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(54) **AMORPHOUS METAL TRANSFORMER**

TRANSFORMATOR AUS AMORPHEM METALL

TRANSFORMATEUR EN MÉTAL AMORPHE

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DE-A1- 19 505 529

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Description

Field of the Invention

[0001] The present invention relates to electrical transformer and particularly to transformers having cores made from amorphous metal alloys.

Background of the Invention

[0002] Traditionally, electrical transformer cores have been formed of grain oriented silicon steel laminations. With the introduction of high grain oriented silicon steel operating losses could be reduced. However, cost of electrical energy continues to rise and reductions in magnetic losses have become an increasingly important design consideration in all sizes of transformers used in an electrical distribution system.

[0003] Amorphous metals have a non-crystalline structure. Used as transformer core materials, core operating losses can be reduced dramatically. Such amorphous ferromagnetic strip is extremely thin, normally one mil versus ten mils of grain oriented silicon steel. Amorphous steel lamination is very brittle and easy fractured. Moreover, the magnetic properties of amorphous metals have been found to be deleteriously affected by mechanical stress during manufacturing of the transformer, e.g. mechanical fixing force created by clamping the coil in the core window. In addition, mechanical stress acts on the transformer core because of displacement of the windings during transient operations of the transformer. In case of a short circuit dynamic forces can be very high.

[0004] Especially in the case of shell-type-transformers with 5 core legs there is no proper solution for radial support of the windings.

[0005] In power transformers based on amorphous metal cores it is usual, to have the core carrying the coils directly (DE 195 05 529 A1, DE 27 53 952 A1) or to have the coils carried indirectly by a separate structure (WO 2010/102669 A1).

[0006] It is accordingly an object of the present invention to provide an amorphous metal transformer where magnetic properties of the amorphous core material are less affected by mechanical forces caused by static and dynamic displacement of the windings.

[0007] A still further object is to provide a method of manufacturing an amorphous transformer.

Summary of the Invention

[0008] In accordance with the present invention there is provided a transformer with an amorphous core. Attached to core legs is a winding structure. In order to reduce mechanical stress of the core caused by dynamic and / or static displacement of the winding structure during transient operation of the transformer a clamping structure is provided. The clamping structure essentially consists of at least two supporting elements. These sup-

porting elements are fastened in the upper and lower supporting frame of the transformer by wedging. The wedging acts as an adjustable mechanical linkage between supporting element and the frame. This linkage allows to adapt the clamping structure to permissible variations in the radial dimensions of the winding structure. The winding structure is clamped between supporting plates located in the window of the transformer core.

Brief Description of the Drawings

[0009] In the accompanying drawing,

Fig. 1 is a perspective view showing a clamping structure applied to windings of 3-leg-transformer;

Fig. 2 is a side view of the 3-leg-transformer;

Fig. 3 is a side view of a core segment of a transformer showing a side core loop;

Fig. 4 is an enlarged view of detail "X" in Fig. 3

Fig. 5 is a top view of a core segment of a transformer showing a side core loop;

Fig. 6 is an enlarged view of detail "Y" in Fig. 5;

Fig. 7 is a perspective view of a supporting element.

Detailed Description of Preferred Embodiments

[0010] Fig. 1 is a perspective view showing a clamping structure 14 applied to windings 4 of a 3-leg-transformer 21 (the core of the transformer is not shown in Fig. 1). To keep the three coils 4 together the winding structure is fastened between the two ridged supporting elements 1. The winding structure 4 is sandwiched between the supporting elements. A upper supporting frame 2 and a lower supporting frame 3 are fixed by tie rods. Fig. 1 shows the two supporting elements 1 in a mounted position. Each side element 1 is attached laterally on a outer winding 4. Each supporting element 1 has end sections 22 with vertical extensions 15. In the mounted position (Fig. 1) each extension 15 projects into a corresponding recess 18 provided in the upper and lower supporting frame 2, 3 respectively. Each extension 15 is fastened in the recess 18 by a wedge 5. This wedging allows adjustment of the distance between the two supporting elements 1 relative to the outer coil 4. Since the dimension of a coil 4 can vary within approximately 2-3 mm it is necessary to adapt the clamping structure 14 to these permissible variations in the size of the winding structure 4. The supporting elements 1 act in radial direction on the outer coils 4. During transient operations of the transformer the influence of variations in the shape of the coil 4 is limited by the clamping structure 14. Prejudice of magnetic properties of the amorphous magnetic material

is reduced.

[0011] Fig. 2 shows a side view of a 3-leg-transformer 21. The core 20 has three core legs 17. On each core leg 17 a coil 4 is attached. The clamping structure 14 keeps the coils together. The magnetic material of the inner core loop 16 and the side core loop 6 is an amorphous alloy. In each window 12 of a side core loop 6 a supporting element 1 is installed. The supporting element 1 extends from the upper supporting frame 2 to the lower supporting frame 3. Both supporting frames 2 and 3 are arranged in a horizontal direction and in parallel to each other. Since the plates 1 are installed in the window 12 of the side core loops 6 they have to be electrically insulated from the supporting frames 2, 3. Therefore an insulation 7 is applied at the joining area between the extensions 15 of the supporting plate 1 and the frames 2, 3.

