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(54) **METHOD OF MANUFACTURING AN AMORPHOUS MAGNETIC CORE AND AMORPHOUS MAGNETIC CORE**

VERFAHREN ZUR HERSTELLUNG EINES AMORPHEN MAGNETKERNS UND AMORPHER MAGNETKERN

PROCÉDÉ POUR FABRIQUER UN NOYAU MAGNÉTIQUE AMORPHE ET NOYAU MAGNÉTIQUE AMORPHE

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Description

[0001] The invention relates in general to manufacturing of an improved amorphous metal magnetic core for electrical inductive apparatus such as transformers and reactors.

[0002] Transformer cores are commonly manufactured using silicon steel laminations as the magnetic core material. Such cores,are rigid, self-supporting and are not very stress sensitive. Alternatively, magnetic cores may be manufactured of amorphous metal lamination layers. Currently, the amorphous metal-based transformer cores are more and more often used in the market. They advantageously offer a very, low level of the no-load losses, called also core losses, which is beneficial for their use in the power grid.

[0003] Amorphous metal-based transformer cores has, however, some drawbacks which are related to the manufacturing process, their handling and assembly in transformers as well as to the increased average level of the noise emitted by a transformer unit, which results from the increased magnetostriction. The difficulties with both handling and assembling is caused by a limited resistance to buckling the core and lack of a self-supportive functionality. This produces issues with stabilization of the amorphous cores and a need for additional supporting frames needed in the design. Improper handling can additionally lead to ribbon deformation or ribbon sliding and induces mechanical stresses, which results in loss of structural integrity and degradation of magnetic properties. To prevent movement of ribbons and to increase rigidity of the core, amorphous cores have been encapsulated or at least part of amorphous metal lamination layers should be coated on the edges with a low-stress and low-viscosity coating material.

[0004] The method for coating the edges of a magnetic core containing strips of amorphous metal is known from patent description US 6,413,351. The lamination layers are coated on the edges with a low-stress, low-viscosity coating material which, when cured, becomes sufficiently rigid to support the lamination layers of amorphous material. The coating material can be applied to the entire edge surface of both sides of the core or only to selected portions of the edges on other side. In either instance, the coating material is applied in a manner that allows built-in stresses to relax out before all coating material is fully cured, however the patent is silent about the noise decreasing level of the core emitted during the work of the transformer with such a core.

[0005] A magnetic core having reduced audible noise and a method of making the amorphous alloy-based magnetic core emanating low audible noise is known from patent US 8,427,272. The method includes: placing the core with multiple layers of high strength tape on the core legs, wherein the tapes have a high tensile strength, high dielectric strength and high service temperature, resulting in reduced level of audible noise. When operated under optimum condition, the reduced level of audible noise is 6-10 dB less when compared with a same -size core that has been coated with resin instead. The method according to this solution is rather labour-consuming. Wrapping the legs of the transformer by using the tapes increases the number of steps during the manufacture of the core. Moreover, the method can have certain limitations in application for bigger cores where the use of high-strength tapes is questionable, since both the dimensions and weight of the core may lead eventually to its buckling despite presence of the tape.

[0006] There is known from US patent description US 4615106 a method of consolidation of a magnetic core containing amorphous metal. The method including the step of thermal spraying an electrically non-conductive material on the edges of the laminations which make up the magnetic core. The document not disclosed any solutions exert an influence on the noise reduction of the amorphous magnetic core.

[0007] The essence of a method of manufacturing an amorphous magnetic core, wherein the method comprises assembling a plurality of lamination layers made of amorphous metal strips to designing a wound core shape or a stacked core shape wherein the wound core shape has two parallel faces formed by edges of the lamination layers and has means for constraining the shape of the core during the manufacturing, whereas the stacked core shape, has side faces formed by edges of the lamination layers, is that the method further comprises: a step of step of introducing between the neighboring lamination layers of the core an organometallic binder for receiving a number of film layers, wherein the thermal expansion coefficient of the film layers is lower than the a thermal expansion coefficient of lamination layers. Each film layer is disposed through the whole cross-section of the core, perpendicular to the both faces of the wound core or to the all side faces of the stacked core. Next step of binding together the lamination layers with the film layers is performed by annealing the core in a magnetic field having value above 800A/m. The lamination layers bonded together with the film layers for reducing audible noise when the core is under operating condition.

Preferably as the organometallic binder a liquid sol is used.

Preferably the liquid sol has a viscosity from 0.1 cps (0,1 mPa·s) to 50 cps (50 mPa·s).

Preferably as the organometallic binder, a single organosillicon sol or a mixture of the various organosillicon sols are used.

Preferably the step of introducing of the organometallic binder between the neighboring lamination layers of the core is performed by brushing at least one part of the face or the side faces of the core formed by edges of the lamination layers.

Alternatively the step of introducing of the organometallic binder between the neighboring lamination layers of the core is performed by immersing in a liquid sol at least a part of the core.

Alternatively the step of introducing of the organometallic binder between the neighboring lamination layers of the core is performed by spraying the organometallic binder on lamination layers before the step of assembling a plurality of

lamination layers made of amorphous metal strips to designing a core shape.

[0008] The essence of an amorphous magnetic core structure having lamination layers made of amorphous metal strips and the film layers made of an organometallic binder, is that the film layers are placed between the eighboring lamination layers. The thermal expansion coefficient of each of the film layers is lower than the thermal expansion coefficients of the neighboring lamination layers. The structure formed by lamination layers bonded with film layers forms the core thereby reducing audible noise when the core is under operating condition.

Preferably in the core structure each of the film layers is disposed in the space between the two neighboring lamination layers and the film layers is are in contact with the two opposite faces of each of the neighboring lamination layers. Preferably the lamination layers have the thermal expansion coefficient near to $7{,}8x10^{-6}$[1/K].

A core having a structure according to claims 8-10 is used in an electrical apparatus.

An electrical apparatus according to claim 11 wherein the electrical apparatus is a power transformer or distribution transformer.

