



(11) **EP 4 002 401 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention
of the grant of the patent:

14.08.2024 Bulletin 2024/33

(51) International Patent Classification (IPC):
H01F 27/26^(2006.01)

(52) Cooperative Patent Classification (CPC):
H01F 27/263

(21) Application number: **20212886.4**

(22) Date of filing: **09.12.2020**

(54) **SELF PRE-BENDING TRANSFORMER CLAMPS**

SELBSTVORBIEGENDE TRANSFORMATORKLEMMEN

PINCES DE TRANSFORMATEUR À PRÉ-COURBURE AUTOMATIQUE

(84) Designated Contracting States:

**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR**

(30) Priority: **23.11.2020 US 202063117036 P**

(43) Date of publication of application:
25.05.2022 Bulletin 2022/21

(73) Proprietor: **Hitachi Energy Ltd**
8050 Zürich (CH)

(72) Inventors:

- **Cardona, Julian**
New Hill, NC North Carolina 27562 (US)

• **Arteaga, Javier**

Youngsville, NC North Carolina 27596 (US)

• **Kraemer, Jonathan**

Apex, NC North Carolina 27502 (US)

• **Elliott, Darren**

Mirco, NC North Carolina 27555 (US)

(74) Representative: **Vossius & Partner**

Patentanwälte Rechtsanwälte mbB

Siebertstrasse 3

81675 München (DE)

(56) References cited:

CH-A- 387 782

JP-U- S5 398 916

US-A1- 2017 018 354

Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

Description

TECHNICAL FIELD

[0001] The present disclosure relates generally to transformer clamps, and more particularly to transformer clamps and related methods.

BACKGROUND

[0002] A transformer typically includes a core, coils, and a transformer clamp structure. The transformer clamp structure provides the stiffness required to withstand the loads in the transformer under different work conditions like lifting the transformer, short circuit operation, and transport of the transformer. In addition, the clamps must provide enough pressure to the core sheets to reduce or prevent the occurrence of vibration of the transformer core sheets when the transformer is in operation.

[0003] There are different ways to achieve the pressure across the transformer core. Typically, fixing studs, rivets or bolts passing through or around the core and attached to the clamps are used to achieve the pressure. This is illustrated in Figure 1. The use of these additional components typically increases manufacturing processes and costs.

[0004] An alternative method is used in which the transformer clamps are made with a pre-bending process. For achieving the pressure required on the transformer core, the transformer clamps are designed to be bent after assembly to have a small curved shape along their geometry (pre-bending). This small curved shape enables giving pressure on core sheets when the clamp is assembled on the core. To assemble the clamp on the transformer core, force is applied to the ends causing the clamp to take on a flattened shape, once the clamp is unbended it provides the pressure required by the core lamination. The pre-bending is illustrated in Figure 2.

[0005] Typically, the rectangular section of the transformer clamps is made by welding two pieces, a C Shape piece and a flat sheet as illustrated in Figure 3. Once these two pieces are welded, a plastic deformation is required to create the pre-bending. One way this is done is by applying a load in the middle of the clamps as shown in Figures 4A and 4B.

[0006] Figures 5 and 6 illustrate an example of a two piece C Shape 502 and flat sheet 504 of transformer clamp 500 that is assembled but not yet bent after assembly using the process illustrated in Figures 4A and 4B. Simulations have been carried out to validate the pressure exerted on the transformer core finding that the transformer clamp of Figures 5 and 6 bent after assembly do not provide a constant pressure along the transformer core as shown in Figure 7. In Figure 7, the white color 700 indicates a minimum pressure, the lighter color 702 indicates a pressure nearly half as much as the desired pressure, and the darker color 704 indicates pressure

equal to or higher than the desired pressure. The lighter color 702 may be even lighter, indicating an even lower pressure when the transformer clamp of Figure 5 and 6 is overtightened as illustrated in Figure 8.

[0007] US 2017/018354 A1 relates to a tension bar for applying pressure more uniformly by the core bracket of a transformer. The tension bar may include a bow-shaped flat bar having at least one tightening bolt disposed therein. The at least one tightening bolt may be adjusted to apply pressure on a channel bracket clamping the yoke of a transformer. The tension bar may allow for tension to be applied uniformly along the length of the channel bracket used to clamp the yoke.

[0008] CH 387 782 A relates to a transformer core having leg laminations that are clamped together by plates which are pre-set or biased pieśel in the manner of arched leaf springs. Yoke laminations are clamped by transverse members which may or may not be similarly pre-set. The pre-set plates may have holes to receive studs on the transverse members and holes to receive retaining bolts during assembly. The transverse members are held by tie bolts and also carry U-straps having clamping screws, these straps forming a base for the transformer. Clamping elements may serve to compress the windings and interlocking of the transverse members and the plates may be effected by retaining members affixed to the latter instead of by means of studs. Additional clamping in a leg may be provided by means of straps or bolts in the case where the spring-like plates prove insufficient.

[0009] JPS5398916U relates to a clamp for an iron core said clamp being curved in advance so that the central portion in the longitudinal direction of the clamp protrudes in the direction to the iron core.

SUMMARY

[0010] The invention for which protection is sought is defined by the independent claims. The dependent claims concern particular embodiments. Described herein is a transformer clamp that includes a first plate having a curved portion of a predetermined curvature between a first end portion and a second end portion of the transformer clamp. The transformer clamp includes a second plate attached to the first plate and curved based on the curvature of the curved portion, wherein the curvature enables the transformer clamp to distribute a substantially uniform pressure across a first surface of a transformer coupled to the transformer clamp. The second plate is attached substantially perpendicular to the first plate.

[0011] Advantages that can be achieved with the claimed invention is that the pre-bending can be achieved without requiring loads to bend. The resulting geometry of the transformer clamp reduces manufacturing time, and increases the accuracy of the transformer clamp providing the desired dimensions. The transformer clamp supports loads in different work conditions and provides

a substantially uniform pressure over the transformer part coupled to the transformer clamp.

[0012] Further described herein is a method for creating a transformer clamp. The method includes determining, based on a first surface of a transformer, a curvature for a first plate of the transformer clamp. The method includes forming a curved portion in the first plate between a first end portion and a second end portion of the transformer clamp based on the curvature determined. The method includes curving a second plate along the curved portion to form a curved contact surface having a curvature based on the curvature of the curved portion, the curved contact surface reshaping to apply a substantially uniform pressure across the first surface of the transformer coupled to the curved contact surface in response to a clamping force applied to the first end portion and the second end portion of the transformer clamp.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The accompanying drawings, which are included to provide a further understanding of the disclosure and are incorporated in and constitute a part of this application, illustrate certain non-limiting embodiments of the claimed invention. In the drawings:

Figure 1 is an illustration of a prior art transformer clamp having bolts that go through the transformer core;

Figure 2 is an illustration of pressure forming across a transformer core when a force is applied to unbend the prior art transformer clamp;

Figure 3 is an illustration of a prior art transformer clamp having a C shape and flat sheet;

Figures 4A and 4B are illustrations of providing a bend in the prior art transformer clamp illustrated in Figure 3;

Figure 5 is a sectional view illustrating components of a prior art C shape and flat sheet transformer clamp bent after assembly of the transformer clamp; Figure 6 is a view illustrating an assembled view of the prior art C shape and flat sheet transformer clamp of Figure 5;

Figure 7 is an illustration of pressure exerted by the rectangular beam of the prior art transformer clamp of Figures 5 and 6 on the transformer core;

Figure 8 is an illustration of overtightening the prior art transformer clamp of Figures 5 and 6;

Figure 9 is an illustration of plates of a transformer clamp according to some embodiments of the claimed invention;

Figure 10 is an illustration of the plates of Figure 9 being assembled according to some embodiments of the claimed invention;

Figure 11 is a top view of a transformer clamp according to some embodiments of the claimed invention;

Figure 12 is an illustration of an example of a trans-

former clamp bend according to some embodiments; Figure 13 is an illustration of a distributed load across a transformer clamp according to some embodiments of the claimed invention;

Figure 14 is an illustration of a maximum deformation of a transformer clamp according to some embodiments;

Figure 15 is an illustration of setting the curvature of a plate of the transformer clamp to a maximum deformation according to some embodiments of the claimed invention;

Figure 16 is an illustration of components of the transformer clamp of Figure 11 according to some embodiments of the claimed invention;

Figure 17 is an illustration of the transformer clamp components of Figure 11 when assembled according to some embodiments of the claimed invention; Figure 18 is an example of pressure exerted by the transformer clamp illustrated in Figure 12 on the transformer core according to some embodiments of the claimed invention;

Figure 19 is a front view of a transformer assembly clamped by the transformer clamp illustrated in Figure 16 according to some embodiments of the claimed invention;

Figure 20 is an isometric view of the transformer assembly illustrated in Figure 19;

Figure 21 is a top view of a C-shape and plate transformer clamp according to some embodiments of the claimed invention;

Figure 22 is an isometric view of the C-shape and plate transformer clamp of Figure 21;

Figure 23 is an isometric view of a mounting mechanism according to some embodiments;

Figure 24 is a top view of a transformer assembly having the mounting mechanism of Figure 23 according to some embodiments;

Figure 25 is an isometric view of the C-shape and plate transformer claim of Figure 21;

Figure 26 is an isometric view of another mounting mechanism according to some embodiments;

Figure 27 is a top view of a transformer assembly having the mounting mechanism of Figure 26 according to some embodiments;

Figure 28 is an isometric view of another mounting mechanism according to some embodiments;

Figure 29 is a top view of a transformer assembly having the mounting mechanism of Figure 28 according to some embodiments;

Figures 30 and 31 are flow charts illustrating operations of creating a transformer clamp according to some embodiments of the claimed invention; and

Figure 32 is a flow chart illustrating a process of connecting transformer clamps with a mounting mechanism that reduces and, in some scenarios, prevents the occurrence of damage to the bolts used to attach the mounting mechanism to the transformer clamps according to some embodiments.

DETAILED DESCRIPTION

[0014] The invention as claimed will now be described more fully hereinafter with reference to the accompanying drawings, in which examples of are shown. These embodiments are provided so that this disclosure will convey the scope of present invention as set forth in the appended claims to those skilled in the art. It should also be noted that these embodiments are not mutually exclusive. Components from one embodiment may be tacitly assumed to be present/used in another embodiment.

[0015] The following description presents various embodiments of the disclosed subject matter. These embodiments are presented as teaching examples and are not to be construed as limiting the scope of the disclosed subject matter. For example, certain details of the described embodiments may be modified, omitted, or expanded upon without departing from the scope of the described subject matter.

[0016] Figure 9 is an illustration of plates 902, 906 of a transformer clamp 900 according to some embodiments of the claimed invention. Figure 10 illustrates the plates 902, 906 of the transformer clamp 900 when the transformer clamp has been assembled. Turning to Figures 9 - 11, according to various embodiments of the claimed invention, a T-section geometry is used that allows optimizing of the cross-section material in relation to the greater stresses required. In other words, the first plate 902 of transformer clamp 900 has variable lengths from a first length L1 to a second length L2 where the second length is greater than the first length. The pre-bending is achieved by joining two sheets together perpendicularly to form the transformer clamp 900. Specifically, first plate 902 (e.g., a flat sheet) has a curved portion 904 and is joined to the plate 906. The first plates 902, and the second plate 906 may be joined by welding the first plate 902 and the second plate 906 together. Thus, the second plate 906 is attached perpendicular to first plate 902 so that the first plate 902 is joined along the center axis of second plate 906. When joined, the second plate 906 follows the curvature 910 illustrated in Figure 11, achieving an assembly with an arched geometry that imparts a bending of the second plate 906. The bending forms a curved contact surface 908 of the second plate 906. The curvature 910 typically ranges from 3 mm to 8 mm and depends on the desired pressure to be applied to the transformer and the dimensions of the transformer. For example, the desired pressure in various embodiments of the claimed invention is on the order of 0.15 MPa. In other embodiments, the second plate 906 may be attached perpendicular to the first plate 902 anywhere along the first plate 906 provided that the second plate 906 follows the curvature 910.

[0017] The curvature is determined based on a desired pressure to be applied to the transformer core of the transformer and a dimension of the transformer core. The desired pressure may be around 0.15 MPa.

[0018] In one embodiment of the claimed invention,

the curvature 910 may be determined by determining a maximum deformation of transformer clamp based on a distributed load and length of the transformer clamp, which in turn is based on the transformer core length.

[0019] For example, turning to Figure 12, when a load is applied at the end of the plate and with the cross section of the beam being constant, then a deformation forms as shown in Figure 12. Thus, the beam has more deformation in the middle and there is no contact between the plate of the transformer clamp and the transformer core, so there is no pressure from the transformer clamp towards the transformer core.

[0020] To avoid this deformation in the middle of the transformer clamp plate, the cross section of the transformer clamp plate 902 needs to be increased in accordance with the deformation of the transformer clamp plate, which requires a variable cross section. Turning to Figures 13 and 14, the maximum deformation δ is determined for the transformer clamp using a distributed load Q^* where Q^* is calculated based on the contact surface area of the transformer clamp surface area and the pressure on the transformer core to be reached (e.g., 0.15 MPa). The curvature of the plate is determined by setting the curvature to the maximum deformation δ as illustrated in Figure 15, where the maximum deformation δ is calculated in accordance with

$$\delta = \frac{5QL^4}{384EI}$$

where Q is the distributed load (e.g., 0.15 MPa), L is the length of the second plate 906 of transformer clamp 900, E is the modulus of elasticity, and I is the moment of inertia.

[0021] Turning to Figures 11 and 16-17, the first plate 902 may include a plurality of mounting holes 912 formed approximately midway between an end portion 914, 916 of the first plate 902 and a middle portion 918 of the first plate 902 to enable a tie rod 1802 (see Figures 16 - 17) to be connected to the first plate 902 at each of the plurality of mounting holes 912.

[0022] Support tabs 920 can be attached proximate each mounting hole 912 of the first plate 902. Each support tab 920 can have a mounting hole 922 to enable lifting of the transformer 1800 as illustrated in Figures 16-17. In some embodiments of the claimed invention, not all support tabs 920 have the mounting hole 922. Instead, only the transformer clamps 900 that are used to lift the transformer have mounting holes 922.

[0023] In some embodiments of the claimed invention, the support tab 920 may have a slot 924 that fits into a slot 926 of first plate 902 as illustrated in Figure 16. This enables the support tabs 920 to be mounted at fixed locations on the first plate 902.