[0012] Fig. 3 is a side view of a core segment of the 3-leg-transformer showing the side core loop 6. The supporting structure 1 is in tight contact with the outer circumferential surface 9 of the winding 4. This clamping of the winding structure 4 reduces the displacement of the coils during transient operation of the transformer. Between the supporting structure 1 and the circumferential surface 9 of the windings 4 an electric insulation 8 is arranged.

[0013] Fig. 4 is an enlarged view of detail "X" in Fig. 3. The extension 15 projects in the recess 18 and is surrounded by insulation 7 and fixed by the wedge 5. The plane area 13 of the coil and the supporting element 1 is separated by the insulation 8. Two radial extensions 11 of the supporting plate 1 hold the coil 4 in the window 12 of the core 20. The insulation 8 extends also in radial direction and separates the radial extension 11 and the adjacent end surface 11 of the coil 4. For safety reason each wedge 5 is secured in the recess 18 by an adhesive.

[0014] Fig. 5 is a top view of a core segment of the 3-leg-transformer showing the area of the side core loop 6. The winding 4 has rectangular cross section with rounded edges. The contact area of supporting element 1 is a plane structure. As mentioned above, this plane structure 1 of the supporting element is in tight contact with the plane area 13 of the circumferential surface 9 of the coil 4. The wedging generates a radial force pressing the supporting element 1 on to the plane area 13. The winding structure 4 is clamped between the lateral supporting elements 1.

[0015] Fig. 6 shows detail "Y" of Fig. 5 in an enlarged view. The recess 18 is of rectangular shape. The extension 15 in the recess 18 is surrounded by insulation 7. The wedge 5 is pressing the supporting element 1 in direction of the coil 4 (in fig. 6 from left to right). As already mentioned, the clamping structure 14 is adjustable in respect of the distance between the supporting plates 1 and plain area 13 of the coil 4 by wedging 5.

[0016] Fig. 7 shows a perspective view of a supporting element 1. The supporting element 1 essentially consists of plane area. On each end section 22 there are two extensions 15. To increase the section modulus of ele-

ment 1 the edge of plane area shows a deflection. The supporting element 1 is made of steel.

[0017] A transformer according to the invention can be manufactured by a process comprising the steps:

- a. forming a winding structure (4) having a circumferential surface (9);
- b. fixing a insulation (8) on the surface (9);
- c. providing at least two supporting elements (1) having end sections (22) with extensions (15);
- d. fixing an insulation (7) on each extension (15);
- e. providing a opened side core loop (6) made of laminations of amorphous material;
- f. inserting the opened side core loop (6) into the winding structure (4);
- g. closing lamination of side core loop (6);
- h. providing a first supporting frame (2) and a second supporting frame (3), each supporting frame (2, 3) having recesses (8);
- i. fixing an insulation (7) between a supporting plate (1) and a winding structure (4);
- j. joining the first supporting frame (2) and the second supporting frame (3), whereby each extension (15) is put into a corresponding recess (18) and whereby the winding structure (4) is clamped between the first supporting frame (2) and the second supporting frame (3) by tie rods;
- k. inserting a wedge (5) in each recess (18);
- l. applying a force on the wedge (5) in order clamp the windings structure (4) between the supporting plates (1).

[0018] The invention provides sufficient support of the windings against dynamic forces which makes the winding structure 4 "short-circuit-proof". In case of a short circuit the core 20 is not damaged. During operation of the transformer displacement of the windings is reduced. Dynamic forces of the winding have a reduced effect on the magnetic properties of the amorphous magnetic material.

[0019] The foregoing merely illustrates the principal of the invention. Those skilled in the art will be able to devise numerous arrangements which, although not explicitly described or shown herein, embody those principles and are within the scope of the invention.

List of used reference signs

[0020]

- | | |
|---|--------------------------------------|
| 1 | supporting element |
| 2 | first supporting frame, upper frame |
| 3 | second supporting frame, lower frame |
| 4 | winding structure, coil |
| 5 | wedge |
| 6 | side core loop |
| 7 | insulation between 1 and 2 |
| 8 | insulation between 1 and 4 |

9 circumferential surface of the coil
 10 end-surface of the coil
 11 radial extension
 12 window
 13 plane area of 9
 14 clamping structure
 15 extension of 1
 16 inner core loop
 17 core leg
 18 recess
 19
 20 core
 21 3-leg-transformer
 22 end section

Claims

1. Amorphous metal transformer, comprising:

a magnetic core (20), the core (20) comprising a core leg (17) with a winding structure (4) attached to this leg (17), the winding structure (4) having an outer circumferential surface (9), whereby the outer circumferential surface (9) has a plane area (13) located in a window (12) of the core (20);

a clamping structure (14), arranged to reduce mechanical stress of the core (20) caused by the dynamic and / or static displacement of the winding structure during transient operations of the transformer, the clamping structure (14) comprising:

- a first supporting frame (2);
- a second supporting frame (3);
- at least two supporting elements (1), dedicated to the winding structure (4), wherein each supporting element (1) supports the plane area (13) of the outer circumferential surface (9) of the winding structure (4);
- means for adjustably interconnecting each supporting element (1) with the first supporting frame (2) and the second supporting frame (3).