[0009] The improved amorphous magnetic core according to the invention is self-supporting structure, where mechanical stability is obtained. The lamination layers in amorphous cores, which usually tend to separate each other and to straighten themselves are formed to a desired shape and then bonded together in a form of a bulk component thanks to the unique organometallic binders with almost zeroed thermal expansion coefficients. The organometallic binders is introduced between the lamination layers during manufacturing process, but before the thermomagnetic treatment process, which is annealing at the standard treatment temperature (normally 350-400°C) and in the presence of magnetic field (normally 800-1000A/m). The organometallic binders used provide at the same time in the amorphous cores a specific tensile stress state condition in the laminations layers, decreasing the resulting noise level emitted by amorphous magnetic core during operation of the device with such core. The improved magnetic core is consolidated with an organometallic binder, which bond together the lamination turns. An improved method assures penetrating of the organometallic binder in a liquid sol form between the lamination turns, however, resulting properties of the solidified binder prevent from unwanted stress development in the core, which would increase its losses. The present invention provides technology of the low no-load loss amorphous metal magnetic cores manufacturing which assures self-supporting functionality what as well as the decreased audible noise emission of an electrical device built based on a new and improved core.

[0010] The invention will be more fully understood with reference to the drawing in which:

fig.1 shows the first exemplary embodiment of the invention as a wound amorphous metal magnetic core in an axonometric view,

fig.2 shows a detail "a" from fig.1,

fig.3 shows the second exemplary embodiment of the invention as a stacked amorphous metal magnetic core in an axonometric view,

fig.4 shows a detail "b" from fig.3,

fig.5 shows the step of introducing the organometallic binder between the lamination layers of a core in the first embodiment of the invention,

fig.6 shows the step of the other way of introducing the organometallic binder between the lamination layers of a part of the core in the first embodiment of the invention,

fig.7 shows the step of the other way of introducing the organometallic binder between the lamination layers of a whole core in the first embodiment of the invention,

fig.8 shows the step of the another way of introducing the organometallic binder between the lamination layers of a core in the first embodiment of the invention,

fig.9 shows the step of introducing the organometallic binder between the lamination layers of a core in the second embodiment of the invention.

[0011] In the first embodiment of the invention a core 1 has two leg portions 2 and 4, and two yoke portions 3 and 5 which are formed from amorphous alloy strip lamination layers 6. In one of the yoke portion, for example 3, a distributed gap 7 is formed by staggered overlapping of the ends of the amorphous alloy strip lamination layers 6. Between the two neighboring lamination layers 6 a very thin film layers 8 of organometallic binder is introduced for at least part of legs or

yokes. The lamination layers 6 and the film layers 8 form a structure of a core. The edges of the lamination layers and the film layers define two parallel faces 9 of the core. The core is supported from an external side by a band 10 of ferromagnetic material placed perpendicularly to the core faces. The ferromagnetic material can be a silicon steel of 0.2-0.3 mm thickness and it is used to constrain the shape of the core, since the core tends to straighten and/or to open during manufacturing step when not constrained. The film layers 8 are made of an organometallic material forming a organometallic binder 11, especially having a form of liquid sol.

[0012] In the second embodiment of the invention a core 1' has two leg portions 2' and 4', and two yoke portions 3' and 5' which are formed from amorphous alloy strip lamination layers 6'. Between the two neighboring lamination layers 6' a very thin film layers 8' of organometallic binder is introduced for at least part of legs or yokes. The lamination layers 6' and the film layers 8' form a structure of a core 1'. The edges of the lamination layers and the film layers define side surfaces 9' of the core. The film layers 8' are made of an organometallic material forming an organometallic binder 11, especially having a form of liquid sol.

[0013] The method according to the invention is realized in the following way.

[0014] First the process of assembling a plurality of lamination layers 6 made of amorphous metal strips to designing a core shape is performed in a known way. It can be performed either by winding of the lamination layers with a controlled tension in order to obtain the filling factor of the core above 80% or by stacking of the lamination layers with a controlled compression in order to obtain the filling factor of the core above 80%.

[0015] In the both embodiments of the invention, the step of introducing between the neighboring lamination layers 6 or 6' of the core 1 or 1', respectively, an organometallic binder 11 in a form of a low viscosity liquid sol is applied on the face(s) 9 of the core 1 or side surface(s) 9' of the core 1'. The organometallic binder in a form of a liquid sol a can be applied with the use of a brush or equivalent technique. Such method is shown in fig.5 only for the first embodiment of the invention. It is understood that the similar method is used for the second embodiment of the invention, what is not presented in the drawing. The organometallic binder penetrates easily in-between the neighboring lamination layers 6 or 6' filling all the gaps in the core structure forming a very thin film layers 8 or 8' of organometallic binder 11. The bonding material adheres well to the lamination layers and is capable for penetrating through the core with substantial wicking between the core lamination layers. Accordingly, bonding materials in a liquid sol forms having a viscosity from 0.1 cps (0,1 mPa·s) to about 50 cps (50 mPa·s) are preferred. Preferably the organometallic binder in a liquid sol form has a viscosity from 0.1 cps (0,1 mPa·s) to 10 cps (10 mPa·s). As an exemplary organometallic binder, a mixture of organosilicons, namely Triethoxymethylsilane (T) and Diethoxydimethylsilane (D) is used with a molar ratios T/D=1:2, 1:1, 2:1 or 4:1 respectively. As the organometallic binder also the sole organosilicon may be used. The amount of the organometallic binder material in a liquid sol form applied must be sufficient to result in substantial wicking between the lamination layers of the core.

[0016] In the next step, the bonding between the neighboring lamination layers 6 or 6' is obtained during standard thermomagnetic treatment of the cores at 350-400°C when the organometallic binder melts and then solidifies during cooling. Complex hardening/solidification steps such as UV or chemical curing are not necessary to set the bonding materials of the present invention. Accordingly, the present invention provides an improved method for providing increased mechanical strength to amorphous alloy cores with substantially reduced risk of degradation of the mechanical properties thereof.

[0017] In the both embodiments of the invention the other ways of the introducing of the organometallic binder 11 between the neighboring lamination layers 6 or 6' of the core 1 or 1' are performed after assembling of the core and next by immersing a part of a core 1 or 1' (fig.6) or the whole core 1 or 1' (fig.7) in a tank 12 filled with the organometallic binder 11 having a liquid sol form. Such methods are shown in fig.6 and fig.7 only for the first embodiment of the invention. It is understood that the similar method is used for the second embodiment of the invention, what is not presented in the drawing. The organometallic binder can be applied partly either on subsequent legs and yokes or on the whole core depending on the needs.

