



(12) **EUROPEAN PATENT APPLICATION**

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

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

(21) Application number: **20212886.4**

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

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

(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
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

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

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Remarks:

Amended claims in accordance with Rule 137(2) EPC.

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

(57) A transformer clamp (900) is provided that includes a first plate (902) having a curved portion (904) of a predetermined curvature between a first end portion and a second end portion of the clamp. The clamp includes a second plate (906) attached to the first plate and curved based on the curvature of the curved portion, wherein the curvature enables the clamp to distribute a substantially uniform pressure across a first surface of a transformer coupled to the clamp. The clamp may have

a mounting mechanism. A method includes determining a curvature for a first plate and forming a curved portion in the plate based on the curvature. The method includes curving a second plate along the curved portion to form a curved contact surface having a curvature based on the curvature and the curved contact surface reshaping to apply a substantially uniform pressure across a surface of a transformer coupled to the clamp.

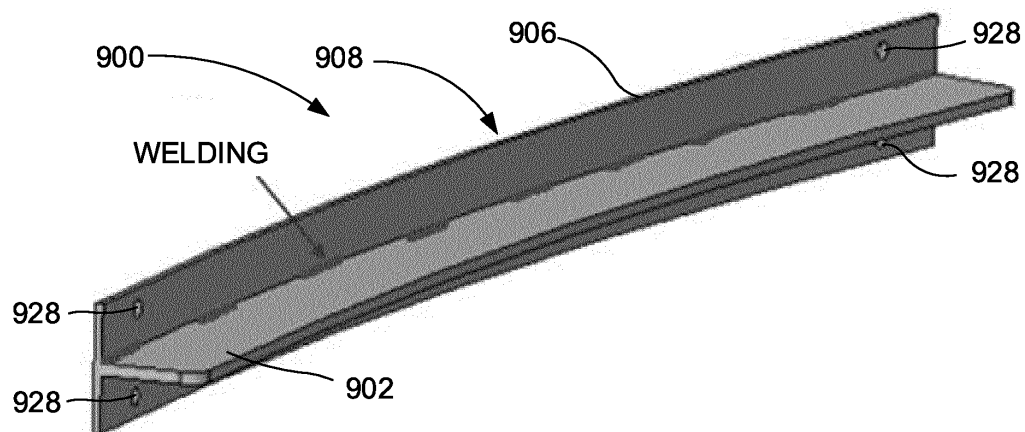


Figure 10

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.

SUMMARY

[0007] According to some embodiments of inventive concepts, a transformer clamp is provided 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.

[0008] Advantages that can be achieved with these inventive concepts 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.

[0009] According to other embodiments of inventive concepts a method is provided 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.

[0010] According to further embodiments of inventive concepts, a transformer clamp for a transformer is provided that includes a plate connected to at least one tab portion proximate an end portion of the plate. The transformer clamp includes a mounting mechanism connected to the plate, the mounting mechanism having a back wall adjacent a surface of a transformer core of the transformer and having sidewalls, each sidewall adjacent to one of the at least one tab portion and 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.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] 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 inventive concepts. 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 inventive concepts;

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

Figure 11 is a top view of a transformer clamp according to some embodiments of inventive concepts;

Figure 12 is an illustration of an example of a transformer clamp bend according to some embodiments;

Figure 13 is an illustration of a distributed load across a transformer clamp according to some embodiments of inventive concepts;

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 inventive concepts;

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

Figure 17 is an illustration of the transformer clamp components of Figure 11 when assembled according to some embodiments of inventive concepts;

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 inventive concepts;

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

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 inventive concepts;

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 of inventive concepts;

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

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 of inventive concepts;

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

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

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

Figures 30 and 31 are flow charts illustrating operations of creating a transformer clamp according to some embodiments of inventive concepts; 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 of inventive concepts.

DETAILED DESCRIPTION

[0012] Inventive concepts will now be described more fully hereinafter with reference to the accompanying drawings, in which examples of embodiments of inventive concepts are shown. Inventive concepts may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will convey the scope of present inventive concepts 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.

[0013] 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.

[0014] Figure 9 is an illustration of plates 902, 906 of a transformer clamp 900 according to some embodiments of inventive concepts. 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 these inventive concepts, 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 inventive concepts 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.

[0015] 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.

[0016] In one embodiment of inventive concepts, 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.

[0017] 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 to-

wards the transformer core.

[0018] 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.

[0019] 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.

[0020] 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 inventive concepts, 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.

[0021] In some embodiments of inventive concepts, 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.

[0022] 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.

[0023] 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.

[0024] 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.

[0025] 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.

[0026] 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.

[0027] 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 inventive concepts, 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.

[0028] In some embodiments of inventive concepts, 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).

[0029] In various other embodiments of inventive concepts, 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.

[0030] Figures 21 and 22 illustrate a C-shape and plate transformer clamp 2100 according to various embodiments of inventive concepts. 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 inventive concepts is on the order of 0.15 MPa.

[0031] 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.

[0032] 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 inventive concepts, 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.

[0033] 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.

[0034] 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 of inventive concepts 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.

[0035] 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.

[0036] 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.

[0037] 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.

[0038] 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.

[0039] Figure 26 illustrates another embodiment of the mounting mechanism according to various embodiments of inventive concepts. 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.

[0040] Figure 28 illustrates a further embodiment of the mounting mechanism according to various embodiments of inventive concepts. 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.

[0041] Figure 30 illustrates a process of creating the transformer clamp 900, 2100 in an embodiment of inventive concepts. 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.

[0042] 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.

[0043] 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.

[0044] 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.

[0045] 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.

[0046] In block 3105, a support tab is attached proximate each mounting hole of the first plate. In some embodiments of inventive concepts, each support tab has a mounting hole to enable lifting of the transformer. In other embodiments of inventive concepts, 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.

[0047] 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.

[0048] 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 of inventive concepts, 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.

[0049] 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.

[0050] 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).

[0051] In various embodiments of inventive concepts, 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.

[0052] 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.

[0053] 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.

[0054] 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 following description.

[0055] 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.

[0056] 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.

[0057] 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 inventive concepts.

[0058] Many variations and modifications can be made to the embodiments without substantially departing from the principles of the present inventive concepts. All such variations and modifications are intended to be included herein within the scope of present inventive concepts. 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, which fall within the spirit and scope of present inventive concepts. Thus, to the maximum extent allowed by law, the scope of present inventive concepts are to be determined by the broadest permissible interpretation of the present disclosure including the examples of embodiments and their equivalents, and shall not be restricted or limited by the foregoing detailed description.

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).

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). 5
3. The transformer clamp of and of Claims 1-2 wherein the second plate (906, 2112) is attached substantially perpendicular to the first plate (902, 2104, 2108). 10
4. The transformer clamp of any of Claims 1-3, 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). 15 20
5. The transformer clamp of Claim 4, 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. 25
6. The transformer clamp of any of Claims 1-5 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. 30 35
7. The transformer clamp of Claim 6 wherein the second transformer clamp comprises a transformer clamp (900) comprising the first plate (902, 2104, 2108) and the second plate (906, 2112). 40
8. The transformer clamp of any of Claims 1-7, further comprising at least one tab portion (936, 2500) proximate an end portion (930, 932, 2120, 2122) of the second plate (906, 2112). 45
9. The transformer clamp of any of Claims 1-8, further comprising a mounting mechanism (1904, 2600, 2800) connected to the second plate (906, 2112), the mounting mechanism (1904, 2600, 2800) having a back wall (2302) adjacent a surface of a transformer core of the transformer and having sidewalls (2308), each sidewall (2308) adjacent to one of the at least one tab portion (936, 2500) and enabled to engage the one of the at least one tab portion (936, 2500) responsive to the transformer core applying a force to the mounting mechanism (1904, 2600, 2800) in response to another force applied to the trans- 50 55

former core.

10. 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).
11. The method of Claim 10 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).
12. The method of any of Claims 10-11 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).
13. The method of any of Claims 10-12 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.
14. A transformer clamp (500, 900, 2100) comprising:
 - a plate (504, 906, 2112) connected to at least one tab portion (936, 2500) proximate an end portion (506, 508, 930, 932, 2120, 2122) of the plate (504, 906, 2112); and
 - a mounting mechanism (1904, 2600, 2800) connected to the plate (504, 906, 2112), the mounting mechanism (1904, 2600, 2800) having a back wall (2302) adjacent a surface of a trans-

former core (1906) of the transformer and having sidewalls (2308), each sidewall (2308) adjacent to one of the at least one tab portion (936, 2500) and enabled to engage the one of the at least one tab portion (936, 2500) responsive to the transformer core applying a force to the mounting mechanism (1904, 2600, 2800) in response to another force applied to the transformer core.

15. The transformer clamp (500, 900, 2100) of Claim 14 wherein the mounting mechanism (1904) further comprises a plate (2304) attached to the back wall (2302) and adjacent each sidewall (2308).

Amended claims in accordance with Rule 137(2) EPC.

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).

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. The transformer clamp of Claim 5 wherein the second transformer clamp comprises a transformer clamp (900) comprising the first plate (902, 2104, 2108) and the second plate (906, 2112).
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).

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.