[0024] The second plate 906 may have mounting holes 928 proximate each end portion 930, 932 of the second plate 906. The mounting holes 928 are used to connect

the transformer clamp 900 to another transformer clamp operatively coupled to an opposite surface of a transformer being clamped. Note that the clamping force is applied to the end portions 930, 932 of the transformer clamp 900 responsive to the transformer clamp being connected to the second transformer clamp. The second transformer clamp may be any transformer clamp including the transformer clamp 900.

[0025] To aid in the assembly of the transformer clamp 900, the second plate 906 may, in some embodiments of the transformer clamp 900, have proximate the center of each end portion of the second plate 906 a slot 934 which receives a tab portion 936 of the first plate 902. This aligns the second plate 906 to the first plate 902 along the center axis of the second plate 906.

[0026] Figure 18 illustrates simulations that were performed to validate the pressure exerted on the transformer clamp of Figures 9-11, and 16-17. In Figure 18, the white color 1400 indicate a minimum pressure and the dark color 1402 indicates pressure equal to or higher than the desired pressure. The simulations that were performed show that the T-section beam shape of the transformer clamp 900 enables a pressure of 0.15 MPa to be reached along the core as shown. The transformer clamp 900 provides a substantially uniform pressure across the surface of the transformer core.

[0027] Figure 19 is a front view of a transformer assembly clamped by the transformer clamp illustrated in Figure 16 and Figure 20 is an isometric view of the transformer clamp. The transformer clamps 900A-900D are shown clamping a transformer 1800. The transformer clamp 900A and transformer clamp 900B are connected to each other by the tie rods 1902 via mounting holes 912. Other types of connectors may be used to connect the transformer clamp 900A to the transformer clamp 900B via the mounting holes 912.

[0028] The transformer clamp 900A, using the mounting holes 928 proximate each end portion 914, 916 of second plate 906, is also connected to transformer clamp 900C that is coupled to an opposite surface of the transformer 1900 of the surface where the transformer clamp 900A is coupled to the transformer 1900. The clamping force is applied to the end portions 914, 916 of the transformer clamp via the transformer clamp 900A being connected to the transformer clamp 900C via mounting mechanism 1904. Thus, the clamping force is applied to the ends 914, 916 substantially perpendicular to the second plate 906. Transformer clamp 900B is similarly connected to transformer clamp 900D.

[0029] The transformer clamp 900 is typically connected to a transformer core surface of a transformer core 1906 above or below the winding area of the transformer windings 1908. In other words, the transformer clamps 900 are above the top of winding area of the transformer windings 1908 and below the bottom of the winding area of the transformer windings 1908. Put another way, in these embodiments of the claimed invention, the transformer clamps 900A to 900D hold the transformer cores

in place with a substantially uniform pressure across the transformer core at the top and bottom of the transformer cores.

[0030] In some embodiments, supports 1910 may be used to reduce or prevent the occurrence of transformer windings 1908 moving towards the transformer clamps 900A to 900D during transport of the transformer 1900. The transformer clamps 900 hold the supports 1910 in place when the tie rods 1902 are tightened to hold the transformer clamps together. The tightening of the tie rods 1902 pushes the plate 902 against the supports 1910. The supports may be wood supports, plastic supports, or any other type of material that is of sufficient stiffness to withstand the force applied by the transformer clamp when the tie rods 1902 are tightened to hold transformer clamps 900 together (e.g., transformer clamp 900A to transformer clamp 900B and transformer clamp 900C to transformer clamp 900D).

[0031] In various other embodiments, the second plate 906 may have additional mounting holes and support tabs to aid in positioning the transformer clamps to the correct position on the transformer such as mounting holes 938, 940 and support tabs 942 as illustrated in Figures 19 and 20. For example, in some embodiments, there may be space limitations where the mounting hole 922 of support tabs 920 are unable to be used. In these embodiments, mounting hole 938 may be used as an alternative place to lift the transformer.

[0032] Figures 21 and 22 illustrate a C-shape and plate transformer clamp 2100 according to various embodiments of the claimed invention. The C-shape 2102 has a top plate 2104, a side plate 2106 and a bottom plate 2108. The top plate 2104 and bottom plate 2108 have variable lengths from a first length L1 to a second length L2 where the second length is greater than the first length. The top plate 2104 and bottom plate 2108 have a curved portion 2110 and are joined to the plate 2112 where the curvature of the curved portion 2110 is determined as described above. The C-shape 2102 and the plate 2112 may be joined by welding the top plate 2104 and bottom plate 2108 to the plate 2112. Thus, the plate 2112 is attached perpendicular to the top plate 2104 and the bottom plate 2108 of the C-shape 2102 along the top and the bottom of plate 2112. When joined, the plate 2112 follows the curvature 2114 illustrated in Figure 21, achieving an assembly with an arched geometry that imparts a bending of the plate 2112. The bending forms a curved contact surface 2116 of the plate 2112. The curvature 2114 typically ranges from 3 mm to 8 mm and depends on the desired pressure to be applied to the transformer and the dimensions of the transformer. For example, the desired pressure in various embodiments of the claimed invention is on the order of 0.15 MPa.

[0033] The transformer clamp 2100 may include a plurality of mounting holes 2118 formed proximate the end portion 2120, 2122 of the C-shape 2102 to enable a tie rod to be connected to the top plate 2104 and bottom plate 2108 at each of the plurality of mounting holes 2118.

[0034] Support tabs 2124 can be attached proximate each mounting hole 2118. Each support tab 2124 can have a mounting hole 2126 to enable lifting of the transformer. In some embodiments of the claimed invention, not all support tabs 2126 have the mounting hole 2128. Instead, only the transformer clamps 2100 that are used to lift the transformer have mounting holes 2126.

[0035] The side plate 2106 of C-shape 2102 and plate 2112 may have mounting holes 2128 proximate each end portion 2120, 2122 of the C-shape 2102. The mounting holes 2128 are used to connect the transformer clamp 2100 to another transformer clamp operatively coupled to an opposite surface of a transformer being clamped. Note that the clamping force is applied to the end portions 2120, 2122 of the transformer clamp 2100 responsive to the transformer clamp being connected to the second transformer clamp. The second transformer clamp may be any transformer clamp including the transformer clamp 2100.

[0036] Figure 23 illustrates the mounting mechanism 1904 and the tab portion 936. As previously indicated, the tab portion 936 aligns the second plate 906 to the first plate 902 during assembly of the transformer clamp 900. The tab portion 936 in some embodiments may also be used to reduce and, in some scenarios, prevent the occurrence of damage to the bolts 2300 used to attach the mounting mechanism 1904 to the transformer clamps 900.

[0037] For example, during transport of the transformer 1900, the transformer 1900 may be subject to force 2400, as illustrated in Figure 24, that are sufficiently high enough to cause the transformer cores 1906 to move in the direction of the force 2400. The force 2400 may be the result of a vehicle transporting the transformer 1900 braking hard to avoid an accident, a chain breaking when the transformer 1900 is being lifted, etc. The transformer cores 1906 move in the direction of the force 2400 and push on the back wall 2302 of mounting mechanism 1904. The force 2400 may be in the direction shown in Figure 24 or in the opposite direction of the direction shown. The plate 2304 reduces or prevents the occurrence of transformer cores 1906 bending the back wall 2302 when the transformer cores 1906 push against the back wall 2302.

[0038] Without the tab portion 936, the pushing on the back wall 2302 can result in the mounting mechanism 1904 pushing against the bolts 2300 located in slots 2306 of side wall 2308. When the force 2400 is high enough, the bolts 2300 may shear off. When the bolts 2300 shear off, the clamping force applied to the transformer clamp 900 is significantly reduced and the transformer clamp 900 would no longer provide the substantially uniform pressure across the transformer core 1906 and can damage the transformer 1900.

[0039] With the tab portion 936, the occurrence of the mounting mechanism 1904 from moving far enough to shear off the bolts 2300 is reduced or prevented. The reduction or prevention of the occurrence of movement

is due to the tab portion 936 being proximate the edge 2310 of side wall 2308. The edge 2310 pushes against tab portion 936 and the tab portion 936 reduces or prevents the occurrence of movement of the side wall 2308 from moving any further, which prevents or reduces the occurrence of the bolts 2300 from being exposed to forces from the transformer core movement that could shear the bolts 2300. In other embodiments, the edge 2310 of side wall 2308 may be moved to engage (i.e., contact) the tab portion 936 during installation of the mounting mechanism 1904. In these embodiments, the occurrence of the edge 2310 of side wall 2308 from moving is reduced or prevented, which in turn prevents or reduces the occurrence of the back wall 2302 of mounting mechanism 1904 from moving when the force 2400 is applied to the transformer cores 1906.

[0040] Figure 25 illustrates how a tab can be added to the C-shape and flat plate transformer clamp 500 and C-shape and flat plate transformer clamp 2100 to operate like the tab portion 936 of transformer clamp 900. A tab 2500 can be mounted proximate the end portions of the flat plate 504, 2112 of the C-shape and flat plate transformers 500, 2100. The tab 2500 can then be used to reduce or prevent the occurrence of the mounting mechanism 1904 from moving as described above.

[0041] Figure 26 illustrates another embodiment of the mounting mechanism. In Figure 26, the mounting mechanism 2600 does not have plate 2304. The thickness 2602 of the back wall 2302 is increased to better withstand the force applied by the transformer core moving to reduce, and in some cases prevent, the occurrence of movement of the sidewalls 2308 towards the tab portion 936, 2500. Figure 27 illustrates the mounting mechanism 2600 connecting transformer clamps to each other.

[0042] Figure 28 illustrates a further embodiment of the mounting mechanism. In Figure 28, the back wall 2302 of mounting mechanism 2800 has an increased dimension and plates 2802 and 2804 are formed by bending the back wall 2304. The two plates 2802 and 2804 of the back wall 2302 act to stiffen the back wall 2302 to better withstand the force applied by the transformer core moving to reduce and in some cases, prevent, the occurrence of movement of the sidewalls 2308 towards the tab portion 936, 2500. Figure 29 illustrates the mounting mechanism 2800 connecting transformer clamps to each other.

[0043] Figure 30 illustrates a process of creating the transformer clamp 900, 2100 in an embodiment of the claimed invention. In block 3001, a curvature to be applied to a first plate of the transformer clamp is determined based on a first surface of a transformer. For example, the curvature 910 of the curved portion 904 to be applied to the first plate 902 is determined based on at least one of the length of the transformer clamp 900 (which in turn is based on transformer core parameters such as a dimension of the transformer core), and the pressure to be applied to the transformer clamp (e.g., 0.15 MPa). Thus, at least one of the length or the pressure or both the

length and the pressure is used. In other embodiments, the curvature 2114 to be applied to the top plate 2104 and the bottom plate 2108 of C-shape 2102 is determined based on at least one of the length of the transformer clamp 2100 (which in turn is based on transformer core parameters), and the pressure to be applied to the transformer clamp (e.g., 0.15 MPa). Thus, at least one of the length or the pressure or both the length and the pressure is used.

[0044] In block 3003, a curvature portion 2110 in the first plate is formed between a first end portion 2120 and a second end portion 2122 of the transformer clamp based on the curvature determined to be applied. For example, the curved portion 904 is formed between end portions 914, 916 of the transformer clamp 900. The curved portion may be formed by laser cutting, water cutting, etc. In the C-shape and flat plate transformer clamp 2100, the curved portion 2110 is formed between end portions 2120, 2122.

[0045] In block 3005, a second plate is attached to the first plate by curving the second plate along the curved portion to provide a curved contact surface having a curvature based on the curvature of the curved portion, the curved contact surface reshaping to apply a substantially uniform pressure across the first surface of the transformer coupled to the curved contact surface in response to a clamping force applied to the first end portion and the second end portion of the transformer clamp. For example, the plate 906 of transformer clamp 900 may be curved along the curved portion 904 of plate 902 to form the curved contact surface 908. When the transformer clamp 900 is connected to another transformer clamp, the force applied to the transformer clamp 900 by tightening of the transformer clamp 900 to the mounting mechanism 1904 provides the force sufficient to reshape the curved contact surface 908 to apply the substantially uniform pressure across the first surface (e.g., transformer core) of a transformer coupled to the curved contact surface 908. In other embodiments, the plate 2112 of transformer clamp 2100 may be curved along the curved portion 2110 of plates 2104, 2108 to form the curved contact surface 2116. When the transformer clamp 2100 is connected to another transformer clamp, the force applied to the transformer clamp 2100 by tightening of the transformer clamp 2100 to the mounting mechanism 1904 provides the force sufficient to reshape the curved contact surface 2116 to apply the substantially uniform pressure across the first surface (e.g., transformer core) of a transformer coupled to the curved contact surface 2116.

[0046] Turning to Figure 31, further operations can be performed during creation of the transformer clamp 900. For example, in block 3101, a plurality of mounting holes is formed in the first plate, each of the plurality of mounting holes formed approximately midway between an end of the first plate and a middle of the first plate to enable a tie rod to be connected to the first plate at each of the plurality of mounting holes. For example, mounting holes

912 may be formed in first plate 902 either before or after the second plate 906 is connected to first plate 902. In other embodiments, a plurality of mounting holes 2118 is formed in plates 2104, 2108 proximate the end portions 2120, 2122.

[0047] In block 3103, mounting holes are formed proximate each end of the second plate for connecting the second plate to a second transformer clamp operatively coupled to an opposite surface of the first surface wherein the clamping force is applied to the first end and the second end of the transformer clamp responsive to the transformer clamp being connected to the second transformer clamp. For example, in transformer clamp 900, mounting holes 928 may be formed in second plate 906 either before or after the second plate 906 is connected to first plate 902. In C-shape and flat plate transformer clamp 2100, mounting holes 2128 may be formed in the plate 2106 and flat plate 2112.

[0048] In block 3105, a support tab is attached proximate each mounting hole of the first plate. In some embodiments, each support tab has a mounting hole to enable lifting of the transformer. In other embodiments, only support tabs that are part of transformer clamps that are at the top of a transformer have mounting holes. An example of a support tab having holes is support tab 920 having mounting hole 922. In the embodiments of C-shape transformer and flat plate transformer clamp 2100, another example of a support tab having holes is support tabs 2124.

[0049] As described above, a force may be applied to a transformer core that is of sufficient force to cause the transformer core to move against the mounting mechanism and cause damage to the mounting mechanism and/or the transformer core. Figure 32 illustrates a process of connecting transformer clamps with a mounting mechanism that reduces and, in some scenarios, prevents the occurrences of damage to the bolts used to attach the mounting mechanism to the transformer clamps. Turning to Figure 32, in block 3201, at least one tab portion is connected to a transformer clamp. In some embodiments, the tab portion is part of a plate of the transformer clamp. For example, tab portion 936 is part of plate 902 of transformer clamp 900 and engages plate 906 during assembly of transformer clamp 900. In other embodiments, the tab portion is connected by welding the tab. For example tab portion 2500 may be welded on plate 504, 2112.