[0018] The next step in these embodiments is the same as in the first embodiment.

[0019] In the first embodiment of the invention another way of the step of introducing between the neighboring lamination layers 6 of the core 1 an organometallic binder 11 is applied during the assembling the designed shape of a core by e.g. spraying of each lamination layer 6 directly before winding/shaping of the core 1. The organic binder may be a liquid sol or may have a form of small solid particles 11a, which after spraying on the surface of the layers 6 covered the all surface. In this embodiment of the invention the core 1 may not be supported from en external side by a band of ferromagnetic material like in the previous embodiments.

[0020] In the next step, the bonding between the neighboring lamination layers 6 is obtained during standard thermomagnetic treatment of the cores at 350-400°C when the organometallic binder melts and then solidifies during cooling.

[0021] In the second embodiment of the invention another way of the step of introducing between the neighboring lamination layers 6' of the core 1' an organometallic binder 11 is applied during the assembling the designed shape of a core by e.g. spraying of each lamination layer 6' directly before assembling/stacking of the core 1'. The organometallic binder 11 may be a liquid sol or may have a form of small solid particles 11a, which after spraying on the surface of the

layers 6' covered the all surface.

[0022] In the next step, the bonding between the neighboring lamination layers 6' is obtained during standard thermomagnetic treatment of the cores at 350-400°C when the organometallic binder melts and then solidifies during cooling.

[0023] In all embodiments of the invention the organometallic binder after solidification is electrically isolative and a rigid component. After application of the organometallic binder between the amorphous metal lamination layers and following thermomagnetic treatment, the high strength bulk amorphous metal magnetic core is produced and the high strength structure provides the necessary structural support to make the core self-supporting over the complete operating temperature range of the associated apparatus. The organometallic binder bonds together the amorphous ribbons and having thermal expansion coefficient, CTE, lower than the CTE of amorphous metal lamination layers, which is around $7{,}8 \times 10^{-6}$ [1/K], produces a preferable state of stress in the lamination layers, which enables the reduced audible noise emission without applying significant stresses to the core thus the increase in level of the core losses is avoided.

[0024] The organometallic binder adheres well to amorphous metal lamination layers after the solidification occurring during the thermomagnetic treatment, thus enables the composite core to handle mechanical stresses, and protects the core from stresses developed during coil winding, and it withstands thermal cycling stresses created in the operating environment. The organometallic binders include components, which after solidification, are compatible with the usual transformer coolants or liquid dielectrics, such as mineral oil. The organometallic binder is applied in a liquid sol form having viscosity from 0.1 cps to 50 cps (0,1 mPa.s to 50 mPa.s), which ensures complete penetration of the sol between the laminations of the amorphous magnetic core, including substantial wicking.

[0025] The binder in the form of a liquid sol is introduced between the lamination layers of the core before the thermomagnetic treatment step without the need for molds, using immersion technique, or a simple application with e.g. brushing or equivalent, or spraying techniques. The organometallic binder in the form of a liquid sol is suitable for a standard heat treatment together with the core, which is lead in a conventional way and results in solidification of the sol during thermomagnetic treatment at 350-400°C.

[0026] The core according to the invention is used in electrical apparatus, and especially in power transformer having a decreased level of audible noise during their exploitation.

Empirical example of the invention

[0027] One amorphous Core 1 (about 140mm by 250mm, 20 mm thick, weighing about 3.3kg) of 40mm wide Metglas 2605 SA1 with the distributed gap portion was produced with introducing the organometallic binder at the lower yoke and leg components only. The organometallic binder in a liquid sol form (consisted of Triethoxymethylsilane (T) and Diethoxydimethylsilane (D) with a molar ratios T/D=2:1) was applied on the amorphous core with a brush, ensuring substantial wicking. The core, after sol application, was subjected to thermomagnetic treatment at temperature 370°C and magnetic field H=1000A/m for 90 minutes. The organometallic binder after thermomagnetic treatment at 370°C has a form of a film layer which bonded the lamination layers of the core, creating the improved amorphous metal magnetic core.

[0028] A reference amorphous Core 2 with the distributed gap was manufactured according to the state-of-the-art procedure in which the lateral edges or "faces" were coated with an epoxy resin, which was solidified then.

[0029] The result of the experiment is presented in a table 1 and a table 2.

[0030] The core loss level was measured for all cores at 50 Hz and varying magnetic induction B is given in Table 1. The composite Core 1 revealed slightly decreased core loss than the reference Core 2 after the edge coating, indicating that the organometallic binder, even if penetrating between the laminations, did not produce any substantial stresses in the core. Thus, the manufacturing technology of the present invention do not degrade the magnetic properties of the cores.

Table 1.

Core Loss [Watts/kg]		
Induction B [Tesla]	Core 2	Core 1
	epoxy fixation	organometallic binder
1.3	0.27	0.20
1.4	0.32	0.24

[0031] The sound power emitted by the amorphous cores was measured in anechoic chamber at 1.35T induction B and the results are given below in Table 2. Significant sound power reduction -11.4dB(A) was obtained for the improved amorphous metal magnetic Core 1 with the organometallic binder compared to the reference Gore 2 with the epoxy fixation (state-of-the-art).

Table 2.

Sound Power [dB(A)]		
Induction B [Tesla]	Core 2	Core 1
	with epoxy fixation	with organometallic binder
1.35	53.9	42.5

[0032] The low no-load loss amorphous metal magnetic core was manufactured in this way, having self-supporting functionality with the mechanical resistance. The Core 1 could be handled without permanent deformation. Thus, the present invention provides the manufacturing technology of the improved amorphous magnetic cores with decreased level of the emitted sound power, good mechanical stability and with no degraded magnetic properties.