2. Transformer as claimed in Claim 1, wherein the means for adjustably interconnecting each supporting element (1) with the first supporting frame (2) and the second supporting frame (3) comprises a wedging.

3. Transformer as claimed in to Claim 2, wherein the wedging comprises a wedge (5) which is in a mounted position inserted in a corresponding recess (18) provided in the first supporting frame (2) and the second supporting frame (3) configured to press the supporting element (1) against the plane area (13).

4. Transformer as claimed in Claim 3, further comprising an insulation (7) configured to separate electrically the extension (15) and the corresponding supporting frame (2, 3).

5. Transformer as claimed in Claim 3, wherein, in the mounted position, the wedge (5) is arranged to taper in plumb line.

6. Transformer as claimed in Claim 3, wherein, in the mounted position, the wedge (5) is fixed in the recess (18) by an adhesive.

7. Transformer as claimed in Claim 1, wherein the at least two supporting elements (1) are C-shaped, having radial extensions (11), whereby in the mounting position each of these radial extensions (11) support a lateral subarea of a dedicated end-surface (10) of the winding structure (4).

8. Transformer as claimed in Claim 1, wherein the at least two supporting elements (1) are arranged essentially parallel to each other.

9. Transformer as claimed in Claim 1, wherein each supporting element (1) has end sections (22) having two extensions (15) and wherein in a mounting position each extension is fixed in a corresponding recess (18) by a wedge (5).

10. A method of manufacturing an amorphous transformer comprising the steps of:

- a. forming a winding structure(4) having a circumferential surface (9);
- b. fixing an insulation (8) on, the surface (9) ;
- c. providing at least two supporting elements (1) having end sections (22) with extensions (15);
- d. fixing an insulation (7) on each extension (15);
- e. providing an opened side core loop (6) made of laminations of amorphous material;
- f. inserting the opened side core loop (6) into the winding structure;
- g. closing the lamination of the side core loop (6);
- h. providing a first supporting frame (2) and a second supporting frame (3), each supporting frame (2, 3) having recesses (8);
- i. fixing an insulation (7) between a supporting plate (1) and the winding structure (4);
- j. joining the first supporting frame (2) and the second supporting frame (3), whereby each extension (15) is put into a corresponding recess (18) and whereby the winding structure (4) is clamped between the first supporting frame (2) and the second supporting frame (3) by tie rods;
- k. inserting a wedge (5) in each recess (18);
- l. fastening by applying a force on the wedge (5).

Patentansprüche

1. Transformator aus amorphem Metall, welcher umfasst:

einen Magnetkern (20), wobei der Kern (20) einen Kernschenkel (17) mit einer an diesem Schenkel (17) befestigten Wicklungsstruktur (4) umfasst, wobei die Wicklungsstruktur (4) eine Außenumfangsfläche (9) aufweist, wobei die Außenumfangsfläche (9) einen ebenen Bereich (13) aufweist, der sich in einem Fenster (12) des Kerns (20) befindet;
eine Klemmstruktur (14), die dafür eingerichtet ist, mechanische Beanspruchungen des Kerns (20) zu verringern, die durch die dynamische und/oder statische Verschiebung der Wicklungsstruktur während transients Vorgänge des Transformators verursacht werden, wobei die Klemmstruktur (14) umfasst:

- einen ersten Stützrahmen (2);
- einen zweiten Stützrahmen (3);
- mindestens zwei Stützelemente (1), die für die Wicklungsstruktur (4) bestimmt sind, wobei jedes Stützelement (1) den ebenen Bereich (13) der Außenumfangsfläche (9) der Wicklungsstruktur (4) stützt;
- Mittel zum verstellbaren Verbinden jedes Stützelements (1) mit dem ersten Stützrahmen (2) und dem zweiten Stützrahmen (3).

2. Transformator nach Anspruch 1, wobei die Mittel zum verstellbaren Verbinden jedes Stützelements (1) mit dem ersten Stützrahmen (2) und dem zweiten Stützrahmen (3) eine Keilverbindung umfassen.

3. Transformator nach Anspruch 2, wobei die Keilverbindung einen Keil (5) umfasst, welcher in einer montierten Position in eine entsprechende Aussparung (18) eingesetzt ist, die in dem ersten Stützrahmen (2) und dem zweiten Stützrahmen (3) vorgesehen ist, und welcher dafür ausgebildet ist, das Stützelement (1) gegen den ebenen Bereich (13) zu pressen.

4. Transformator nach Anspruch 3, welcher ferner eine Isolation (7) umfasst, die dafür ausgebildet ist, die Verlängerung (15) und den entsprechenden Stützrahmen (2, 3) elektrisch zu trennen.

5. Transformator nach Anspruch 3, wobei, in der montierten Position, der Keil (5) derart angeordnet ist, dass er sich in lotrechter Richtung verjüngt.

6. Transformator nach Anspruch 3, wobei, in der montierten Position, der Keil (5) durch einen Klebstoff in der Aussparung (18) befestigt ist.

