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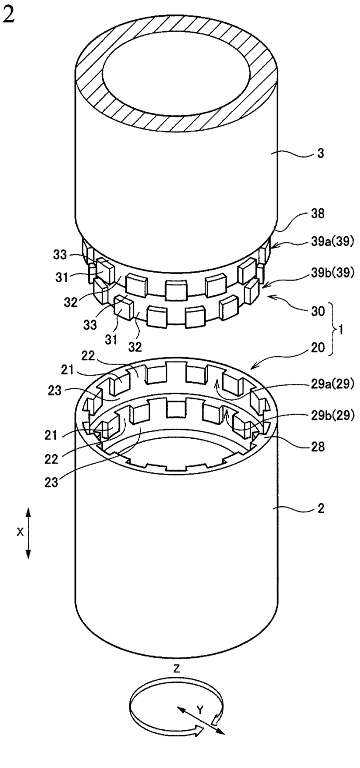
(54) **JOINT STRUCTURE FOR STEEL-PIPE PILE, AND STEEL-PIPE PILE**

(57) A joint structure of a steel-pipe pile which connects a first steel-pipe pile and a second steel-pipe pile in series, includes an external fitting end portion which is an opening end of the first steel-pipe pile and a column shaped internal fitting end portion which configures a portion inserted into the external fitting end portion on one end of the second steel-pipe pile. The external fitting end portion includes a plurality of external fitting convex portions which protrude from an inner circumferential surface thereof toward an inner side in a radial direction; an external fitting groove portion which is formed between the external fitting convex portions; and an external fitting engagement groove which is formed at a position of the inner side in the axial direction from the external fitting convex portion and the external fitting groove portion. The internal fitting end portion includes a plurality of internal fitting convex portions which protrude from an outer circumferential surface thereof toward an outer side in a radial direction.

FIG. 2



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Description

[Technical Field of the Invention]

[0001] The present invention relates to a joint structure of a steel-pipe pile for fitting together an external fitting end portion and an internal fitting end portion capable of being fitted to each other, at a work site, and for connecting an upper steel-pipe pile and a lower steel-pipe pile in an axial direction, and to a steel-pipe pile using the joint structure. More particularly, the present invention relates to a joint structure of a steel-pipe pile and a steel-pipe pile which are used in civil engineering and construction fields of, for example, building foundations and bridge foundations.

[0002] Priority is claimed on Japanese Patent Application No. 2012-255304, filed on November 21,2012, the content of which is incorporated herein by reference.

[Related Art]

[0003] In the related art, an object of a joint structure of a steel-pipe pile is to connect an upper steel-pipe pile and a lower steel-pipe pile in an axial direction, the joint structure of a steel-pipe pile is roughly classified into a screw-type, a key type, and a gear-type, and joint structures of a steel-pipe pile disclosed in Patent Documents 1 to 3 are suggested.

[0004] In the joint structure of a steel-pipe pile disclosed in Patent Document 1, a screw-type joint structure of a steel-pipe pile is used, a male thread portion is formed on an end portion of one steel-pipe pile, and a female thread portion is formed on an end portion of the other steel-pipe pile. In the joint structure of a steel-pipe pile disclosed in Patent Document 1, for example, a lower steel-pipe pile in which the female thread portion is formed on the end portion is buried under the ground, the male thread portion formed on an end portion of an upper steel-pipe pile is screwed to the female thread portion of the lower steel-pipe pile, and thus, the upper steel-pipe pile and the lower steel-pipe pile are connected together in an axial direction.

[0005] In the joint structure of a steel-pipe pile disclosed in Patent Document 2, a key type joint structure of a steel-pipe pile is used, a key member is assembled to an inward groove portion of a female side end portion of a steel-pipe pile in advance, and after a male side end portion of the steel-pipe pile is inserted into the female side end portion of the steel-pipe pile, the key member is pushed into a center side of the steel-pipe pile, and thus, the male side end portion of the steel-pipe pile and the female side end portion of the steel-pipe pile engage with each other.

