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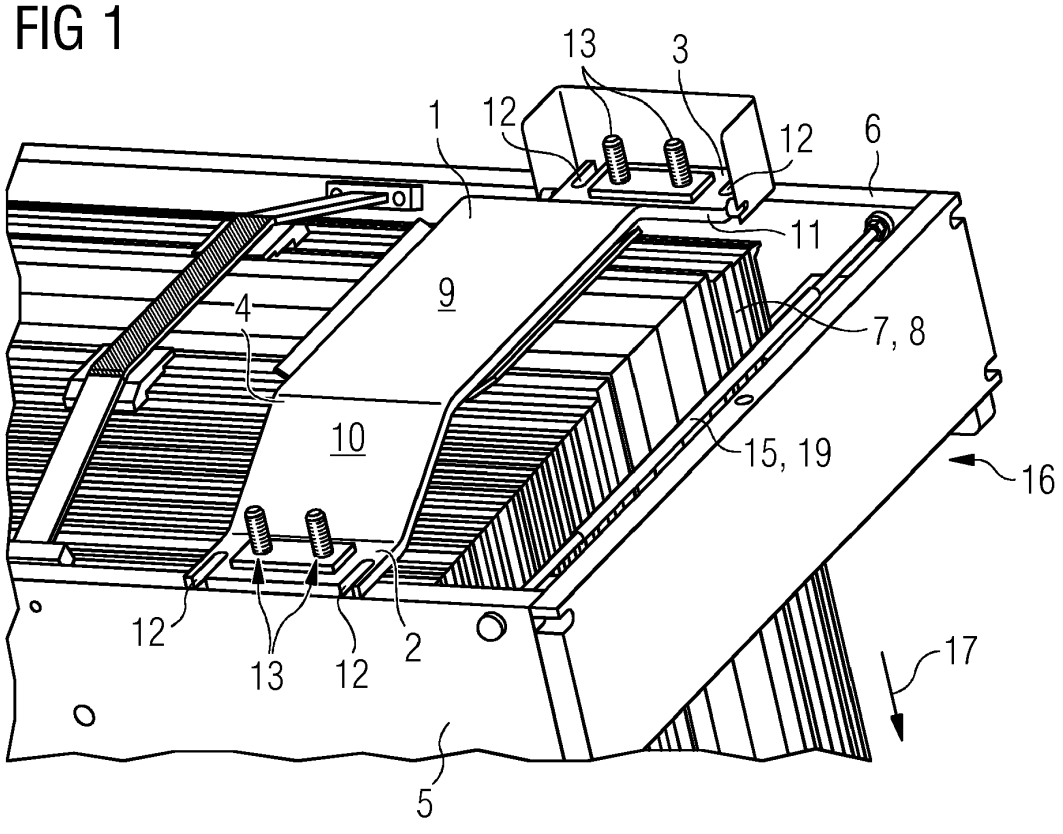
(54) **CLAMPING BRIDGE AND CLAMPING SYSTEM FOR AN ELECTRIC TRANSFORMER**

(57) The invention relates to a clamping bridge (1) for a clamping system for an electric transformer, said clamping bridge (1) comprising a first mounting portion (2) for mounting the clamping bridge (1) on a first clamping frame member (5) of said clamping system, a second mounting portion (3) for mounting the clamping bridge (1) on a second clamping frame member (6) of the clamping system, as well as a retaining portion (4) adapted to be brought into contact with a laminated yoke (7) of a transformer core (8) of said transformer, wherein the clamping bridge (1) is made of an epoxy resin laminate.

FIG 1



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Description

Field of the invention

[0001] The invention relates to a clamping bridge for a clamping system for an electric transformer, said clamping bridge comprising a first mounting portion for mounting the clamping bridge on a first clamping frame member of said clamping system, a second mounting portion for mounting the clamping bridge on a second clamping frame member of the clamping system, as well as a retaining portion adapted to be brought into contact with a laminated yoke of a transformer core of said transformer.

[0002] Moreover, the invention relates to a clamping system for an electric transformer, said clamping system comprising a first clamping frame with a first clamping frame member and a second clamping frame member adapted to be arranged on opposing sides of a laminated yoke of a transformer core of said transformer, at least one tension element, preferably horizontal tie bars, connecting the first clamping frame member to the second clamping frame member under tensile stress, as well as a clamping bridge connecting the first clamping frame member to the second clamping frame member.