[0050] In some embodiments, the tab portion is connected adjacent to an end portion of a plate of the transformer clamp that is contacting the transformer core. For example, plate 906 of transformer clamp 900, plate 2112 of transformer clamp 2100, and the flat plate 504 of transformer clamp 500 touch the transformer core. In various embodiments, the tab portion 936, 2500 is provided adjacent to an end portion 506, 508, 930, 932, 2120, 2122 of a plate 504, 906, 2112 of the transformer clamp.

[0051] In block 3203, a mounting mechanism having a back wall and sidewalls is connected to transformer

clamps by placing the back wall adjacent a surface of the transformer core of the transformer and connecting each sidewall to one of the transformer clamps adjacent to one of the at least one tab portion, wherein each sidewall is enabled to engage the one of the at least one tab portion responsive to the transformer core applying a force to the mounting mechanism in response to another force applied to the transformer core.

[0052] For example, mounting mechanism 1904, 2600, 2800 having a back wall 2302 and sidewalls 2308 is connected to the transformer clamps 500, 900, 2100 by placing back wall 2302 adjacent a side surface of the transformer core 1906 and connecting each sidewall 2308 to one of the transformer clamps 500, 900, 2100 adjacent to one of the tab portions (936, 2500).

[0053] In various embodiments, the mounting mechanism 1904, 2600, 2800 is attached to the transformer clamps such that one of the sidewalls 2308 engages the at least one tab portion 936, 2500 of one of the transformer clamps. In these embodiments, the force applied by the transformer does not move the sidewalls 2308 to engage the at least one tab portion 936, 2500 since the sidewalls 2038 are already contacting the at least one tab portion 936, 2500.

[0054] As can be seen from the foregoing, a transformer clamp has been described that provides substantially uniform pressure to the surface of a transformer during operation, increases the accuracy of the manufactured parts to the desired dimensions, provides a reduction in part count which results in lower weight and a simple manufacturing process which leads to a significant reduction in manufacturing costs, and provides a precise curvature to enable the substantial uniform pressure to be achieved.

[0055] Furthermore, the transformer clamp provides a tab portion that enables a mounting mechanism to reduce and/or prevent the occurrence of shear forces from shearing off bolts used to connect the mounting mechanism to the transformer clamp.

[0056] Generally, all terms used herein are to be interpreted according to their ordinary meaning in the relevant technical field, unless a different meaning is clearly given and/or is implied from the context in which it is used. All references to a/an/the element, apparatus, component, means, step, etc. are to be interpreted openly as referring to at least one instance of the element, apparatus, component, means, step, etc., unless explicitly stated otherwise. The steps of any methods disclosed herein do not have to be performed in the exact order disclosed, unless a step is explicitly described as following or preceding another step and/or where it is implicit that a step must follow or precede another step. Any feature of any of the embodiments disclosed herein may be applied to any other embodiment, wherever appropriate. Likewise, any advantage of any of the embodiments may apply to any other embodiments, and vice versa. Other objectives, features and advantages of the enclosed embodiments will be apparent from the above description.

[0057] As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. Well-known functions or constructions may not be described in detail for brevity and/or clarity.

[0058] As used herein, the terms "comprise", "comprising", "comprises", "include", "including", "includes", "have", "has", "having", or variants thereof are open-ended, and include one or more stated features, integers, elements, steps, components or functions but does not preclude the presence or addition of one or more other features, integers, elements, steps, components, functions or groups thereof. Furthermore, as used herein, the common abbreviation "e.g.", which derives from the Latin phrase "exempli gratia," may be used to introduce or specify a general example or examples of a previously mentioned item, and is not intended to be limiting of such item. The common abbreviation "i.e.", which derives from the Latin phrase "id est," may be used to specify a particular item from a more general recitation.

[0059] It should also be noted that in some alternate implementations, the functions/acts noted in the blocks may occur out of the order noted in the flowcharts. For example, two blocks shown in succession may in fact be executed substantially concurrently or the blocks may sometimes be executed in the reverse order, depending upon the functionality/acts involved. Moreover, the functionality of a given block of the flowcharts and/or block diagrams may be separated into multiple blocks. Finally, other blocks may be added/inserted between the blocks that are illustrated, and/or blocks/operations may be omitted without departing from the scope of the claimed invention.

[0060] Many variations and modifications can be made to the embodiments. Accordingly, the above disclosed subject matter is to be considered illustrative, and not restrictive, and the examples of embodiments are intended to cover all such modifications, enhancements, and other embodiments. The scope of the invention is defined by the appended claims.

Claims

1. A transformer clamp (900, 2100) comprising:

a first plate (902, 2104, 2108) having a curved portion (904, 2110) of a predetermined curvature (910, 2120) between a first end portion (914, 930, 2120, 2122) and a second end portion (916, 932) of the transformer clamp; and
a second plate (906, 2112) attached to the first plate (902, 2104, 2108) and curved based on the curvature (910, 2120) of the curved portion (904, 2110), wherein the curvature (910, 2120) enables the transformer clamp (900, 2100) to distribute a substantially uniform pressure across a first surface of a transformer coupled

- to the transformer clamp (900, 2100), wherein the second plate (906, 2112) is attached substantially perpendicular to the first plate (902, 2104, 2108) by joining the second plate (906, 2112) to the curved portion of the first plate (902, 2104, 2108) such that the second plate (906, 2110) follows the curvature (910, 2120) of the curved portion (904, 2110) and imparting a bending of the second plate (906, 2112) that forms a curved contact surface (908) of the second plate (906, 2112) configured to be pressed across the first surface of the transformer.
2. The transformer clamp of Claim 1 wherein the second plate (906, 2112) reshapes to a substantially flat contact surface based on an external pressure applied to the transformer clamp (900, 2100).
 3. The transformer clamp of any of Claims 1-2, wherein the first plate (902) includes a plurality of mounting holes (912), at least one mounting hole (912) formed approximately midway between an end portion (914, 916) of the first plate (902) and a middle portion (918) of the first plate (902).
 4. The transformer clamp of Claim 3, further comprising a support tab (920) attached proximate each mounting hole (912) of the first plate (902), wherein at least one of the support tabs (902) has a support tab mounting hole (922) to enable lifting of the transformer.
 5. The transformer clamp of any of Claims 1-4 wherein the second plate (906, 2112) further comprises mounting holes (928, 2128) proximate each end portion (930, 932, 2120, 2122) of the second plate (906, 2112) and configured to be connected to a second transformer clamp operatively coupled to a second transformer core surface.
 6. An assembly of the transformer clamp of Claim 5 and a second transformer clamp wherein the second transformer clamp comprises a transformer clamp (900) according to one of Claims 1 - 5.
 7. A method for creating a transformer clamp (900, 2100), the method comprising:
 - determining (2601), based on a first surface of a transformer, a curvature (910, 2110) for a first plate (902, 2104, 2108) of the transformer clamp (900, 2100);
 - forming (2603) a curved portion (904, 2110) in the first plate (902, 2104, 2108) between a first end portion (914, 2120) and a second end portion (916, 2122) of the first plate (902, 2104, 2108) based on the curvature (910, 2110) determined; and

curving (2605) a second plate (906, 2112) along the first plate (902, 2104, 2108) to form a curved contact surface (908, 2116) having a curvature based on the curvature (910, 2110) of the curved portion (904, 2110), the curved contact surface (908, 2116) reshaping to apply a substantially uniform pressure across the first surface of the transformer coupled to the curved contact surface (908, 2116) in response to a clamping force applied to the first end portion (914, 2120) and the second end portion (916, 2122) of the transformer clamp (900, 2100), wherein curving the second plate (906, 2110) along the first plate (902, 2104, 2108) comprises attaching the second plate (906, 2110) perpendicular to the first plate (902, 2104, 2108) by joining the second plate (906, 2112) to the curved portion of the first plate (902, 2104, 2108) such that the second plate (906, 2110) follows the curvature (910, 2120) of the curved portion (904, 2110) and imparting a bending of the second plate (906, 2112) that forms the curved contact surface (908, 2116) of the second plate (906, 2112) configured to be pressed across the first surface of the transformer.

8. The method of Claim 7 wherein the curved contact surface (908, 2116) reshapes to be a substantially flat contact surface responsive to a clamping force being applied to the first end portion (914, 2120) and the second end portion (916, 2122) of the transformer clamp (900, 2100).
9. The method of any of Claims 7-8 wherein determining the curvature (910) for the first plate (902, 2104, 2108) comprises determining the curvature based on at least one of a desired pressure to be applied to a transformer core of the transformer and a dimension of the transformer core.

Patentansprüche

1. Transformatorklemme (900, 2100), aufweisend:

eine erste Platte (902, 2104, 2108) mit einem gekrümmten Abschnitt (904, 2110) mit einer vorbestimmten Krümmung (910, 2120) zwischen einem ersten Endabschnitt (914, 930, 2120, 2122) und einem zweiten Endabschnitt (916, 932) der Transformatorklemme; und
eine zweite Platte (906, 2112), die an der ersten Platte (902, 2104, 2108) angebracht und auf Grundlage der Krümmung (910, 2120) des gekrümmten Abschnitts (904, 2110) gekrümmt ist, wobei die Krümmung (910, 2120) der Transformatorklemme (900, 2100) ermöglicht, einen im Wesentlichen gleichmäßigen Druck über eine

- erste Oberfläche eines mit der Transformator-
klemme (900, 2100) gekoppelten Transforma-
tors zu verteilen,
wobei die zweite Platte (906, 2112) im Wesent-
lichen senkrecht zu der ersten Platte (902, 2104,
2108) angebracht ist, indem die zweite Platte
(906, 2112) mit dem gekrümmten Abschnitt der
ersten Platte (902, 2104, 2108) so verbunden
ist, dass die zweite Platte (906, 2110) der Krüm-
mung (910, 2120) des gekrümmten Abschnitts
(904, 2110) folgt, und der zweiten Platte (906,
2112) eine Biegung verliehen wird, die eine ge-
krümmte Kontaktfläche (908) der zweiten Platte
(906, 2112) bildet, die dafür konfiguriert ist, auf
die erste Oberfläche des Transformators ge-
drückt zu werden.
2. Transformatorklemme nach Anspruch 1, wobei sich
die zweite Platte (906, 2112) auf Grundlage eines
auf die Transformatorklemme (900, 2100) ausgeüb-
ten externen Drucks zu einer im Wesentlichen fla-
chen Kontaktfläche verformt.
3. Transformatorklemme nach einem der Ansprüche 1
und 2, wobei die erste Platte (902) eine Vielzahl von
Befestigungsöffnungen (912) aufweist, wobei mindes-
tens ein Befestigungsloch (912) ungefähr auf hal-
bem Weg zwischen einem Endabschnitt (914, 916)
der ersten Platte (902) und einem mittleren Abschnitt
(918) der ersten Platte (902) gebildet ist.
4. Transformatorklemme nach Anspruch 3, ferner auf-
weisend eine Stützzunge (920), die in der Nähe je-
des Befestigungslochs (912) der ersten Platte (902)
angebracht ist, wobei mindestens eine der Stützzun-
gen (902) ein Stützzungen-Befestigungsloch (922)
aufweist, um ein Anheben des Transformators zu
ermöglichen.
5. Transformatorklemme nach einem der Ansprüche 1
bis 4, wobei die zweite Platte (906, 2112) ferner Be-
festigungsöffnungen (928, 2128) in der Nähe jedes En-
dabschnitts (930, 932, 2120, 2122) der zweiten Plat-
te (906, 2112) aufweist und so konfiguriert ist, dass
sie mit einer zweiten Transformatorklemme verbun-
den werden kann, die funktionell mit einer zweiten
Transformatorkernoberfläche gekoppelt ist.
6. Anordnung aus der Transformatorklemme nach An-
spruch 5 und einer zweiten Transformatorklemme,
wobei die zweite Transformatorklemme eine Trans-
formatorklemme (900) nach einem der Ansprüche 1
bis 5 aufweist.
7. Verfahren zum Herstellen einer Transformatorklem-
me (900, 2100), wobei das Verfahren umfasst:
- Bestimmen (2601) einer Krümmung (910, 2110)
- für eine erste Platte (902, 2104, 2108) der Trans-
formatorklemme (900, 2100) auf Grundlage ei-
ner ersten Oberfläche eines Transformators;
Bilden (2603) eines gekrümmten Abschnitts
(904, 2110) in der ersten Platte (902, 2104,
2108) zwischen einem ersten Endabschnitt
(914, 2120) und einem zweiten Endabschnitt
(916, 2122) der ersten Platte (902, 2104, 2108)
auf Grundlage der bestimmten Krümmung (910,
2110); und
Krümmen (2605) einer zweiten Platte (906,
2112) entlang der ersten Platte (902, 2104,
2108), um eine gekrümmte Kontaktfläche (908,
2116) zu bilden, die eine auf der Krümmung
(910, 2110) des gekrümmten Abschnitts (904,
2110) basierende Krümmung aufweist, wobei
sich die gekrümmte Kontaktfläche (908, 2116)
so verformt, dass ein im Wesentlichen gleich-
mäßiger Druck auf die erste Oberfläche des mit
der gekrümmten Kontaktfläche (908, 2116) ge-
koppelten Transformators ausgeübt wird, wenn
eine Klemmkraft auf den ersten Endabschnitt
(914, 2120) und den zweiten Endabschnitt (916,
2122) der Transformatorklemme (900, 2100)
ausgeübt wird,
wobei das Krümmen der zweiten Platte (906,
2110) entlang der ersten Platte (902, 2104,
2108) ein Anbringen der zweiten Platte (906,
2110) senkrecht zu der ersten Platte (902, 2104,
2108) umfasst, indem die zweite Platte (906,
2112) mit dem gekrümmten Abschnitt der ersten
Platte (902, 2104, 2108) so verbunden wird, so
dass die zweite Platte (906, 2110) der Krüm-
mung (910, 2120) des gekrümmten Abschnitts
(904, 2110) folgt, und der zweiten Platte (906,
2112) eine Biegung verliehen wird, die die ge-
krümmte Kontaktfläche (908, 2116) der zweiten
Platte (906, 2112) bildet, die dafür konfiguriert
ist, auf die erste Oberfläche des Transformators
gedrückt zu werden.
8. Verfahren nach Anspruch 7, wobei sich die ge-
krümmte Kontaktfläche (908, 2116) zu einer im We-
sentlichen flachen Kontaktfläche umformt, wenn ei-
ne Klemmkraft auf den ersten Endabschnitt (914,
2120) und den zweiten Endabschnitt (916, 2122) der
Transformatorklemme (900, 2100) ausgeübt wird.
9. Verfahren nach einem der Ansprüche 7 und 8, wobei
das Bestimmen der Krümmung (910) für die erste
Platte (902, 2104, 2108) ein Bestimmen der Krüm-
mung auf Grundlage eines gewünschten Drucks, der
auf einen Transformatorkern des Transformators
ausgeübt werden soll, und/oder einer Abmessung
des Transformatorkerns umfasst.