[0006] In the joint structure of a steel-pipe pile disclosed in Patent Document 3, a gear-type joint structure of a steel-pipe pile is used, and although this joint structure is based on the screw type, the problems of a screw-type joint structure of a steel-pipe pile are solved. In the joint structure of a steel-pipe pile disclosed in Patent Document 3, a plurality of outward engagement convex portions are provided along an axial direction in a male side end portion of a steel-pipe pile, and a plurality of inward engagement convex portions are provided along the axial direction in a female side end portion of the steel-pipe pile. In the joint structure of a steel-pipe pile disclosed in Patent Document 3, the male side end portion and the female side end portion of the steel-pipe pile are fitted together, the steel-pipe pile is relatively rotated so that the outward engagement convex portion and the inward engagement convex portion mesh with each other, and thus, an upper steel-pipe pile and a lower steel-pipe pile are connected together in the axial direction.

[0007] In the joint structure of a steel-pipe pile disclosed in Patent Document 3, the outward engagement convex portion and the inward engagement convex portion mesh with each other. Accordingly, when a bending load or a tension load is applied to a joint portion of the steel-pipe pile, the outward engagement convex portion and the inward engagement convex portion come into contact with each other, and thus, the loads are transmitted to a main body of the steel-pipe pile. It is necessary to set a contact area between the outward engagement convex portion and the inward engagement convex portion or an attachment area of the engagement convex portion with respect to the end portion of the steel-pipe pile to sufficiently withstand the bearing strength or shear strength used to transmit the loads. In addition, it is also necessary to set a thickness of the end portion of the steel-pipe pile to sufficiently withstand the loads transmitted from the engagement convex portions.

[Citation List]

[Patent Document]

[0008] [Patent Document 1] Japanese Unexamined Patent Application, First Publication No. H07-82738 (Page 7 and FIG. 2)

[Patent Document 2] Japanese Unexamined Patent Application, First Publication No. 2000-257058 (Page 10 and FIG. 6)

[Patent Document 3] Japanese Unexamined Patent Application, First Publication No. H11-43937 (Page 6 and FIG. 1)

[Summary of the Invention]

[Problems to be Solved by the Invention]

[0009] However, in the screw-type joint structure of a steel-pipe pile disclosed in Patent Document 1, when the male thread portion of the upper steel-pipe pile is screwed to the female thread portion of the lower steel-pipe pile, it is necessary to rotate the upper steel-pipe pile a predetermined rotation number of times at a work site. Accordingly, there is a problem that labor for the rotation increases and construction costs increase. In the key type joint structure of a steel-pipe pile disclosed in Patent Document 2, although the labor for rotating the steel-pipe pile in the screw-type joint structure of a steel-pipe pile can be omitted, the key member is separately required, and complicated machining is required in which the inward groove portion is formed on the female side end portion of the steel-pipe pile and the key member is assembled in advance. Accordingly, there is a problem that machining costs increase and the cost of materials in a joint portion of the steel-pipe pile also increase to withstand the complicated machining.

[0010] Moreover, in the gear-type joint structure of a steel-pipe pile disclosed in Patent Document 3, when the male side end portion of the steel-pipe pile is inserted into the female side end portion of the steel-pipe pile, a notch portion is provided between engagement convex portions adjacent in the circumferential direction of the steel-pipe pile so that the outward engagement convex portion and the inward engagement convex portion do not interfere with each other. Moreover, the engagement convex portions and the notch portion are provided in a row in the axial direction. Accordingly, in the joint structure of a steel-pipe pile disclosed in Patent Document 3, there are the following problems.

[0011] In the joint structure of a steel-pipe pile disclosed in Patent Document 3, the engagement convex portions are intermittently provided in the circumferential direction of the steel-pipe pile, and thus, are provided in a row in the axial direction. Accordingly, a cross-sectional defect occurs when viewed in the axial direction, and the bending load and the tension load which can be transmitted to the engagement convex portion are decreased by the cross-sectional defect. Therefore, in the joint structure of a steel-pipe pile disclosed in Patent Document 3, in order to withstand a predetermined bending load and tension load, it is necessary to use the engagement convex portion enlarged by the cross-sectional defect when viewed in the axial direction, and it is necessary to increase the number of steps of the engagement convex portion in the axial direction. Accordingly, there is a problem that machining costs and the cost of materials in the joint structure of the steel-pipe pile increase.