Background art

[0003] Electrical transformers and electrical power transformers in particular, usually feature a transformer core consisting of multiple laminations. Windings of a particular phase are arranged on each core column of this laminated core. In order to form a closed magnetic circuit, the ends of said core columns are connected by yokes of the laminated core; upper ends of the columns are connected to each other by an upper yoke whereas lower ends of the columns are connected to each other by a lower yoke.

[0004] In order to guarantee stability of the laminated core, the laminations are pressed together by means of a clamping system. To this end, clamping frames are employed which are positioned around the upper and lower yokes of the laminated core. Respective members of these clamping frames are positioned on opposing sides of the yoke and are held together under tension, such that the respective yoke is wedged in between said clamping frame members.

[0005] For the windings of an electric (power) transformer it is of utmost importance to maintain mechanical stability. Therefore, each winding is pressed between two pressure plates which are inserted between the upper yoke and the upper ending of the winding, and between the lower yoke and the lower end of the winding respectively. In order to maintain the required pressure on said pressure plates, the clamping frame assigned to the upper yoke is connected to the clamping frame assigned to the lower yoke via tension elements. After pressing the clamping frames assigned to the upper and lower yoke towards each other, the clamping frames are firmly attached to the tension elements such that said tension elements keep the distance between both clamping frames fixed.

[0006] In order to provide stability to the whole clamping system during this winding pressing procedure, to absorb vertical forces produced during transportation, loading and unloading of the transformer, and to provide support to the transformer cover under vacuum load, it is known to employ clamping bridges. Such clamping bridges are connected to two opposing clamping frame members of one clamping frame in such a way that they each cover the respective yoke at least partially. When external pressure is applied on one clamping frame, say of the one assigned to the upper yoke, in order to move it closer to the clamping frame assigned to the lower yoke, said bridges will retain the yoke thereby avoiding that the yoke is lifted from its position and/or that the respective core laminations deform under pressure.

[0007] Known clamping bridges are made of magnetic steel grade (EN 10025 S235xx or S355xx) and therefore constitute an electric connection between the clamping frame members of one clamping frame. Electro-magnetic fields originating from the windings and connection thus generate eddy currents that unhinderedly flow through the whole clamping frame. This may result in the creation of hotspots within the active part of the transformer and may also lead to gassing.

[0008] In order to avoid this and to achieve the required electrical isolation, additional elements for electric isolation are usually positioned between the clamping bridge and other electroconductive elements of the clamping frame, e.g. the clamping frame members. However, it has been observed that the reliability of such isolation measures depends crucially on manufacturing accuracy and that the employed isolation elements can break due to stresses prevailing in the clamping system while winding pressing and/or lifting of the active part of the transformer during the tank process.

Object of the invention

[0009] It is therefore an object of the invention to present a clamping bridge for a clamping system, employment of which in a clamping system for an electric transformer leads to the above-mentioned problems being avoided. In particular, the proposed clamping bridge should minimize losses and heat or gassing problems stemming from eddy currents in the transformer's laminated core, and at the same time feature an increased reliability as compared to known isolation measures.

[0010] Moreover, it is an object of the present invention to present a clamping system featuring the aforementioned advantages.

Description of the invention

[0011] A clamping bridge for a clamping system for an electric transformer, said clamping bridge comprising a

first mounting portion for mounting the clamping bridge on a first clamping frame member of said clamping system, a second mounting portion for mounting the clamping bridge on a second clamping frame member of the clamping system, as well as a retaining portion adapted to be brought into contact with a laminated yoke of a transformer core of said transformer, accomplishes an object of the invention in that the clamping bridge is made of an epoxy resin laminate.

[0012] By employing epoxy resin (laminate) the clamping bridge itself can be used as a means for electric isolation between the first clamping frame member and the second clamping frame member. Thus, additional elements for electric isolation, as they are employed in the prior art, become moot and effects attributed to eddy currents through the clamping frame can be effectively minimized. At the same time, clamping bridges made of epoxy resin laminate have structural strength and stability properties facilitating to reliably keep the laminated yoke in shape and position when pressure is exerted on the first and second clamping frame members.

[0013] In a preferred embodiment of clamping bridge according to the invention, the epoxy resin laminate is realized as epoxy woven glass cloth.

[0014] Such a material provides the clamping bridge with optimal electric isolation and stiffness properties and thereby greatly improves the overall stability of the corresponding clamping frame and at the same time reduces stray losses in the clamping system.