Revendications

1. Une pince de transformateur (900, 2100) comprenant

une première plaque (902, 2104, 2108) comportant une partie incurvée (904, 2110) d'une courbure prédéterminée (910, 2120) entre une première partie d'extrémité (914, 930, 2120, 2122) et une seconde partie d'extrémité (916, 932) de la pince de transformateur ; et une seconde plaque (906, 2112) fixée à la première plaque (902, 2104, 2108) et incurvée en fonction de la courbure (910, 2120) de la partie incurvée (904, 2110), la courbure (910, 2120) permettant à la pince de transformateur (900, 2100) de répartir une pression sensiblement uniforme sur une première surface d'un transformateur accouplé à la pince de transformateur (900, 2100), la seconde plaque (906, 2112) étant fixée sensiblement perpendiculairement à la première plaque (902, 2104, 2108) en joignant la seconde plaque (906, 2112) à la partie incurvée de la première plaque (902, 2104, 2108) de sorte que la seconde plaque (906, 2110) suive la courbure (910, 2120) de la partie incurvée (904, 2110) et confère une courbure à la seconde plaque (906, 2112) qui forme une surface de contact incurvée (908) de la seconde plaque (906, 2112) conçue pour être pressée à travers la première surface du transformateur.

2. La pince de transformateur selon la revendication 1, la seconde plaque (906, 2112) changeant de forme pour être une surface de contact sensiblement plate en fonction d'une pression externe appliquée à la pince de transformateur (900, 2100).

3. La pince de transformateur selon l'une quelconque des revendications 1 et 2, la première plaque (902) comprenant une pluralité de trous de montage (912), au moins un trou de montage (912) étant formé approximativement à mi-chemin entre une partie d'extrémité (914, 916) de la première plaque (902) et une partie centrale (918) de la première plaque (902).

4. La pince de transformateur selon la revendication 3, comprenant en outre une languette de support (920) fixée à proximité de chaque trou de montage (912) de la première plaque (902), au moins l'une des languettes de support (902) ayant un trou de montage de languette de support (922) pour permettre le levage du transformateur.

5. La pince de transformateur selon l'une quelconque des revendications 1 à 4, la seconde plaque (906, 2112) comprenant en outre des trous de montage

(928, 2128) à proximité de chaque partie d'extrémité (930, 932, 2120, 2122) de la seconde plaque (906, 2112) et conçus pour être reliés à une seconde pince de transformateur accouplée fonctionnellement à une seconde surface de noyau de transformateur.

6. Un ensemble de la pince de transformateur selon la revendication 5 et d'une seconde pince de transformateur, la seconde pince de transformateur comprenant une pince de transformateur (900) selon l'une quelconque des revendications 1 à 5.

7. Un procédé pour créer d'une pince de transformateur (900, 2100), le procédé comprenant les étapes consistant à :

déterminer (2601), sur la base d'une première surface d'un transformateur, une courbure (910, 2110) pour une première plaque (902, 2104, 2108) de la pince de transformateur (900, 2100) ;

former (2603) une partie incurvée (904, 2110) dans la première plaque (902, 2104, 2108) entre une première partie d'extrémité (914, 2120) et une seconde partie d'extrémité (916, 2122) de la première plaque (902, 2104, 2108) sur la base de la courbure (910, 2110) déterminée ; et courber (2605) une seconde plaque (906, 2112) le long de la première plaque (902, 2104, 2108) pour former une surface de contact incurvée (908, 2116) ayant une courbure basée sur la courbure (910, 2110) de la partie incurvée (904, 2110), la surface de contact incurvée (908, 2116) changeant de forme pour appliquer une pression sensiblement uniforme à travers la première surface du transformateur accouplée à la surface de contact incurvée (908, 2116) en réponse à une force de serrage appliquée à la première partie d'extrémité (914, 2120) et à la seconde partie d'extrémité (916, 2122) de la pince à transformateur (900, 2100),

la courbure de la seconde plaque (906, 2110) le long de la première plaque (902, 2104, 2108) comprenant l'étape consistant à fixer la seconde plaque (906, 2110) perpendiculairement à la première plaque (902, 2104, 2108) en joignant la seconde plaque (906, 2112) à la partie incurvée de la première plaque (902, 2104, 2108) de sorte que la seconde plaque (906, 2110) suive la courbure (910, 2120) de la partie incurvée (904, 2110) et confère une courbure à la seconde plaque (906, 2112) qui forme la surface de contact incurvée (908, 2116) de la seconde plaque (906, 2112) conçue pour être pressée à travers la première surface du transformateur.

8. Le procédé selon la revendication 7, la surface de contact incurvée (908, 2116) changeant de forme

pour être une surface de contact sensiblement plate en réponse à une force de serrage appliquée à la première partie d'extrémité (914, 2120) et à la seconde partie d'extrémité (916, 2122) de la pince de transformateur (900, 2100).

5

9. Le procédé selon l'une quelconque des revendications 7 et 8, la détermination de la courbure (910) pour la première plaque (902, 2104, 2108) comprenant l'étape consistant à déterminer la courbure sur la base au moins d'une pression souhaitée à appliquer à un noyau de transformateur du transformateur et d'une dimension du noyau de transformateur.