Claims

1. A method of manufacturing an amorphous magnetic core (1, 1'), wherein the method comprises assembling a plurality of lamination layers (6, 6') made of amorphous metal strips to designing a wound core shape (1) or a stacked core shape (1') wherein the wound core shape (1) has two parallel faces (9) formed by edges of the lamination layers (6) and has means for constraining the shape of the core (1) during the manufacturing, whereas the stacked core (1') has side faces (9') formed by edges of the lamination layers (6'), **characterized in that the method further comprises:**

   - a step of introducing between the neighbouring lamination layers (6, 6') of each said core (1,1') respectively, an organometallic binder (11, 11a) for forming a number of film layers (8, 8') of the binder, wherein the thermal expansion coefficient of the film layers (8, 8') is lower than the thermal expansion coefficient of core lamination layers (6, 6'), and wherein each film layer (8, 8') is disposed through the whole cross-section of the core (1,1') perpendicular to the both faces (9) of the wound core (1) or to all side faces (9') of the stacked core (1'), and
   - a step of binding together the lamination layers (6, 6') with the film layers (8, 8') by annealing the core (1,1') at a temperature 350-400°C and in a magnetic field having value above 800 A/m, wherein the lamination layers bonded with the film layers (8, 8'), form the core (1, 1') thereby reducing audible noise when the core is under operating condition.

2. A method of the claim 1, **characterized in that** as the organometallic binder (11, 11a) a liquid sol is used.

3. A method of the claim 2, **characterized in that** the liquid sol has a viscosity from 0.1 cps (0,1 mPa·s) to 50 cps (50 mPa·s).

4. A method of the claim 1-3, **characterized in that** as the organometallic binder a single organosillicon sol or a mixture of the various organosillicon sols are used.

5. A method according to any previous claims, **characterized in that** the step of introducing of the organometallic binder (11) between the neighboring lamination layers (6, 6') of the core is performed by brushing at least one part of the face (9) or the side faces (9') formed by edges of the lamination layers (6, 6').

6. A method according to claims 1-4, **characterized in that** the step of introducing of the organometallic binder (11) between the neighboring lamination layers of the core is performed by immersing in a liquid sol at least a part of the core (1, 1').

7. A method according to claims 1-4, **characterized in that** the step of introducing of the organometallic binder (11) between the neighboring lamination layers (6, 6') of the core is performed by spraying the organometallic binder (11a) on lamination layers (6, 6') before the step of assembling a plurality of lamination layers (6, 6') made of amorphous metal strips to designing a core shape.

8. An amorphous magnetic structure of a core (1,1') wherein the structure comprises lamination layers (6, 6' made of amorphous metal strips and film layers (8, 8') made of an organometallic binder (11, 11a), placed between the

neighboring lamination layers (6; 6'), wherein the thermal expansion coefficient of each of the film layers (8, 8') is lower than the thermal expansion coefficients of the neighboring lamination layers (6, 6'), and the structure formed by lamination layers (6, 6') bonded with the film layers (8, 8') forming the core (1, 1') thereby reducing audible noise when the core is under operating condition.

9. A core structure according to claim 8, characterize in that each of the film layers (8, 8') is disposed in the space between the two neighboring lamination layers (6, 6') and the film layers (8, 8') are in contact with the two opposite faces of each of the neighboring lamination layers (6, 6').

10. A core according to claims 8-9, **characterized in that** the thermal expansion coefficient of the lamination layers (6, 6') is around 7,8 $x10^{-6}$ [1/K].

11. An electrical apparatus with a core (1, 1') having a structure according to claims 9-10.

12. An electrical apparatus according to claim 11 wherein the electrical apparatus is a power transformer or a distribution transformer.

Patentansprüche

1. Verfahren zur Herstellung eines amorphen Magnetkerns (1, 1'), welches das Zusammenfalten mehrerer aus Streifen eines amorphen Metalls erzeugten Laminierungsschichten (6, 6'), die ein Bandkern (1) oder ein Faltkern (1') bilden, wobei der Bandkern (1) zwei parallele Flächen (9) hat, die von den Kanten der Laminierungsschichten (6) geformt sind und über Mittel zum Einschränken der Form des Kerns (1) während seiner Herstellung verfügt, und der Faltkern (1') seitliche Flächen (9') hat, die von den Kanten der Laminierungsschichten (6') geformt sind, **dadurch gekennzeichnet, dass es folgende Schritte umfasst:**

- Den Schritt der Einführung zwischen die benachbarten Laminierungsschichten (6, 6') des jeden Kerns (1, 1') entsprechend von einem metallorganischen Bindemittels (11, 11a) zum Formen von mehreren Dünnfilmen (8, 8'), wobei der Wärmeausdehnungskoeffizient von Dünnfilmen (8, 8') niedriger als der Wärmeausdehnungskoeffizient der Laminierungsschichten des Kerns (6, 6') ist und jeder Dünnfilm (8, 8') über den ganzen Querschnitt des Kerns (1, 1') senkrecht zu den beiden Flächen (9) des Bandkerns (1) bzw. zu allen Seitenflächen (9') des Faltkerns (1') verteilt ist und
- Den Schritt der Verbindung von Laminierungsschichten (6, 6') mit den Dünnfilmen (8, 8') durch Glühen des Kerns (1, 1') bei der Temperatur von 350-400 °C und in einem Magnetfeld von über 800 A/m, bei welchem die mit den Dünnfilmen (8, 8') verbundenen Laminierungsschichten einen Kern (1, 1') bilden, wodurch das hörbare Geräusch während des Einsatzes des Kerns reduziert wird.

2. Das Verfahren gemäß Anspruch 1, **dadurch gekennzeichnet, dass** als metallorganisches Bindemittel (11, 11a) ein flüssiges Sol eingesetzt wird.

3. Das Verfahren gemäß Anspruch 2, **dadurch gekennzeichnet, dass** das flüssige Sol die Viskosität von 0,1 cps (0,1 mPa·s) bis 50 cps (50 mPa·s) hat.

4. Das Verfahren gemäß den Ansprüchen 1-3, **dadurch gekennzeichnet, dass** als metallorganisches Bindemittel ein einzelnes siliziumorganisches Sol oder eine Mischung von unterschiedlichen siliziumorganischen Solen eingesetzt werden.

5. Das Verfahren gemäß jeglichem der o.a. Ansprüche, **dadurch gekennzeichnet, dass** der Schritt der Einführung des metallorganischen Bindemittels (11) zwischen die benachbarten Laminierungsschichten (6, 6') des Kerns durch das Auftragen mit einem Pinsel auf mindestens einem Teil der Fläche (9) oder der von den Kanten der Laminierungsschichten (6, 6') geformten Seitenflächen (9') erfolgt.

