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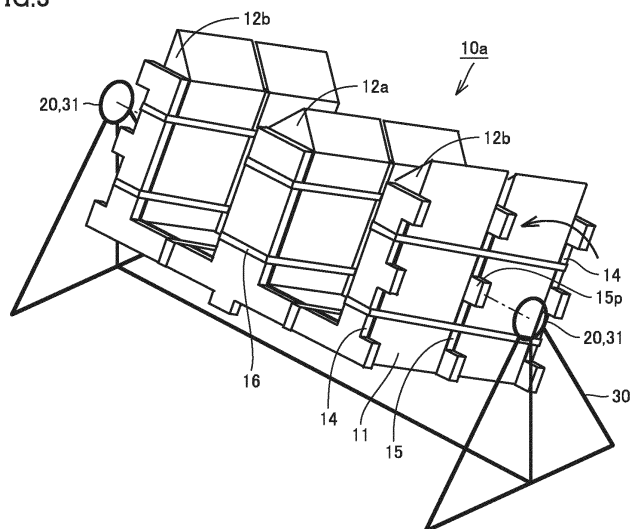
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(54) **SHELL-TYPE TRANSFORMER AND PRODUCTION METHOD THEREFOR**

(57) A method of manufacturing a shell-type transformer includes: forming an E-shaped stacked body having an E shape as seen in a stacking direction of a plurality of electromagnetic steel plates; integrally forming the E-shaped stacked body to form an E-shaped iron core (10a); rotating the E-shaped iron core (10a) such that a lower yoke iron core (11) is located on a lower side; placing the E-shaped iron core (10a) so as to be housed in

a tank main body in a state where the lower yoke iron core (11) is located on the lower side; installing a coil in the E-shaped iron core (10a) inside the tank main body; installing an upper yoke iron core in the E-shaped iron core (10a) having the coil installed therein to form an iron core assembly; and attaching a cover portion to the tank main body to form a tank, and placing the iron core assembly and the coil so as to be enclosed in the tank.

FIG.3



Description

TECHNICAL FIELD

[0001] The present invention relates to a shell-type transformer and a method of manufacturing the shell-type transformer.

BACKGROUND ART

[0002] Japanese Patent Laying-Open No. 59-181521 (PTL 1) is a prior art document disclosing an assembling method for a transformer having a shell-type iron core. According to the assembling method for a transformer having a shell-type iron core as disclosed in PTL 1, excluding a magnetic steel plate in one yoke portion, magnetic steel plates in a main leg portion, a return path leg portion and the other yoke portion are combined with each other, an adhesive is applied to the outer circumferential surface of an iron core excluding a portion that engages with one yoke portion, and then, the adhesive is thermally cured while pressurizing the iron core in the stacking direction of the magnetic steel plates, so as to be integrated as a partial iron core.

[0003] Then, a coil block is inserted into the main leg portion of the partial iron core. Then, the one yoke portion is attached to the partial iron core, thereby producing a transformer main body. The transformer main body assembled as described above is housed in a pair of upper and lower tanks. The iron core is sandwiched between the upper tank and the lower tank and receives pressure in the stacking direction of the magnetic steel plates.

CITATION LIST

PATENT LITERATURE

[0004] PTL 1: Japanese Patent Laying-Open No. 59-181521

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0005] In the assembling method for a transformer having a shell-type iron core as disclosed in PTL 1, the transformer main body including an iron core assembly and a coil needs to be lifted so as to be placed inside the lower tank, which requires a large-sized lifting apparatus. Furthermore, when the transformer main body is laid on its side, the transformer main body is rotated by 90° together with the tank, which requires a large-sized rotation apparatus.

[0006] The present invention has been made in light of the above-described problems. An object of the present invention is to provide a shell-type transformer that can be assembled without using a large-sized apparatus, and a method of manufacturing the shell-type

transformer.

SOLUTION TO PROBLEM

[0007] A method of manufacturing a shell-type transformer according to the present invention includes: stacking a plurality of electromagnetic steel plates and forming an E-shaped stacked body having an E shape as seen in a stacking direction of the plurality of electromagnetic steel plates, the E-shaped stacked body including a lower yoke iron core and three leg iron cores that are vertical to the lower yoke iron core; pressing the E-shaped stacked body for integration from both sides in the stacking direction and forming an E-shaped iron core; rotating the E-shaped iron core such that the lower yoke iron core is located on a lower side; placing the E-shaped iron core so as to be housed in a tank main body in a state where the lower yoke iron core is located on the lower side; installing a coil in the E-shaped iron core inside the tank main body such that a leg iron core located at a middle position among the three leg iron cores is inserted through the coil; installing an upper yoke iron core in the E-shaped iron core having the coil installed therein, and forming an iron core assembly; and attaching a cover portion to the tank main body to form a tank and placing the iron core assembly and the coil so as to be enclosed in the tank.

ADVANTAGEOUS EFFECTS OF INVENTION

[0008] According to the present invention, a shell-type transformer can be assembled without using a large-sized apparatus.

BRIEF DESCRIPTION OF DRAWINGS

[0009]

Fig. 1 is a perspective view for illustrating the step of forming an E-shaped stacked body in a method of manufacturing a shell-type transformer according to the first embodiment of the present invention.

Fig. 2 is a perspective view showing an external appearance of an E-shaped iron core formed in the method of manufacturing a shell-type transformer according to the first embodiment of the present invention.

Fig. 3 is a perspective view for illustrating the step of rotating the E-shaped iron core in the method of manufacturing a shell-type transformer according to the first embodiment of the present invention.

Fig. 4 is an exploded perspective view showing the configurations of a shaft member and a bearing portion at the time when the E-shaped iron core is supported by a rotation support mount in the method of manufacturing a shell-type transformer according to the first embodiment of the present invention.

Fig. 5 is an exploded perspective view showing the

configurations of the shaft member and the bearing portion at the time when the E-shaped iron core is rotated by 90° in the method of manufacturing a shell-type transformer according to the first embodiment of the present invention.

Fig. 6 is a perspective view showing the state where the E-shaped iron core is rotated by 90° in the method of manufacturing a shell-type transformer according to the first embodiment of the present invention. Fig. 7 is a perspective view showing the configuration of a tank main body in which the E-shaped iron core is housed, in the method of manufacturing a shell-type transformer according to the first embodiment of the present invention.

Fig. 8 is a perspective view showing the state where the E-shaped iron core is housed in the tank main body in the method of manufacturing a shell-type transformer according to the first embodiment of the present invention.

Fig. 9 is a perspective view showing the state where the E-shaped iron core is housed in the tank main body in the method of manufacturing a shell-type transformer according to the first embodiment of the present invention.

Fig. 10 is a perspective view showing the state where a coil is installed in the E-shaped iron core inside the tank main body in the method of manufacturing a shell-type transformer according to the first embodiment of the present invention.

Fig. 11 is a perspective view showing the state where an upper yoke iron core is installed in the E-shaped iron core having the coil installed therein in the method of manufacturing a shell-type transformer according to the first embodiment of the present invention. Fig. 12 is a perspective view showing the state where an iron core assembly is formed by installing the upper yoke iron core in the E-shaped iron core having the coil installed therein in the method of manufacturing a shell-type transformer according to the first embodiment of the present invention.

Fig. 13 is a perspective view showing the state where the iron core assembly and the coil are enclosed in a tank that is formed by attaching a cover portion to the tank main body in the method of manufacturing a shell-type transformer according to the first embodiment of the present invention.

Fig. 14 is an exploded perspective view showing the state where a coupling member having a shaft member coupled thereto is attached to an E-shaped iron core in a method of manufacturing a shell-type transformer according to the second embodiment of the present invention.

Fig. 15 is an exploded perspective view showing the state where a coupling member having a shaft member coupled thereto is attached to a holding plate for holding an E-shaped iron core in a method of manufacturing a shell-type transformer according to the third embodiment of the present invention.

Fig. 16 is an exploded perspective view showing a portion surrounded by a circle XVI in Fig. 15 in an enlarged manner.

DESCRIPTION OF EMBODIMENTS

[0010] In the following, a shell-type transformer according to each of the embodiments of the present invention and a method of manufacturing the shell-type transformer will be described with reference to the accompanying drawings. In the following description of the embodiments, the same or corresponding components in the figures will be designated by the same reference characters, and description thereof will not be repeated.

