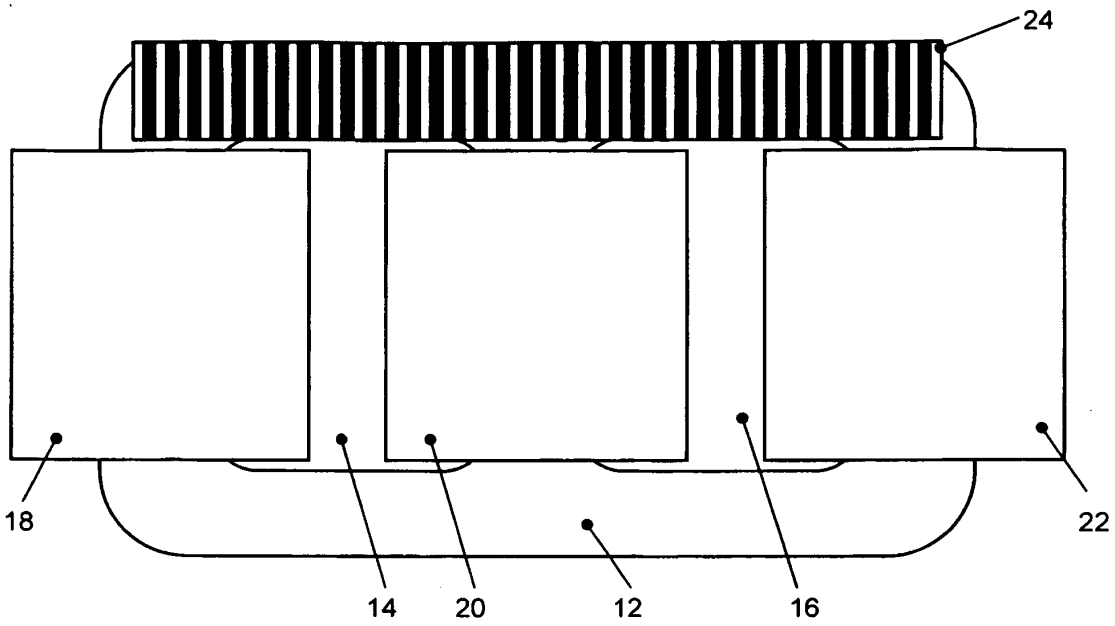

Fig. 1

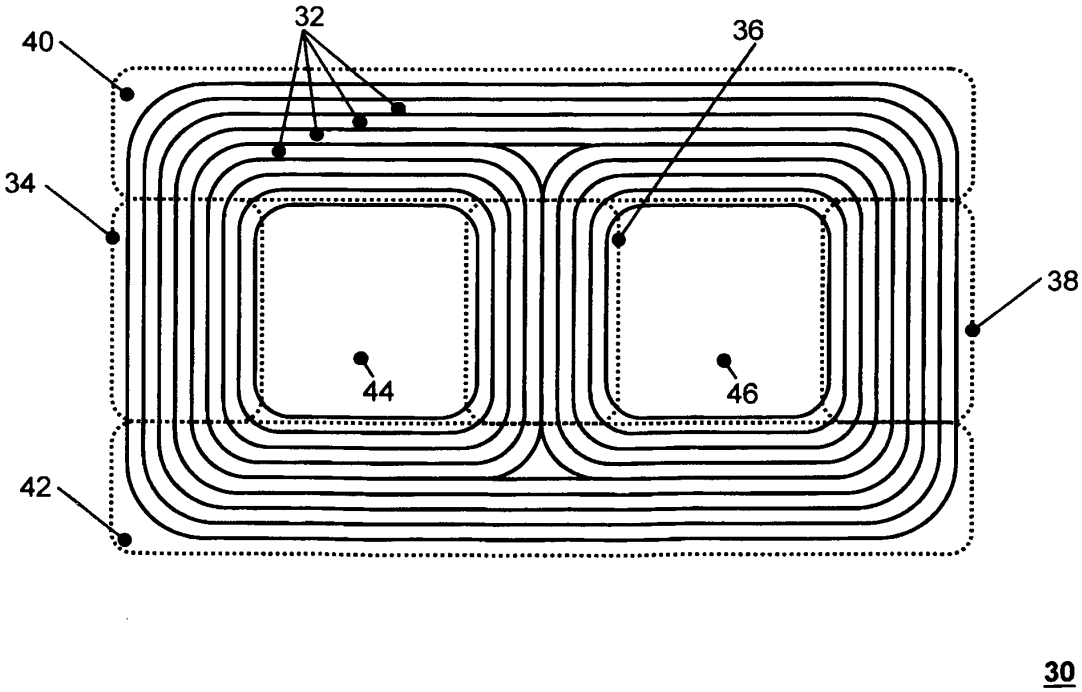

Fig. 2

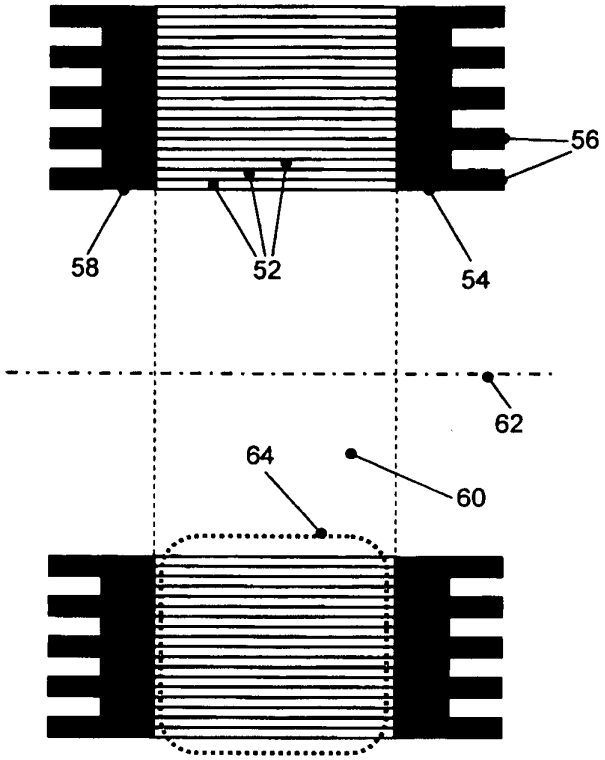

Fig. 3

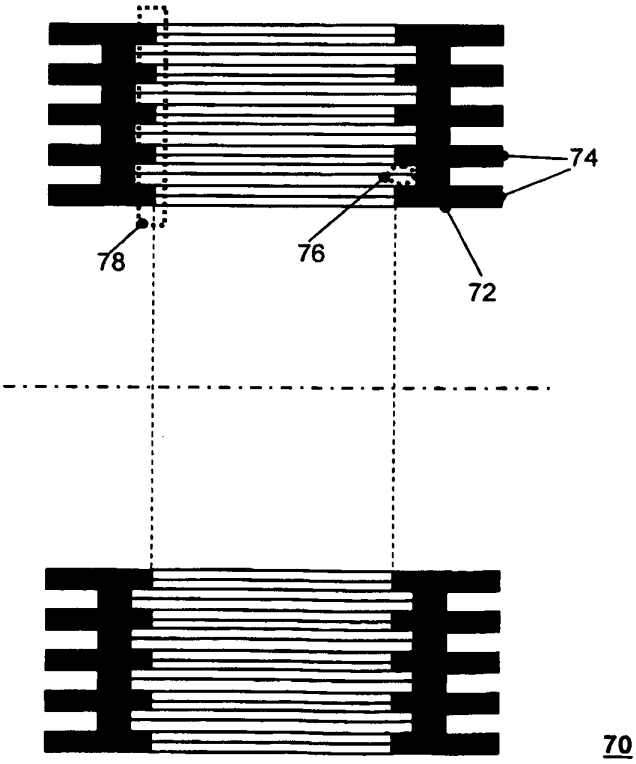