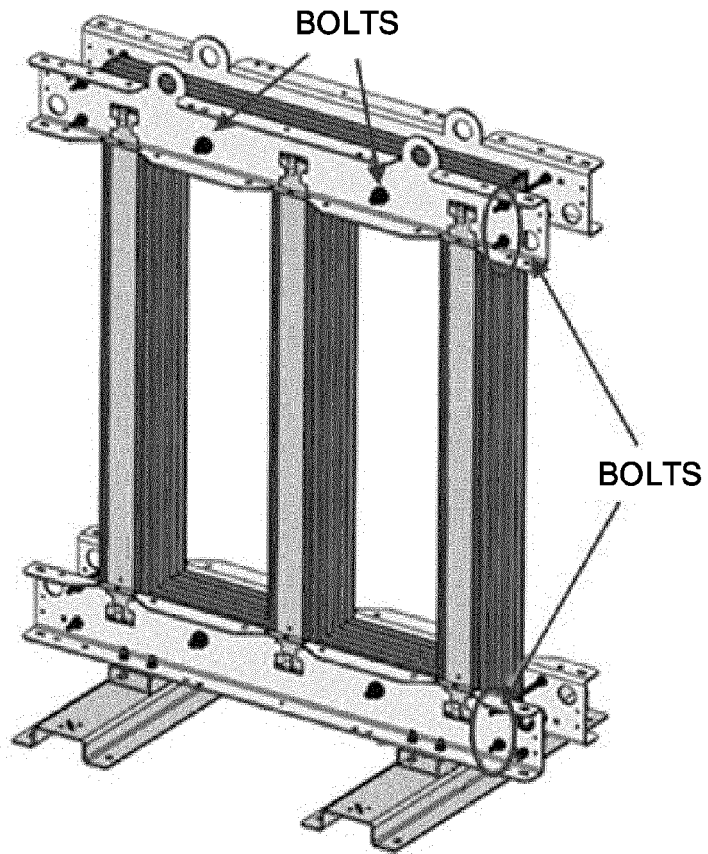


Figure 1

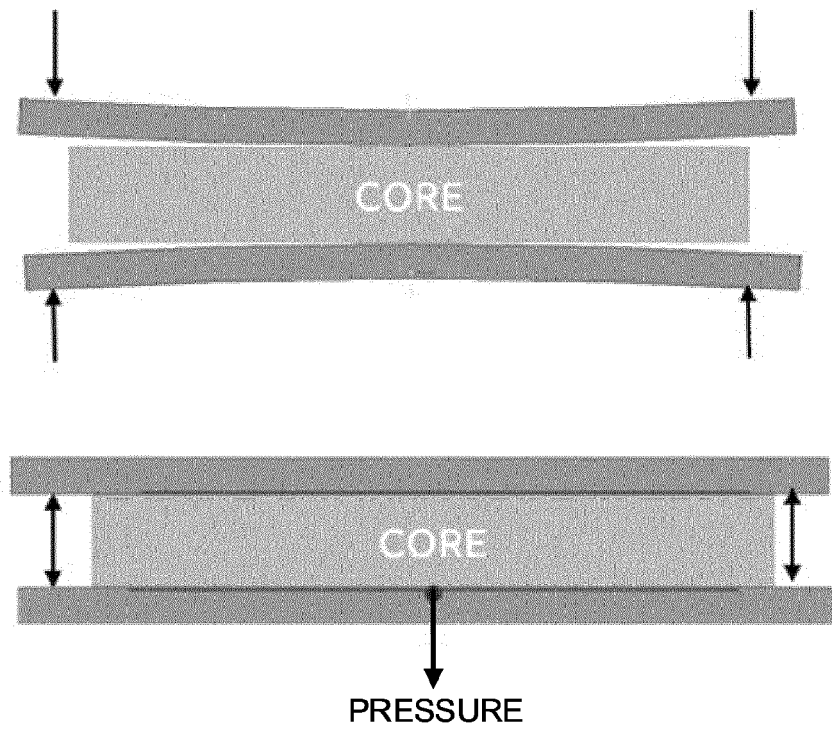


Figure 2

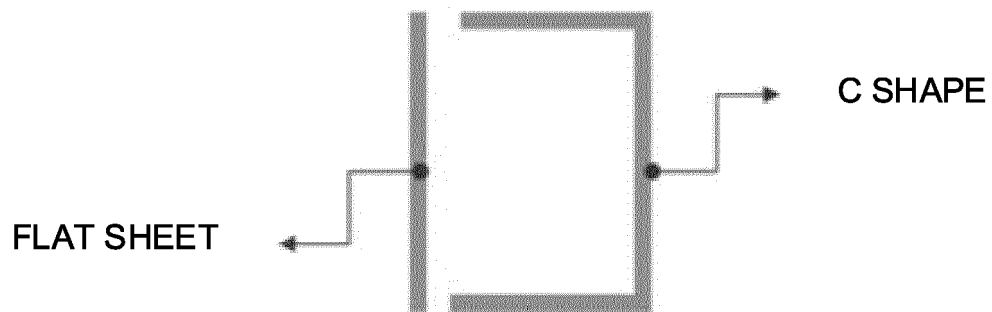


Figure 3

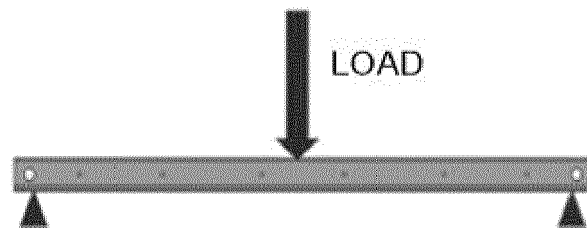


Figure 4A

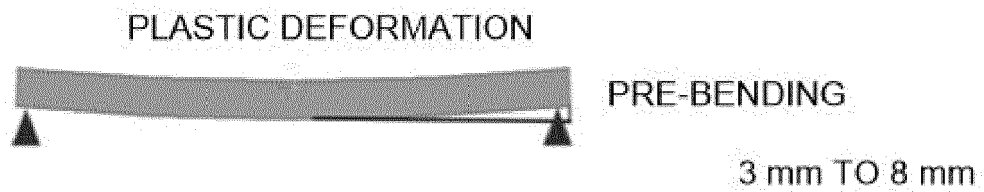


Figure 4B

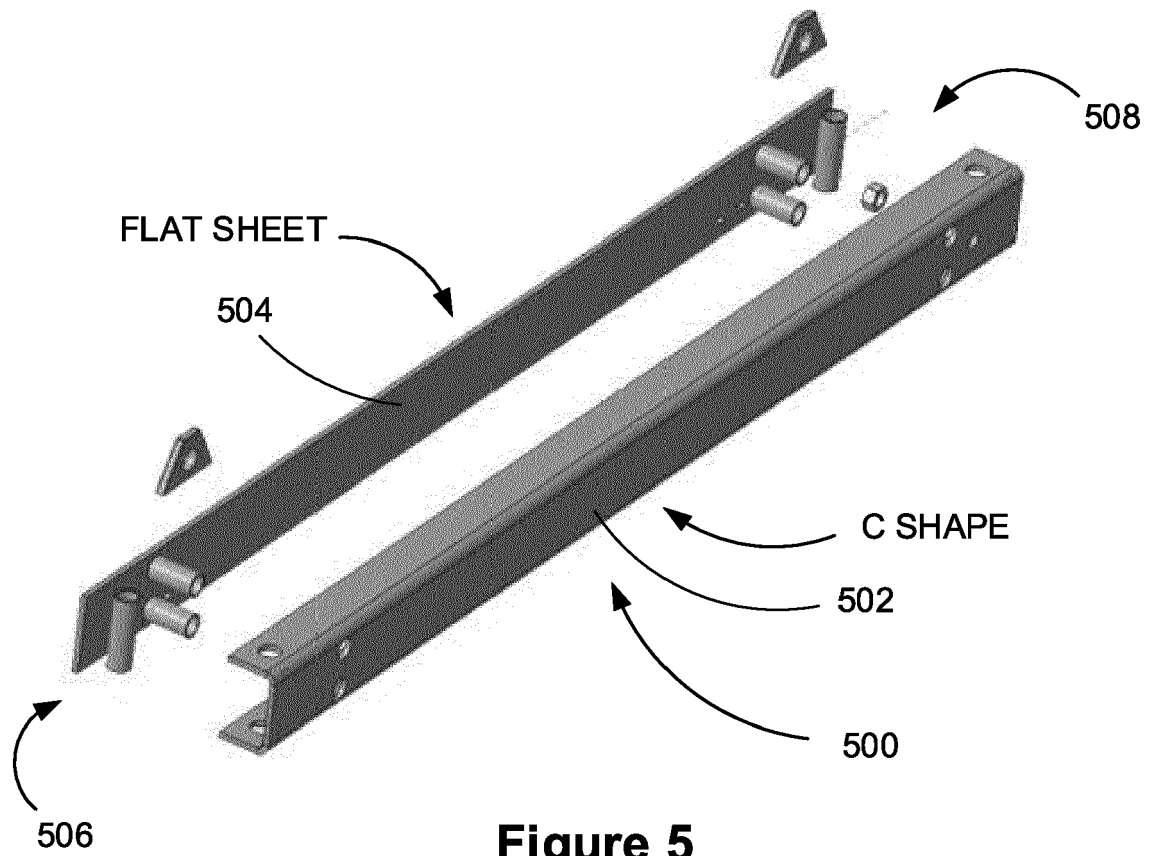


Figure 5

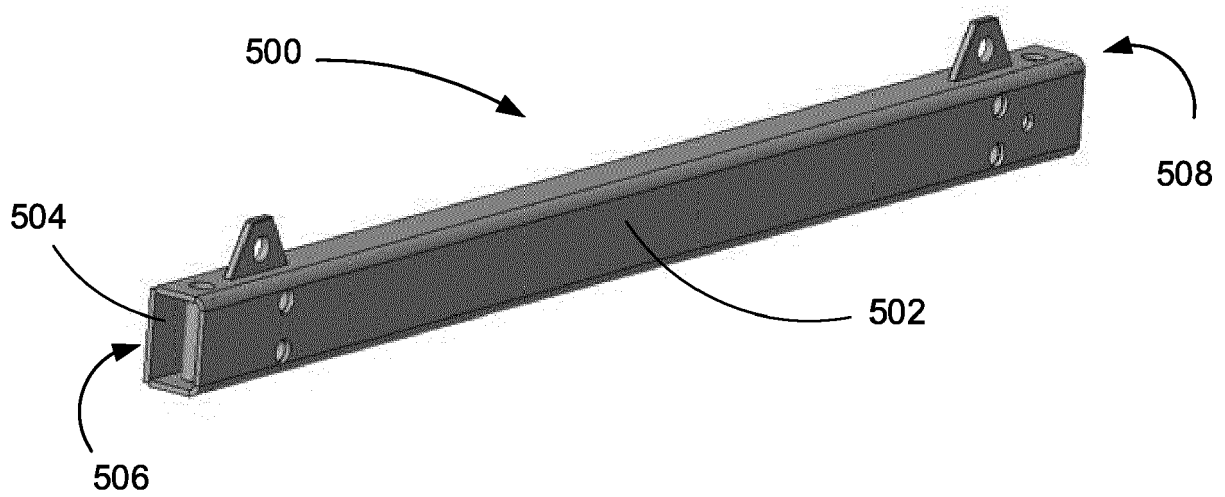


Figure 6

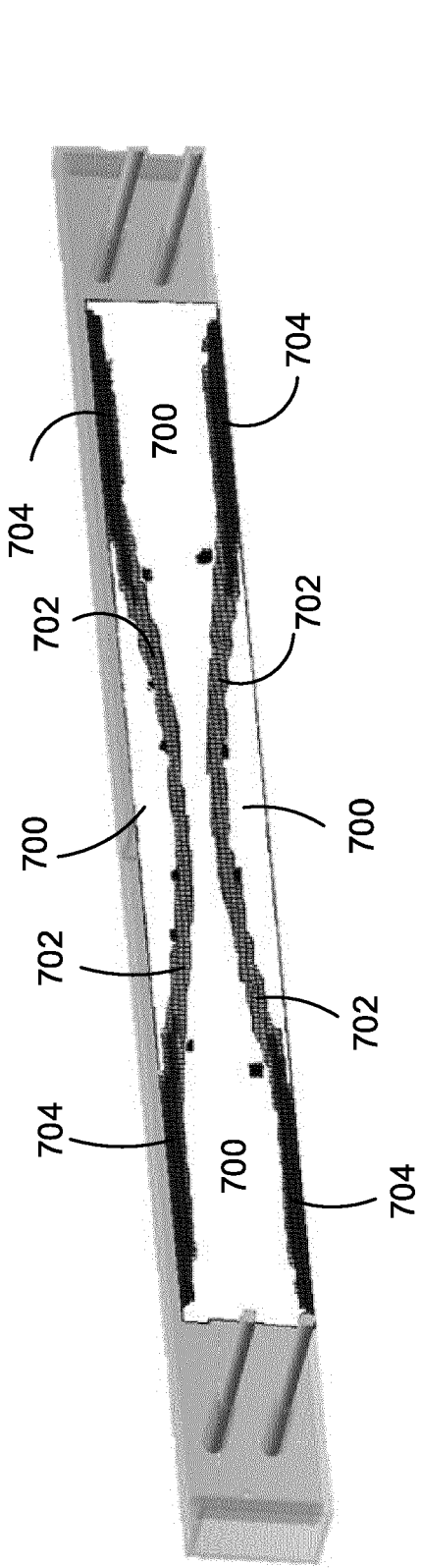


Figure 7

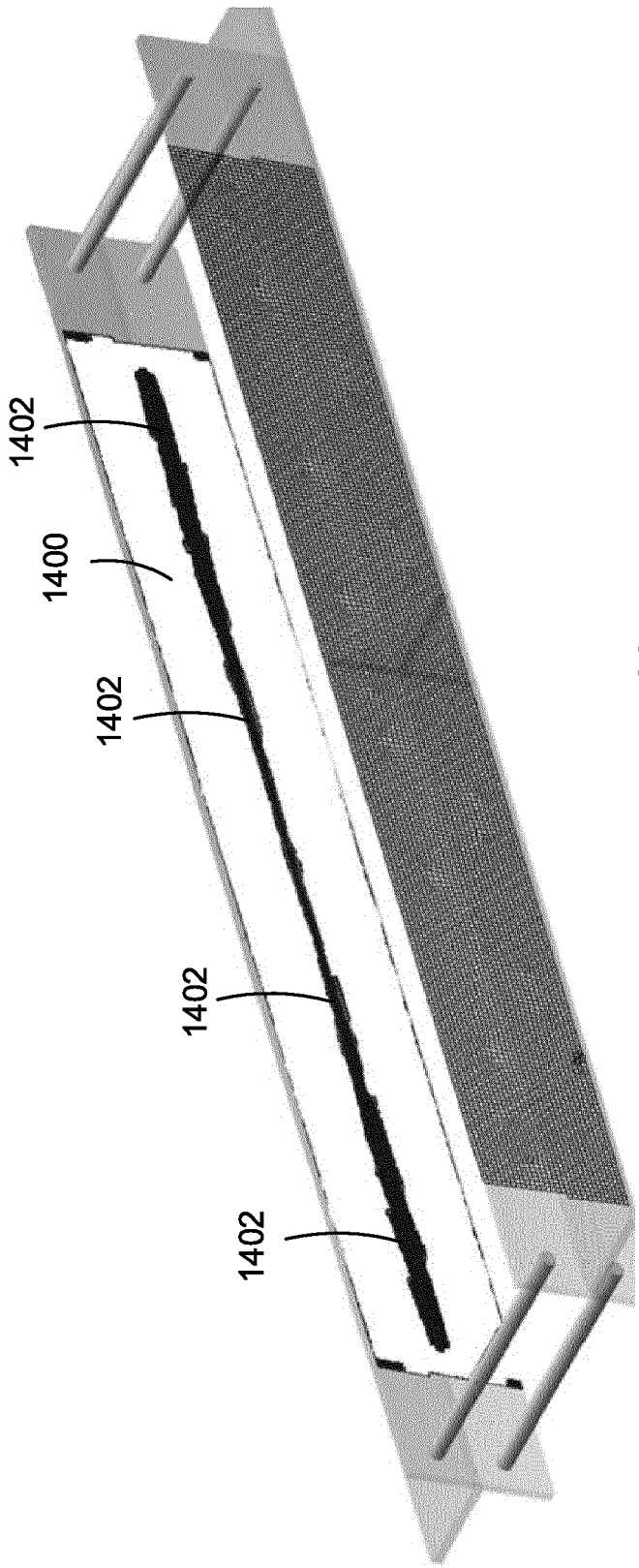


Figure 18

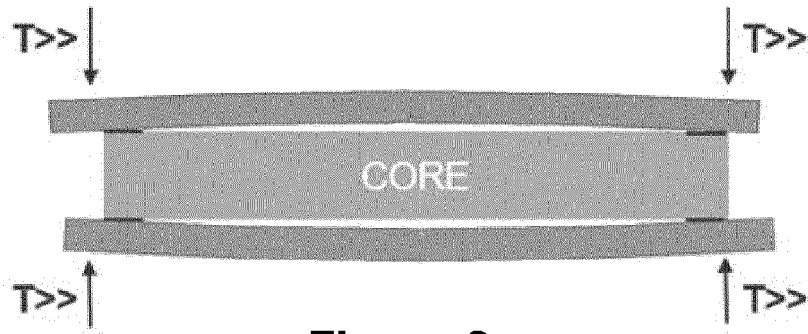


Figure 8

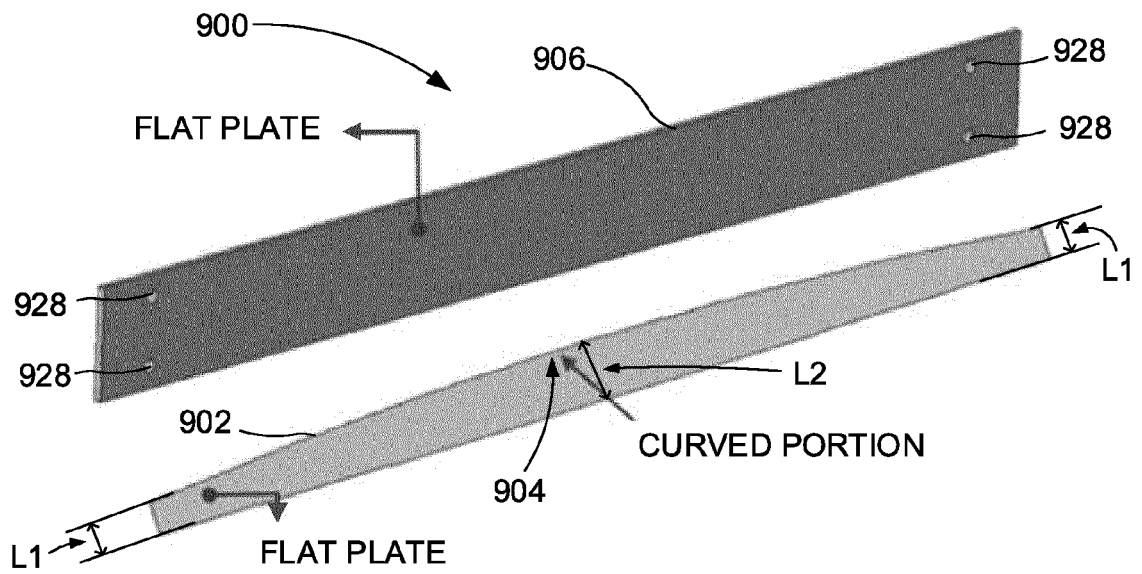


Figure 9