First Embodiment

[0011] Fig. 1 is a perspective view for illustrating the step of forming an E-shaped stacked body in a method of manufacturing a shell-type transformer according to the first embodiment of the present invention. As shown in Fig. 1, in the step of forming an E-shaped stacked body in the method of manufacturing a shell-type transformer according to the first embodiment of the present invention, a plurality of electromagnetic steel plates 1 are stacked to form an E-shaped stacked body 10 having an E shape as seen in the stacking direction of the plurality of electromagnetic steel plates 1.

[0012] E-shaped stacked body 10 includes a lower yoke iron core 11 and three leg iron cores that are vertical to lower yoke iron core 11. These three leg iron cores include a leg iron core 12a located at the middle position and two leg iron cores 12b located on both sides.

[0013] E-shaped stacked body 10 includes a pressing plate 14 made of a nonmagnetic material and disposed at each of both ends in the above-mentioned stacking direction. Pressing plate 14 has an E shape that is approximately identical to the shape formed of lower yoke iron core 11 and the three leg iron cores as seen in the stacking direction.

[0014] Pressing plate 14 includes three protruding portions that are spaced apart from each other and located along the side edge of each of two leg iron cores 12b as seen in the stacking direction. Furthermore, pressing plate 14 includes one protruding portion at a position on lower yoke iron core 11 on the side opposite to leg iron core 12a as seen in the stacking direction.

[0015] In the present embodiment, E-shaped stacked body 10 includes a retaining plate 15 made of a nonmagnetic material and disposed at the middle position in the stacking direction. Retaining plate 15 has an E shape that is approximately identical to the shape formed of lower yoke iron core 11 and three leg iron cores as seen in the stacking direction.

[0016] Retaining plate 15 includes three protruding portions that are spaced apart from each other and located along the side edge of each of two leg iron cores 12b as seen in the stacking direction. A shaft member,

which will be described later, is coupled to a protruding portion 15p among the three protruding portions that is located at the middle position. Furthermore, retaining plate 15 includes one protruding portion at a position on lower yoke iron core 11 on the side opposite to leg iron core 12a as seen in the stacking direction.

[0017] Retaining plate 15 only has to include at least one protruding portion 15p at a position along the side edge of each of two leg iron cores 12b as seen in the stacking direction, but does not have to include other protruding portions.

[0018] Fig. 2 is a perspective view showing an external appearance of an E-shaped iron core formed in the method of manufacturing a shell-type transformer according to the first embodiment of the present invention. As shown in Fig. 2, in the step of forming an E-shaped iron core in the method of manufacturing a shell-type transformer according to the first embodiment of the present invention, E-shaped stacked body 10 is pressed for integration from both sides in the stacking direction to thereby form an E-shaped iron core 10a.

[0019] In the present embodiment, lower yoke iron core 11, three leg iron cores, two pressing plates 14, and retaining plate 15 are bound with a band 16 to thereby integrally form E-shaped stacked body 10.

[0020] Specifically, leg iron core 12a, two pressing plates 14 and retaining plate 15 are bound along two zones with two bands 16. Each of two leg iron cores 12b, two pressing plates 14 and retaining plate 15 are bound along two zones with two bands 16. Lower yoke iron core 11, two pressing plates 14 and retaining plate 15 are bound along two zones with two bands 16.

[0021] Band 16 is made of a material such as polyetheretherketone having heat resistance and insulating oil resistance. In addition, band 16 may be made of a binding tape having heat resistance and insulating oil resistance.

[0022] Fig. 3 is a perspective view for illustrating the step of rotating the E-shaped iron core in the method of manufacturing a shell-type transformer according to the first embodiment of the present invention. Fig. 3 shows the state where E-shaped iron core 10a is in the middle of rotation.

[0023] As shown in Fig. 3, in the step of rotating E-shaped iron core 10a in the method of manufacturing a shell-type transformer according to the first embodiment of the present invention, E-shaped iron core 10a is rotated such that lower yoke iron core 11 is located on the lower side.

[0024] Specifically, in the step of rotating E-shaped iron core 10a, cylindrical shaft members 20 each are coaxially coupled to a position along the side edge of a corresponding one of two leg iron cores 12b as seen in the stacking direction. Then, E-shaped iron core 10a is rotated about two shaft members 20 each serving as a rotation axis. In the present embodiment, shaft member 20 is coupled to protruding portion 15p of retaining plate 15. The center of gravity of E-shaped iron core 10a is located along the

straight line that connects the axial centers of two shaft members 20.

[0025] When E-shaped iron core 10a is rotated, a rotation support mount 30 is used. On rotation support mount 30, a pair of bearing portions 31 are provided, each of which is slidably in contact with a corresponding one of two shaft members 20 in the one-to-one relation.

[0026] Fig. 4 is an exploded perspective view showing the configurations of a shaft member and a bearing portion at the time when the E-shaped iron core is supported by a rotation support mount in the method of manufacturing a shell-type transformer according to the first embodiment of the present invention.

[0027] As shown in Fig. 4, shaft member 20 is provided with a hole 21 that extends in the axial direction of shaft member 20. Protruding portion 15p of retaining plate 15 is inserted into hole 21. Protruding portion 15p is provided with a through hole 15h that penetrates through retaining plate 15 in its thickness direction. Figs. 1 to 3 each do not show through hole 15h.

[0028] Shaft member 20 is provided with a through hole 22 that is located at the position corresponding to through hole 15h so as to penetrate through shaft member 20 in its radial direction. Bolt 40 is screwed into a nut 41 in the state where bolt 40 is inserted into through hole 22 and through hole 15h, thereby coupling shaft member 20 to protruding portion 15p of retaining plate 15. Each of two shaft members 20 is coupled to a corresponding one of two protruding portions 15p in the one-to-one relation.

[0029] Bearing portion 31 has a semicircular annular shape. The inner circumferential surface of bearing portion 31 is slidably in contact with the outer circumferential surface of shaft member 20. The inner circumferential surface of bearing portion 31 is slightly larger in radius of curvature than the outer circumferential surface of shaft member 20.

[0030] After shaft member 20 is coupled to protruding portion 15p of retaining plate 15, E-shaped iron core 10a is lifted and disposed such that the outer circumferential surface of shaft member 20 is brought into contact with the inner circumferential surface of bearing portion 31. Thereby, E-shaped iron core 10a is supported by rotation support mount 30.

[0031] For lifting E-shaped iron core 10a, E-shaped iron core 10a may be lifted using a sling hooked over one of the protruding portions of pressing plate 14 and the protruding portions (other than protruding portion 15p) of retaining plate 15. In this case, the protruding portion may be provided with a recessed portion over which a sling is hooked.

[0032] Fig. 5 is an exploded perspective view showing the configurations of the shaft member and the bearing portion at the time when the E-shaped iron core is rotated by 90° in the method of manufacturing a shell-type transformer according to the first embodiment of the present invention. Fig. 6 is a perspective view showing the state where the E-shaped iron core is rotated by 90° in the method of manufacturing a shell-type transformer ac-

according to the first embodiment of the present invention. Fig. 6 does not show through hole 15h.

[0033] In the state where the outer circumferential surface of shaft member 20 is slidably in contact with the inner circumferential surface of bearing portion 31, E-shaped iron core 10a is rotated by 90° as shown in Fig. 5. As described above, since the center of gravity of E-shaped iron core 10a is located along the straight line that connects the axial centers of two shaft members 20, E-shaped iron core 10a can be readily rotated with small rotation force.

[0034] After E-shaped iron core 10a is rotated by 90°, E-shaped iron core 10a is lifted and separated apart from rotation support mount 30. In this state, shaft member 20 is removed from protruding portion 15p as shown in Fig. 6. In this way, protruding portion 15p is attachably and detachably coupled to shaft member 20.

[0035] When E-shaped iron core 10a rotated by 90° is lifted, E-shaped iron core 10a may be lifted with a sling hooked over a protruding portion among the protruding portions of pressing plate 14 and the protruding portions (other than protruding portion 15p) of retaining plate 15. In this case, the protruding portion may be provided with a recessed portion over which a sling is hooked.

[0036] Fig. 7 is a perspective view showing the configuration of a tank main body in which the E-shaped iron core is housed, in the method of manufacturing a shell-type transformer according to the first embodiment of the present invention. As shown in Fig. 7, before E-shaped iron core 10a is housed, an oil path 51 including a pump and allowing circulation of insulating oil therethrough, a reinforcement member 52 for reinforcing tank main body 50 and the like are connected in advance to tank main body 50.