7. Transformator nach Anspruch 1, wobei die mindestens zwei Stützelemente (1) C-förmig sind und radiale Verlängerungen (11) aufweisen, wobei in der Montageposition jede dieser radialen Verlängerungen (11) einen seitlichen Teilbereich einer dafür bestimmten Endfläche (10) der Wicklungsstruktur (4) stützt.

8. Transformator nach Anspruch 1, wobei die mindestens zwei Stützelemente (1) im Wesentlichen parallel zueinander angeordnet sind.

9. Transformator nach Anspruch 1, wobei jedes Stützelement (1) Endabschnitte (22) mit zwei Verlängerungen (15) aufweist und wobei in einer Montageposition jede Verlängerung durch einen Keil (5) in einer entsprechenden Aussparung (18) befestigt ist.

10. Verfahren zur Herstellung eines amorphen Transformators, welches die folgenden Schritte umfasst:

- a. Ausbilden einer Wicklungsstruktur (4), die eine Umfangsfläche (9) aufweist;
- b. Befestigen einer Isolation (7) auf der Fläche (9);
- c. Bereitstellen von mindestens zwei Stützelementen (1), die Endabschnitte (22) mit Verlängerungen (15) aufweisen;
- d. Befestigen einer Isolation (7) an jeder Verlängerung (15);
- e. Bereitstellen einer offenen Seiten-Kernschleife (6), die aus Blechen aus amorphem Material hergestellt ist;
- f. Einsetzen der offenen Seiten-Kernschleife (6) in die Wicklungsstruktur;
- g. Schließen der Bleche der Seiten-Kernschleife (6);
- h. Bereitstellen eines ersten Stützrahmens (2) und eines zweiten Stützrahmens (3), wobei jeder Stützrahmen (2, 3) Aussparungen (8) aufweist;
- i. Befestigen einer Isolation (7) zwischen einer Stützplatte (1) und der Wicklungsstruktur (4);
- j. Verbinden des ersten Stützrahmens (2) und des zweiten Stützrahmens (3), wobei jede Verlängerung (15) in eine entsprechende Aussparung (18) eingesetzt wird und wobei die Wicklungsstruktur (4) zwischen dem ersten Stützrahmen (2) und dem zweiten Stützrahmen (3) durch Zuganker festgeklemmt wird;
- k. Einsetzen eines Keils (5) in jede Aussparung (18);
- l. Befestigen durch Ausüben einer Kraft auf den Keil (5).

Revendications

1. Transformateur en métal amorphe, comprenant :

un noyau (20) magnétique, le noyau (20) comprenant une colonne (17) de noyau avec une structure (4) d'enroulement fixée à cette colonne (17), la structure (4) d'enroulement ayant une surface extérieure (9) circonférentielle, d'où il résulte que la surface extérieure (9) circonférentielle a une zone plane (13) située dans une fenêtre (12) du noyau (20) ;
une structure (14) de serrage, agencée de façon à réduire une contrainte mécanique du noyau (20) causée par le déplacement dynamique et/ou statique de la structure d'enroulement lors d'opérations transitoires du transformateur, la structure (14) de serrage comprenant :