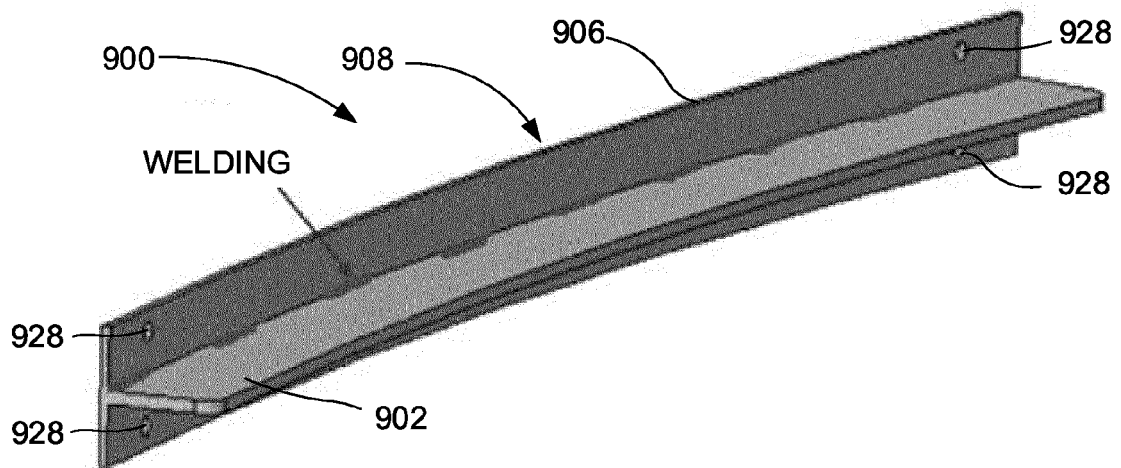


Figure 10

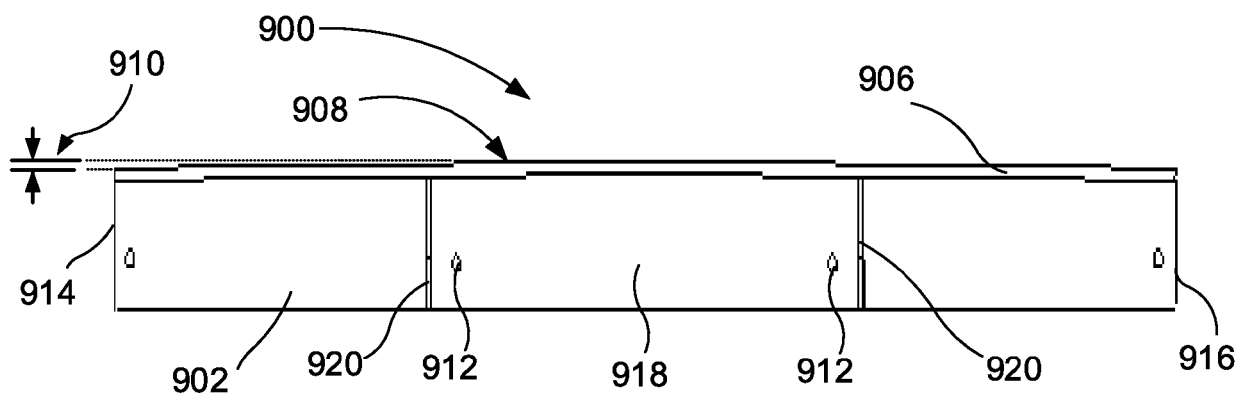


Figure 11

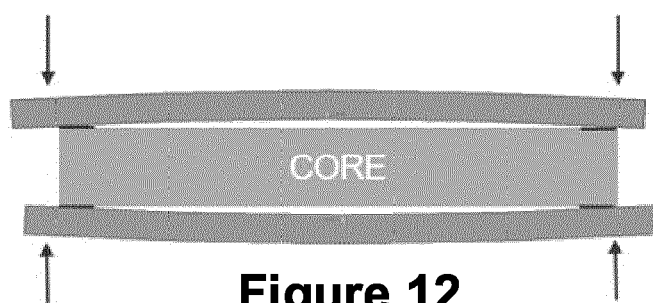


Figure 12

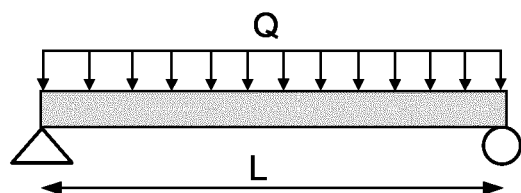


Figure 13

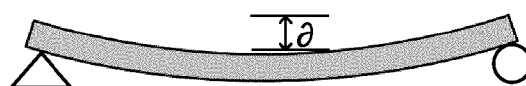


Figure 14



Figure 15

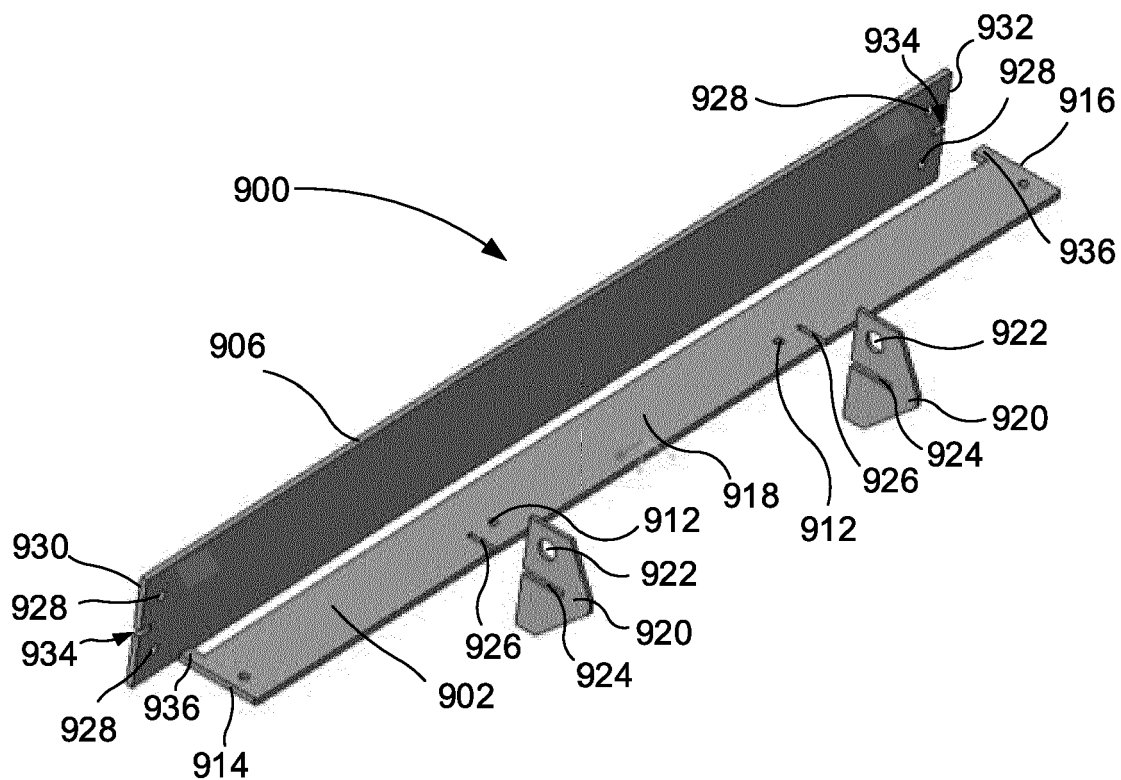


Figure 16

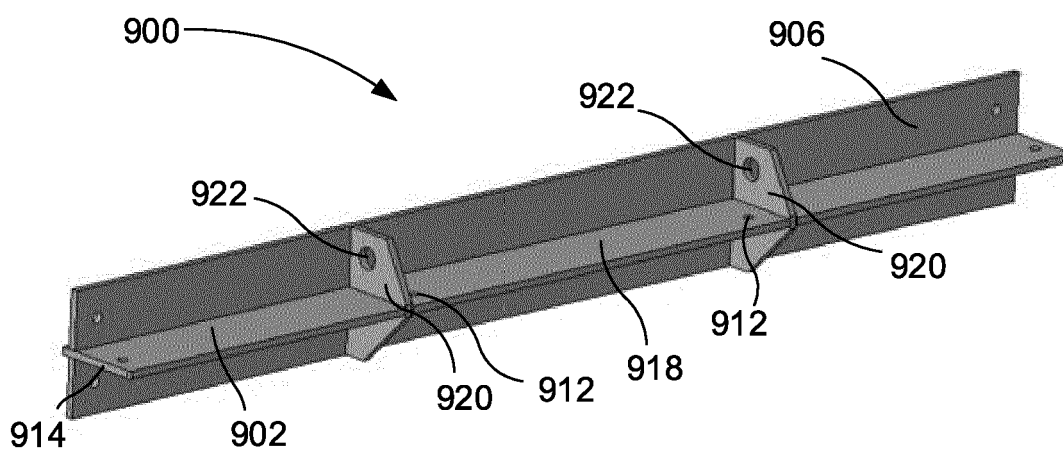


Figure 17

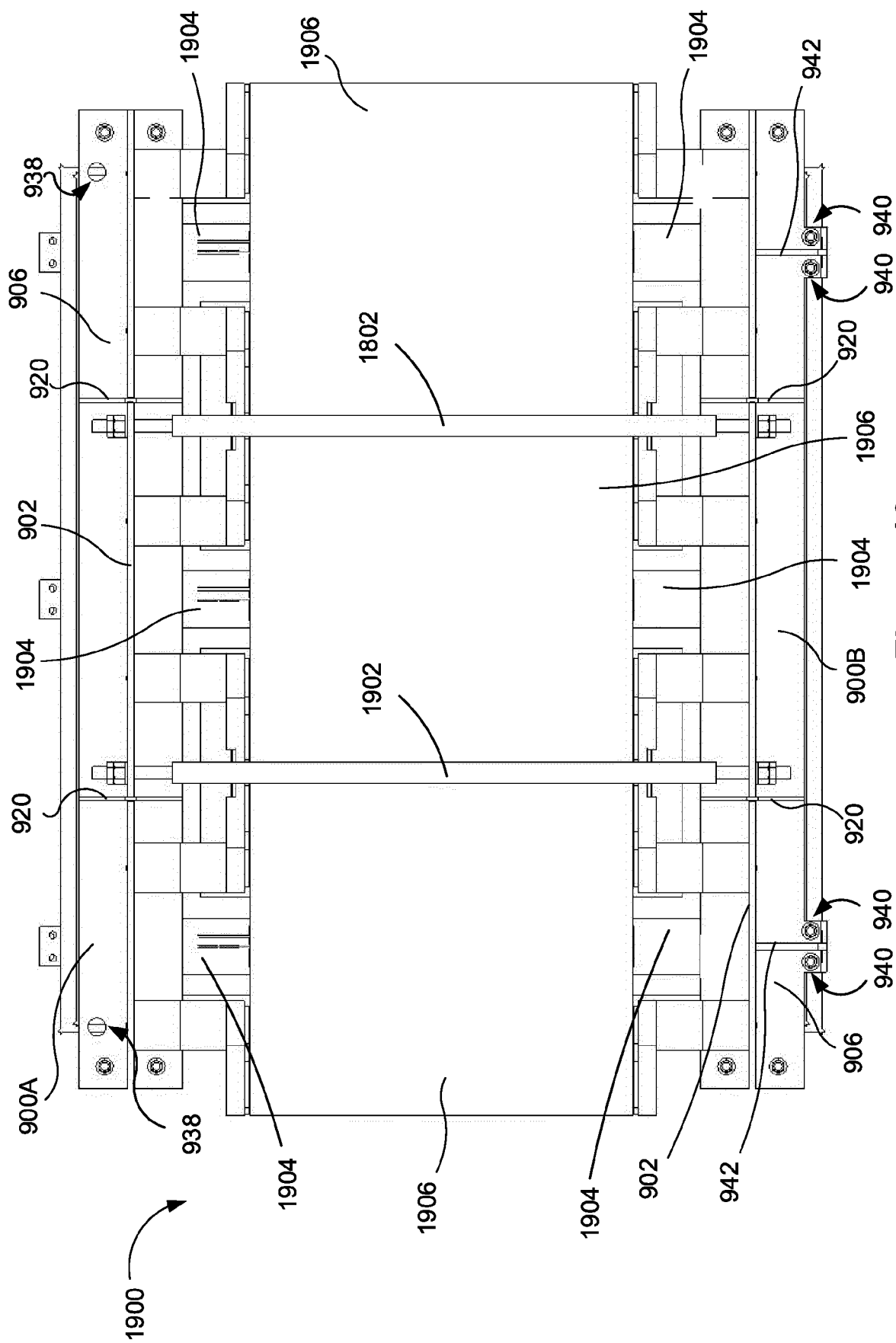


Figure 19

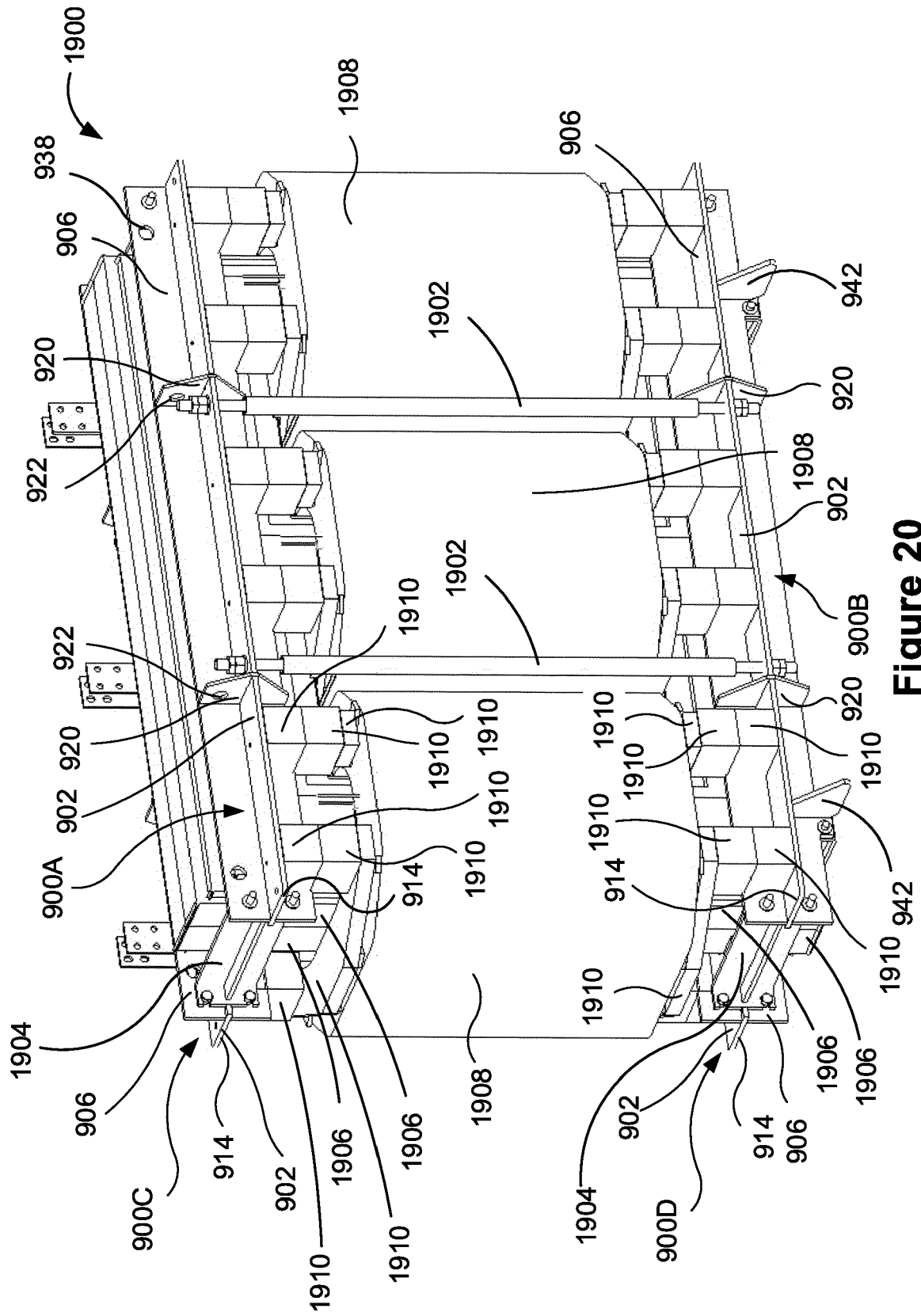


Figure 20

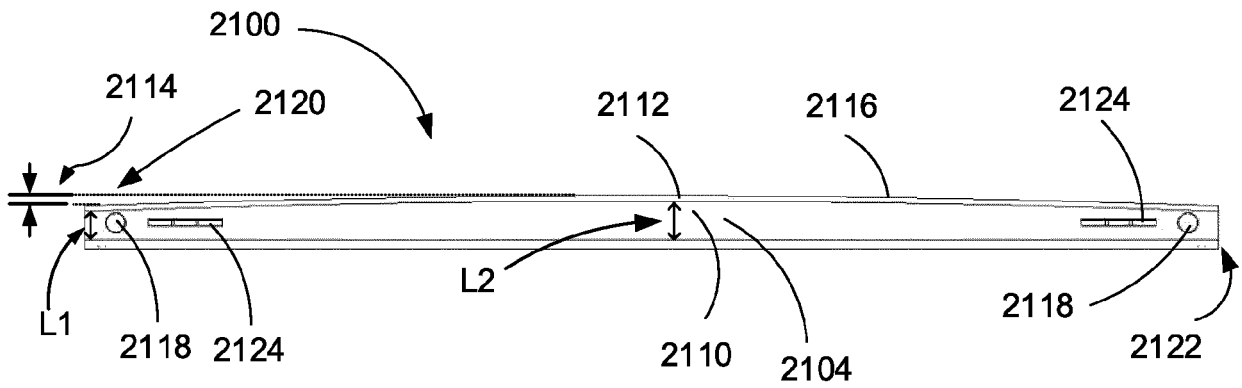


Figure 21

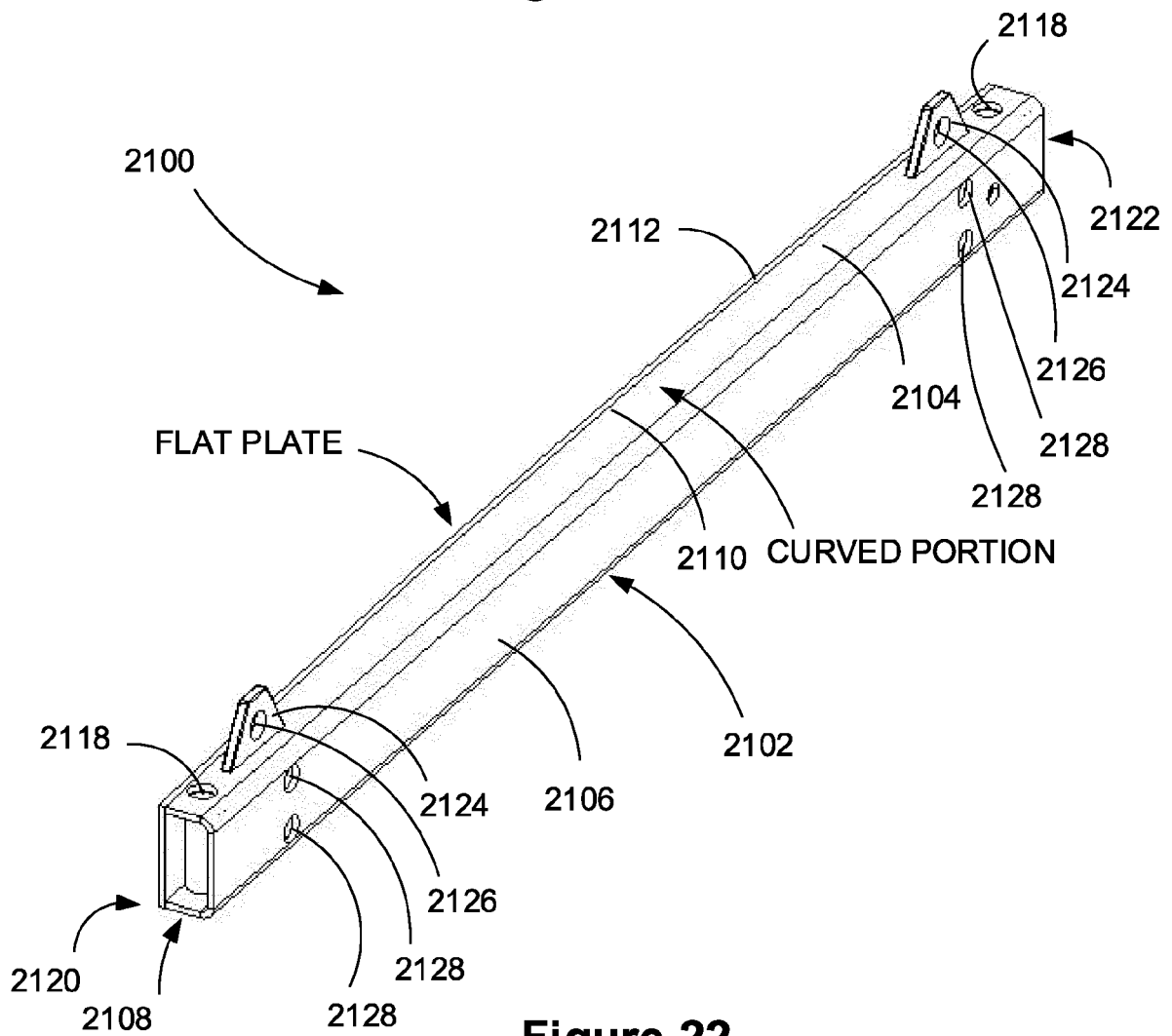


Figure 22