[0037] Fig. 8 is a perspective view showing the state where the E-shaped iron core is housed in the tank main body in the method of manufacturing a shell-type transformer according to the first embodiment of the present invention. Fig. 8 does not show through hole 15h, oil path 51, and reinforcement member 52. As shown in Fig. 8, E-shaped iron core 10a is housed in tank main body 50 in the state where lower yoke iron core 11 is located on the lower side.

[0038] Fig. 9 is a perspective view showing the state where the E-shaped iron core is housed in the tank main body in the method of manufacturing a shell-type transformer according to the first embodiment of the present invention. Fig. 9 does not show oil path 51 and reinforcement member 52. As shown in Fig. 9, tank main body 50 has a volume and a height enough to allow the entire E-shaped iron core 10a to be housed therein.

[0039] Fig. 10 is a perspective view showing the state where a coil is installed in the E-shaped iron core inside the tank main body in the method of manufacturing a shell-type transformer according to the first embodiment of the present invention. Fig. 10 does not show oil path 51 and reinforcement member 52. As shown in Fig. 10, coil 60 is installed in E-shaped iron core 10a inside tank

main body 50 such that leg iron core 12a is inserted through coil 60. In other words, coil 60 is lifted and placed so as to be housed in tank main body 50.

[0040] Fig. 11 is a perspective view showing the state where an upper yoke iron core is installed in the E-shaped iron core having the coil installed therein in the method of manufacturing a shell-type transformer according to the first embodiment of the present invention. Fig. 11 does not show oil path 51 and reinforcement member 52. As shown in Fig. 11, a plurality of electromagnetic steel plates 1 constituting upper yoke iron core 13 are installed in E-shaped iron core 10a in which coil 60 is installed.

[0041] Fig. 12 is a perspective view showing the state where an iron core assembly is formed by installing the upper yoke iron core in the E-shaped iron core having the coil installed therein in the method of manufacturing a shell-type transformer according to the first embodiment of the present invention. Fig. 12 does not show oil path 51 and reinforcement member 52.

[0042] As shown in Fig. 12, upper yoke iron core 13 is installed in E-shaped iron core 10a to thereby form an iron core assembly 10b. In other words, iron core assembly 10b includes lower yoke iron core 11, upper yoke iron core 13, and three leg iron cores 12b, 12a and 12b that are formed by a plurality of electromagnetic steel plates 1 stacked on one another and that are connected to one another. In the present embodiment, iron core assembly 10b further includes two pressing plates 14, retaining plate 15, and band 16.

[0043] Fig. 13 is a perspective view showing the state where the iron core assembly and the coil are enclosed in a tank that is formed by attaching a cover portion to the tank main body in the method of manufacturing a shell-type transformer according to the first embodiment of the present invention.

[0044] As shown in Fig. 13, a cover portion 53 is attached to tank main body 50 to thereby form a tank. Iron core assembly 10b and coil 60 that are immersed in insulating oil are enclosed inside the tank. In addition, a conservator (not shown) is attached to cover portion 53.

[0045] Through the above-described steps, shell-type transformer 100 according to the first embodiment of the present invention is manufactured. In the method of manufacturing shell-type transformer 100 according to the first embodiment of the present invention, for rotating E-shaped iron core 10a by 90°, rotation support mount 30 can be used, which is a rotation apparatus reduced in size as compared with the case where the transformer main body is rotated by 90° together with a tank. This can eliminate the need to use a large-sized rotation apparatus.

[0046] Furthermore, after E-shaped iron core 10a rotated by 90° is lifted and placed so as to be housed in tank main body 50, coil 60 is lifted and placed so as to be housed in tank main body 50. Thus, E-shaped iron core 10a and coil 60 are separately lifted. This allows use of a lifting apparatus that is reduced in size as com-

pared with the case where a transformer main body including an iron core assembly and a coil is lifted. This can eliminate the need to use a large-sized lifting apparatus.

[0047] In the present embodiment, in the state where each of two shaft members 20 is coupled to a corresponding one of two protruding portions 15p in the one-to-one relation and the outer circumferential surface of shaft member 20 is slidably in contact with the inner circumferential surface of bearing portion 31 of rotation support mount 30, E-shaped iron core 10a is rotated. Thereby, E-shaped iron core 10a can be readily rotated. In particular, since the center of gravity of E-shaped iron core 10a is located along the straight line that connects the axial centers of two shaft members 20, E-shaped iron core 10a can be rotated with small rotation force.

[0048] In shell-type transformer 100 according to the present embodiment, the tank is formed of cover portion 53 and tank main body 50 that has a volume and a height enough to allow the entire iron core assembly 10b to be housed therein. Thus, the transformer main body can be readily enclosed in the tank. Furthermore, before the transformer main body is housed in tank main body 50, oil path 51 including a pump and allowing circulation of insulating oil therethrough; reinforcement member 52 for reinforcing tank main body 50; and the like can be connected in advance to tank main body 50. Accordingly, assembly of the transformer main body and assembly of the tank can be concurrently performed, so that the assembling time for shell-type transformer 100 can be shortened.

Second Embodiment

[0049] The following is an explanation about a method of manufacturing a shell-type transformer according to the second embodiment of the present invention. The method of manufacturing a shell-type transformer according to the present embodiment is different from the method of manufacturing shell-type transformer 100 according to the first embodiment mainly in that the retaining plate is provided with a hole in place of the protruding portion and that a coupling member for coupling the shaft member to the retaining plate is used. Accordingly, an explanation will not be given with regard to the same configuration as that in the method of manufacturing a shell-type transformer 100 according to the first embodiment.

[0050] Fig. 14 is an exploded perspective view showing the state where a coupling member having a shaft member coupled thereto is attached to an E-shaped iron core in a method of manufacturing a shell-type transformer according to the second embodiment of the present invention. As shown in Fig. 14, in a shell-type transformer according to the second embodiment of the present invention, retaining plate 15 is not provided with a protruding portion, but coupling member 70 is instead attached to the position located at protruding portion 15p in the

first embodiment.

[0051] Specifically, a plurality of screw holes 15s are provided on the side surface of retaining plate 15. Coupling member 70 is provided with a plurality of through holes 70h at positions corresponding to screw holes 15s. Coupling member 70 is provided with a hole 70t into which shaft member 20a is fitted. Bolt 40a is screwed into screw hole 15s while being inserted into through hole 70h, so that coupling member 70 is attached to retaining plate 15s. Shaft member 20a is fitted in hole 70t of coupling member 70.

[0052] As described above, in the step of rotating the E-shaped iron core in the method of manufacturing a shell-type transformer according to the second embodiment of the present invention, two attachable and detachable coupling members 70 are attached to retaining plate 15, and each of two shaft members 20a is coupled to a corresponding one of two coupling members 70 in the one-to-one relation.

[0053] In the step of rotating E-shaped iron core 10a in the method of manufacturing a shell-type transformer according to the second embodiment of the present invention, cylindrical shaft members 20a each are coaxially coupled to a position along the side edge of a corresponding one of two leg iron cores 12b as seen in the stacking direction. Then, E-shaped iron core 10a is rotated about two shaft members 20a each serving as a rotation axis. As in the first embodiment, E-shaped iron core 10a is rotated by 90° in the state where the outer circumferential surface of shaft member 20a and the inner circumferential surface of bearing portion 31 are slidably in contact with each other.

[0054] After E-shaped iron core 10a is rotated by 90°, coupling member 70 is removed from retaining plate 15. In this way, coupling member 70 is attachably and detachably mounted to retaining plate 15.

[0055] In the shell-type transformer according to the second embodiment of the present invention, retaining plate 15 does not need to have a protruding portion. Thus, the shell-type transformer can be reduced in size as compared with shell-type transformer 100 according to the first embodiment. It is to be noted that shaft member 20a and coupling member 70 may be integrally formed.

Third Embodiment

[0056] The following is an explanation about a method of manufacturing a shell-type transformer according to the third embodiment of the present invention. The method of manufacturing a shell-type transformer according to the present embodiment is different from the method of manufacturing a shell-type transformer 100 according to the first embodiment mainly in that the shell-type transformer does not include a retaining plate, and that a coupling member for coupling a shaft member to a holding plate for holding an E-shaped iron core is used. Thus, an explanation will not be given with regard to the same configuration as that in the method of manufacturing a

shell-type transformer 100 according to the first embodiment.