[0015] In another preferred embodiment of the clamping bridge according to the invention, the epoxy woven glass cloth is EP GC 203 or EP GC 205, as defined in the norm IEC 60893.

[0016] These materials have

- a minimum flexural strength of 340 MPa (measured at 150°C ± 3 K after 1 hour at 150°C ± 3 K not to be less than 50% of the specified value; test method in IEC 60893-2 Subclause 5.1; nominal thickness of sheet to which test is applicable is 1,5 mm or more),

- a minimum Charpy impact strength parallel to laminations of 33 kJ/m^2 (EP GC 203) and 50 kJ/m^2 (EP GC 205) (test method in IEC 60893-2 Subclause 5.4.2; nominal thickness of sheet to which test is applicable is 5 mm or more),

- a minimum Izod impact strength parallel to laminations of 34 kJ/m^2 (EP GC 203) and 54 kJ/m^2 (EP GC 205) (test method in IEC 60893-2 Subclause 5.4.3; nominal thickness of sheet to which test is applicable is 5 mm or more),

- a minimum breakdown voltage at 90°C in oil parallel to laminations of 35 kV (test method in IEC 60893-2 Subclause 6.1; nominal thickness of sheet to which test is applicable is 3 mm or more),

- and a minimum insulation resistance after immersion in water of 5 x 10^4 MΩ (EP GC 203) and 1 x 10^4 MΩ (EP GC 205) (test method in IEC 60893-2 Subclause 6.3).

[0017] Therefore, a clamping bridge made of this material is strong enough to maintain stability of the clamping frame as well as of the transformer's laminated core under stress, and in addition to that provides excellent isolation in order to reduce negative effects associated with eddy currents through the clamping frame.

[0018] In another preferred embodiment of the clamping bridge according to the invention, said retaining portion is arranged in a different plane than said first mounting portion and/or said second mounting portion.

[0019] This lends more flexibility to the clamping bridge, enabling to adapt its form and profile to the respective yoke of the laminated core. In particular, a surface of the yoke may be uneven due to laminations having different lengths. The profile of said surface, therefore, may have a maximum height in a central region with its height falling off in outer regions of said surface. A shift of the clamping bridge's retaining portion with respect to its first and/or second mounting region thus facilitates to, at least approximately, align the shape of the clamping bridge with the shape of the respective yoke or its outer surface facing the clamping bridge.

[0020] In another preferred embodiment of the clamping bridge according to the invention, said retaining portion comprises a first planar section which is arranged substantially parallel to the first mounting portion and/or the second mounting portion.

[0021] This design allows for an optimal approximation of generally encountered yoke (surface) shapes.

[0022] In another preferred embodiment of the clamping bridge according to the invention, the retaining portion comprises a second planar section protruding obliquely from the first planar section and connecting the first planar section with the first mounting portion, as well as a third planar section protruding obliquely from the first planar section and connecting the first planar section with the second mounting portion.

[0023] By continuously connecting the first planar section with the first and second mounting portion of the clamping bridge, said connection being established by the second and third planar section, it is possible to retain the position of most or all of the laminations and thereby the entire shape of the yoke when pressure is applied to the clamping frame during winding pressing.

[0024] In another preferred embodiment of the clamping bridge according to the invention, the clamping bridge has a first set of openings for receiving fastening elements, preferably bolts or screws, for fastening the clamping bridge to the first clamping frame member and/or to the second clamping frame member, and/or the clamping bridge has a second set of openings for receiving tension elements, preferably vertical tie bars, for connecting the first clamping frame member and/or the sec-

ond clamping frame member to a further clamping frame.

[0025] The first set of openings may be realized as elongated holes located in the first and second mounting portion of the clamping bridge, each of which openings can be open at one side. The first set of openings allows for a simple and reliable fastening of the clamping bridge to the first and second clamping frame member.

[0026] The second set of openings for receiving the tension elements for connecting the first clamping frame member and/or the second clamping frame member to a further clamping frame may be positioned in the first and second mounting portion of the clamping bridge. They can be realized as drilled holes which may be positioned between said first set of openings of the respective mounting portion. Preferably, said second set of openings can be supported by one or more support discs or support plates. Said second set of openings allows for a particularly simple and reliable way of receiving the tension elements for connecting the first clamping frame member and/or the second clamping frame member to a further clamping frame. While pressure is applied to the clamping frame (members) these tension elements may be loosely inserted in the respective second set of openings, thereby allowing for a variation of the distance between the clamping frame to which the first and second clamping frame members belong, and a further clamping frame. As soon as the desired pressure (or distance between the clamping frames) has been reached, the tension elements may be tightly fastened to the clamping bridge, e.g. by means of threaded heads of the tension elements and corresponding nuts.