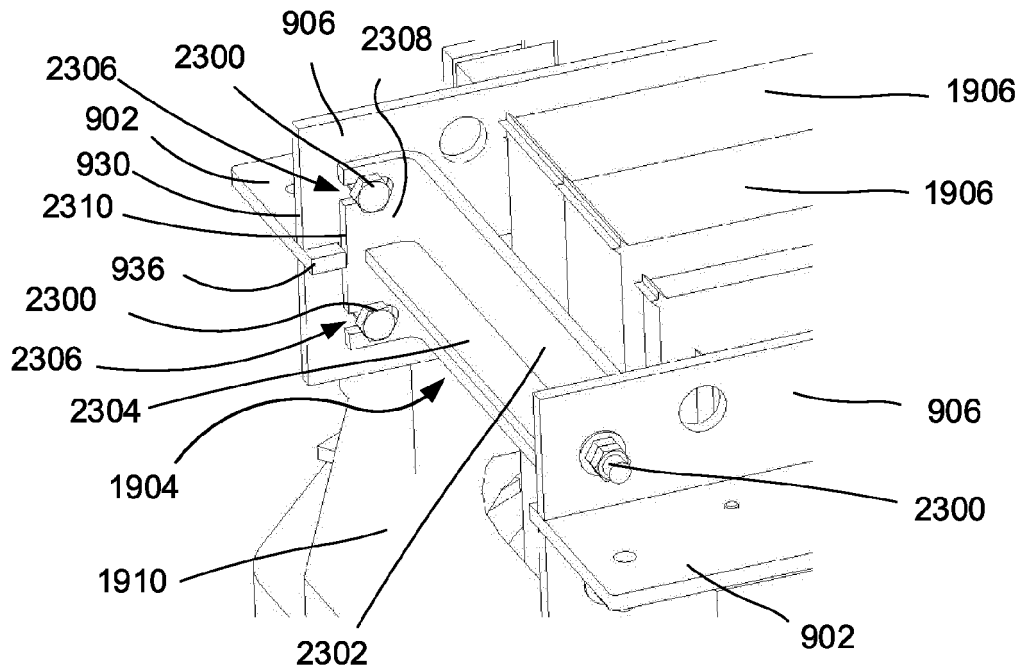


Figure 23

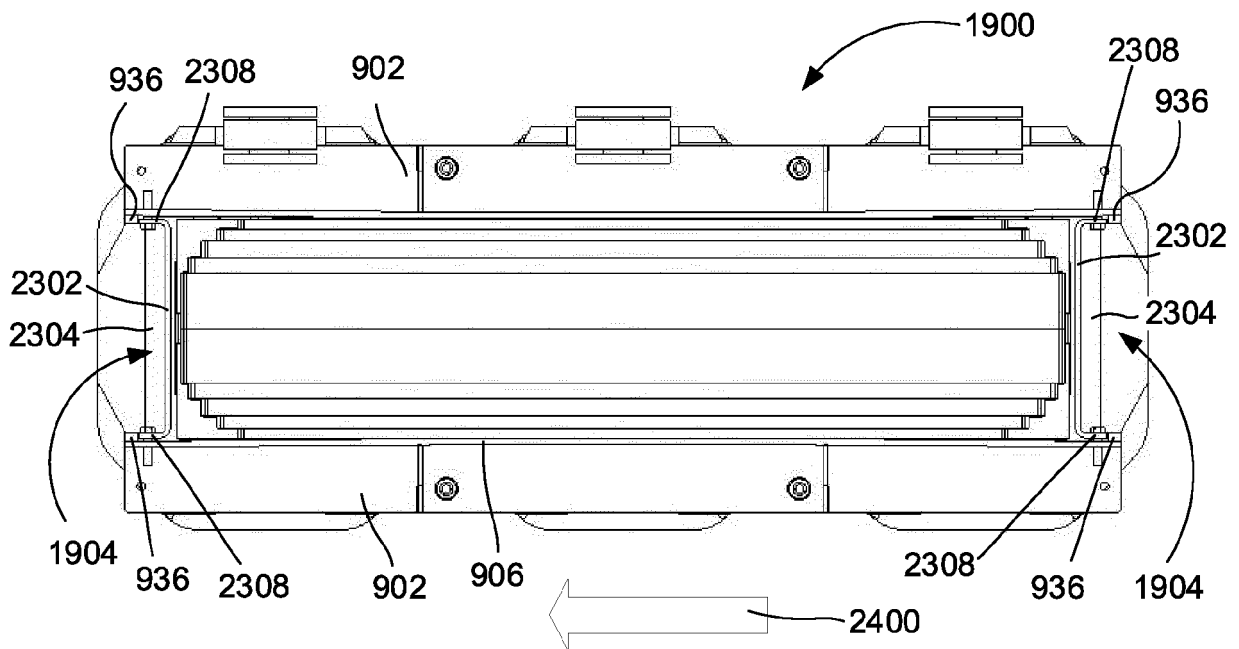


Figure 24

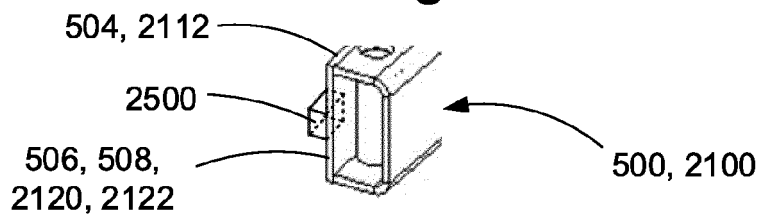


Figure 25

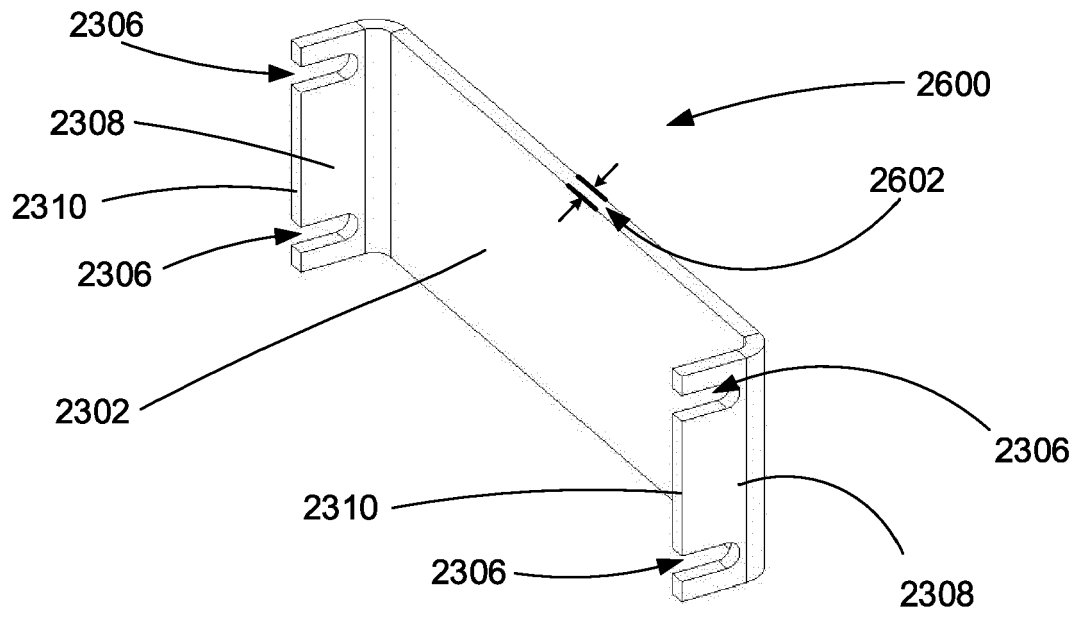


Figure 26

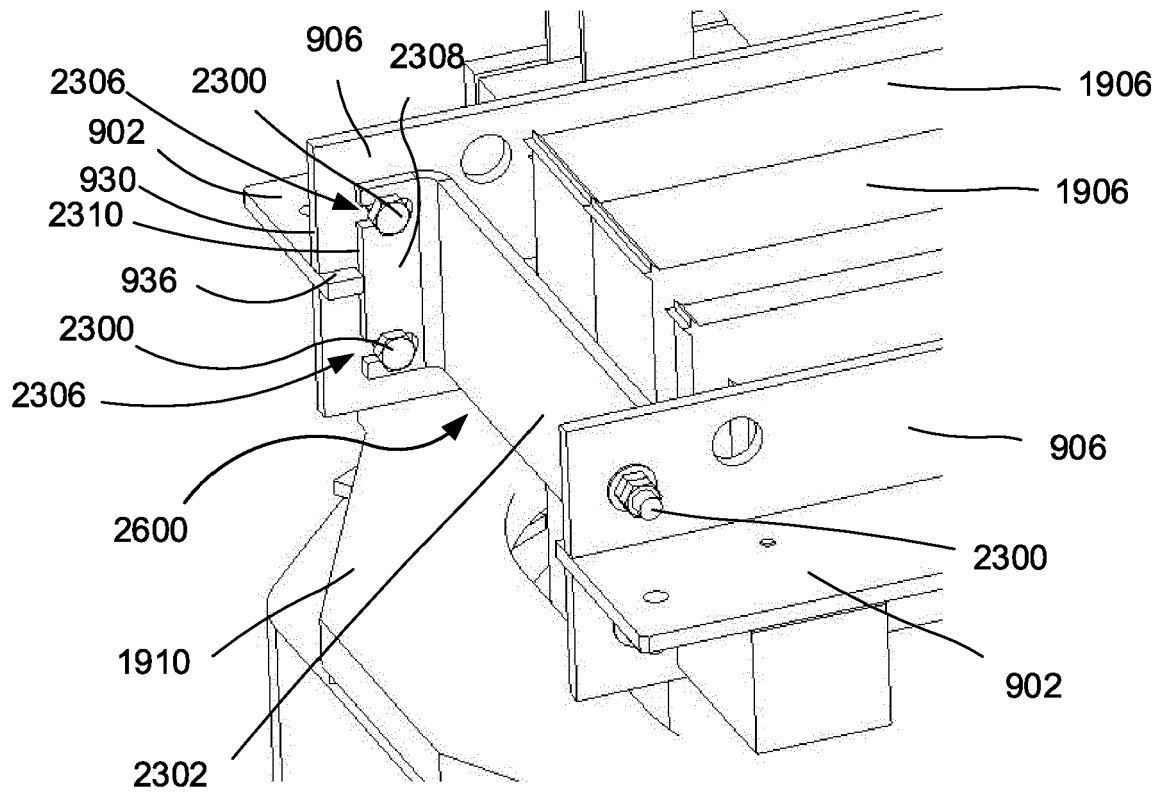


Figure 27

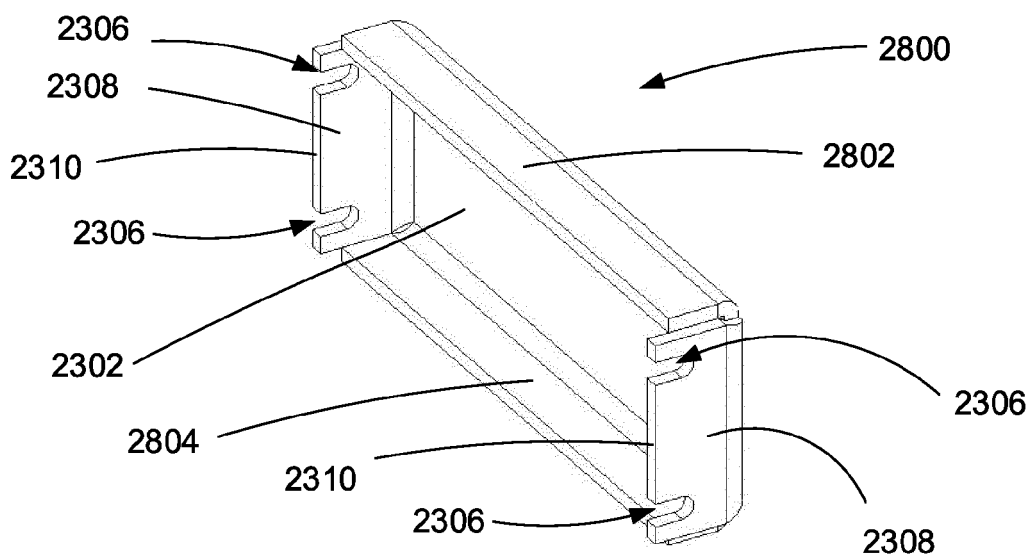


Figure 28

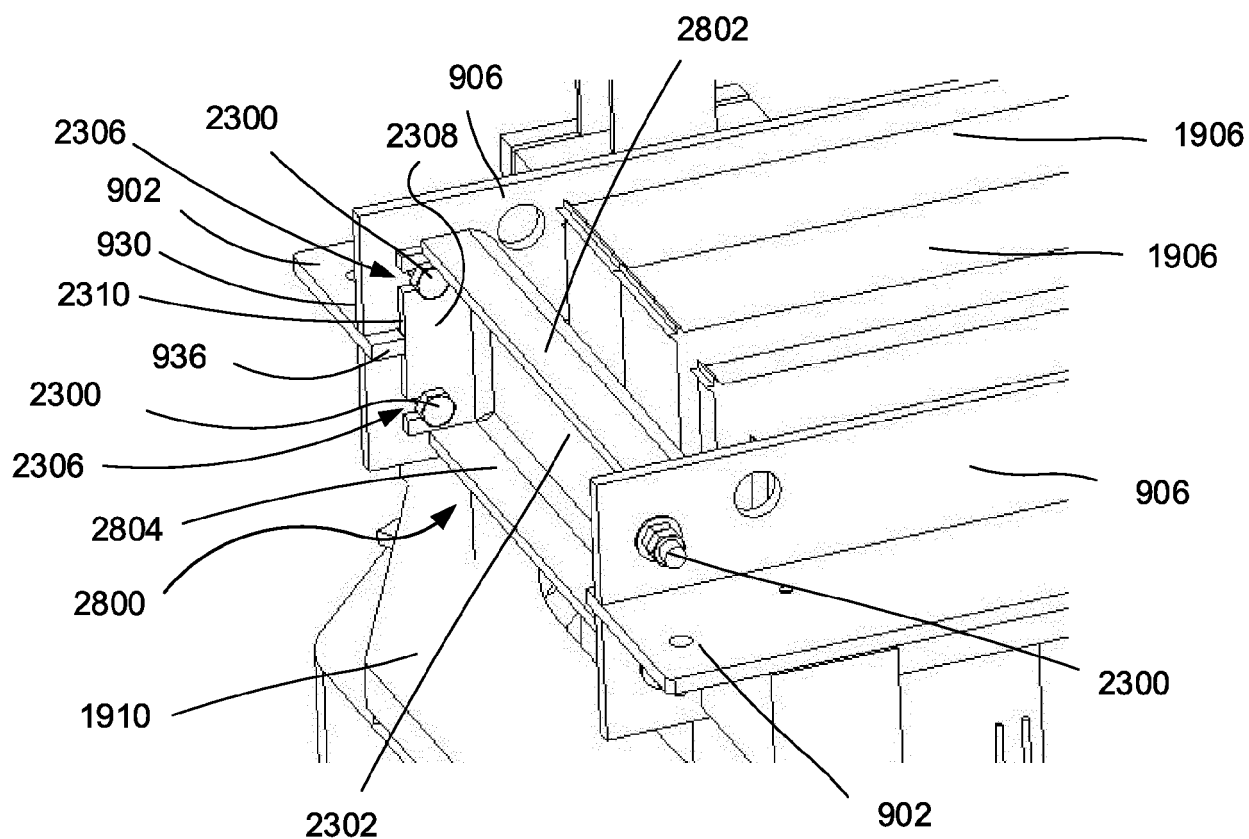


Figure 29

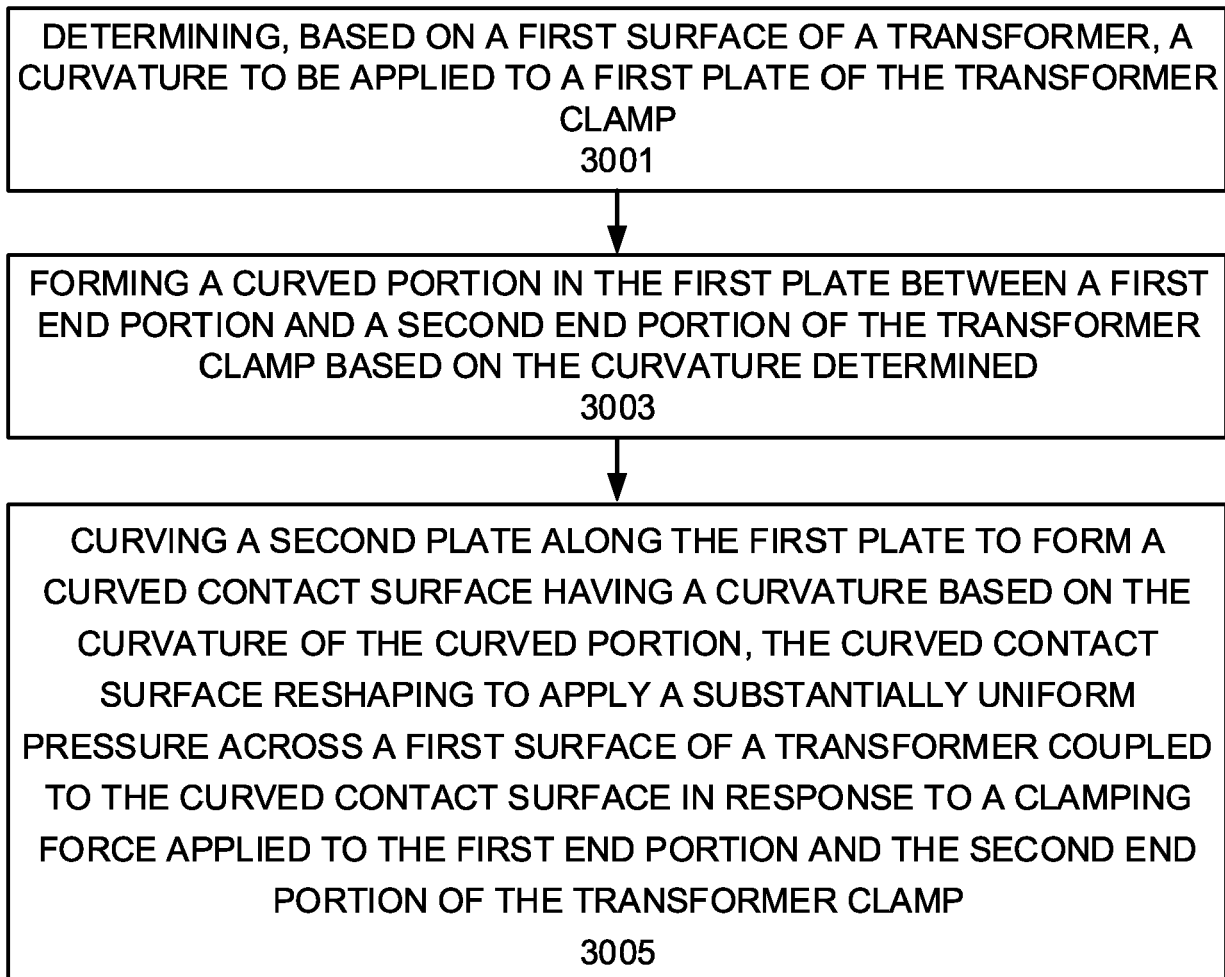


Figure 30

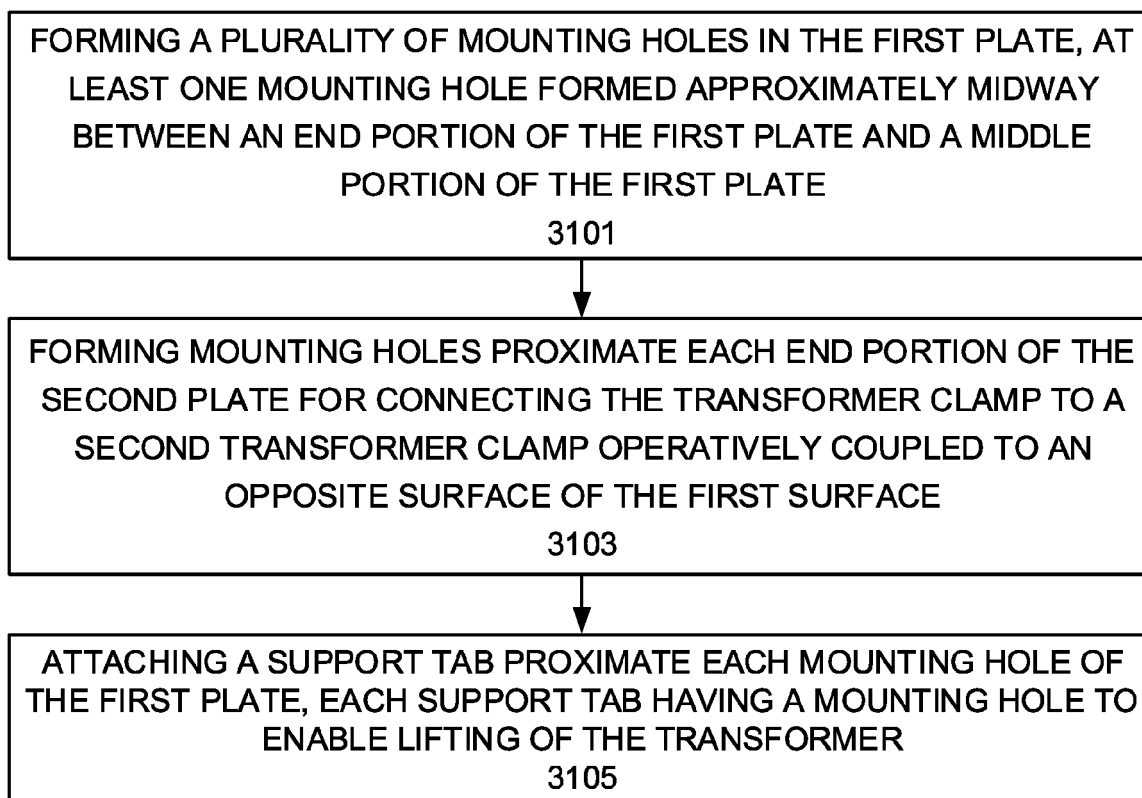


Figure 31

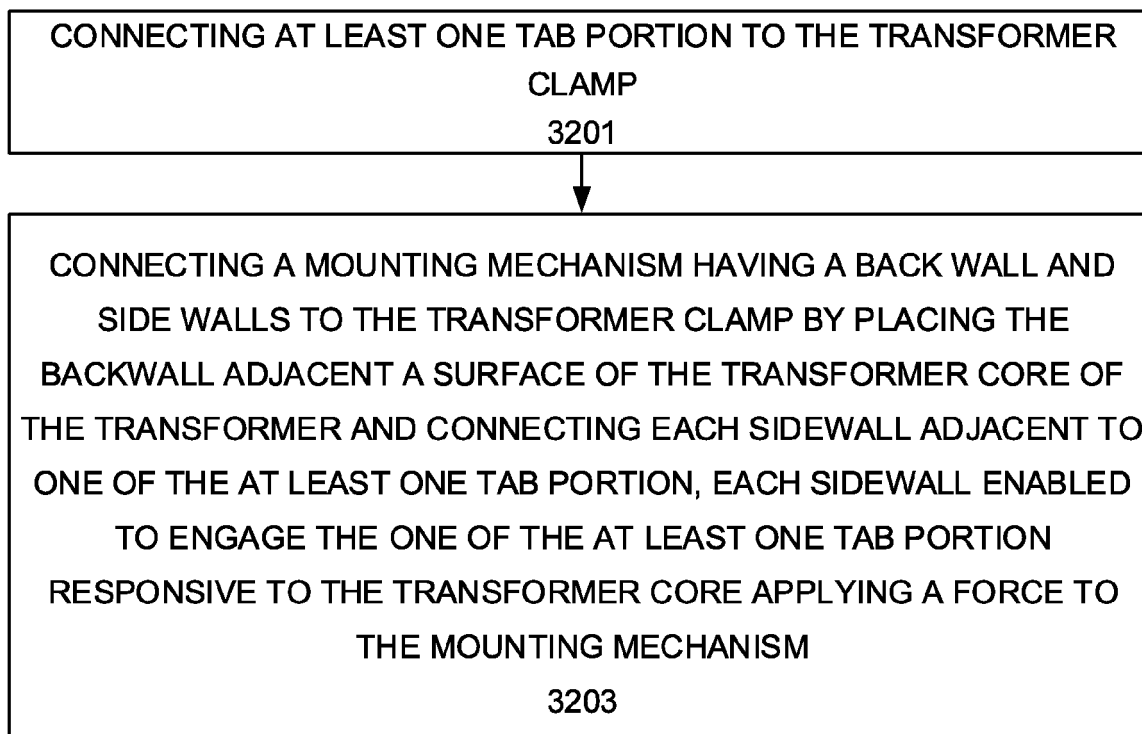


Figure 32



EUROPEAN SEARCH REPORT

Application Number
EP 20 21 2886