[0012] Moreover, in the joint structure of a steel-pipe pile disclosed in Patent Document 3, since the engagement convex portions are provided in a row in the axial direction, the bending load and the tension load transmitted from the engagement convex portion to the main body of the steel-pipe pile cannot be uniform in the circumferential direction of the steel-pipe pile. Accordingly, the bending load and the tension load are concentrated at a predetermined engagement convex portion. Therefore, in the joint structure of a steel-pipe pile disclosed in Patent Document 3, in a design with respect to a plate thickness of the steel-pipe pile, since the plate thickness is set based on the portion at which the bending load and the tension load are concentrated, the plate thickness increases, and thus, there is a problem that the cost of materials of the joint structure increases.

[0013] In addition, in the joint structure of a steel-pipe pile disclosed in Patent Document 3, when the bending load is applied to the steel-pipe pile, the portion in which the engagement convex portions are provided in a row in the axial direction may not be disposed at the portion corresponding to the outermost edge end portion of the steel-pipe pile at which tensile stress becomes maximum. At this time, the bending load is applied to the portion in which the cross-sectional defect is formed, and thus, there is a concern that the steel-pipe pile cannot withstand the bending load and the joint portion of the steel-pipe pile may be damaged. Accordingly, in the joint structure of a steel-pipe pile disclosed in Patent Document 3, there is a problem that a structural defect occurs.

[0014] Therefore, the present invention is made in consideration of the above-described problems, and an object thereof is to provide a joint structure of a steel-pipe pile and a steel-pipe pile in which an increase in labor for rotation of the steel-pipe pile at a work site is prevented, an excessive increase in a plate thickness of the steel-pipe pile is avoided, and there is no concern of damage even when the bending load is applied.

[Means for Solving the Problem]

[0015] In order to solve the above-described problems, the present invention adopts the following measures.

(1) According to a first aspect of the present invention, there is provided a joint structure of a steel-pipe pile which connects a first steel-pipe pile and a second steel-pipe pile in series, the joint structure including: an external fitting end portion which is an opening end of the first steel-pipe pile; and a column shaped internal fitting end portion which configures a portion inserted into the external fitting end portion on one end of the second steel-pipe pile, in which the external fitting end portion includes a plurality of external fitting convex portions which protrude from an inner circumferential surface of the external fitting end portion toward an inner side in a radial direction of the first steel-pipe pile, and are provided along a circumferential direction of the first steel-pipe pile; an external fitting groove portion which is formed between the external fitting convex portions adjacent to each other in the circumferential direction of the first steel-pipe pile; and an external fitting engagement groove which is formed along the circumferential direction at a position of an inner side in an axial direction of the first steel-pipe pile from the external fitting convex portion and the external fitting groove portion on the inner circumferential surface, the internal fitting end portion includes a plurality of internal fitting convex portions which protrude from an outer circumferential surface of the internal fitting end portion toward an outer side in a radial direction of the second steel-pipe pile, and are provided along a cir-

cumferential direction of the second steel-pipe pile, each of the internal fitting convex portions engages with each of the external fitting convex portions in the external fitting engagement groove after the internal fitting end portion is inserted into the external fitting end portion and the first steel-pipe pile and the second steel-pipe pile are relatively rotated around an axis of the first steel-pipe pile, the external fitting convex portions and the external fitting groove portions are formed into a plurality of rows along the axial direction of the first steel-pipe pile, and in at least one set of two rows adjacent to each other among the plurality of rows adjacent to one another, the external fitting convex portions of one row and the external fitting groove portions of the other row are provided to be adjacent in the radial direction of the first steel-pipe pile when viewed in the axial direction of the first steel-pipe pile.

(2) In the aspect according to the above (1), the external fitting end portion may include a plurality of step portions formed along the axial direction of the first steel-pipe pile, the external fitting convex portions and the external fitting groove portions by at least one row may be provided in each of the plurality of step portions, and in two step portions adjacent to each other, the external fitting convex portions of one step portion and the external fitting groove portions of the other step portion may be provided to be adjacent in the radial direction of the first steel-pipe pile when viewed in the axial direction of the first steel-pipe pile.