[0027] The feature 'first set of openings for receiving fastening elements' is independent from the feature second set of openings for receiving tension elements'. In particular, neither of these features is substantial for solving the object of the invention described above. Moreover, neither of these features is essential for the functioning for the clamping bridge with respect to the above-described object of the invention. Additionally, as there exist various possibilities for fastening the clamping bridge to the first clamping frame member and/or to the second clamping frame member - e.g. by gluing the first and second mounting portion to the clamping frame members - as well as for anchoring the tension elements within the clamping frame - e.g. by corresponding receiving means located within the first clamping frame member and/or the second clamping frame member, no significant adaption of the clamping bridge would be made necessary by singling out either of these independent features.

[0028] In another preferred embodiment of the clamping bridge according to the invention, the openings are lined with reinforcing members, preferably realized as glass fibre tubes.

[0029] Due to material properties of the employed epoxy resin laminate, the clamping bridge may have a tendency to delaminate due to threaded heads of the tension elements and/or of the fastening elements. Under pressure the threads might eat into the inner walls of the first and/or second set of openings of the clamping bridge. In order to prevent this, the inner walls of the first set of openings and/or the inner walls of the second set of openings may be reinforced by means of said reinforcing members.

[0030] An object of the invention is also achieved by means of a clamping system for an electric transformer, said clamping system comprising a first clamping frame with

- a first clamping frame member and a second clamping frame member adapted to be arranged on opposing sides of a laminated yoke of a transformer core of said transformer,
- at least one tension element, preferably realized as at least one horizontal tie bar, connecting the first clamping frame member to the second clamping frame member under tensile stress, as well as
- a clamping bridge connecting the first clamping frame member to the second clamping frame member,

whereas the object is achieved in that the clamping bridge is realized according to any of the embodiments described above.

[0031] By employing the clamping bridge according to the invention, additional elements for facilitating electric isolation between the clamping bridge and the other elements of the first clamping frame, in particular the first and second clamping frame members, become unnecessary. Any effects attributed to eddy currents through the clamping frame can thus be effectively minimized. At the same time, clamping bridges according to the invention have structural strength and stability properties facilitating to reliably keep the laminated yoke in shape and position when pressure is exerted on the first clamping frame.

[0032] According to a preferred embodiment the clamping system comprises at least two tension elements, preferably vertical tie bars, connecting the first clamping frame to a further clamping frame of the clamping system, whereas these tension elements are received in a second set of openings of the clamping bridge.

[0033] By having the tension elements for connecting the first clamping frame to a further clamping frame of the clamping system received in the clamping bridge itself, preferably in the first and second mounting portions of the clamping bridge, the winding pressing procedure is significantly simplified. External pressure can be applied to the first clamping frame member and to the second clamping frame member, as well as to those parts of the first and second mounting portions of the clamping bridge which overlap with the first and second clamping frame members respectively. As soon as the desired external pressure, and therefore the desired distance be-

tween the first clamping frame and a further, say second clamping frame has been reached, the pressure may be maintained while the tension elements connecting the first clamping frame to the second clamping frame can be tightly fixed to the clamping bridge. Only after said tight connection has been established, thereby fixing the distance between the first and second clamping frame, the first and second clamping frame members may be relieved from the external pressure.

Brief description of the drawings

[0034] In what follows the invention is described further with regard to an example embodiment. The drawings are, however, only exemplary and are not meant to restrict the scope of the invention as described above.

Fig. 1 shows the clamping bridge according to the invention as a part of a clamping system according to the invention

Fig. 2 shows a detail of the clamping system depicted in Fig. 1

Fig. 3 shows a known clamping system

Ways of carrying out the invention

[0035] Fig. 1 shows a clamping system according to the invention. As such it comprises a first clamping frame 16 which is arranged on an upper yoke 7 of a laminated core of an electric transformer, as well as a further clamping frame 17, which however is not depicted in Fig. 1. The further clamping frame 17 is identical to the first clamping frame 16 and is arranged on a lower yoke of the same laminated core.