6. Das Verfahren gemäß den Ansprüchen 1-4, **dadurch gekennzeichnet, dass** der Schritt der Einführung des metallorganischen Bindemittels (11) zwischen die benachbarten Laminierungsschichten des Kerns durch das Eintauchen von mindestens einem Teil des Kerns (1, 1') in dem flüssigen Sol erfolgt.

7. Das Verfahren gemäß den Ansprüchen 1-4, **dadurch gekennzeichnet, dass** der Schritt der Einführung des me-

tallorganischen Bindemittels (11) zwischen die benachbarten Laminierungsschichten des Kerns durch das Aufsprühen des metallorganischen Bindemittels (11a) auf die Laminierungsschichten (6, 6') vor dem Schritt der Zusammenlegung von mehreren aus Streifen des amorphen Metalls erzeugten Laminierungsschichten (6, 6') zwecks Gestaltung des entworfenen Kerns erfolgt.

8. Die amorphe magnetische Struktur des Kerns (1, 1'), zusammengesetzt aus den Laminierungsschichten (6, 6'), welche aus Streifen des amorphen Metalls erzeugt sind, und aus den Dünnfilmen (8, 8'), welche aus dem zwischen die benachbarten Laminierungsschichten (6, 6') eingeführten metallorganischen Bindemittel (11, 11a) erzeugt sind, und in welcher der Wärmeausdehnungskoeffizient jedes Dünnfilms (8, 8') niedriger als die Wärmeausdehnungskoeffizienten der benachbarten Laminierungsschichten (6, 6') ist, zusammen mit der aus den mit Dünnfilmen (8, 8') verbundenen Laminierungsschichten (6, 6') geformten Struktur bilden den Kern (1, 1'), wodurch das hörbare Geräusch während des Einsatzes des Kerns reduziert wird

9. Die Struktur des Kerns gemäß Anspruch 8, **dadurch gekennzeichnet, dass** jeder der Dünnfilme (8, 8') in dem Raum zwischen zwei benachbarten Laminierungsschichten (6, 6') angebracht ist und die Dünnfilme (8, 8') im Kontakt mit den zwei gegenüberliegenden Flächen der benachbarten Laminierungsschichten (6, 6') sind.

10. Der Kern gemäß den Ansprüchen 8-9, **dadurch gekennzeichnet, dass** der Wärmeausdehnungskoeffizient der Laminierungsschichten (6, 6') ungefähr 7,8 x 10^{-6} [1/K] beträgt.

11. Ein elektrisches Gerät mit einem Kern (1, 1'), welcher die Struktur gemäß den Ansprüchen 9-10 aufweist.

12. Ein elektrisches Gerät gemäß Anspruch 11, welches ein Netztransformator oder ein Verteilertransformator ist.

Revendications

1. Procédé pour fabriquer un noyau magnétique amorphe (1, 1') qui comporte l'assemblage des plusieurs couches stratifiant (6, 6') faites en bandes de métal amorphe formant le noyau enroulé (1) ou le noyau empilé (1'), lequel noyau enroulé (1) a deux surfaces parallèles (9) formées par les bords des couches stratifiées (6) et possède des moyens à limiter la forme du noyau (1) lors de sa création, alors que le noyau empilé (1') a deux surfaces latérales (9') créées par les bords des couches stratifiées (6'), **caractérisé en ce que le procédé comprend en outre les pas suivants** :

   - le pas d'insertion entre deux couches stratifiées adjacentes (6, 6') de chaque noyau (1, 1') respectivement d'un liant organométallique (11, 11a) pour former plusieurs couches minces (8, 8') étant entendu que le coefficient de dilatation thermique des couches minces (8, 8') est inférieur au coefficient de dilatation thermique des couches stratifiées du noyau (6, 6') et chaque couche mince (8, 8') est répartie sur toute la section du noyau (1, 1') perpendiculairement aux deux surfaces (9) du noyau enroulé (1) ou à toutes les surfaces latérales (9') du noyau empilé (1'), et
   - le pas de réunion des couches stratifiées (6, 6') avec les couches minces (8,8') par le recuit du noyau (1, 1') à la température de 350° - 400° C dans le champ magnétique ayant une valeur supérieure à 800 A / m, où les couches stratifiées (8, 8') forment un noyau (1, 1') en réduisant ainsi le bruit audible émis pendant le fonctionnement du noyau.

2. Procédé selon la revendication 1, **caractérisé en ce que** l'on utilise le sol liquide comme liant organométallique (11, 11a).

3. Procédé selon la revendication 2, **caractérisé en ce que** le sol liquide a une viscosité de 0,1 cps (0,1 mPa·s) à 50 cps (50 mPa·s).

4. Procédé selon la revendication 1-3, **caractérisé en ce que** l'on utilise un simple sol organosilicone ou un mélange des différents sols organosilicones
comme liant organométallique.

5. Procédé selon une quelconque des revendications précédentes, **caractérisé en ce que** le pas d'insertion d'un liant organométallique (11) entre deux couches stratifiées adjacentes (6, 6') du noyau est exécuté par la mise à l'aide d'un pinceau sur une partie au moins des surfaces (9(ou des surfaces latérales (9') formées par les bords des

couches stratifiées (6, 6').

6. Procédé selon la revendication 1-4, **caractérisé en ce que** le pas d'insertion d'un liant organométallique (11) entre deux couches stratifiées adjacentes (6, 6') du noyau est exécuté en plongeant dans le sol liquides une partie au moins du noyau (1, 1').

7. Procédé selon la revendication 1-4, **caractérisé en ce que** le pas d'insertion d'un liant organométallique (11) entre deux couches stratifiées adjacentes (6, 6') du noyau est exécuté en pulvérisant un produit liant organométallique (11a) sur les couches laminées (6, 6') avant le pas d'empilement des plusieurs couches stratifiées (6, 6') faites en bandes de métal amorphe afin de former le noyau prévu.

8. La structure magnétique amorphe du noyau (1, 1') laquelle structure contient les couches stratifiées (6, 6') faites en bandes de métal amorphe et les couches minces (8, 8') faites en liant organométallique (11, 11a) placé entre les couches adjacentes stratifiées (6, 6'), dans laquelle le coefficient de dilatation thermique de chaque couche mince (8, 8') est inférieur aux coefficients de dilatation thermique des couches adjacentes stratifiées (6, 6') et la structure formée par les couches stratifiées (6, 6') réunies aux couches minces (8, 8') forment le noyau (1, 1') en réduisant ainsi le bruit audible quand le noyau est en fonctionnement.