(3) In the aspect according to the above (2), in the two step portions adjacent to each other, the external fitting convex portions of the one step portion may be provided at all positions adjacent to the external fitting groove portions of the other step portion in the radial direction of the first steel-pipe pile when viewed in the axial direction of the first steel-pipe pile, and the external fitting convex portions may be provided without gaps along the circumferential direction of the first steel-pipe pile when viewed in the axial direction of the first steel-pipe pile.

(4) In the aspect according to the above (2) or (3), the first steel-pipe pile may be thickened in stages along the axial direction of the first steel-pipe pile, and the plurality of step portions adjacent to one another in the axial direction of the first steel-pipe pile may be formed so that the external fitting convex portions of the step portion positioned at an outer side in the axial direction of the first steel-pipe pile and the external fitting groove portions of the step portion positioned at the inner side in the axial direction of the first steel-pipe pile all have approximately the same thickness.

(5) In the aspect according to any one of the above (1) to (4), the internal fitting end portion may include an internal fitting edge which forms a gap between a tip portion of the external fitting end portion and the internal fitting end portion at the inner side in the axial direction of the second steel-pipe pile in a state where the internal fitting end portion is inserted into the external fitting end portion, the external fitting convex portion may include a first tapered portion which is inclined along the circumferential direction of the first steel-pipe pile on an end surface in the inner side in the axial direction of the first steel-pipe pile so that a height in the axial direction of the first steel-pipe pile is approximately the same as a height of the gap, the external fitting engagement groove may include a second tapered portion which is inclined in the circumferential direction of the first steel-pipe pile to be approximately parallel with the first tapered portion at a portion facing the first tapered portion in the axial direction of the first steel-pipe pile, the internal fitting convex portion may include a third tapered portion which is inclined along the circumferential direction of the second steel-pipe pile to abut the first tapered portion on an end surface in the inner side in the axial direction of the second steel-pipe pile, and a fourth tapered portion which is inclined along the circumferential direction of the second steel-pipe pile to abut the second tapered portion on an end surface in the outer side in the axial direction of the second steel-pipe pile, and the first steel-pipe pile and the second steel-pipe pile may relatively rotate around the axis of the first steel-pipe pile, the first tapered portion and the third tapered portion may abut each other, the second tapered portion and the fourth tapered portion may abut each other, the plurality of external fitting convex portions and the plurality of internal fitting convex portions may engage with each other, the internal fitting edge and the tip portion may abut each other to fill the gap, and the external fitting end portion and the internal fitting end portion may be fitted together.

(6) According to a second aspect of the present invention, there is provided a steel-pipe pile including the joint structure of a steel-pipe pile according to any one of the above (1) to (5).

[Effects of the Invention]

[0016] According to the aspects of the above (1) to (6), in at least one set of two rows among the plurality of rows adjacent to one another in the axial direction of the steel-pipe pile, since the external fitting convex portions of the one row and the external fitting groove portions of the other row are provided to be adjacent to each other in the radial direction of the steel-pipe pile when viewed in the axial direction of the steel-pipe pile, a cross-sectional defect does not occur when viewed in the axial direction, and the lower steel-pipe pile and the upper steel-pipe pile can be connected together. Accordingly, in order to withstand a predetermined bending load and tension load, it is not necessary to enlarge the external fitting convex portions and the internal fitting convex portions by the cross-sectional defects, and it is not necessary to increase the number of steps in the external fitting step portion and the internal fitting step portion beyond the number necessary to do something, and thus, it is possible to avoid a case where a machining coat or the cost of materials of the joint structure of a steel-pipe pile is increased.

[0017] Moreover, according to the aspects of the above (1) to (6), in at least one set of two rows among the plurality of rows adjacent to one another in the axial direction of the steel-pipe pile, since the external fitting convex portions of the one row and the external fitting groove portions of the other row are provided to be adjacent to each other in the radial direction of the steel-pipe pile when viewed in the axial direction of the steel-pipe pile, the bending load and the tension load applied to the external fitting convex portion and the internal fitting convex portion can be uniform in the circumferential direction. Accordingly, the loads transmitted from the external fitting convex portions and the internal fitting convex portions to a main body of the steel-pipe pile can be uniform in the circumferential direction, and an increase in a plate thickness of the steel-pipe pile can be avoided. Therefore, it is possible to avoid a case where the cost of materials of the joint structure is increased.