[0036] The first clamping frame 16 comprises a first clamping frame member 5 arranged on one side of the yoke 7, as well as a second clamping frame member 6 arranged on an a side of the yoke 7 opposite of the first clamping frame member 5. The first clamping frame member 5 and the second clamping frame member 6 are connected to each other under tensile stress by means of one or more tension elements 15, which may be realized as horizontal tie bars 19. Due to these tension elements 15, said first clamping frame 16 exerts a force on the yoke 7 pressing it laminations against each other thereby holding the yoke 7 together.

[0037] A clamping bridge 1 is mounted on both clamping frame members 5, 6 such that it partially covers the yoke 7. Since the clamping bridge 1 is made of epoxy resin laminate, it facilitates on the one hand an electric isolation between the first clamping frame member 5 and the second clamping frame member 6, and on the other hand it features sufficient structural strength to fulfill its purpose, namely to retain the position of most or all of the laminations and thereby the shape of the yoke 7 when pressure is applied to the first clamping frame 16. Said clamping bridge 1 comprises a first mounting portion 2 for mounting the clamping bridge 1 on the first clamping frame member 5, as well as a second mounting portion 3 for mounting the clamping bridge 1 on the second clamping frame member 6. In order to mount the clamping bridge 1 on the clamping frame members 5, 6, the clamping bridge 1 is placed on the clamping frame members 5, 6 such that the fist mounting portion 2 at least partially overlaps with the first clamping frame member 5 and that the second mounting portion 3 at least partially overlaps with the second clamping frame member 6. By means of fastening elements 14, which are left out in Fig. 1 for reasons of clarity but can be seen from Fig. 2, the first mounting portion 2 is fixed to the first clamping frame member 5 and the second mounting portion 3 is fixed to the second clamping frame member 6. In order to receive said fastening elements 14, which may be realized as screws or bolts, the first mounting portion 2 and the second mounting portion 3 have a first set of openings 12 which themselves are realized as elongated holes that are open towards the sides of the clamping bridge 1.

[0038] The clamping bridge 1 also comprises a retaining portion 4 which is adapted to be brought into contact with a laminated yoke 7. Said retaining portion 4 comprises a first planar section 9, which is arranged in a plane different from a plane in which the first mounting portion 2 and the second mounting portion 3 are positioned. Said first planar section 9 is connected to the first mounting portion 2 by means of a second planar section 10 protruding obliquely from the first planar section 9. The transition from the first planar section 9 to the second planar section 10, as well from the second planar section 10 to the first mounting portion 2 may be facilitated by kinked or bent sections of the retaining portion 4.

[0039] Correspondingly, said first planar section 9 is connected to the second mounting portion 3 by means of a third planar section 11 protruding obliquely from the first planar section 9. The transition from the first planar section 9 to the third planar section 11, as well from the third planar section 11 to the second mounting portion 3 may be facilitated by kinked or bent sections of the retaining portion 4.

[0040] Due to its structure the retaining portion 4 of the clamping bridge 1 resembles the structure of the yoke 7 in good approximation. The yoke 7 depicted in Fig. 1 is assembled out of multiple laminations having different height. As a result, a surface of the yoke 7 facing the clamping bridge 1 is uneven due to laminations having different height. The profile of the yoke 7 has a maximum height in a central region with its height falling off in outer regions of said surface. Hence, the clamping bridge 1 allows to retain the position of most or all of the laminations and thereby the entire shape of the yoke 7 when pressure is applied to the first clamping frame 16 during the procedure of winding pressing.

[0041] During winding pressing an external force is exerted on the first clamping frame 16 which conveys said external pressure to windings of the transformer ar-

ranged on core columns between the upper yoke 7 and the lower yoke. During this procedure the first clamping frame 16 and the further clamping frame 17, which is attributed to the lower yoke, are loosely connected such that their distance may still be varied. To this end, tension elements 15 are foreseen which can be tightly fixed to the further clamping frame 17 but are, at first, only loosely inserted into a corresponding second set of openings 13 of the first clamping frame 16. In the embodiment depicted in Fig. 1 and 2, said second set of openings 13 is arranged in the clamping bridge 1, in particular in the first mounting portion 2 and the second mounting portion 3 of the clamping bridge 1. The openings of said second set of openings 13 are realized as bore holes which in Fig. 1 and 2 are covered by support plates 8 aiding with the stability of the mounting portions 2, 3 when the tension elements 15 are tightly fixed to the clamping bridge 1. However, the positions of the second set of openings 13 may directly and unambiguously be deferred from the position of the upper ends of the vertical tie bars 20 serving as tension elements 15 for connecting the first clamping frame 16 to the further clamping frame 17.