10

15

20

25

30

35

40

45

50

55

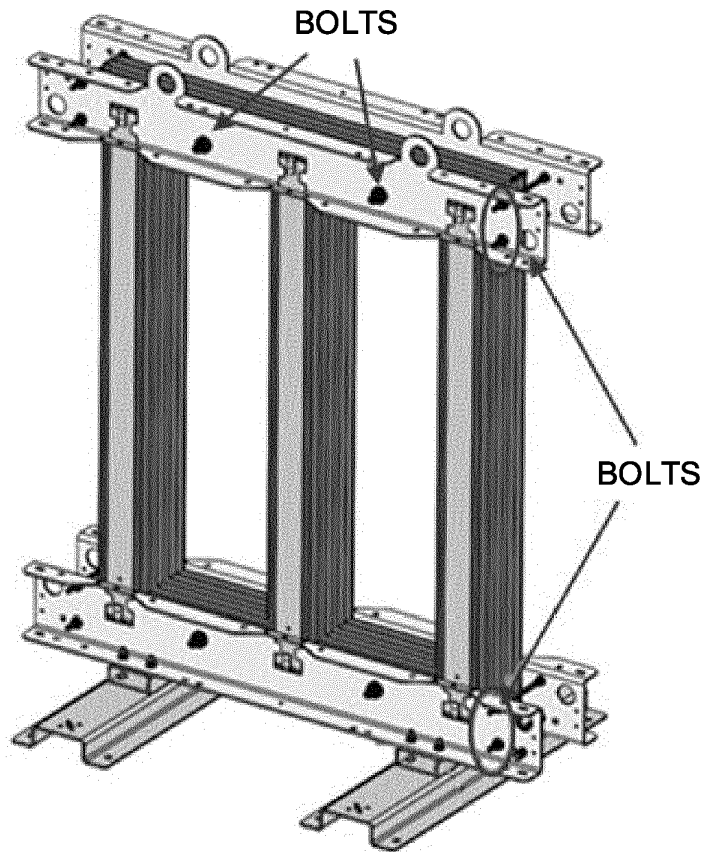


Figure 1

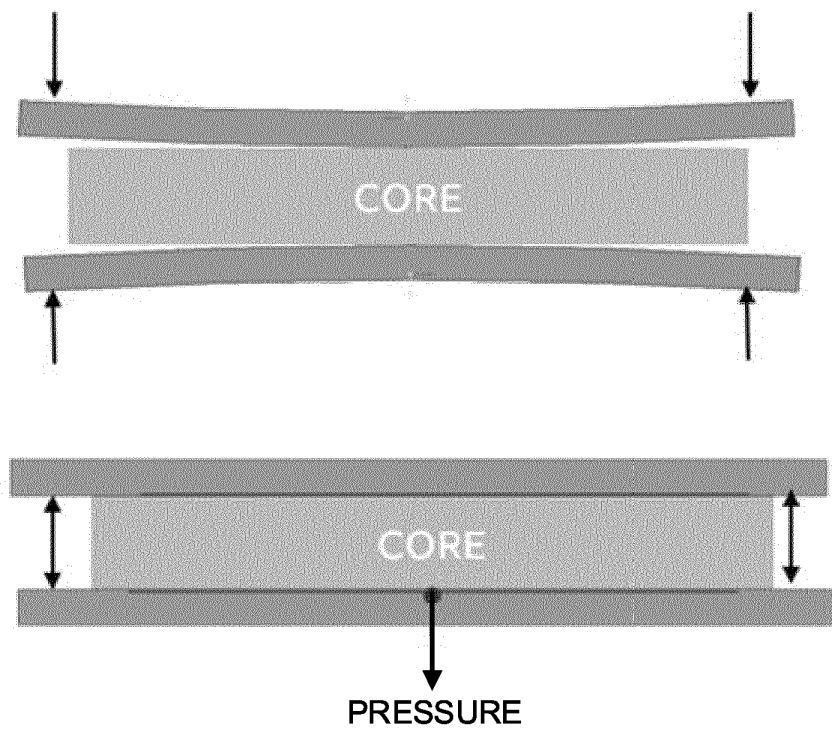


Figure 2

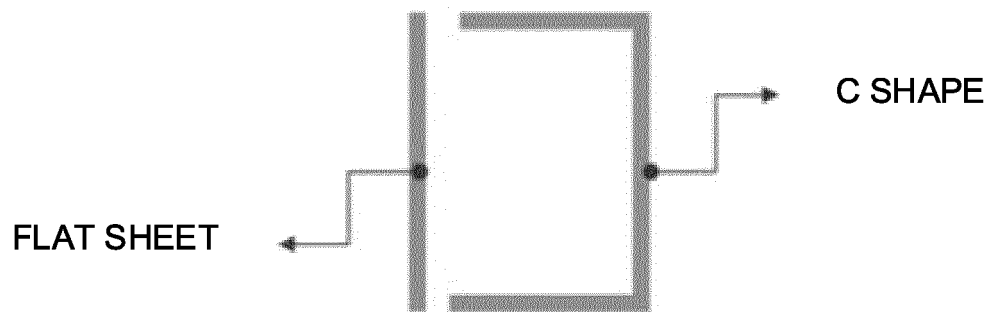


Figure 3

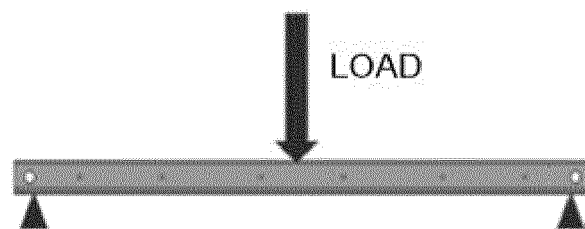


Figure 4A

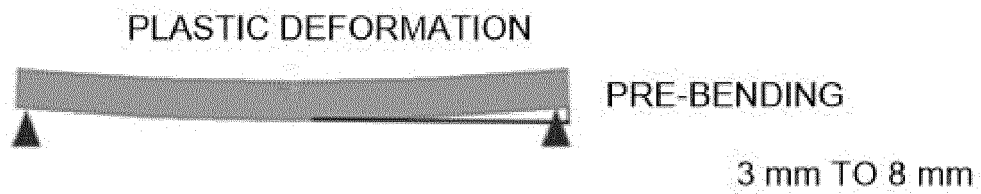


Figure 4B

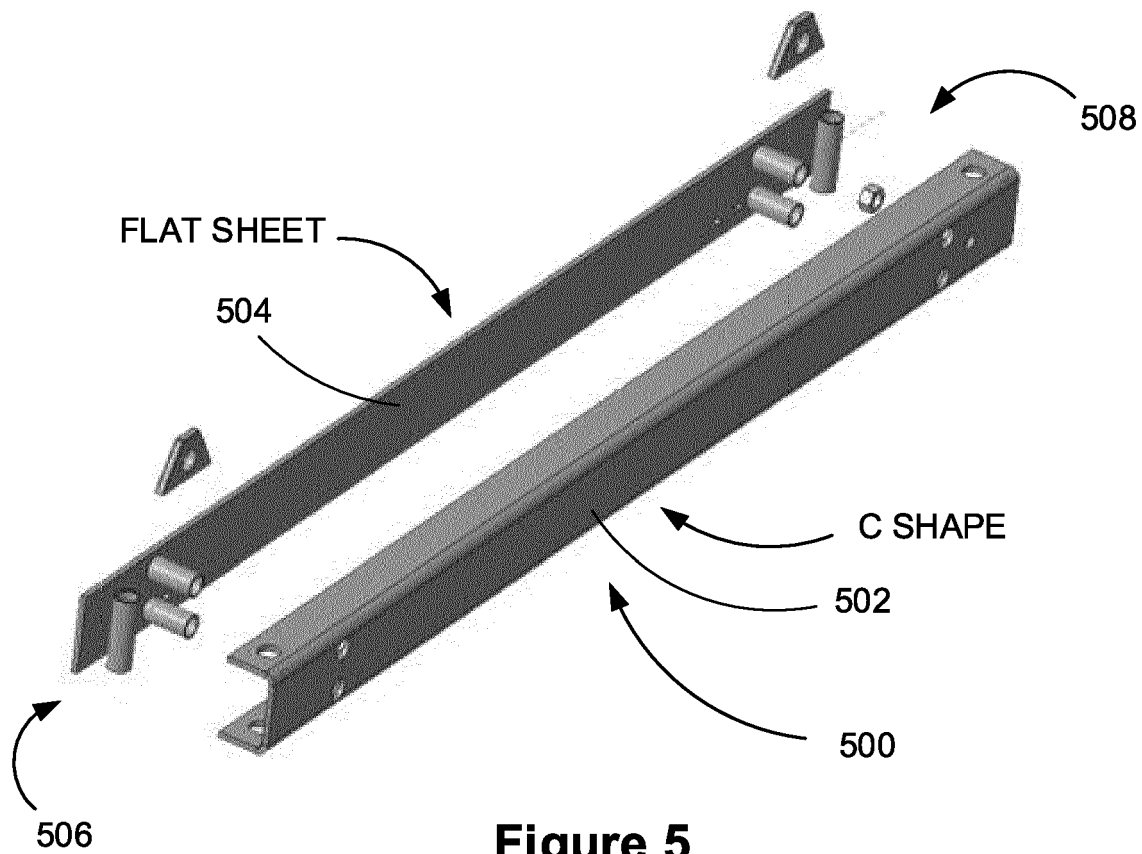


Figure 5

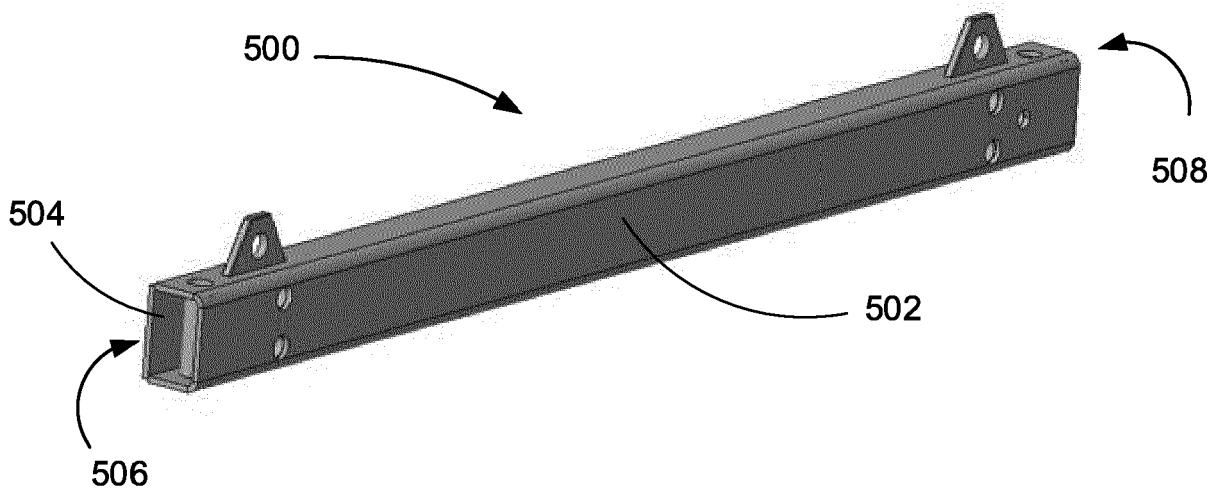


Figure 6

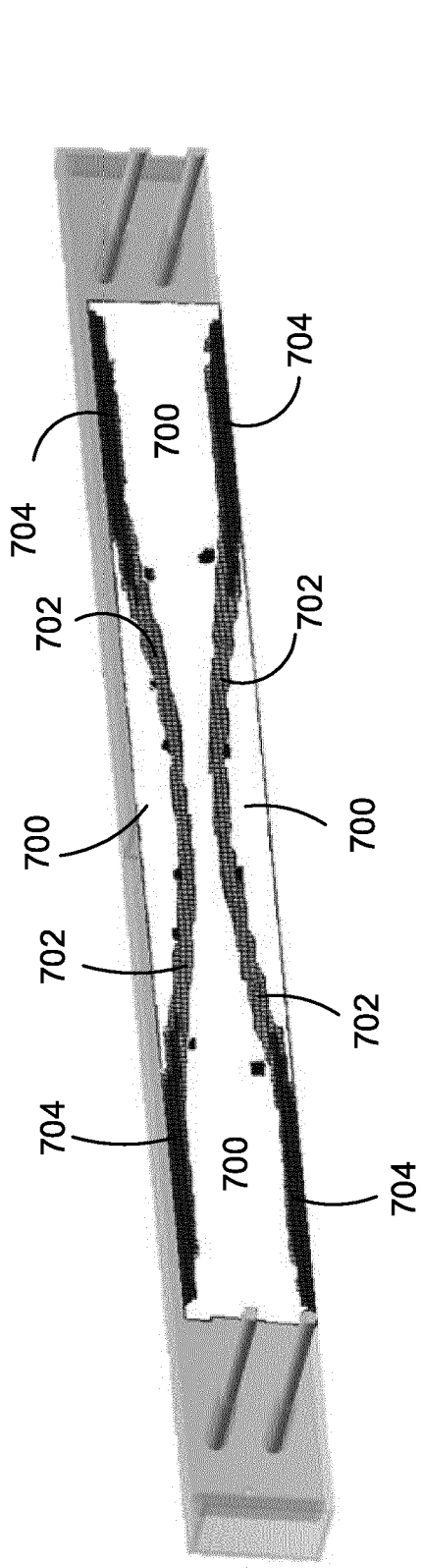


Figure 7