9. La structure du noyau selon la revendication 8, **caractérisé en ce que** chacune des couches minces (8, 8') est placées dans l'espace entre deux couches stratifiées adjacentes (6, 6'), et les couches minces (8, 8') sont en contact avec deux surfaces opposées des deux couches stratifiées adjacentes (6, 6').

10. Un noyau selon la revendication 8-9, **caractérisé en ce que** le coefficient de dilatation thermique des couches laminées s'élève à $7{,}8 \times 10^{-6}$ [1/K] environ.

11. Un appareil électrique avec le noyau (1, 1') ayant la structure selon les revendications 9-10.

12. Un appareil électrique selon la revendication 11 qui est le transformateur de puissance ou le transformateur de distribution.

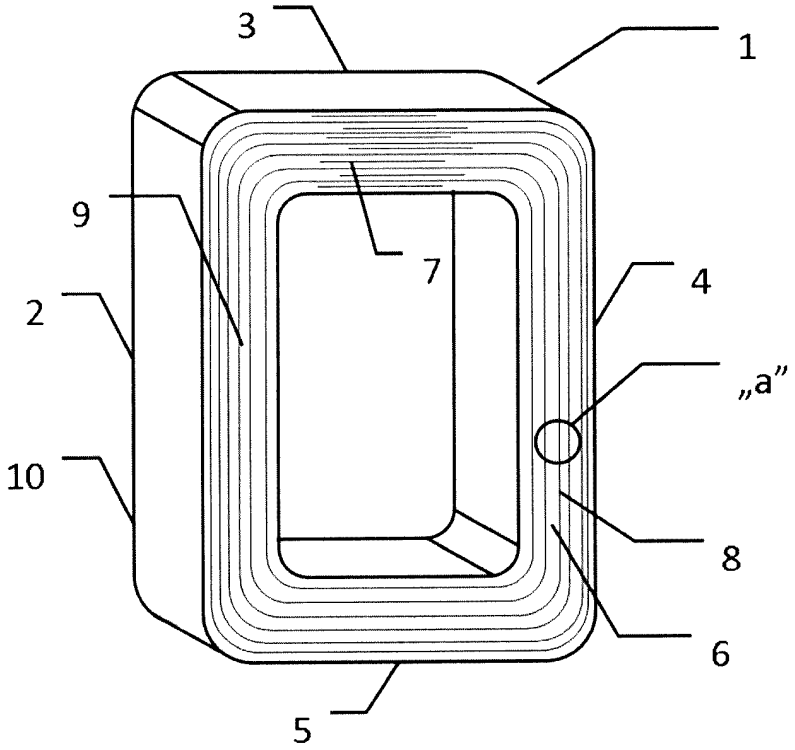


Fig.1

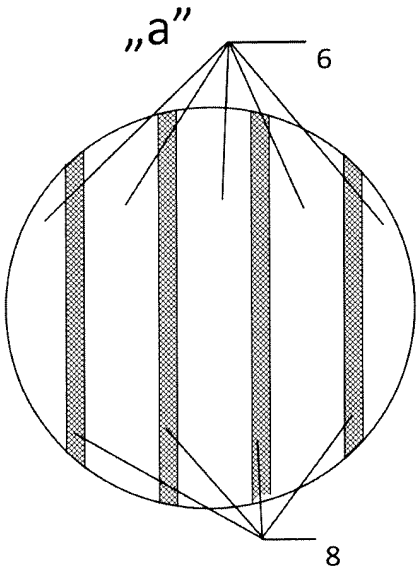


Fig.2

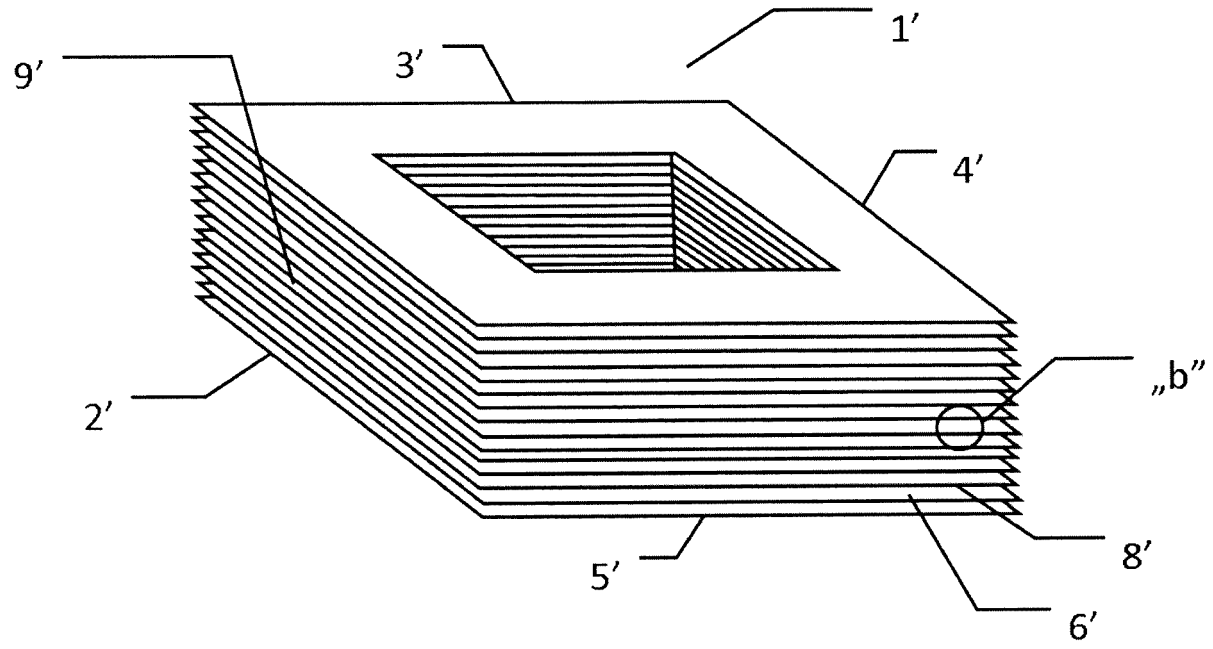


Fig.3