[0042] As soon as the desired pressure on the windings has been achieved, the vertical tie bars 20 are tightly fixed to the first clamping frame 16 by means of threaded nuts 21 tightened against the support plates 8. Thereby, the relative positions of the first clamping frame 16 and the second clamping frame 17 are fixed and the distance between the clamping frames 16, 17 cannot be varied any longer. Thus, the pressure on the windings is maintained without the external pressure having to be exerted any longer on the first clamping frame 16.

[0043] In order to avoid delamination of the clamping bridge 1, the inner walls of the first set of openings 12 and/or of the second set of openings 13 are lined with reinforcing members 18 which are preferably realized as glass fibre tubes.

[0044] Fig. 3 shows a clamping system according to the state of the art. It can be seen that multiple elements for electric isolation are employed in order to facilitate isolation between the clamping bridge, the clamping frame members, and the fastening and tension elements.

Reference signs

[0045]

1 clamping bridge
2 first mounting portion
3 second mounting portion
4 retaining portion
5 first clamping frame member
6 second clamping frame member
7 yoke
8 core
9 first planar section
10 second planar section
11 third planar section
12 first set of openings
13 second set of openings
14 fastening elements
15 tension elements
16 first clamping frame
17 further clamping frame
18 reinforcing members
19 horizontal tie bar
20 vertical tie bar

Claims

1. Clamping bridge (1) for a clamping system for an electric transformer, said clamping bridge (1) comprising

   - a first mounting portion (2) for mounting the clamping bridge (1) on a first clamping frame member (5) of said clamping system,
   - a second mounting portion (3) for mounting the clamping bridge (1) on a second clamping frame member (6) of the clamping system, as well as
   - a retaining portion (4) adapted to be brought into contact with a laminated yoke (7) of a transformer core (8) of said transformer,

   characterized in that the clamping bridge (1) is made of an epoxy resin laminate.

2. The clamping bridge (1) according to claim 1, **characterized in that** the epoxy resin laminate is realized as epoxy woven glass cloth.

3. The clamping bridge (1) according to claim 2, **characterized in that** the epoxy woven glass cloth is EP GC 203 or EP GC 205, as defined in the norm IEC 60893.

4. The clamping bridge (1) according to any of the claims 1 to 3, **characterized in that** said retaining portion (4) is arranged in a different plane than said first mounting portion (2) and/or said second mounting portion (3) .

5. The clamping bridge (1) according to any of the claims 1 to 4, **characterised in that** said retaining portion (4) comprises a first planar section (9) which is arranged substantially parallel to the first mounting portion (2) and/or the second mounting portion (3).

6. The clamping bridge (1) according to claim 5, **characterized in that** the retaining portion (4) comprises

   - a second planar section (10) protruding obliquely from the first planar section (9) and connecting the first planar section (9) with the first mounting portion (2), as well as

- a third planar section (11) protruding obliquely from the first planar section (9) and connecting the first planar section (9) with the second mounting portion (3).

7. The clamping bridge (1) according to any of the claims 1 to 6, **characterized in that** the clamping bridge (1) has a first set of openings (12) for receiving fastening elements (14), preferably bolts or screws, for fastening the clamping bridge (1) to the first clamping frame member (5) and/or to the second clamping frame member (6), and/or the clamping bridge (1) has a second set of openings (13) for receiving tension elements (15), preferably vertical tie bars, for connecting the first clamping frame member (5) and/or the second clamping frame member (6) to a further clamping frame (17).

8. The clamping bridge (1) according to claim 7, **characterized in that** the openings are lined with reinforcing members (18), preferably realized as glass fibre tubes.

9. Clamping system for an electric transformer, said clamping system comprising a first clamping frame (16) with

- a first clamping frame member (5) and a second clamping frame member (6) adapted to be arranged on opposing sides of a laminated yoke (7) of a transformer core (8) of said transformer,
- at least one tension element (15), preferably at least one horizontal tie bar, connecting the first clamping frame member (5) to the second clamping frame member (6) under tensile stress, as well as
- a clamping bridge (1) connecting the first clamping frame member (5) to the second clamping frame member (6),

characterized in that the clamping bridge (1) is realized according to any of the claims 1 to 8.

10. The clamping system according to claim 9, **characterized in that** it comprises at least two further tension elements (15), preferably vertical tie bars, connecting the first clamping frame (16) to a further clamping frame (17) of the clamping system, whereas these tension elements (15) are received in a second set of openings (13) of the clamping bridge (1).