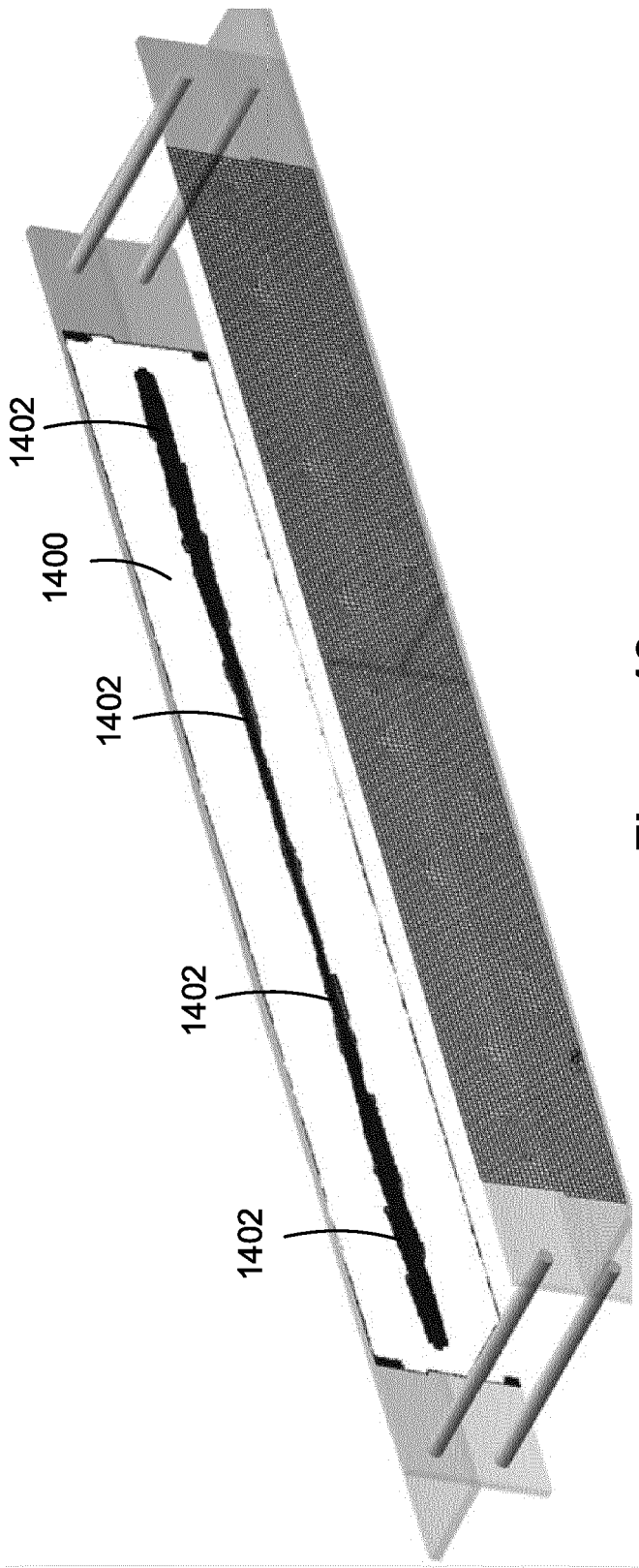


Figure 18

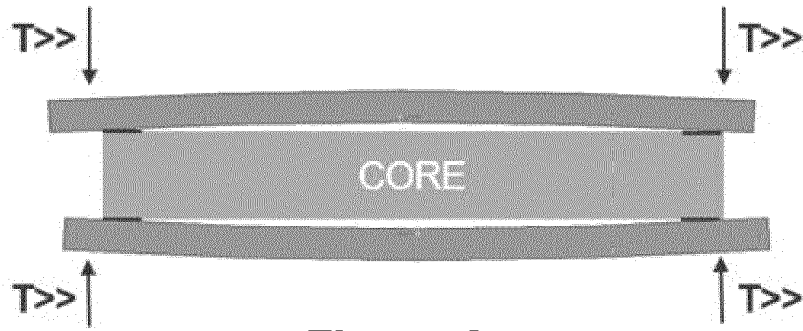


Figure 8

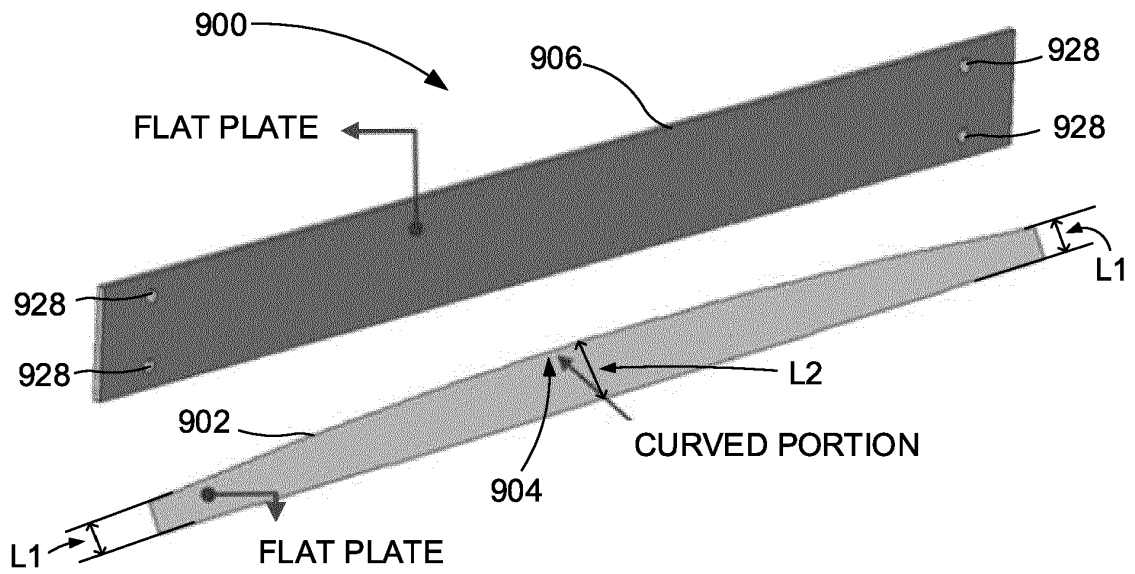


Figure 9

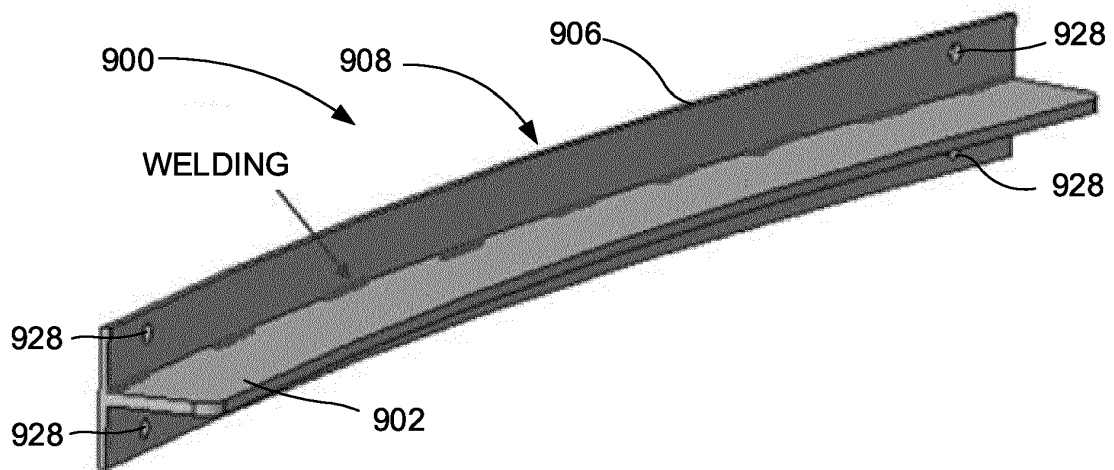


Figure 10

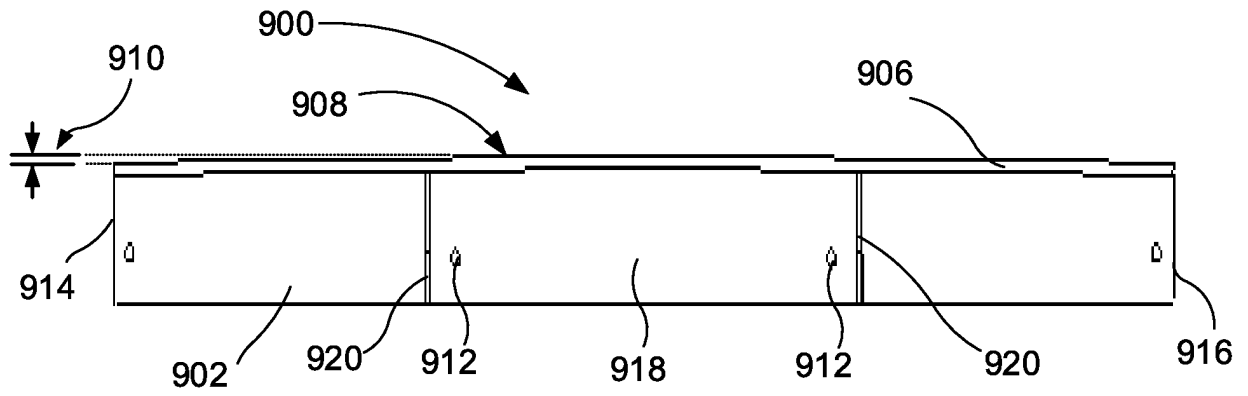


Figure 11

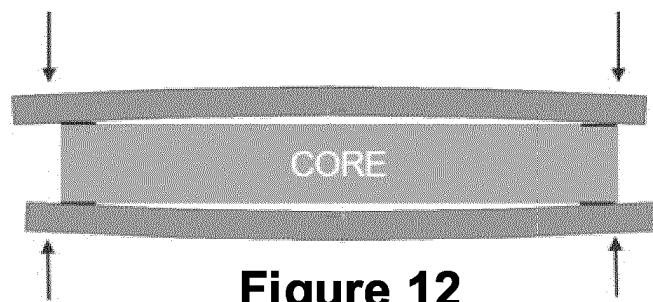


Figure 12

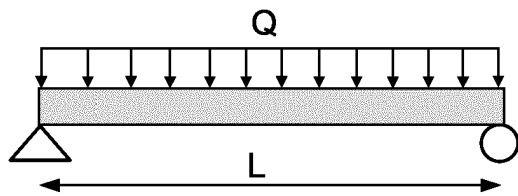


Figure 13

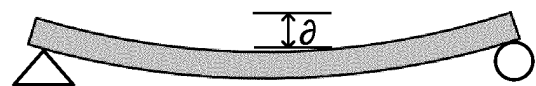


Figure 14



Figure 15

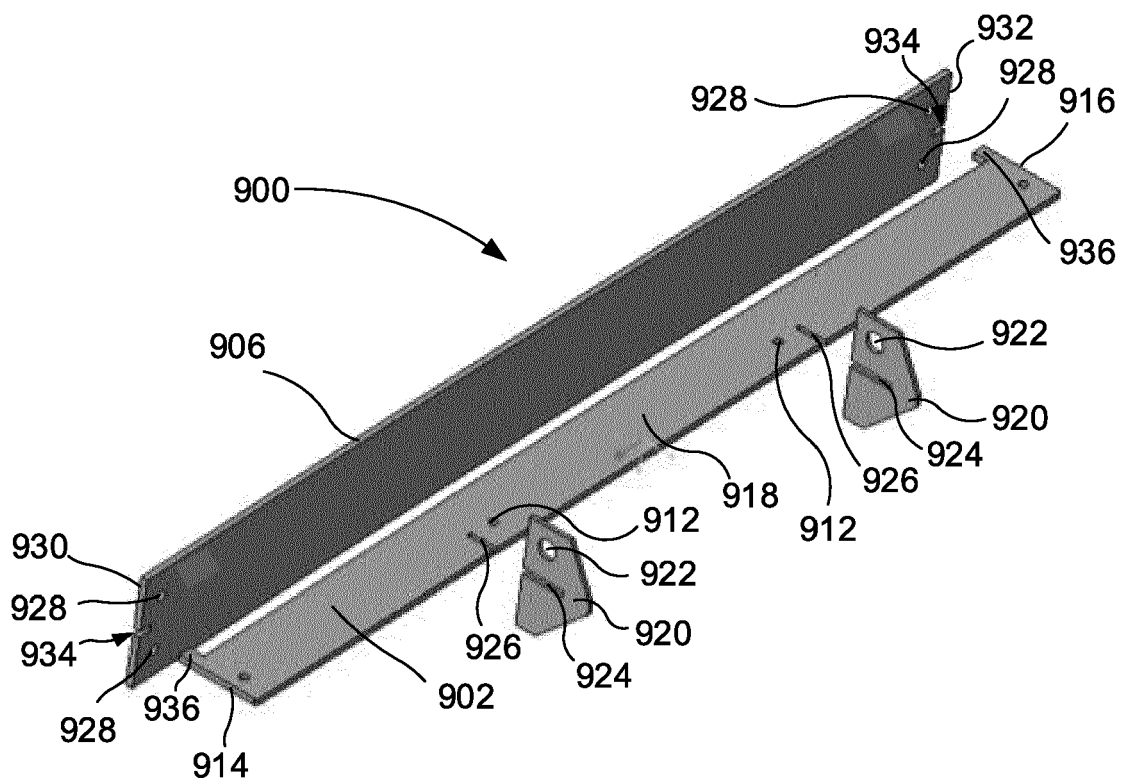