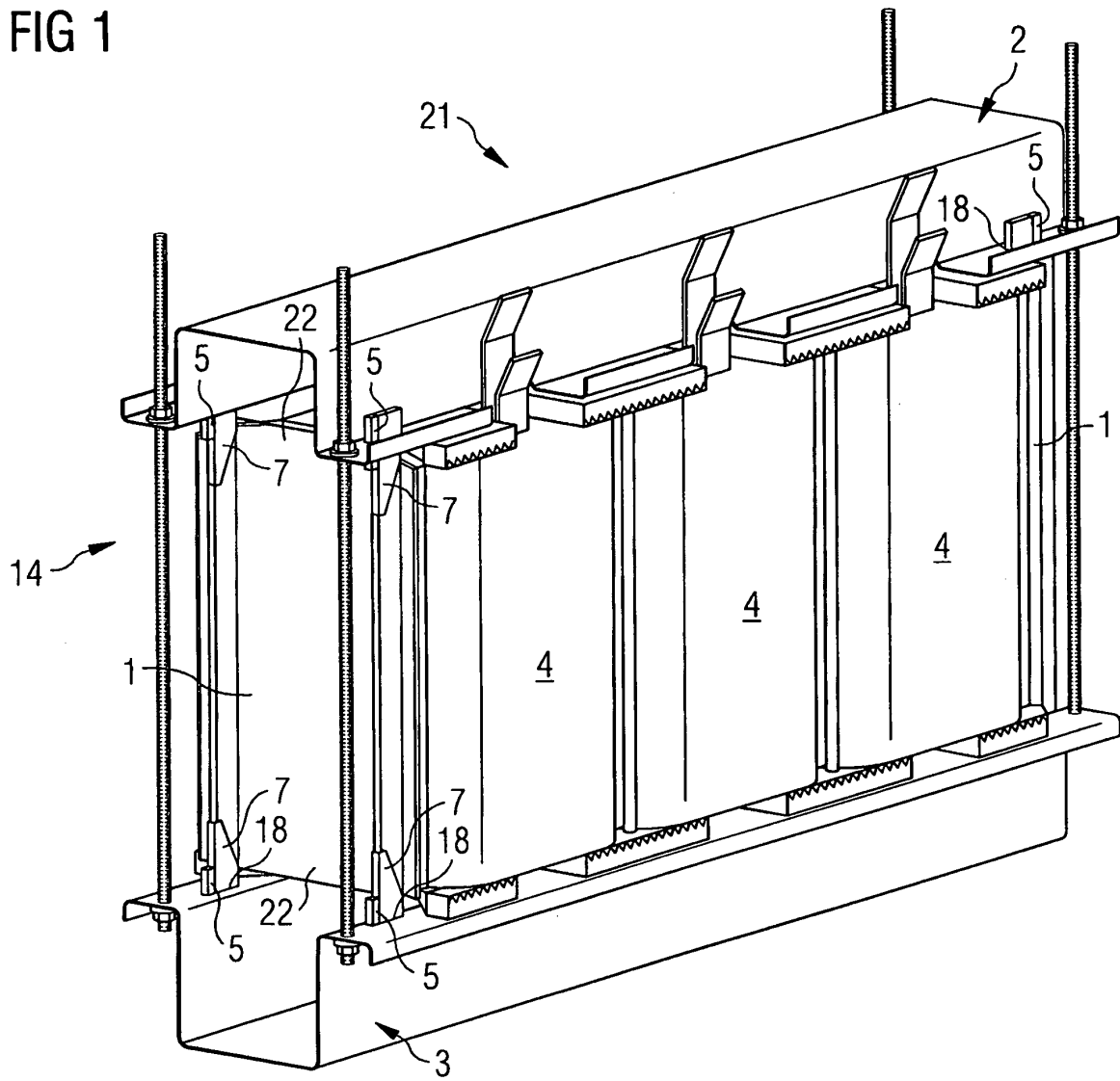
- un premier cadre de support (2) ;
- un deuxième cadre de support (3) ;
- au moins deux éléments de support (1), dédiés à la structure (4) d'enroulement, dans lequel chaque élément de support (1) supporte la zone plane (13) de la surface extérieure (9) circonférentielle de la structure (4) d'enroulement ;
- des moyens pour interconnecter de façon ajustable chaque élément de support (1) avec le premier cadre de support (2) et le deuxième cadre de support (3).

2. Transformateur selon la revendication 1, dans lequel les moyens pour interconnecter de façon ajustable chaque élément de support (1) avec le premier cadre de support (2) et le deuxième cadre de support (3) comprennent un coinçage.
3. Transformateur selon la revendication 2, dans lequel le coinçage comprend un biseau (5) qui est, dans une position montée, inséré dans un évidement (18) correspondant dans le premier cadre de support (2) et le deuxième cadre de support (3), configuré pour presser l'élément de support (1) contre la zone plane (13).
4. Transformateur selon la revendication 3, comprenant en outre une isolation (7) configurée pour séparer électriquement l'extension (15) et le cadre de support (2, 3) correspondant.
5. Transformateur selon la revendication 3, dans lequel, dans la position montée, le biseau (5) est agencé de façon à s'amincir à la verticale.
6. Transformateur selon la revendication 3, dans lequel, dans la position montée, le biseau (5) est fixé dans l'évidement (18) par un adhésif.
7. Transformateur selon la revendication 1, dans lequel les au moins deux éléments de support (1) sont en forme de C, ayant des extensions radiales (11), d'où

il résulte que, dans la position de montage, chacune de ces extensions radiales (11) supporte une sous-zone latérale d'une surface d'extrémité (10) dédiée de la structure (4) d'enroulement.

8. Transformateur selon la revendication 1, dans lequel les au moins deux éléments de support (1) sont agencés sensiblement parallèles l'un à l'autre.
9. Transformateur selon la revendication 1, dans lequel chaque élément de support (1) a des sections (22) d'extrémité ayant deux extensions (15) et dans lequel, dans une position de montage, chaque extension est fixée dans un évidement (18) correspondant par un biseau (5).
10. Procédé de fabrication d'un transformateur amorphe comprenant les étapes de :
 - a. formation d'une structure (4) d'enroulement ayant une surface (9) circonférentielle ;
 - b. fixation d'une isolation (8) sur la surface (9) ;
 - c. prévision d'au moins deux éléments de support (1) ayant des sections (22) d'extrémité avec des extensions (15) ;
 - d. fixation d'une isolation (7) sur chaque extension (15) ;
 - e. prévision d'une boucle (6) de noyau latérale ouverte constituée de stratifications de matériau amorphe ;
 - f. insertion de la boucle (6) de noyau latérale ouverte dans la structure d'enroulement ;
 - g. fermeture de la stratification de la boucle (6) de noyau latérale ;
 - h. prévision d'un premier cadre de support (2) et d'un deuxième cadre de support (3), chaque cadre de support (2, 3) ayant des évidements (8) ;
 - i. fixation d'une isolation (7) entre une plaque de support (1) et la structure (4) d'enroulement ;
 - j. jonction du premier cadre de support (2) et du deuxième cadre de support (3), d'où il résulte que chaque extension (15) est mise dans un évidement (18) correspondant et d'où il résulte que la structure (4) d'enroulement est serrée entre le premier cadre de support (2) et le deuxième cadre de support (3) par des barres de liaison ;
 - k. insertion d'un biseau (5) dans chaque évidement (18) ;
 - l. fixation par application d'une force sur le biseau (5).