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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	US 2017/018354 A1 (SARKAR SUBHAS [US]) 19 January 2017 (2017-01-19)	1,2,4,6,7,10,11,13	INV. H01F27/26
A	* abstract; figures 1-3 * * page 1, paragraph 1 - page 2, paragraph 13 *	3,5,12	
A	----- CH 387 782 A (OERLIKON MASCHF [CH]) 15 February 1965 (1965-02-15) * page 1, left-hand column, line 33 - right-hand column, line 64; figures 1-3 *	1-7,10-13	
A	----- JP S53 98916 U (KEISHIBAURA ELECTRIC CO., LTD.) 10 August 1978 (1978-08-10) * page 2, paragraph 2 - page 3, paragraph 1; figures 1-3 *	1-7,10-13	

			TECHNICAL FIELDS SEARCHED (IPC)
			H01F
1 The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
Munich		20 May 2021	Kardinal, Ingrid
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03.82 (P04C01)



Application Number

EP 20 21 2886

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☒ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

1-7, 10-13

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).

**LACK OF UNITY OF INVENTION
SHEET B**

Application Number

EP 20 21 2886

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-7, 10-13

A transformer clamp and a method of creating the same wherein a first plate having a curved portion of a predetermined curvature between a first end portion and a second end portion of the clamp is attached to a second plate which is curved based on the curvature of the curved portion, wherein the curvature enables the clamp to distribute a substantially uniform pressure across a first surface of a transformer coupled to the clamp.

2. claims: 8, 9, 14, 15

A transformer clamp having a [clamp] plate provided with at least one tab portion proximate an end portion of the plate and a mounting mechanism having side walls 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.

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 20 21 2886

5

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
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

20-05-2021

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2017018354 A1	19-01-2017	NONE	
CH 387782 A	15-02-1965	CH 387782 A ES 277475 A1 GB 941940 A	15-02-1965 16-12-1962 20-11-1963
JP S5398916 U	10-08-1978	JP S5398916 U JP S5721292 Y2	10-08-1978 08-05-1982

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EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82