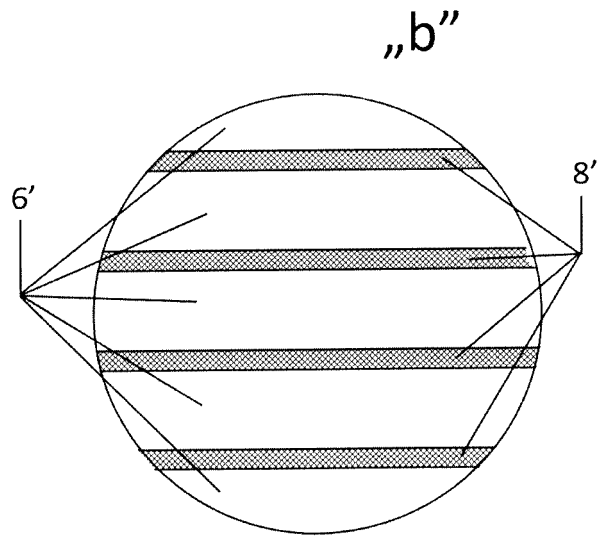


Fig.4

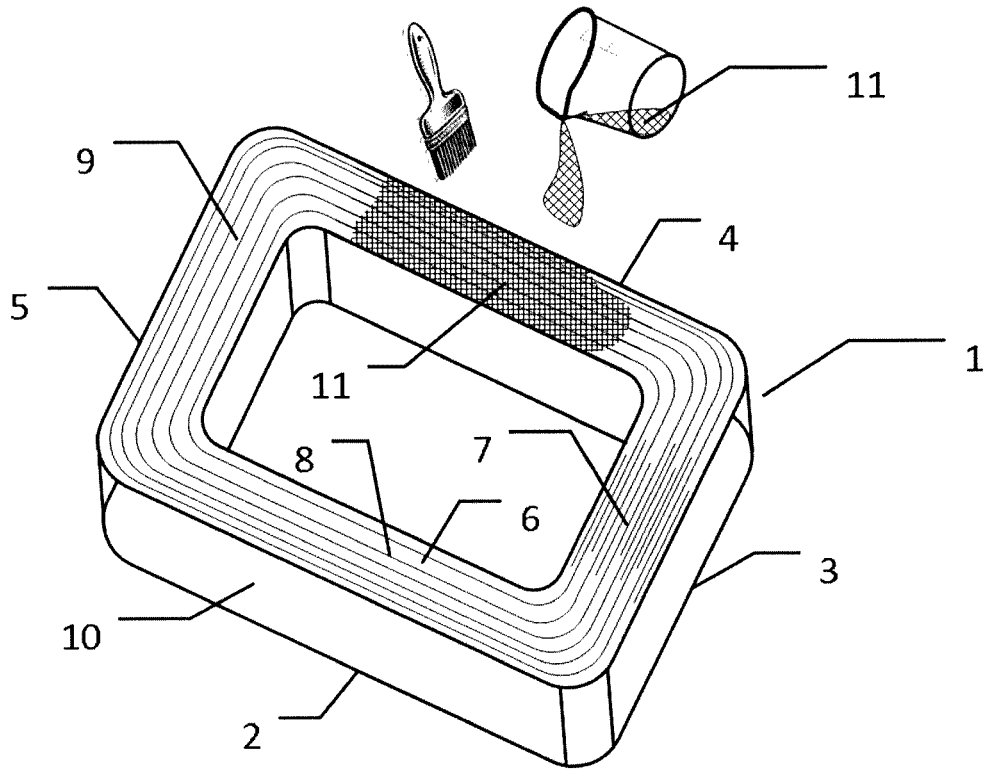


Fig.5

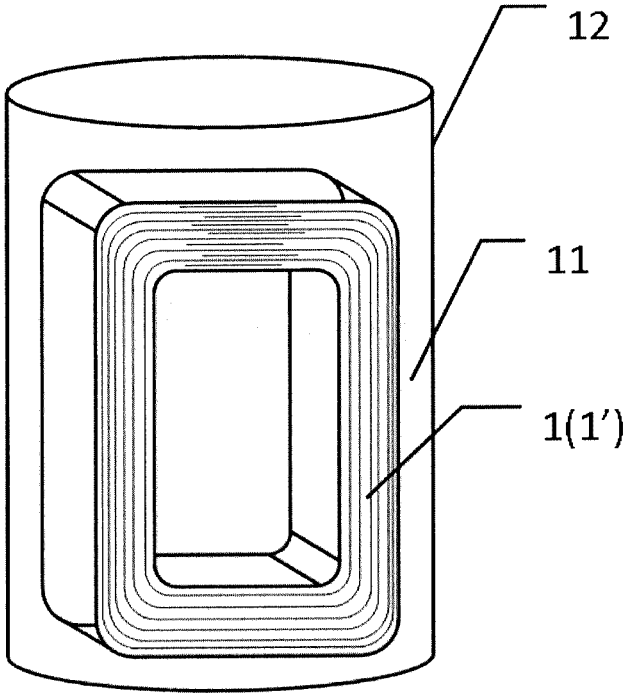


Fig.6

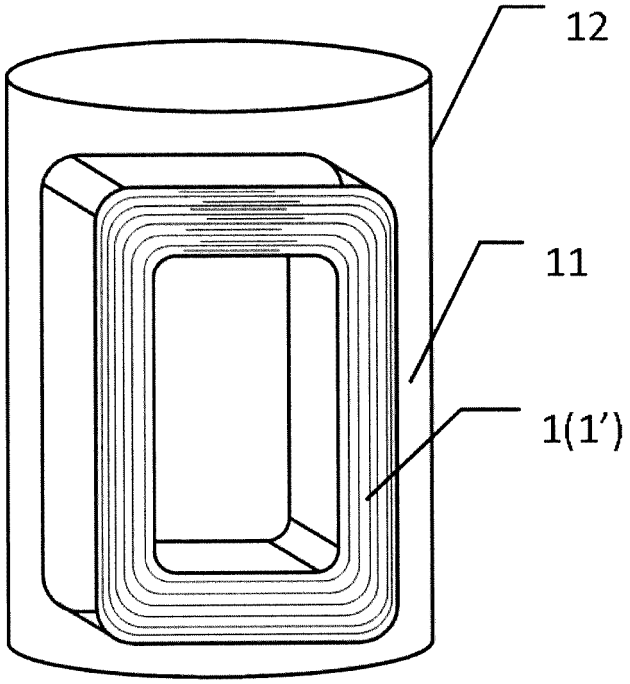


Fig.7

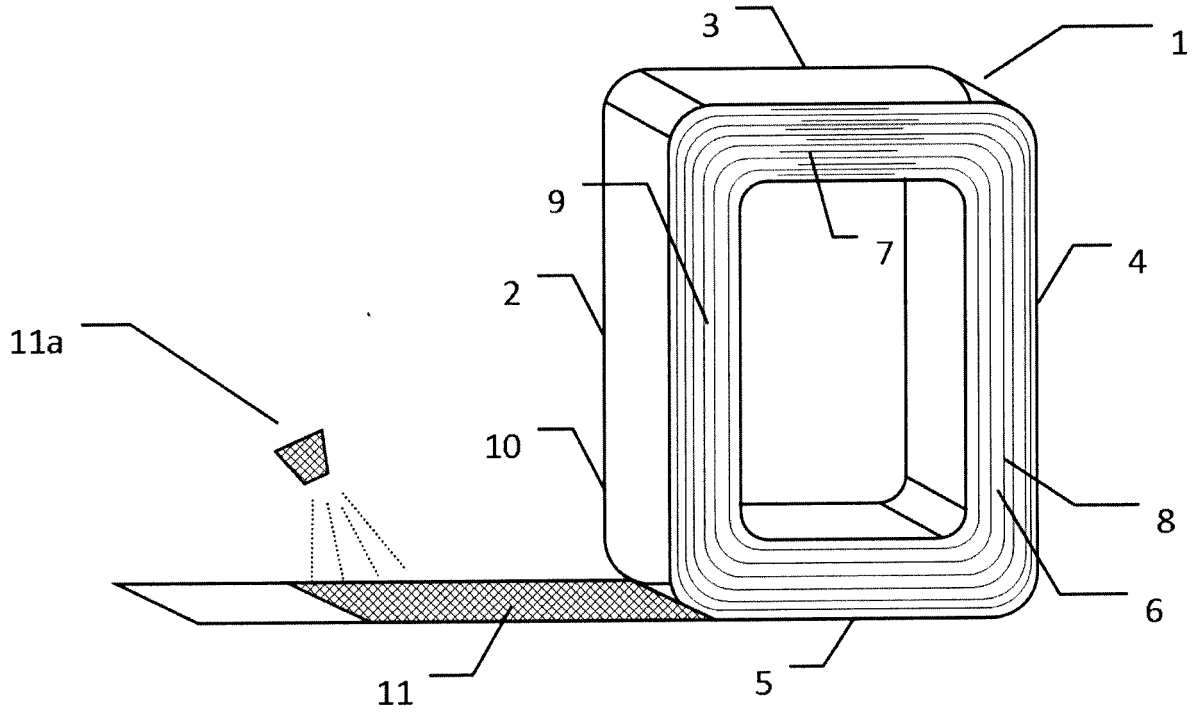


Fig.8

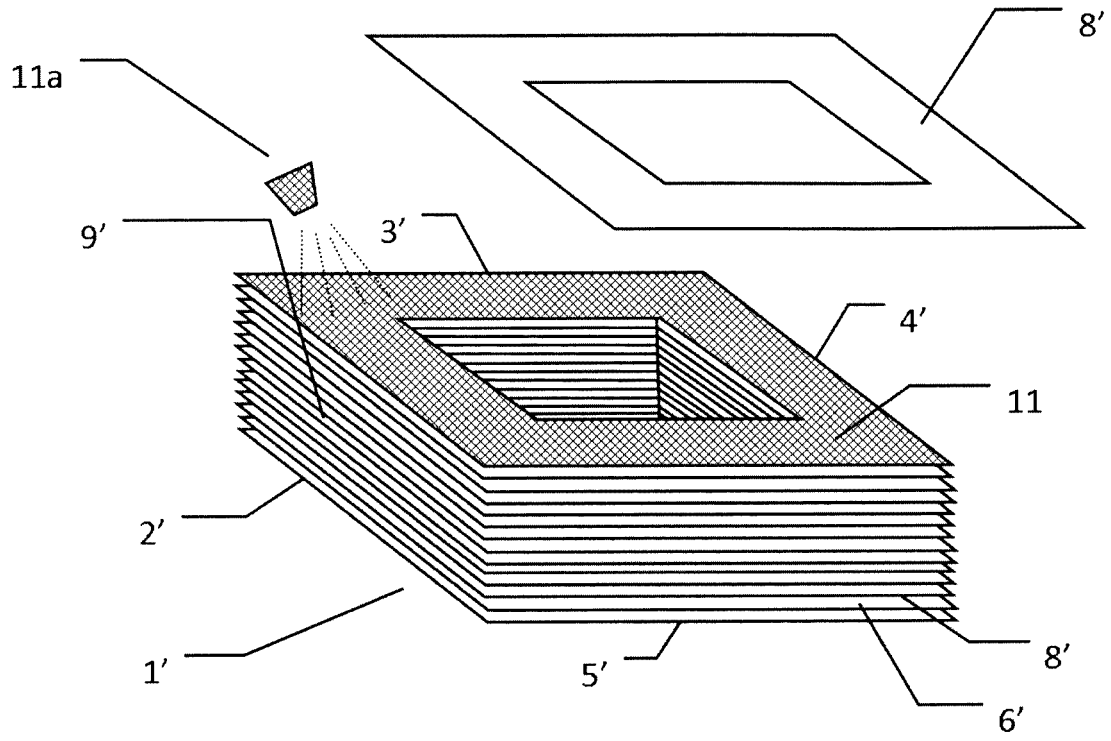


Fig.9

REFERENCES CITED IN THE DESCRIPTION

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- US 8427272 B **[0005]**
- US 4615106 A **[0006]**