FIG 1



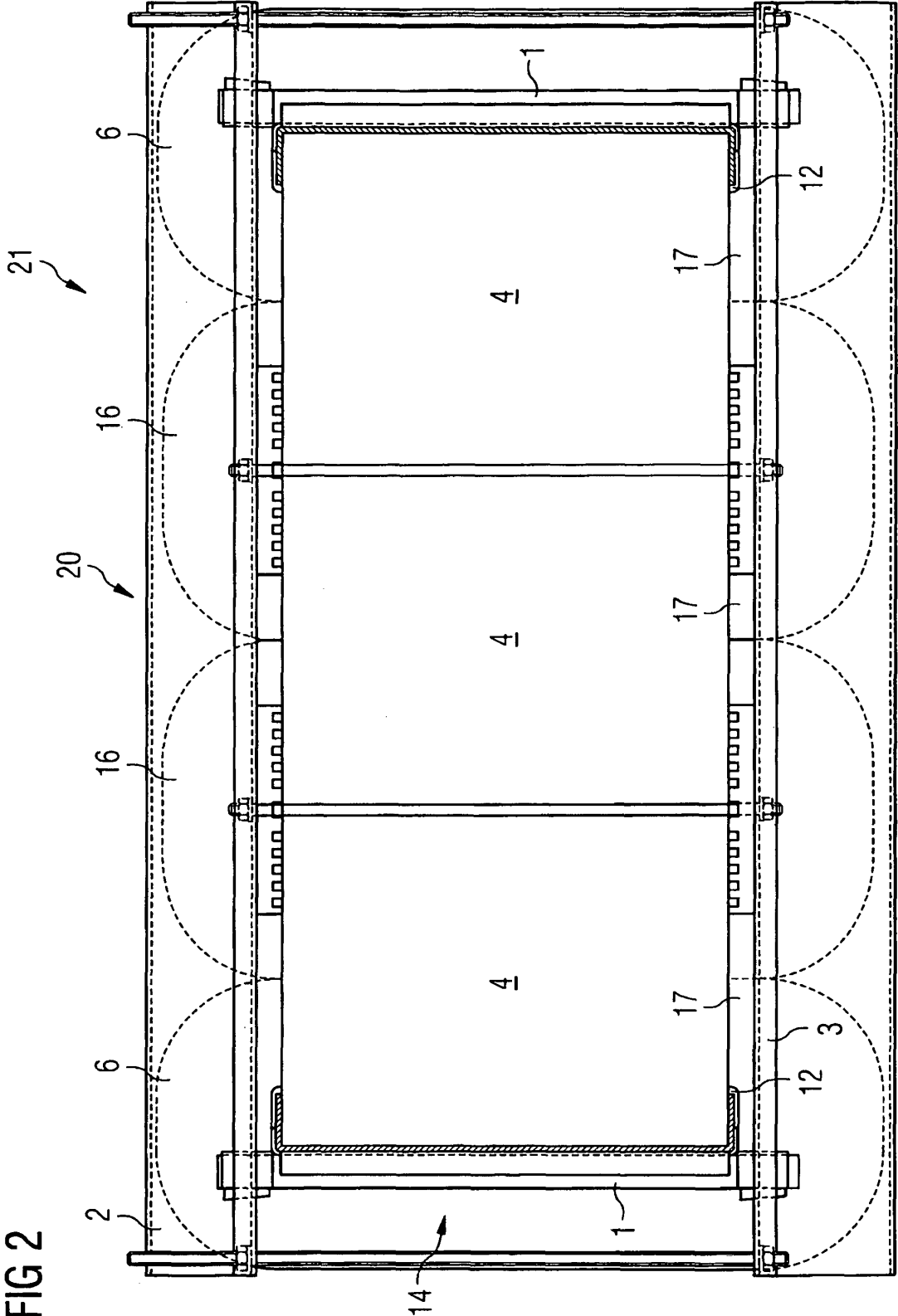


FIG 3