[0057] Fig. 15 is an exploded perspective view showing the state where a coupling member having a shaft member coupled thereto is attached to a holding plate for holding an E-shaped iron core in a method of manufacturing a shell-type transformer according to the third embodiment of the present invention. Fig. 16 is an exploded perspective view showing a portion surrounded by a circle XVI in Fig. 15 in an enlarged manner.

[0058] As shown in Figs. 15 and 16, in a shell-type transformer according to the third embodiment of the present invention, an E-shaped iron core 10a1 does not include a retaining plate. In the step of rotating the E-shaped iron core in the method of manufacturing a shell-type transformer according to the third embodiment of the present invention, E-shaped iron core 10a1 is held by two holding plates 80, each of which is disposed at a corresponding one of both ends in the stacking direction. Two holding plates 80 are fastened with a bolt 81 and a nut 82 and thereby fixed to E-shaped iron core 10a1.

[0059] A coupling member 70a is attached to the position located at protruding portion 15p in the first embodiment. Specifically, two holding plates 80 each have a side surface that is provided with a plurality of screw holes 80s. Coupling member 70a is provided with a plurality of through holes 70ah at positions corresponding to screw holes 80s. Coupling member 70a is provided with a hole 70at into which shaft member 20b is fitted. Bolt 40b is screwed into screw hole 80s while being inserted into through hole 70ah, so that coupling member 70a is attached to two holding plates 80. Shaft member 20b is fitted in hole 70at of coupling member 70a.

[0060] As described above, in the step of rotating the E-shaped iron core in the method of manufacturing a shell-type transformer according to the third embodiment of the present invention, each of two attachable and detachable coupling members 70a for coupling two holding plates 80 is attached to two holding plates 80, and each of two shaft members 20b is coupled to a corresponding one of two coupling members 70a in the one-to-one relation.

[0061] In the step of rotating E-shaped iron core 10a1 in the method of manufacturing a shell-type transformer according to the third embodiment of the present invention, cylindrical shaft members 20b each are coaxially coupled to the position along the side edge of a corresponding one of two leg iron cores 12b as seen in the stacking direction. Then, E-shaped iron core 10a1 is rotated about two shaft members 20b each serving as a rotation axis. As in the first embodiment, E-shaped iron core 10a1 is rotated by 90° in the state where the outer circumferential surface of shaft member 20b and the inner circumferential surface of bearing portion 31 are slidably in contact with each other.

[0062] After E-shaped iron core 10a1 is rotated by 90°, coupling member 70a is removed from two holding plates 80. In this way, coupling member 70a is attachably and

detachably mounted to two holding plates 80. Furthermore, two holding plates 80 are removed from E-shaped iron core 10a1.

[0063] Since the shell-type transformer according to the third embodiment of the present invention does not include a retaining plate, this shell-type transformer can be reduced in size as compared with shell-type transformer 100 according to the first embodiment. In addition, shaft member 20b and coupling member 70a may be integrally formed.

[0064] It is noted that the embodiments disclosed herein are illustrative in every respect, and do not serve as a basis for restrictive interpretation. Therefore, the technical scope of the present invention should not be interpreted by the above embodiments only, and is defined based on the description in the scope of the claims. Further, any modifications within the meaning and scope equivalent to the scope of the claims are encompassed.

REFERENCE SIGNS LIST

[0065] 1 electromagnetic steel plate, 10 E-shaped stacked body, 10a, 10a1 E-shaped iron core, 10b iron core assembly, 11 lower yoke iron core, 12a, 12b leg iron core, 13 upper yoke iron core, 14 pressing plate, 15, 15s retaining plate, 15h, 22, 70ah, 70h through hole, 15p protruding portion, 15s, 80s screw hole, 16 band, 20, 20a, 20b shaft member, 21, 70at, 70t hole, 30 rotation support mount, 31 bearing portion, 40, 40a, 40b, 81 bolt, 41, 82 nut, 50 tank main body, 51 oil path, 52 reinforcement member, 53 cover portion, 60 coil, 70, 70a coupling member, 80 holding plate, 100 shell-type transformer.

Claims

1. A method of manufacturing a shell-type transformer, the method comprising:

stacking a plurality of electromagnetic steel plates and forming an E-shaped stacked body having an E shape as seen in a stacking direction of the plurality of electromagnetic steel plates, the E-shaped stacked body including a lower yoke iron core and three leg iron cores that are vertical to the lower yoke iron core; pressing the E-shaped stacked body for integration from both sides in the stacking direction, and forming an E-shaped iron core; rotating the E-shaped iron core such that the lower yoke iron core is located on a lower side; placing the E-shaped iron core so as to be housed in a tank main body in a state where the lower yoke iron core is located on the lower side; installing a coil in the E-shaped iron core inside the tank main body such that a leg iron core located at a middle position among the three leg iron cores is inserted through the coil;

- installing an upper yoke iron core in the E-shaped iron core having the coil installed therein, and forming an iron core assembly; and attaching a cover portion to the tank main body to form a tank, and placing the iron core assembly and the coil so as to be enclosed in the tank.
2. The method of manufacturing a shell-type transformer according to claim 1, wherein in the rotating the E-shaped iron core,
- two shaft members cylindrically formed each are coaxially coupled to a position along a side edge of a corresponding one of two leg iron cores on both sides among the three leg iron cores as seen in the stacking direction, and the E-shaped iron core is rotated about the two shaft members each serving as a rotation axis.
3. The method of manufacturing a shell-type transformer according to claim 2, wherein the E-shaped iron core includes a retaining plate made of a nonmagnetic material and disposed at a middle position in the stacking direction, the retaining plate has two protruding portions attachably and detachably coupled to the two shaft members, and in the rotating the E-shaped iron core, each of the two shaft members is coupled to a corresponding one of the two protruding portions in a one-to-one relation.
4. The method of manufacturing a shell-type transformer according to claim 2, wherein the E-shaped iron core includes a retaining plate made of a nonmagnetic material and disposed at a middle position in the stacking direction, in the rotating the E-shaped iron core,
- two coupling members configured to be attachable and detachable are mounted to the retaining plate, and each of the two shaft members is coupled to a corresponding one of the two coupling members in a one-to-one relation.
5. The method of manufacturing a shell-type transformer according to any one of claims 1 to 4, wherein in the forming an E-shaped iron core, the E-shaped stacked body is pressed with a band for integration.
6. The method of manufacturing a shell-type transformer according to claim 2, wherein in the rotating the E-shaped iron core,
- the E-shaped iron core is held by two holding plates, each of which is disposed at a corresponding one of both ends in the stacking direction,
- two coupling members configured to be attachable and detachable for coupling the two holding plates are attached to the two holding plates, and each of the two shaft members is coupled to a corresponding one of the two coupling members in a one-to-one relation.
7. The method of manufacturing a shell-type transformer according to claim 6, wherein the two holding plates are fastened with a fastening member so as to be fixed to the E-shaped stacked body.
8. A shell-type transformer comprising:
- a tank;
- an iron core assembly including a lower yoke iron core, an upper yoke iron core and three leg iron cores that are formed by a plurality of electromagnetic steel plates stacked on one another and that are connected to one another, the iron core assembly being enclosed in the tank; and a coil enclosed in the tank and disposed such that a leg iron core located at a middle position among the three leg iron cores is inserted through the coil, wherein the tank is formed of
- a tank main body in which the iron core assembly is housed, and a cover portion attached to the tank main body.
9. The shell-type transformer according to claim 8, wherein the iron core assembly includes a retaining plate made of a nonmagnetic material and disposed at a middle position in a stacking direction of the plurality of electromagnetic steel plates.
10. The shell-type transformer according to claim 9, wherein the retaining plate includes at least one protruding portion at a position along a side edge of each of two leg iron cores on both sides among the three leg iron cores as seen in the stacking direction.
11. The shell-type transformer according to any one of claims 8 to 10, wherein the iron core assembly includes a band for binding each of the lower yoke iron core and the three leg iron cores.