Figure 16

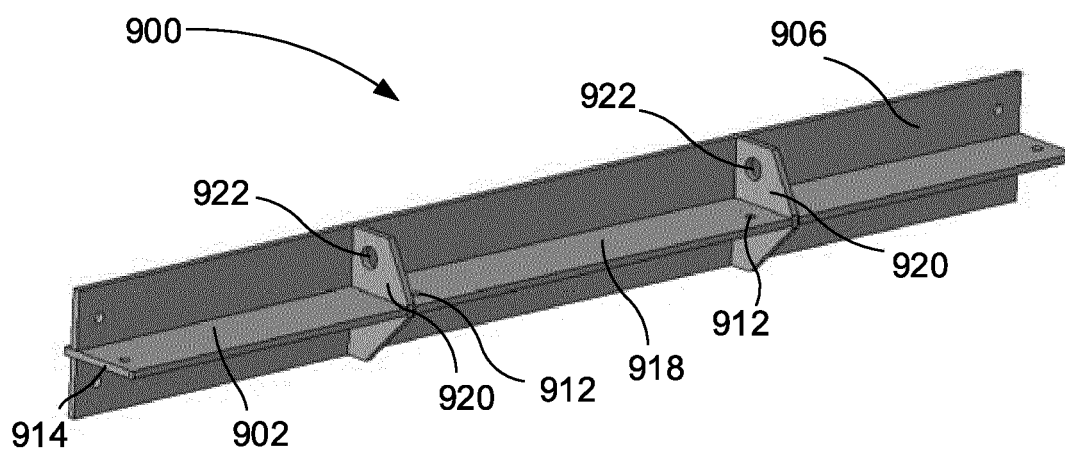


Figure 17

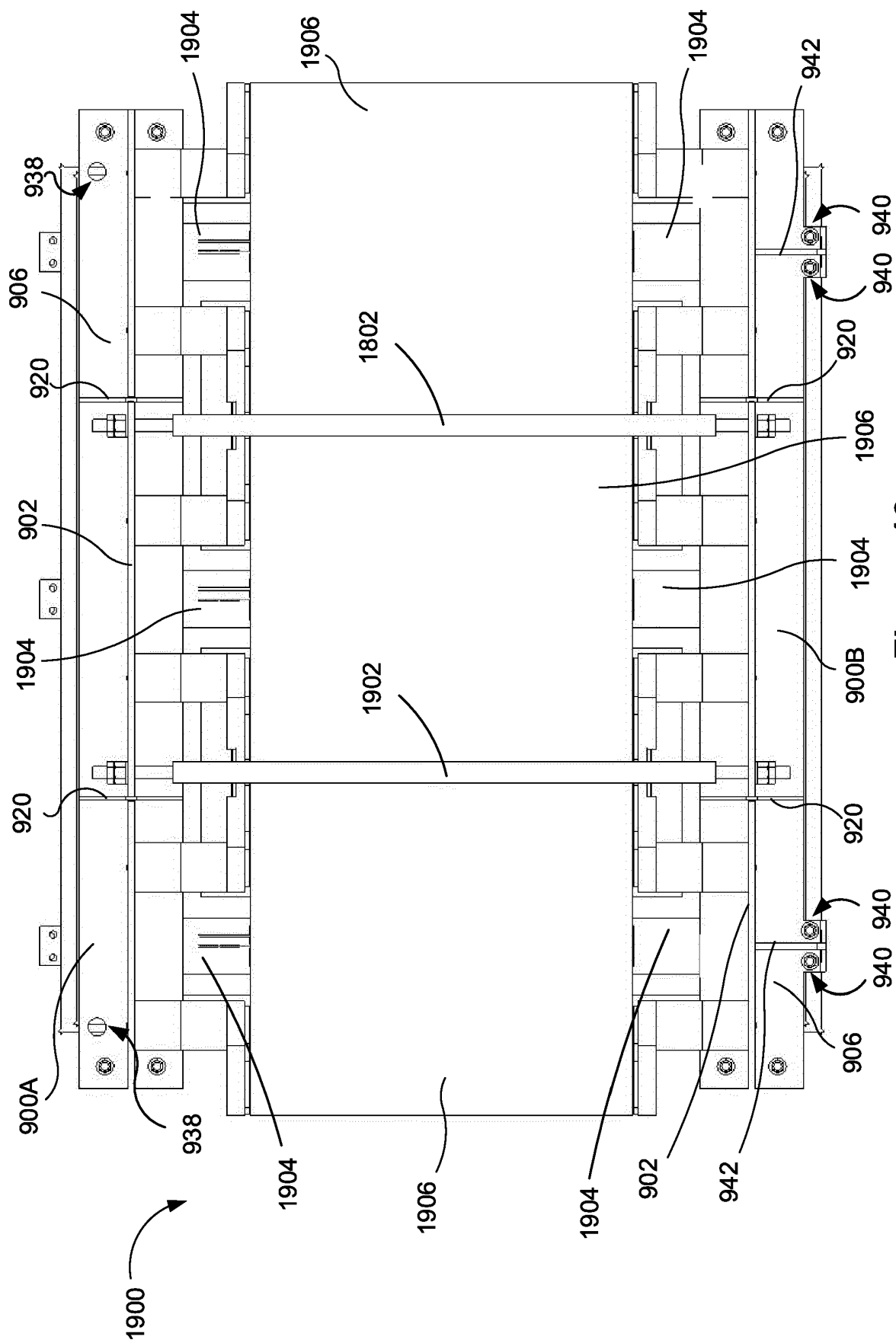


Figure 19

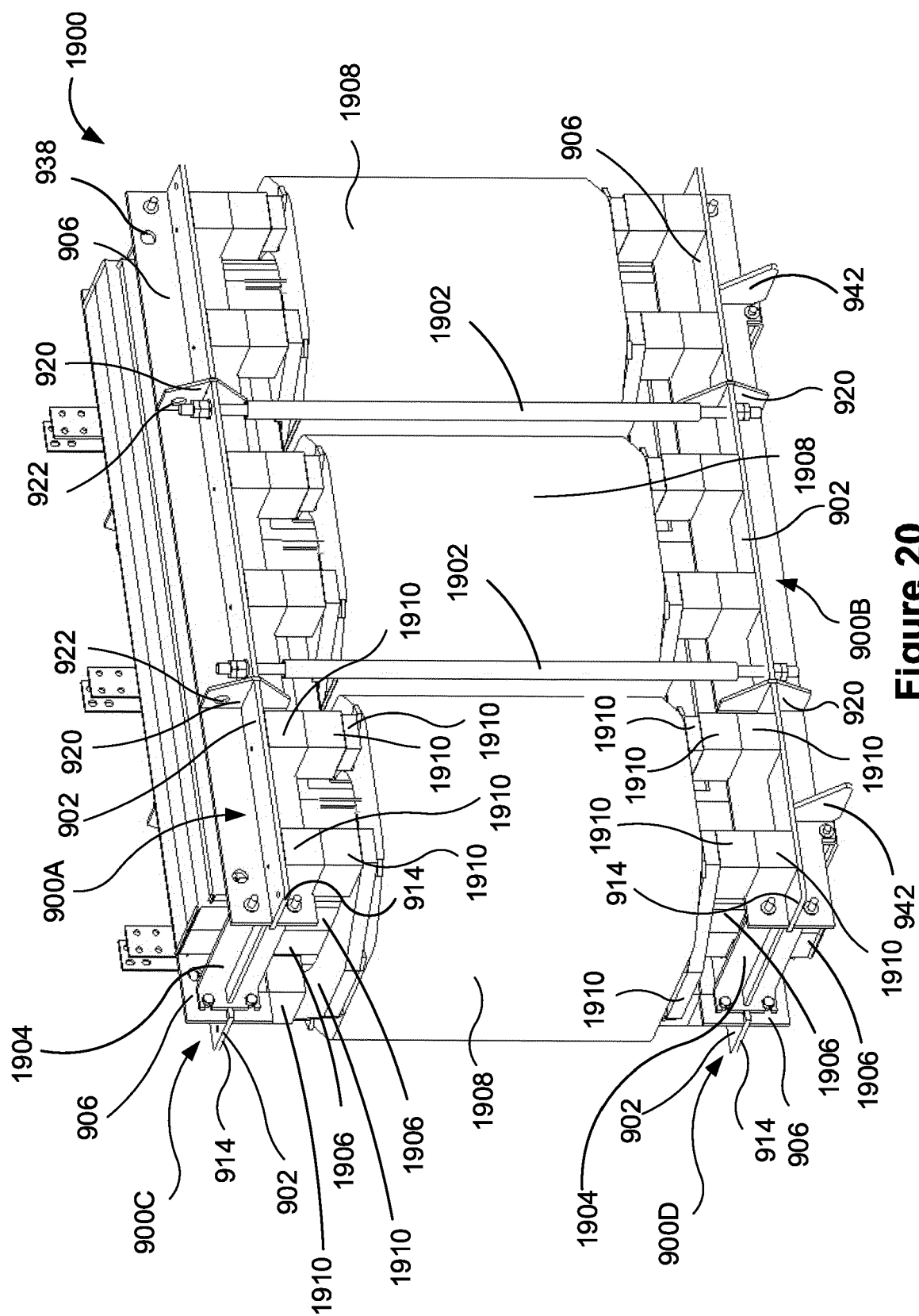


Figure 20

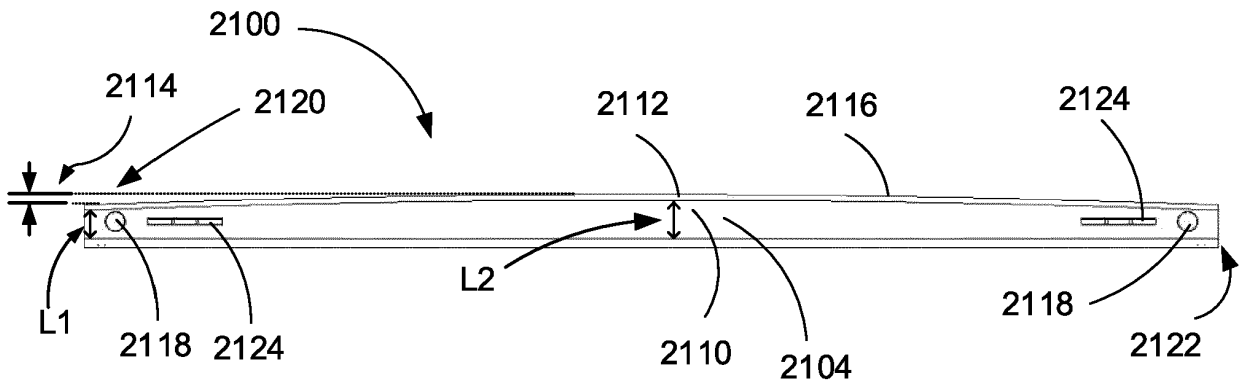


Figure 21

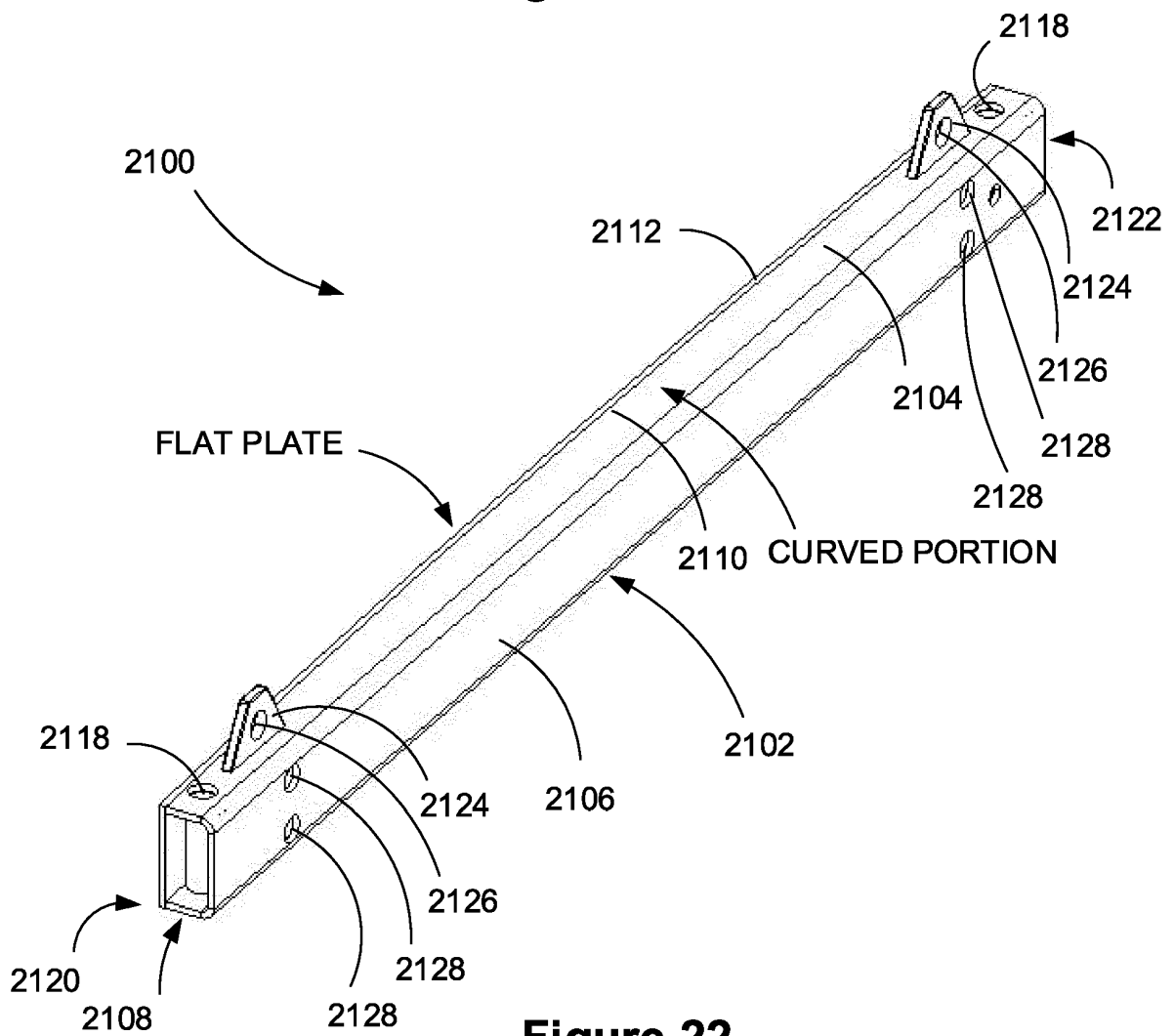


Figure 22

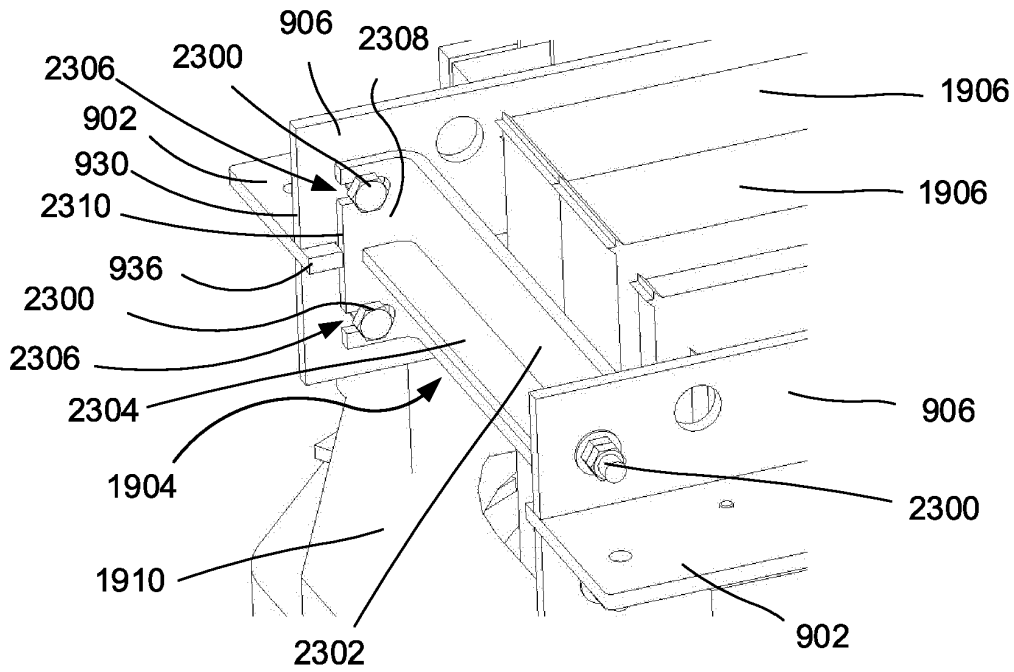


Figure 23

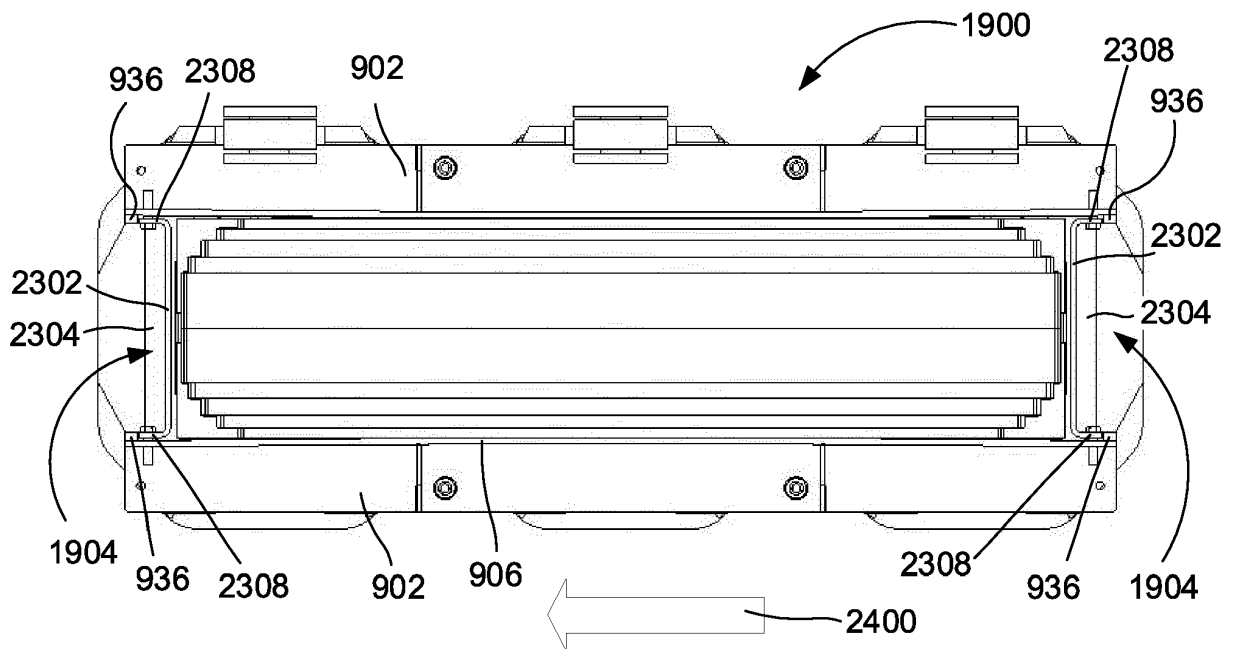


Figure 24

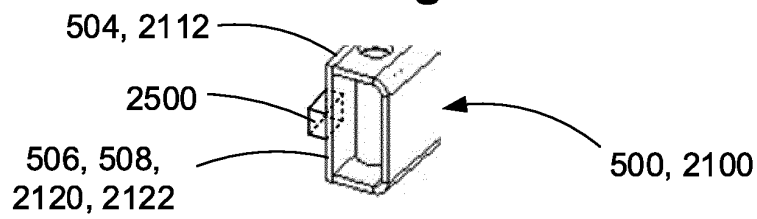


Figure 25

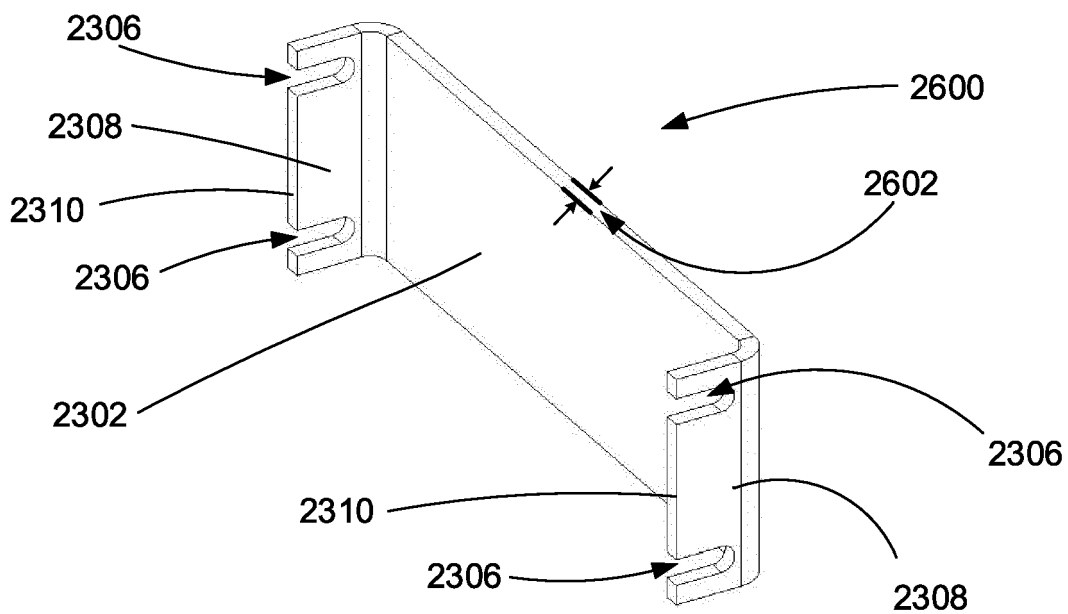