[0018] According to the aspects of the above (1) to (6), in at least one set of two rows among the plurality of rows adjacent to one another in the axial direction of the steel-pipe pile, since the external fitting convex portions of the one row and the external fitting groove portions of the other row are provided to be adjacent to each other in the radial direction of the steel-pipe pile when viewed in the axial direction of the steel-pipe pile, even when the bending load is applied to a portion at which the lower steel-pipe pile and the upper steel-pipe pile are connected together, any external fitting convex portion of the plurality of rows and any internal fitting convex portion of the plurality of rows can be accurately disposed on a portion corresponding to the outermost edge end portion of the steel-pipe pile at which tensile stress becomes the maximum. Accordingly, the bending load can be accurately applied to any external fitting convex portion and any internal fitting convex portion, and it is possible to avoid a case where the external fitting end portion and the internal fitting end portion are damaged.

[0019] Particularly, according to the aspect of the above (2), in two step portions adjacent to each other in the axial direction of the steel-pipe pile, since the external fitting convex portions of the one step portion and the external fitting groove portions of the other step portion are provided to be adjacent to each other in the radial direction of the steel-pipe pile when viewed in the axial direction of the steel-pipe pile, the upper steel-pipe pile can be inserted into the lower steel-pipe pile while the external fitting convex portions and the internal fitting convex portions do not interfere with each other.

[0020] Particularly, according to the aspect of the above (3), since the external fitting convex portions provided in each of the plurality of step portions are formed to fill gaps along the circumferential direction when viewed in the axial direction of the steel-pipe pile, contact areas between the external fitting convex portions and the internal fitting convex portions are maximized, and load bearing capacity with respect to the tensile load and the bending load can be increased.

[0021] Particularly, according to the aspect of the above (4), the plate thickness of the steel-pipe pile is thickened in stages along the axial direction from the outer side (upper side) in the axial direction of the lower steel-pipe pile toward the inner side (lower side) in the axial direction, and from the outer side (lower side) in the axial direction of the upper steel-pipe pile toward the inner side (upper side) in the axial direction, and thus, a plurality of step portions are formed. Accordingly, a structure in which the plate thickness of the steel-pipe pile is increased in stages according to the number of steps of the external fitting convex portions and the internal fitting convex portions in the axial direction can be easily realized.

[0022] Particularly, according to the aspect of the above (5), in the state where the external fitting convex portions and the internal fitting convex portions engage with each other in the axial direction, the tip portion of the external fitting end portion and the internal fitting edge of the internal fitting end portion abut each other, and thus, complete fitting between the external fitting end portion and the internal fitting end portion can be visually confirmed from the outside. In addition, the third tapered portion abuts the first tapered portion, the fourth tapered portion abuts the second tapered portion, and thus, the internal fitting convex portion can smoothly move in the circumferential direction on the external fitting engagement groove, and the external fitting end portion and the internal fitting end portion can be easily fitted together. Moreover, since the internal fitting convex portion is locked by the locking portion formed on the external fitting engagement groove, an excessive rotation of the steel-pipe pile can be prevented.

[Brief Description of the Drawings]

[0023]

FIG. 1 is a perspective view showing a state where steel-pipe piles are connected together using a joint structure of a steel-pipe pile according to a first embodiment of the present invention.

FIG. 2 is a perspective view showing the joint structure of a steel-pipe pile according to the first embodiment of the present invention.

FIG. 3 is a partially cutaway side view showing an external fitting end portion according to the first embodiment of the present invention.

FIG. 4A is a plan view showing the external fitting end portion according to the first embodiment of the present invention.

FIG. 4B is a plan view showing a modification of the external fitting end portion.

FIG. 5 is an enlarged front view showing an external fitting convex portion, an external fitting groove portion, and an external fitting engagement groove.

FIG. 6 is a view taken along line A-A of FIG. 5 and showing the external fitting convex portion, the external fitting groove portion, and the external fitting engagement groove.

FIG. 7 is a side view showing an internal fitting end portion according to the first embodiment of the present invention.

FIG. 8A is a plan view showing the internal fitting end portion according to the first embodiment of the present invention.

FIG. 8B is a plan view showing a modification of the internal fitting end portion.