FIG.1

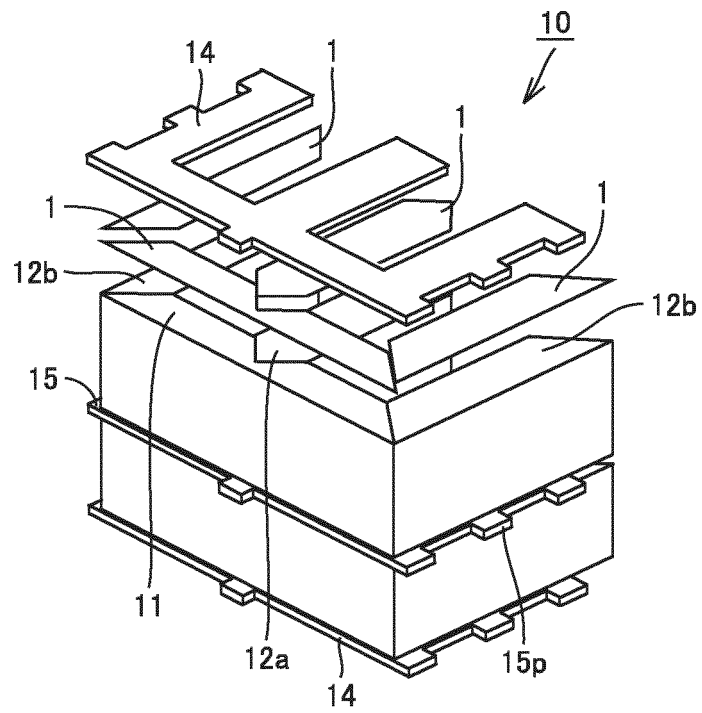


FIG.2

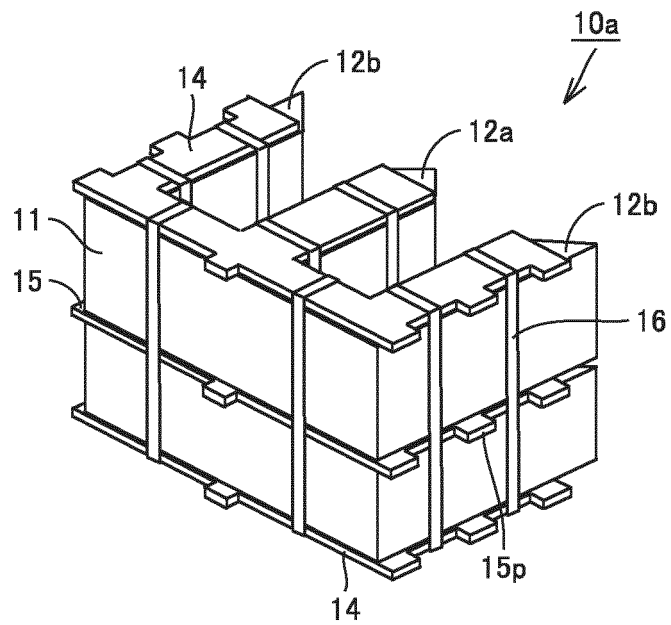


FIG.3

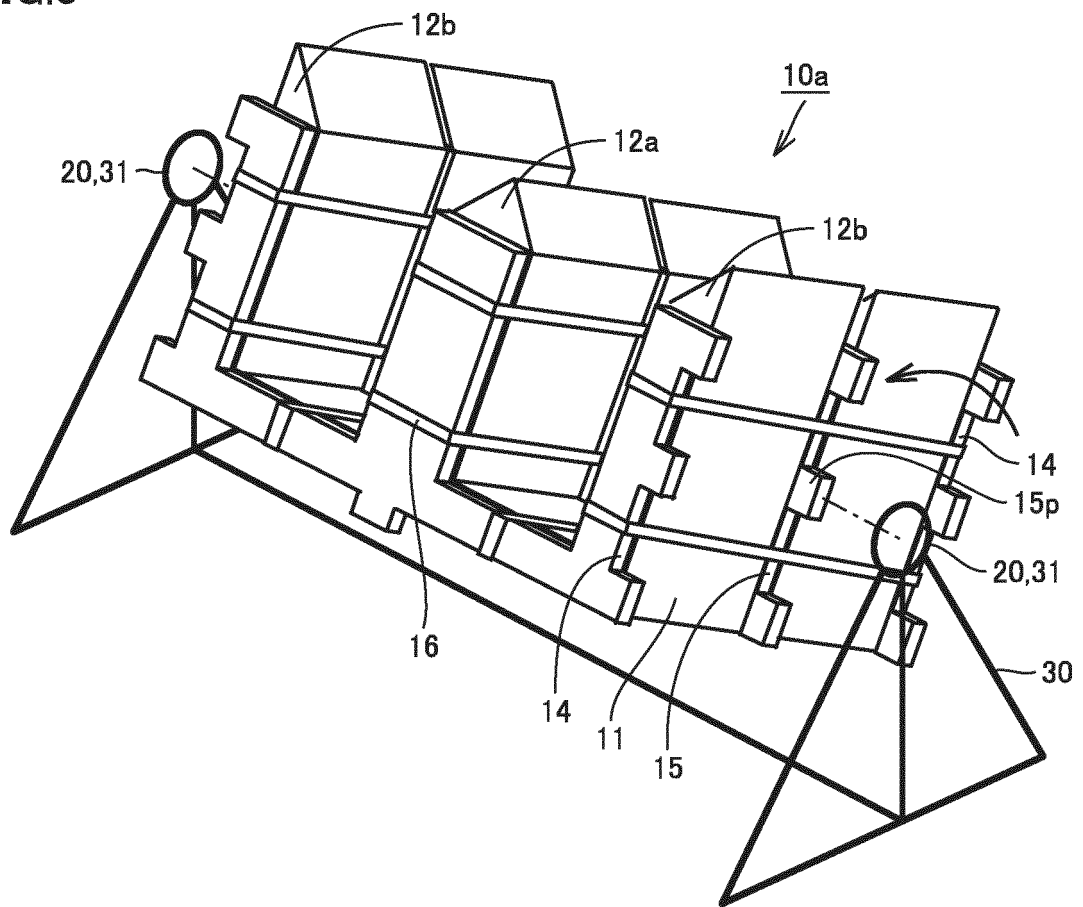


FIG.4

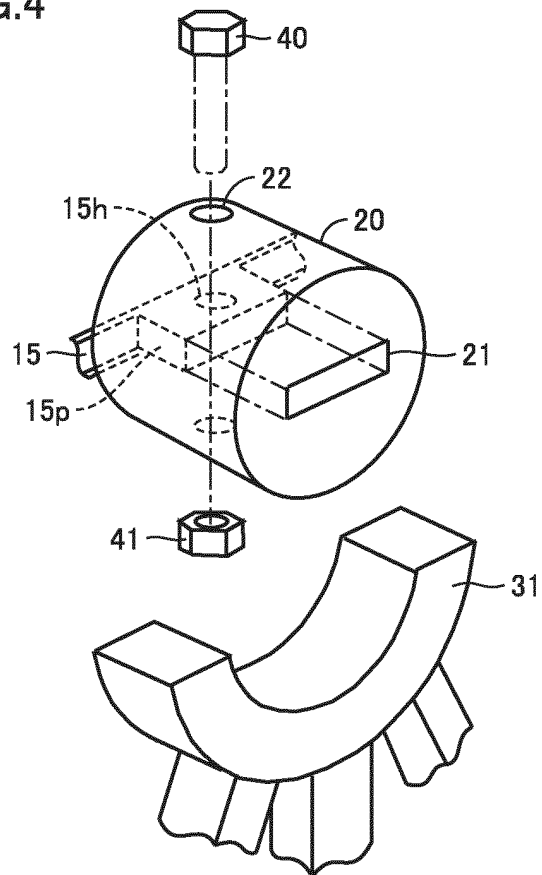


FIG.5

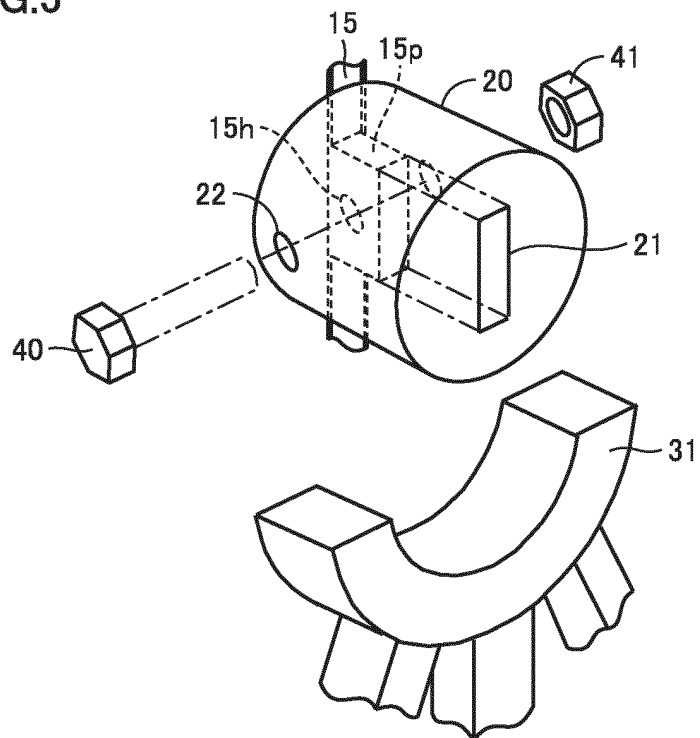


FIG.6

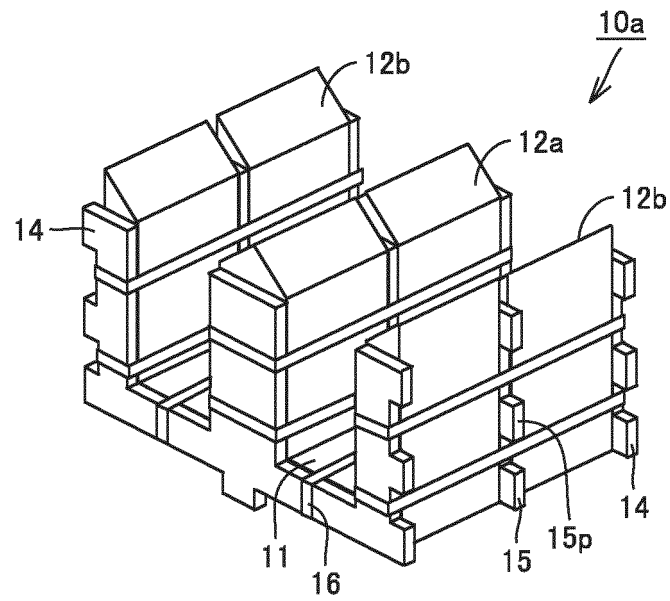


FIG.7

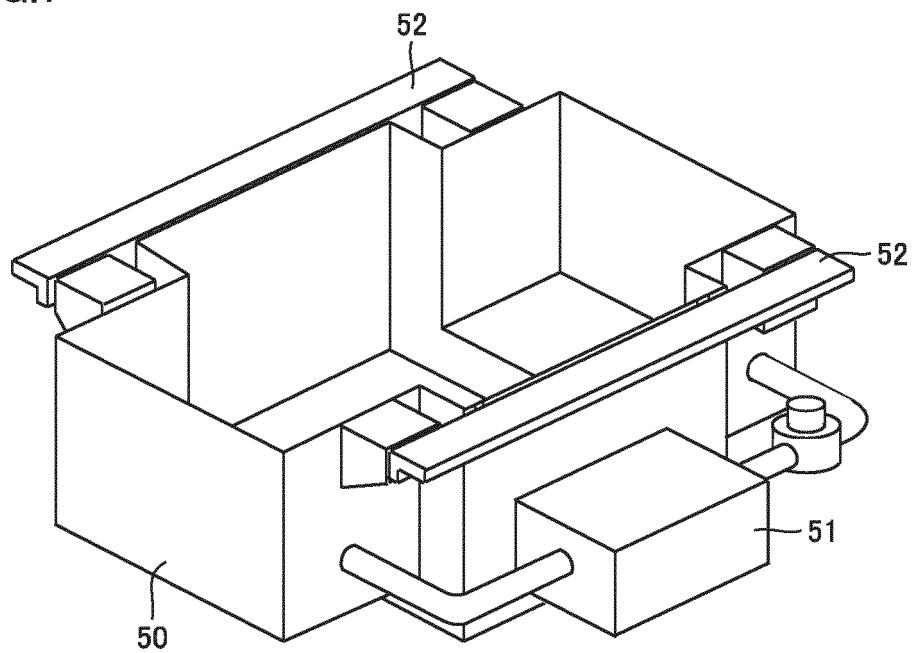


FIG.8

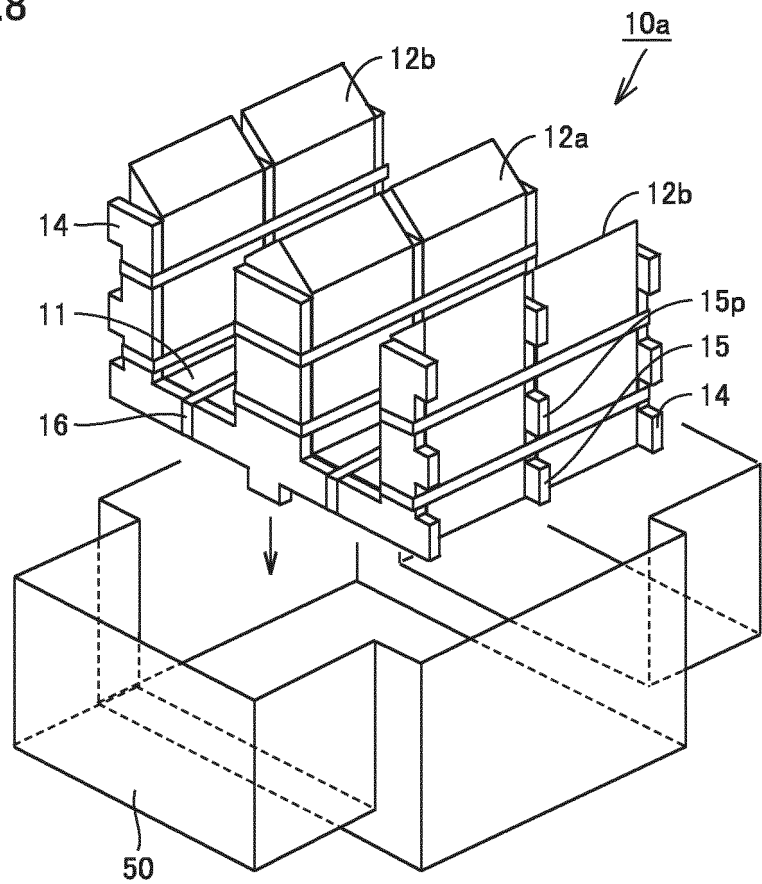


FIG.9

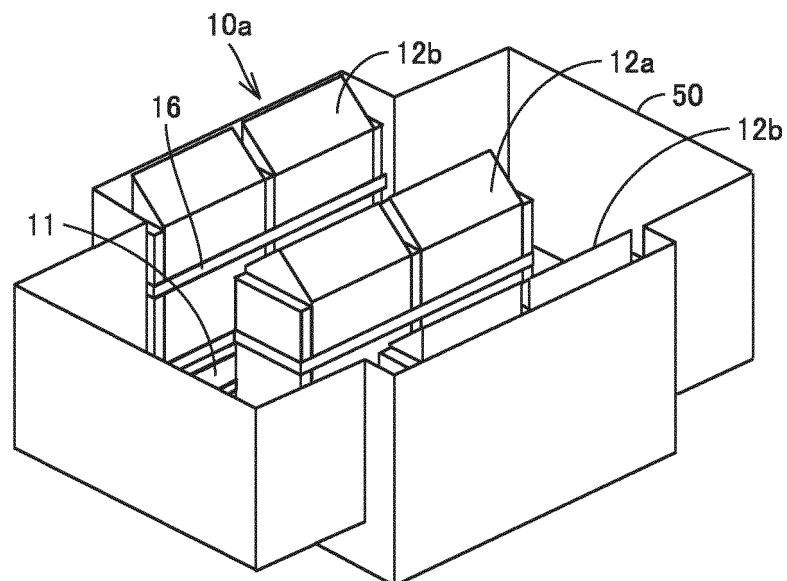


FIG.10

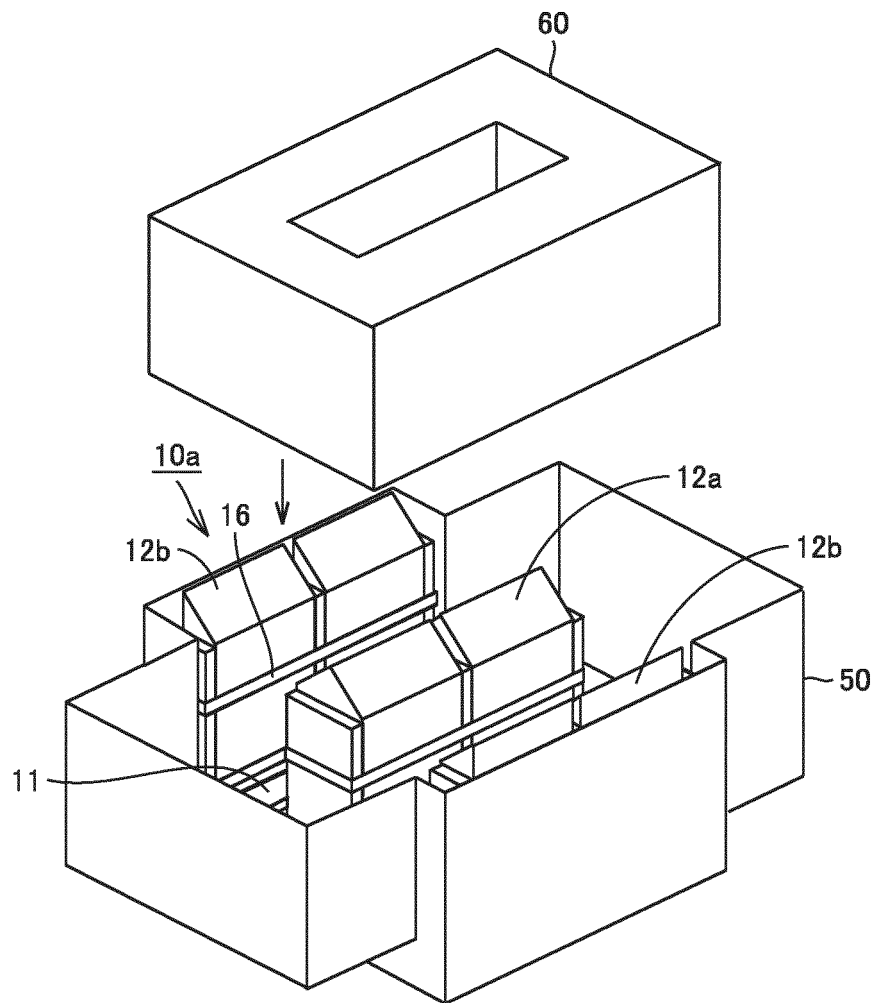


FIG.11

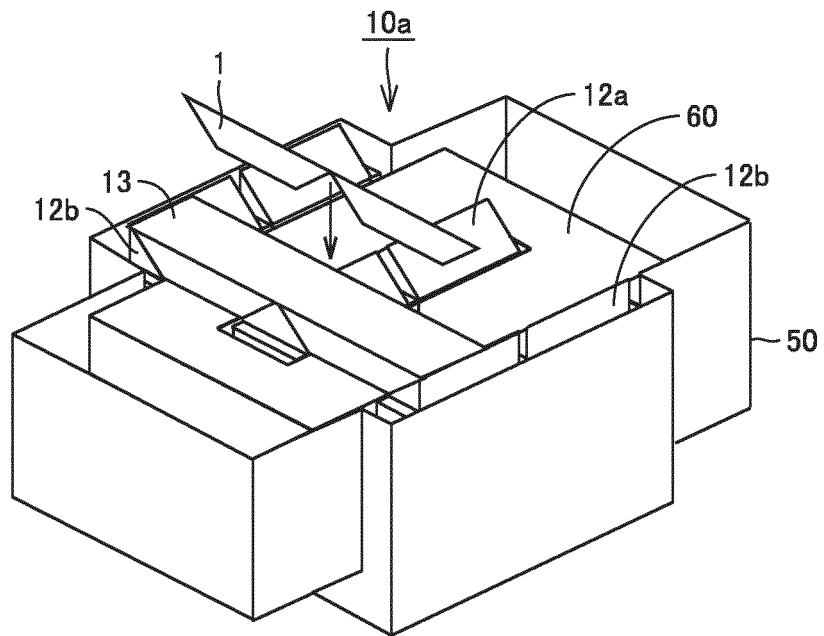


FIG.12