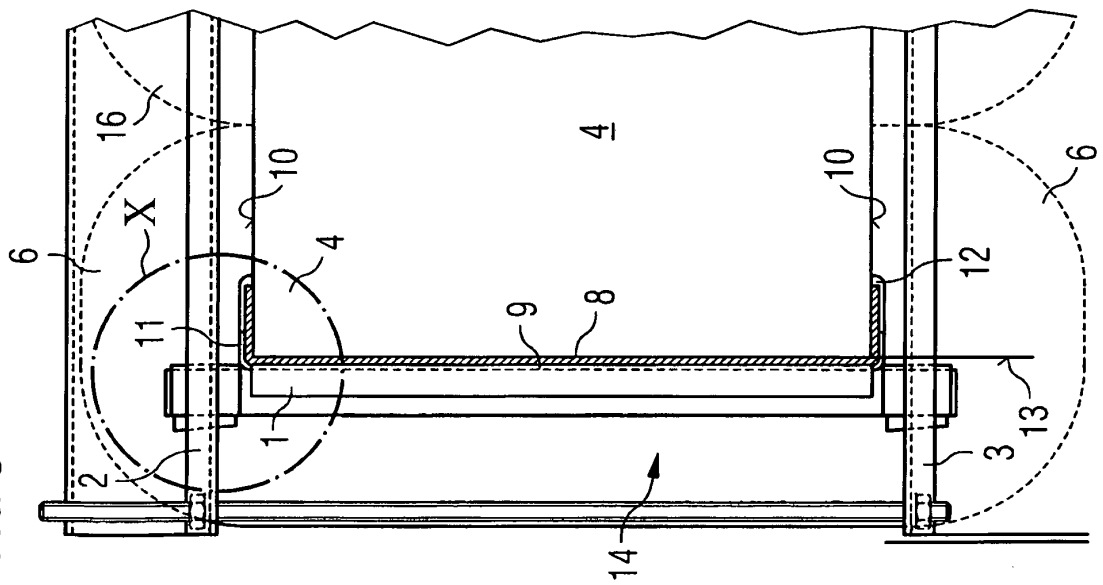
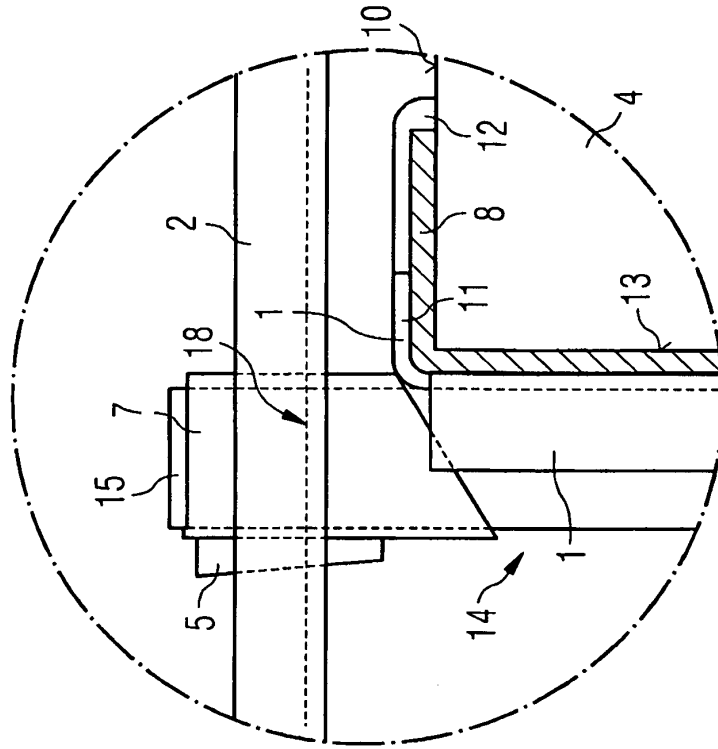