FIG 1

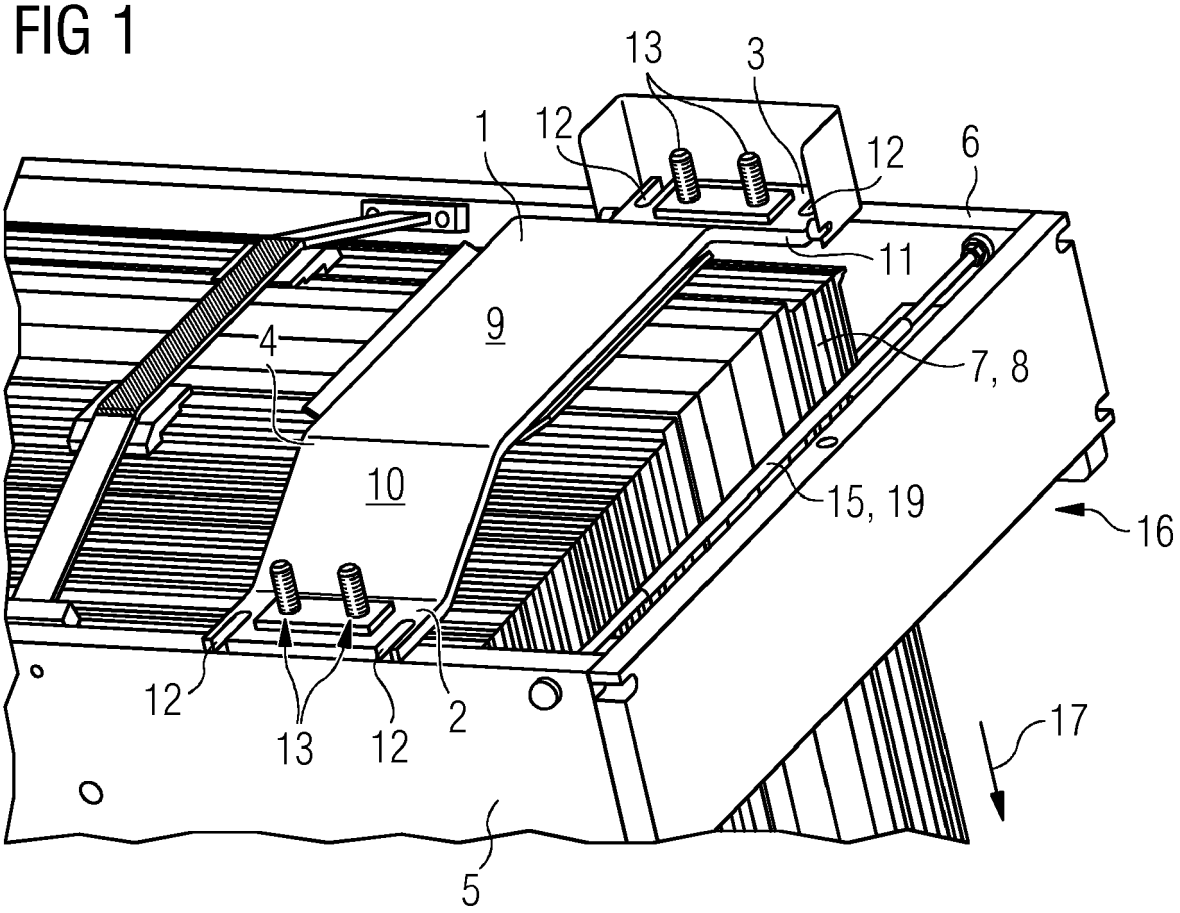
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FIG 2