Figure 26

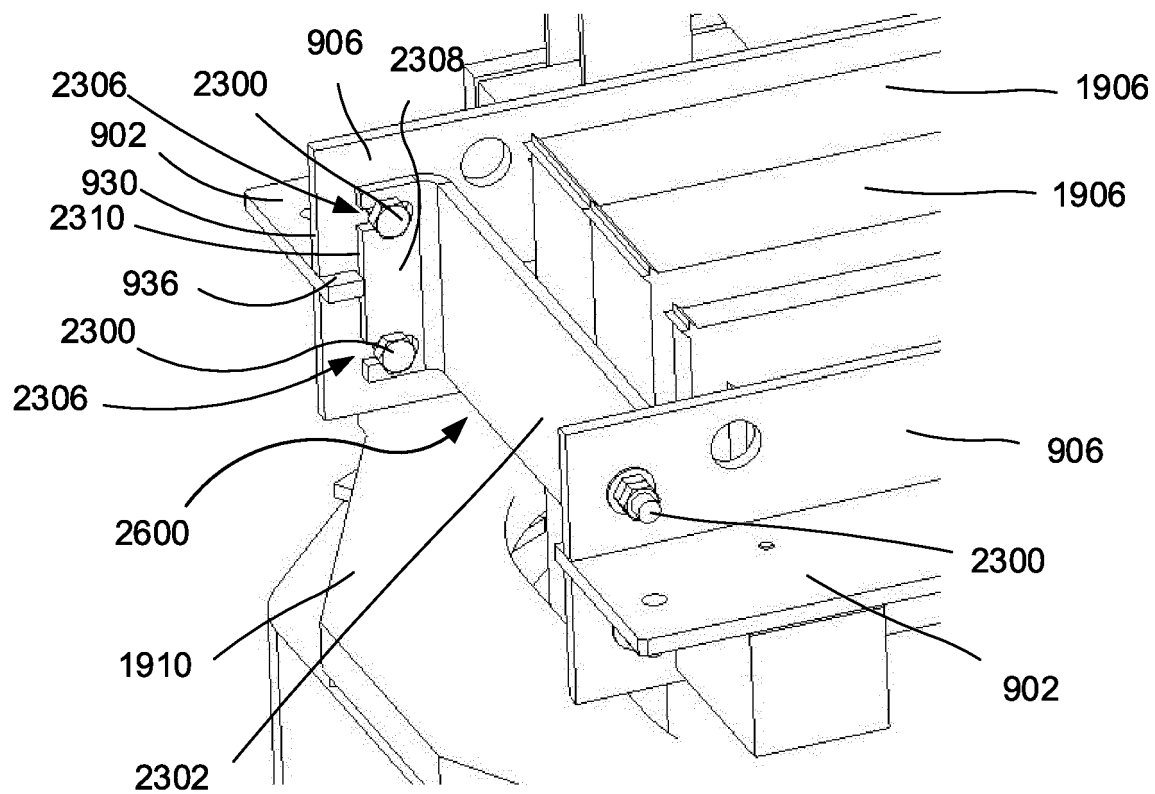


Figure 27

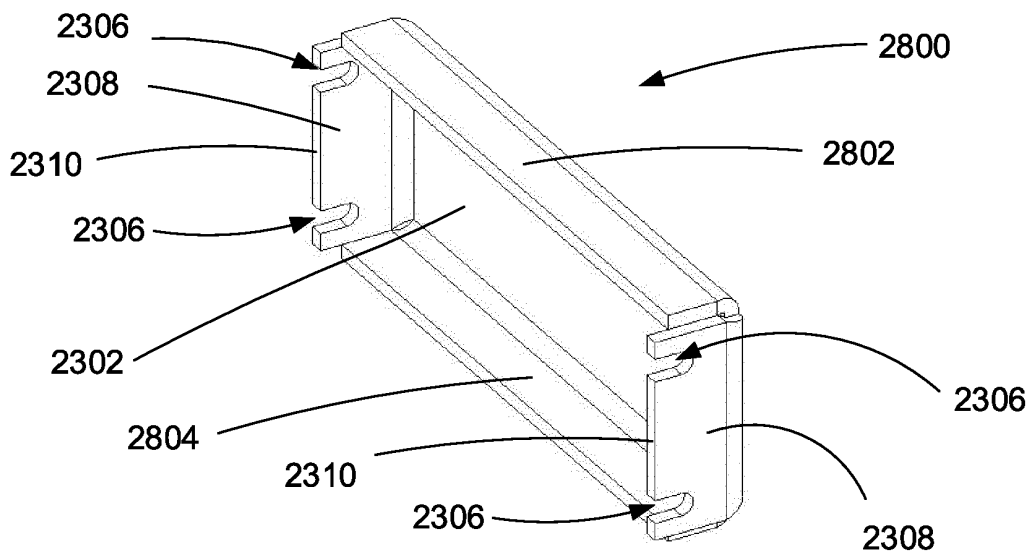


Figure 28

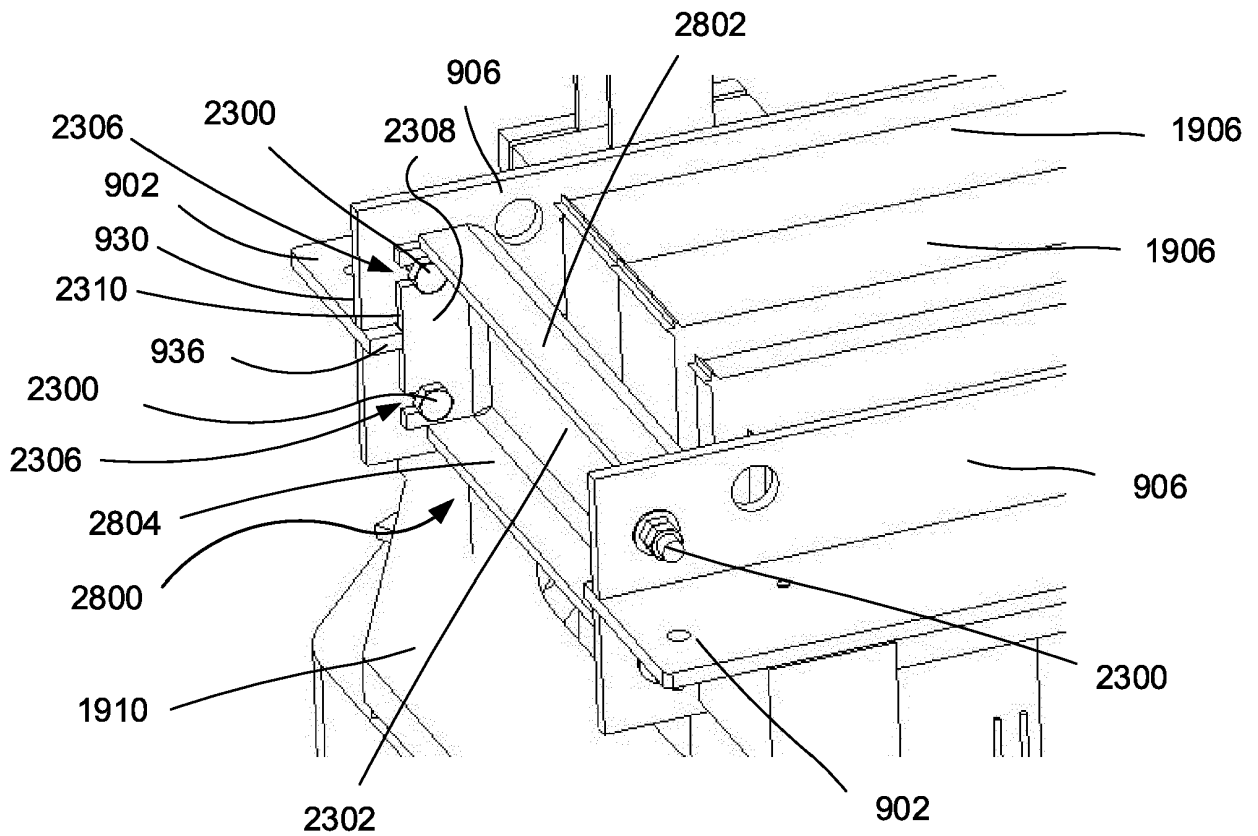


Figure 29

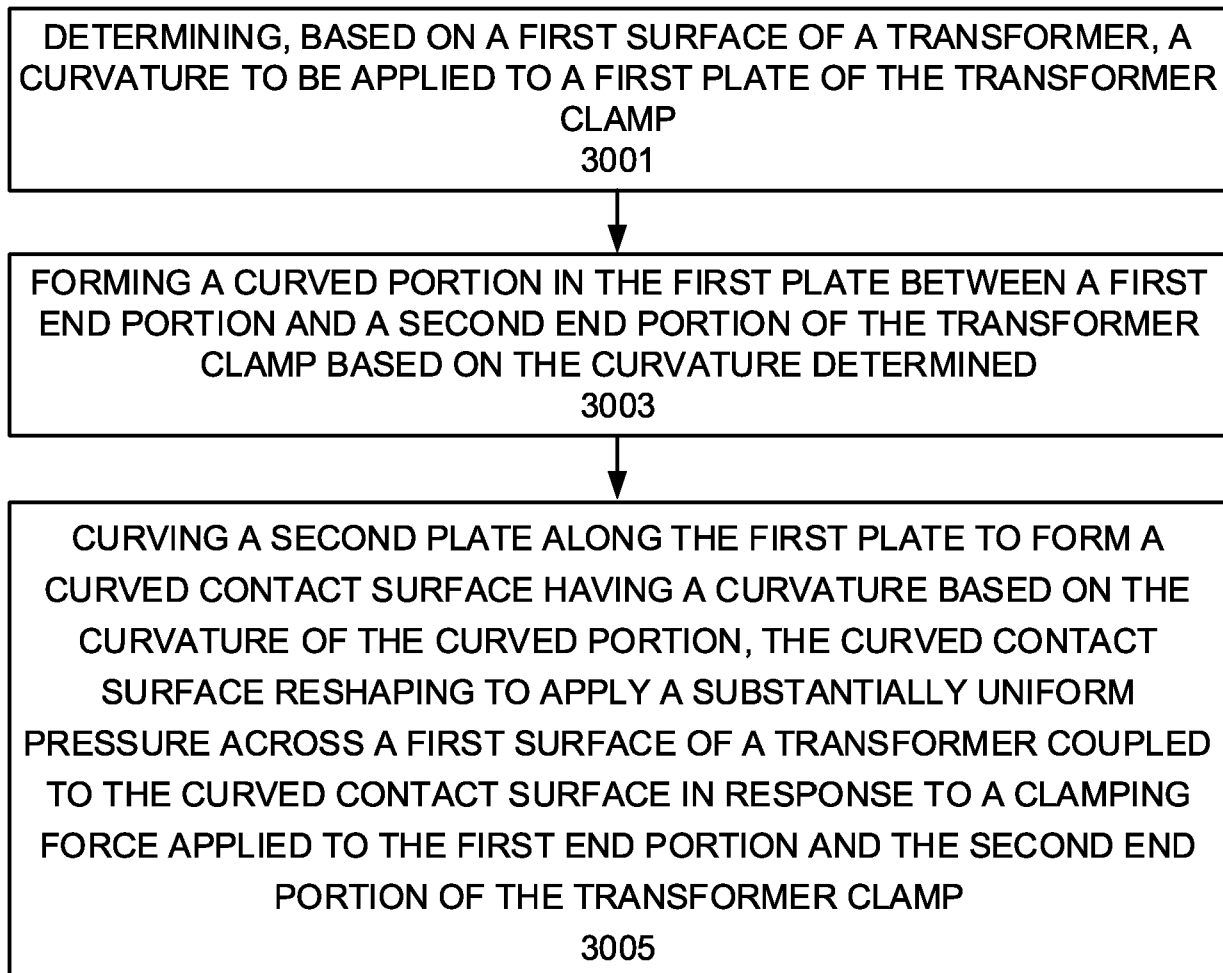


Figure 30

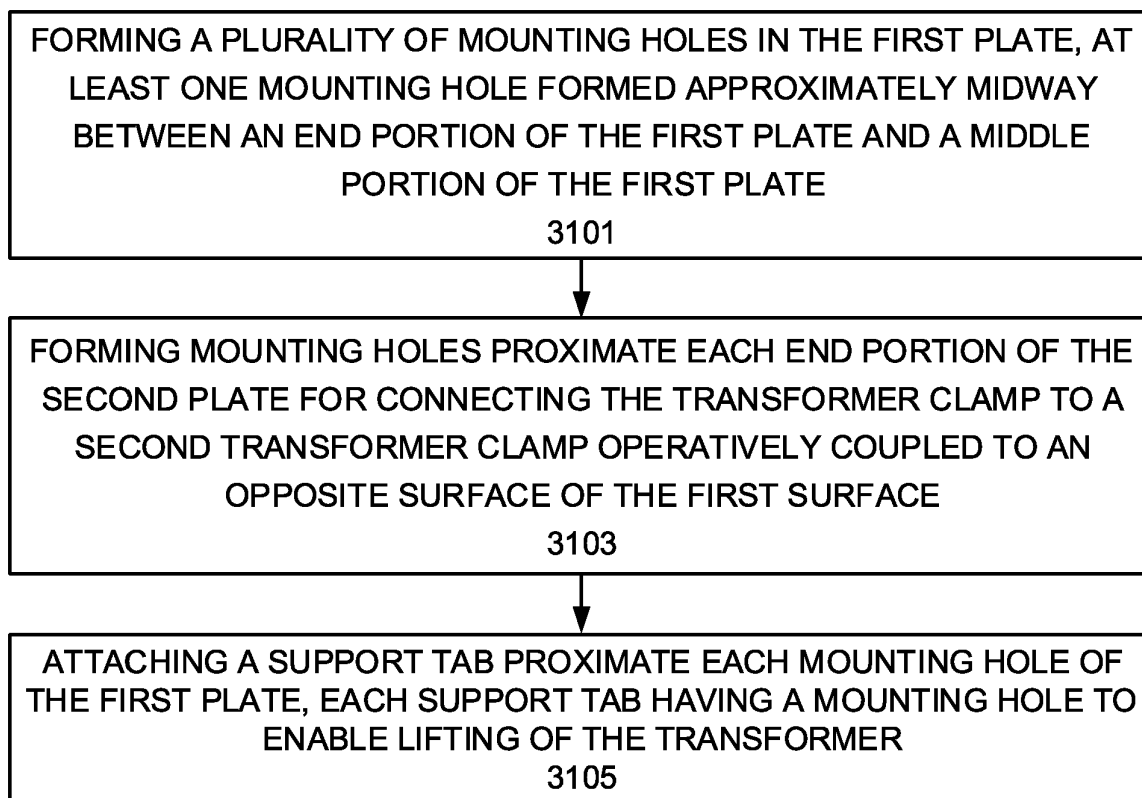


Figure 31

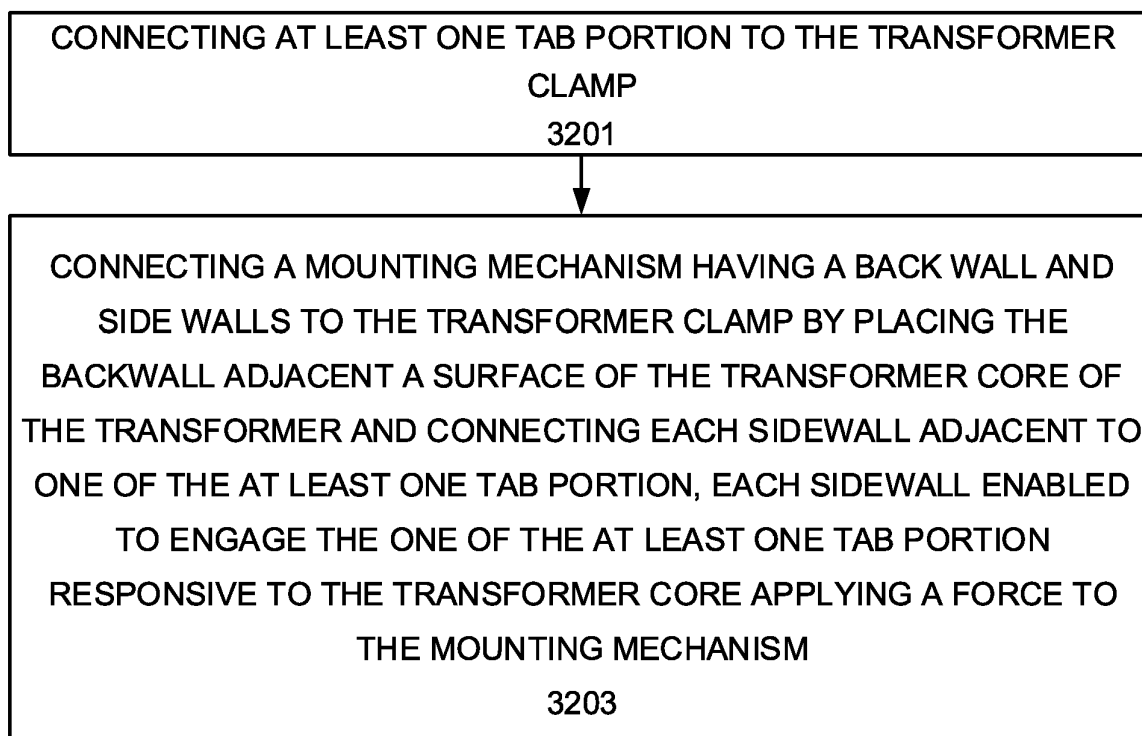


Figure 32

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 2017018354 A1 [0007]
- CH 387782 A [0008]
- JP S5398916 U [0009]