FIG 4



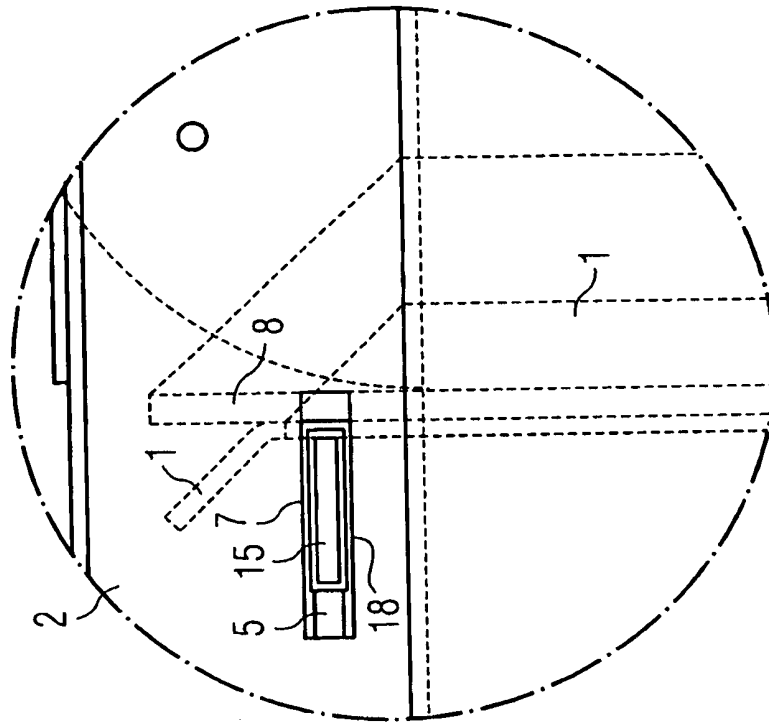


FIG 6

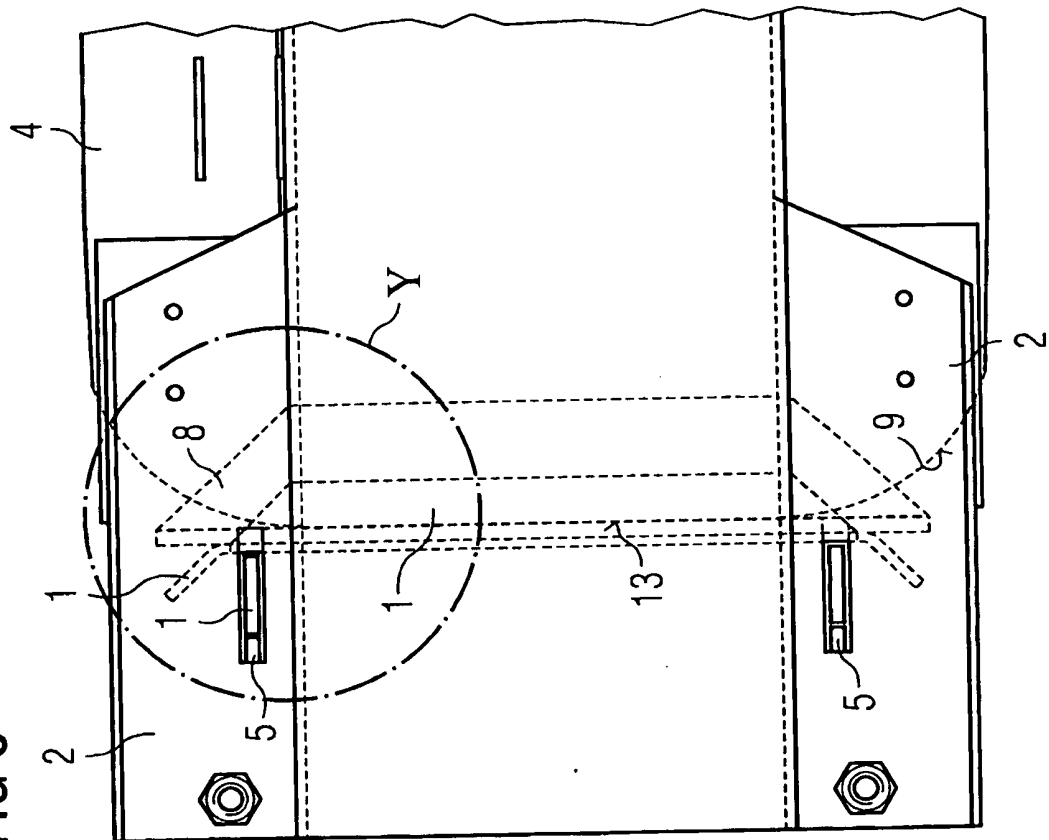
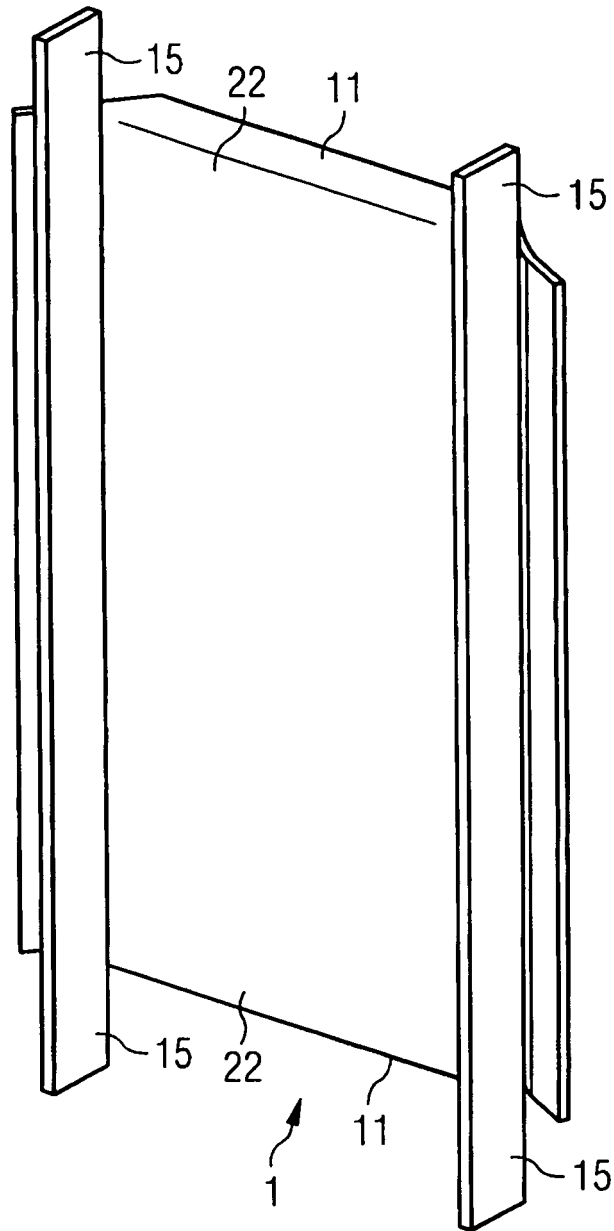


FIG 5

FIG 7



REFERENCES CITED IN THE DESCRIPTION

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