Fig. 4

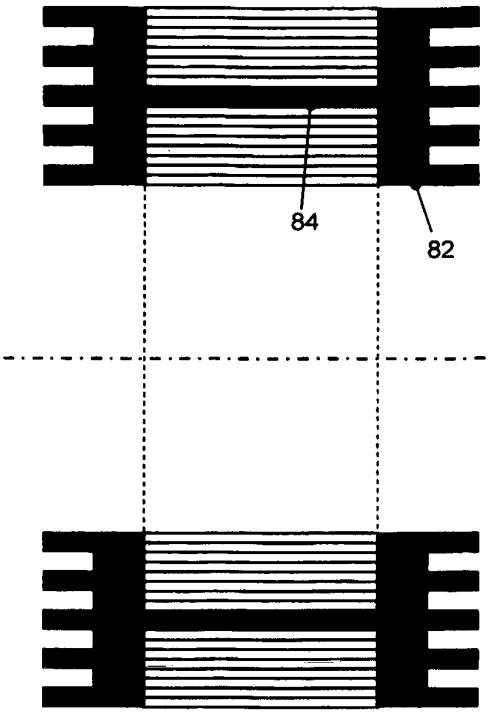

Fig. 5

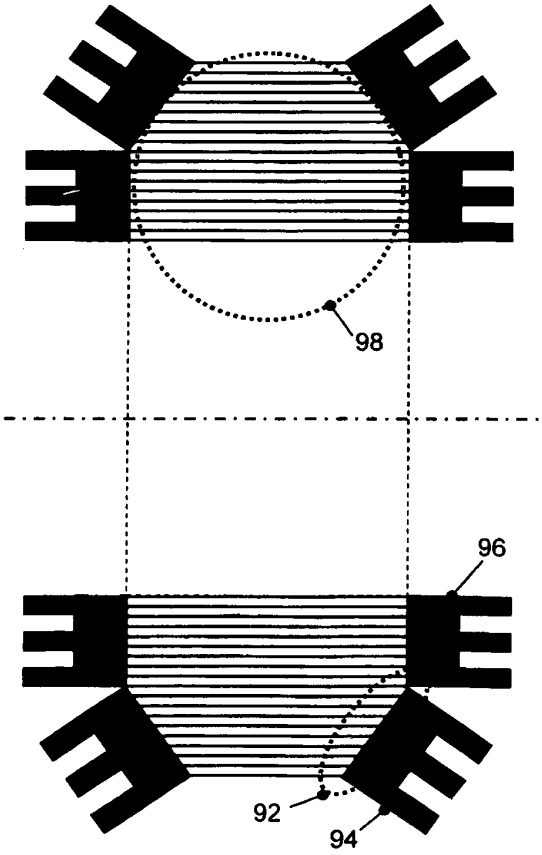

Fig. 6

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 6411188 B **[0003]**