FIG. 9 is an enlarged front view showing an internal fitting convex portion, an internal fitting groove portion, and an internal fitting engagement groove.

FIG. 10 is a view taken along line B-B of FIG. 9 and showing the internal fitting convex portion, the internal fitting groove portion, and the internal fitting engagement groove.

FIG. 11 is a perspective view showing a state where the internal fitting end portion is inserted into the external fitting end portion in the first embodiment of the present invention.

FIG. 12 is a partial cross-sectional perspective view showing a state where the internal fitting end portion is inserted into the external fitting end portion in the first embodiment of the present invention.

FIG. 13 is an enlarged perspective view showing a state where the internal fitting convex portion passes through the external fitting groove portion in the first embodiment of the present invention.

FIG. 14A is an enlarged front view showing the state where the internal fitting convex portion passes through the external fitting groove portion in the first embodiment of the present invention.

FIG. 14B is an enlarged view which shows a portion indicated by a two-dot chain line of FIG. 14A and shows a modification of the external fitting convex portion.

FIG. 15 is a perspective view showing a state where an upper steel-pipe pile relatively rotates in the first embodiment of the present invention.

FIG. 16 is an enlarged perspective view showing a state where the external fitting convex portion and the internal fitting convex portion engage with each other in the first embodiment of the present invention.

FIG. 17 is an enlarged front view showing a state where the external fitting convex portion and the internal fitting convex portion engage with each other in the first embodiment of the present invention.

FIG. 18 is a perspective view showing a modified shape of the joint structure of the steel-pipe pile according to the first embodiment of the present invention.

FIG. 19 is a perspective view showing a modified shape of the joint structure of the steel-pipe pile according to the first embodiment of the present invention, which is different from FIG. 18.

FIG. 20 is a perspective view showing a joint structure of a steel-pipe pile according to a second embodiment of the present invention.

FIG. 21A is a plan view showing an external fitting end portion in the second embodiment of the present invention.

FIG. 21B is a plan view showing a modification of the external fitting end portion.

FIG. 22A is a plan view showing an internal fitting end portion in the second embodiment of the present invention.

FIG. 22B is a plan view showing a modification of the internal fitting end portion.

FIG. 23 is an enlarged perspective view showing a state where an internal fitting convex portion passes through an external fitting groove portion in the second embodiment of the present invention.

FIG. 24 is an enlarged front view showing a state where the internal fitting convex portion passes through the external fitting groove portion in the second embodiment of the present invention.

FIG. 25 is a perspective view showing a state where the upper steel-pipe pile relatively rotates in the second embodiment of the present invention.

FIG. 26 is an enlarged perspective view showing a state where the external fitting convex portion and the internal fitting convex portion engage with each other in the second embodiment of the present invention.

FIG. 27 is an enlarged front view showing a state where the external fitting convex portion and the internal fitting convex portion engage with each other in the second embodiment of the present invention.

[Embodiments of the Invention]

[0024] Hereinafter, embodiments of the present invention will be described in detail with reference to the drawings.

(First Embodiment)

[0025] First, a joint structure of a steel-pipe pile according to a first embodiment of the present invention will be described with reference to FIGS. 1 and 2. As shown in FIG. 1, the joint structure 1 of a steel-pipe pile according to the first embodiment is used to connect (join) a lower steel-pipe pile 2 (first steel-pipe pile) and an upper steel-pipe pile 3 (second steel-pipe pile) along an axial direction X.

[0026] As shown in FIG. 2, the joint structure 1 includes an external fitting end portion 20 provided on an upper end (opening end) of the lower steel-pipe pile 2, and a column shaped internal fitting end portion 30 provided on a lower end (one end) of the upper steel-pipe pile 3. In the joint structure 1, the internal fitting end portion 30 of the upper steel-pipe pile 3 is fitted to the external fitting end portion 20 of the lower steel-pipe pile 2 which is buried under the ground.

[0027] In the joint structure 1 of the first embodiment, two external fitting step portions 29 (29a and 29b) arranged in the axial direction X of the lower steel-pipe pile 2 are provided on the external fitting end portion 20, and two internal fitting step portions 39 (39a and 39b) arranged in the axial direction X of the upper steel-pipe pile 3 are provided on the internal fitting end portion 30.