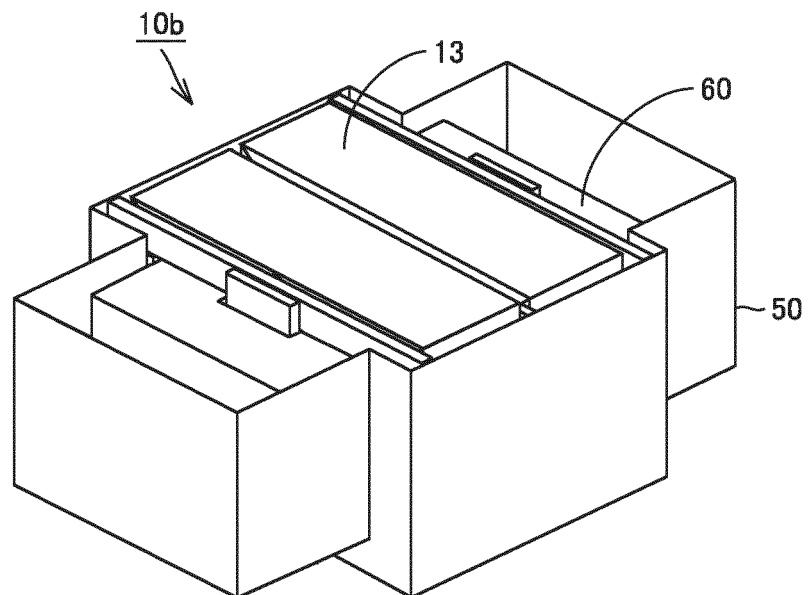


FIG.13

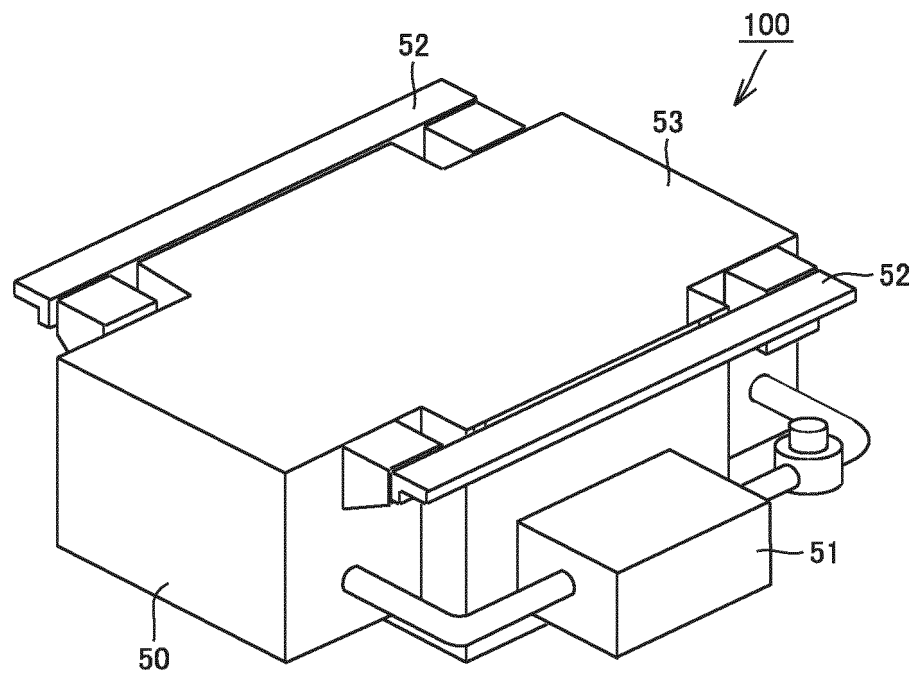


FIG.14

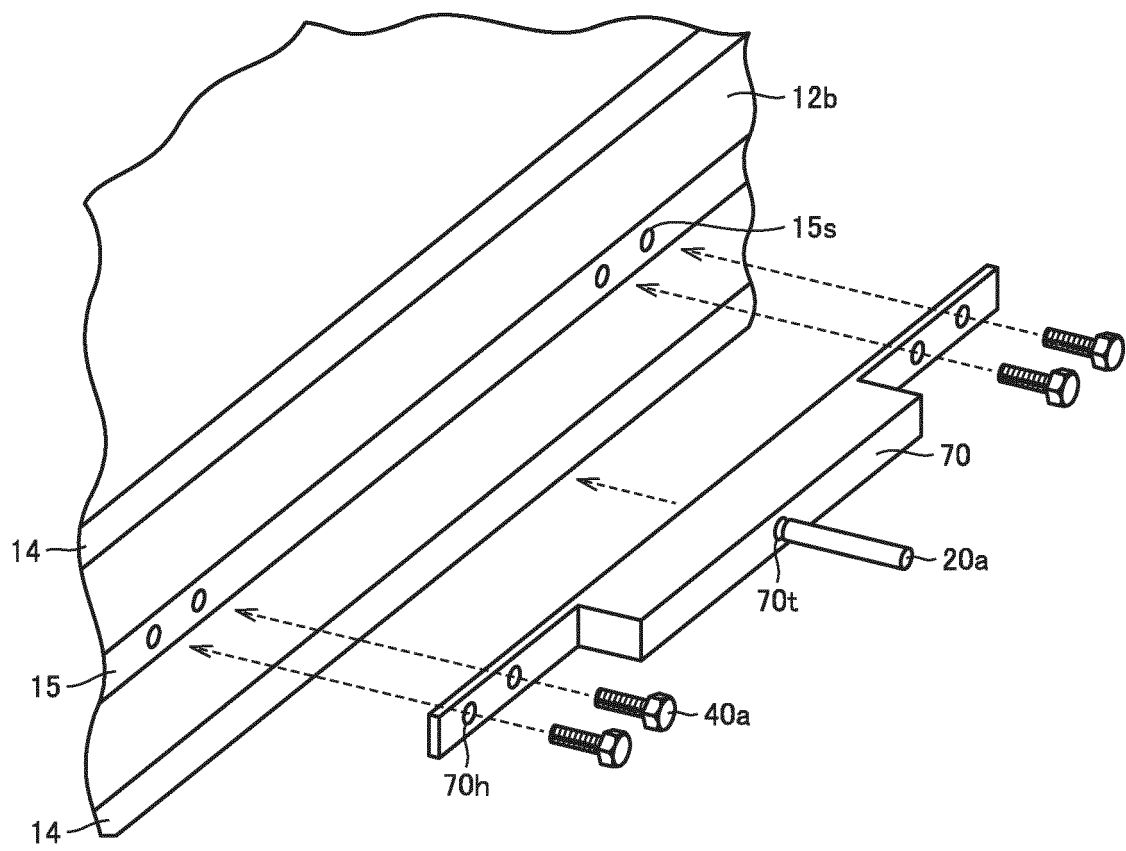


FIG.15

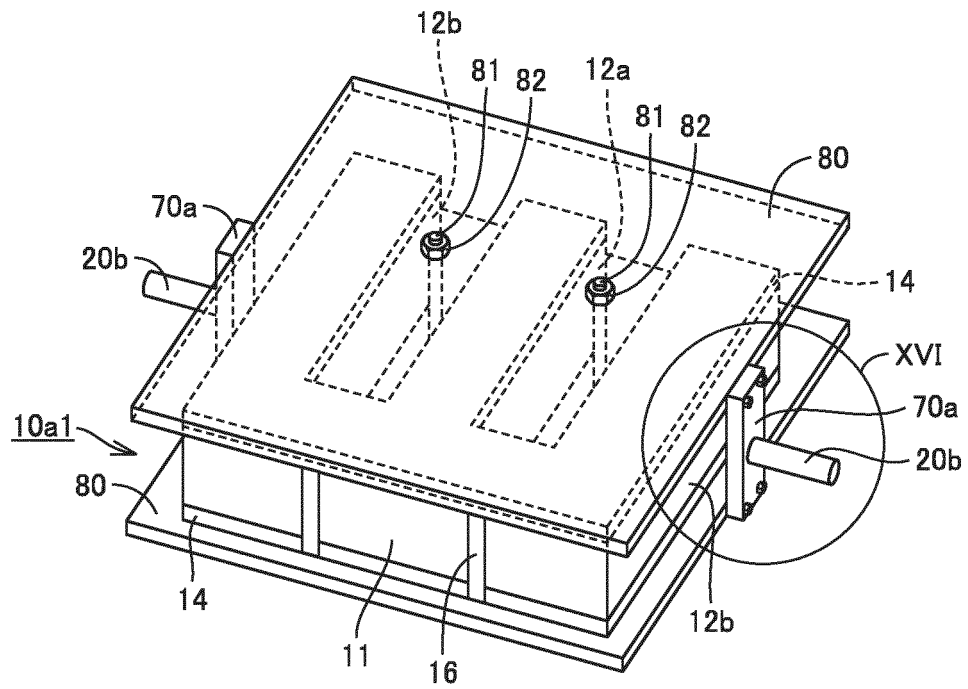
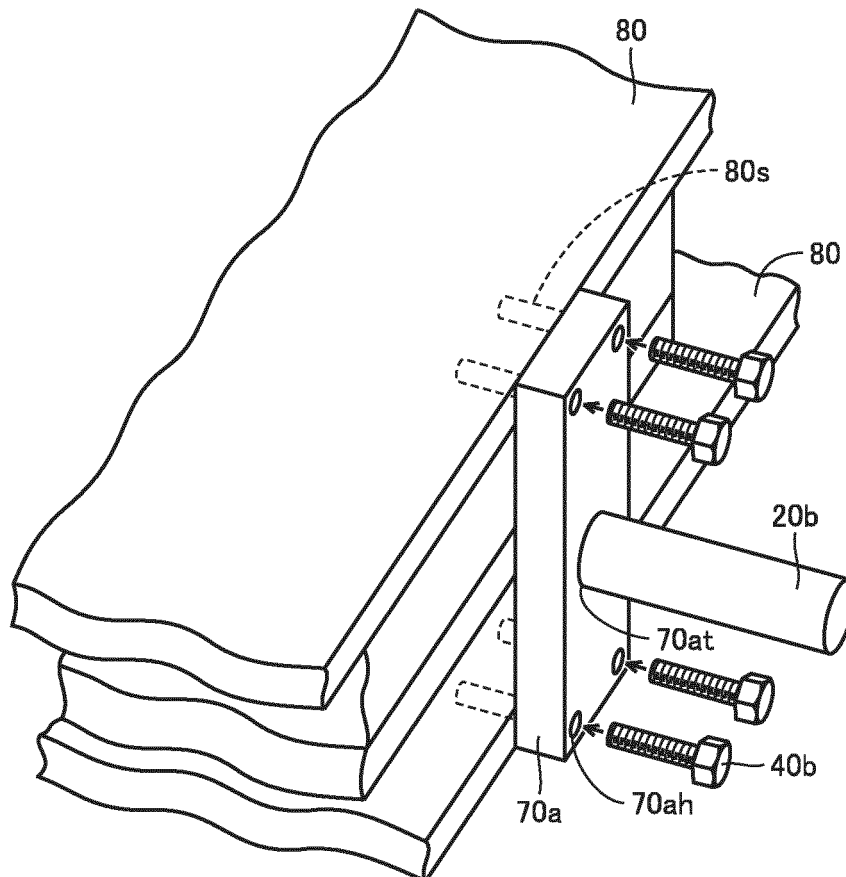


FIG.16



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2017/027969

A. CLASSIFICATION OF SUBJECT MATTER

H01F41/00(2006.01)i, H01F27/02(2006.01)i, H01F27/26(2006.01)i, H01F30/10(2006.01)i, H01F41/02(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H01F41/00, H01F27/02, H01F27/26, H01F30/10, H01F41/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2017

Kokai Jitsuyo Shinan Koho 1971-2017 Toroku Jitsuyo Shinan Koho 1994-2017

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 2003-217957 A (Hitachi, Ltd.), 31 July 2003 (31.07.2003), paragraphs [0011] to [0058]; fig. 1 to 6 (Family: none)	1, 5 2-4, 6-11
X Y A	JP 52-38120 A (Hitachi, Ltd.), 24 March 1977 (24.03.1977), page 2, lower right column, line 3 to page 3, lower left column, line 16; fig. 2 (Family: none)	8, 11 1, 5 2-4, 6-7, 9-10
A	WO 2009/031286 A1 (Toshiba Corp.), 12 March 2009 (12.03.2009), & JP 2009-64936 A & US 2010/0154202 A1 & KR 10-2010-0044249 A & CN 101809685 A & BR PI0816727 A	1-11

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

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Date of the actual completion of the international search
03 October 2017 (03.10.17)Date of mailing of the international search report
24 October 2017 (24.10.17)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

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Patent documents cited in the description

- JP 59181521 A [0002] [0004]