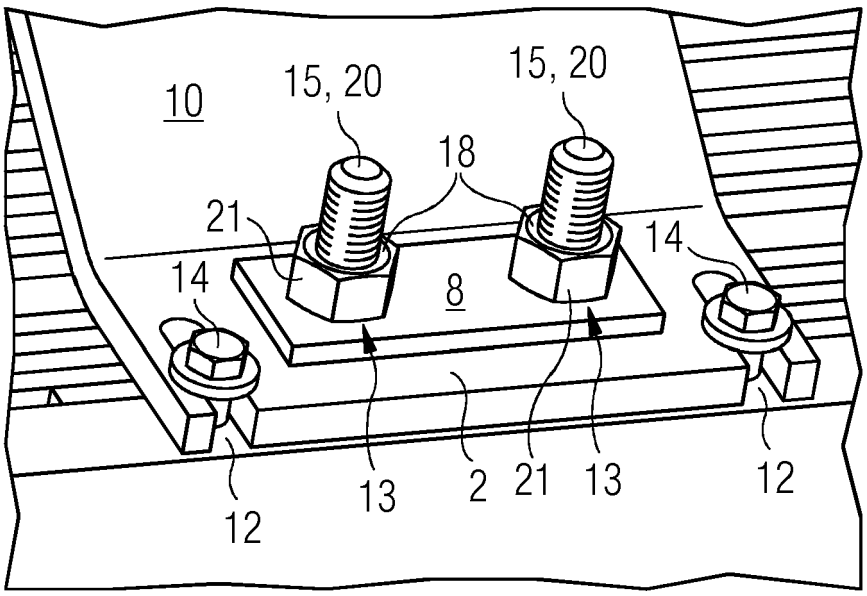
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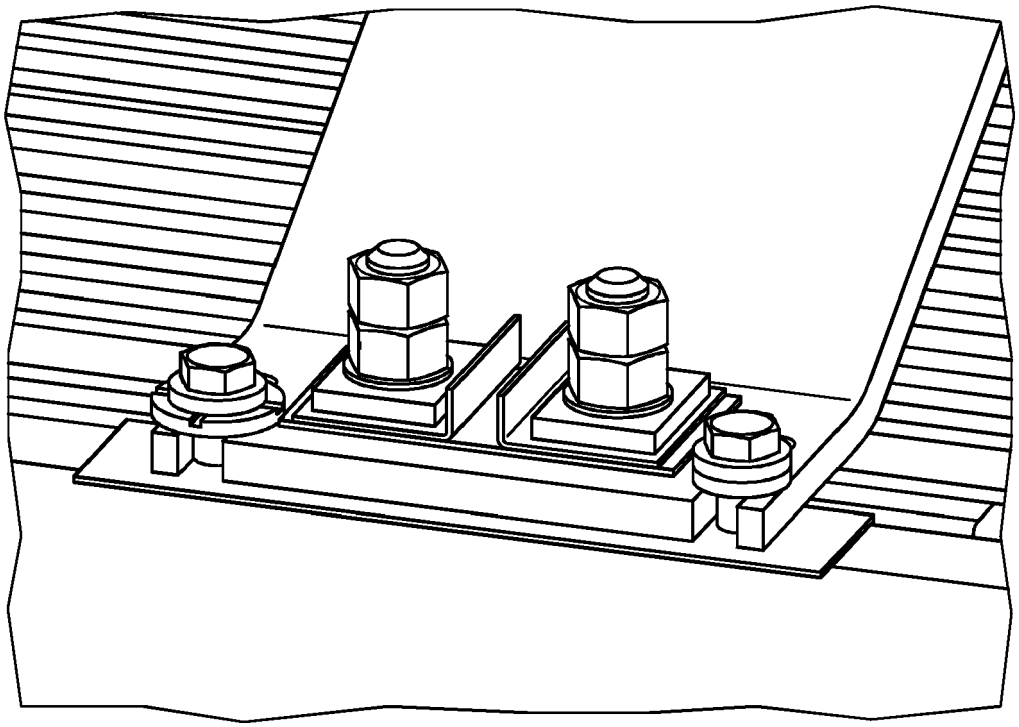
FIG 3



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EUROPEAN SEARCH REPORT

Application Number
EP 18 21 1817

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	EP 0 246 430 A1 (GEN ELECTRIC [US]) 25 November 1987 (1987-11-25) * abstract; figures 1,2,4 * * column 6, line 8 - column 8, line 33 * * claims 13-16 * -----	1,4,5,9 2,3,6-8, 10	INV. H01F27/26 H01F27/30
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Y	US 3 436 707 A (DERBYSHIRE CHARLES E ET AL) 1 April 1969 (1969-04-01) * abstract; figures 1,2 * -----	6-8	
Y	WO 00/02211 A1 (SIEMENS AG [DE]; GUTBERLET STEPHAN [DE]; HOPPE JENS [DE]) 13 January 2000 (2000-01-13) * abstract; figure 1 * -----	10	
			TECHNICAL FIELDS SEARCHED (IPC) H01F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	5 June 2019	Tano, Valeria

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 18 21 1817

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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