[0028] As shown in FIG. 3, a tip portion 28 of the external fitting end portion 20 is formed on the external fitting end portion 20. Each external fitting step portion 29 (29a and 29b) includes a plurality of external fitting convex portions 21 which are formed to protrude toward a center side (an inner side in a radial direction) in an axis orthogonal direction Y (a direction (radial direction) orthogonal to the axial direction X: refer to FIG. 1) of the lower steel-pipe pile 2 on an inner wall surface (inner circumferential surface) of the external fitting end portion 20, a plurality of external fitting groove portions 22 which are formed among the plurality of external fitting convex portions 21, and an external fitting engagement groove 23 which is formed on the inner side (lower side) in the axial direction X of the lower steel-pipe pile 2 from the plurality of external fitting convex portions 21 and the plurality of external fitting groove portions 22.

[0029] A plate thickness of the lower steel-pipe pile 2 is thickened in stages in the axial direction X and the external fitting step portion 29 is formed so that the external fitting convex portions 21 of the first external fitting step portion 29a in the outer side (upper side) in the axial direction X of the lower steel-pipe pile 2, and the external fitting groove portions 22 of the second external fitting step portion 29b in the inner side (lower side) in the axial direction X of the lower steel-pipe pile 2 have approximately the same thickness in the axis orthogonal direction Y of the lower steel-pipe pile 2. The external fitting convex portion 21 of the first external fitting step portion 29a has a thickness having a predetermined width t1 in the axis orthogonal direction Y on the outer side (upper side) in the axial direction X of the lower steel-pipe pile 2.

[0030] In each external fitting step portion 29 (29a and 29b), the external fitting convex portion 21 is formed to protrude in an approximately rectangular shape in the axis orthogonal direction Y of the lower steel-pipe pile 2. In each external fitting step portion 29 (29a and 29b), the external fitting groove portions 22 are formed among the plurality of external fitting convex portions 21, and each external fitting groove portion has a predetermined width in a circumferential direction Z (refer to FIG. 1) of the lower steel-pipe pile 2. In each external fitting step portion 29 (29a and 29b), the external fitting engagement groove 23 is formed on the inner side (lower side) in the axial direction X of the lower steel-pipe pile 2 from the external fitting convex portions 21 and the external fitting groove portions 22, and has a predetermined height in the axial direction X of the lower steel-pipe pile 2 and approximately the same thickness as the external fitting groove portion 22 in the axis orthogonal direction Y.

[0031] The external fitting convex portions 21 are formed on the first external fitting step portion 29a on the outer side (upper side) in the axial direction X of the lower steel-pipe pile 2, and the second external fitting step portion 29b adjacent to the first external fitting step portion 29a on the inner side (lower side) in the axial direction X of the lower steel-pipe pile 2 from the first external fitting step portion 29a. At this time, the external fitting convex portions 21 of the first external fitting step portion 29a and the external fitting convex portions 21 of the second external fitting step portion 29b are formed at positions which deviate in the axial direction X. In other words, the external fitting convex portions 21 of the first external fitting step portion 29a and the external fitting convex portions 21 of the second external fitting step portion 29b are formed at positions different from each other in the axial direction X.

[0032] As shown in FIG. 4A, in the external fitting end portion 20, the external fitting convex portions 21 are formed on the first external fitting step portion 29a, and the external fitting convex portions 21 of the second external fitting step portion 29b are formed at all positions adjacent to the external fitting groove portions 22 formed on the first external fitting step portion 29a in the axis orthogonal direction Y when viewed in the axial direction. Accordingly, the external fitting convex portions 21 of the first external fitting step portion 29a and the external fitting convex portions 21 of the second external fitting step portion 29b are alternately formed without gaps in the circumferential direction Z when viewed in the axial direction.

[0033] In addition, the external fitting convex portions 21 are not limited to the above, and for example, as shown in FIG. 4B, the external fitting convex portions 21 of the second external fitting step portion 29b may be formed at partial positions adjacent to the external fitting groove portions 22 formed on the first external fitting step portion 29a in the axis orthogonal direction Y when viewed in the axial direction. In other words, the external fitting convex portions 21 of the first external fitting step portion 29a and the external fitting convex portions 21 of the second external fitting step portion 29b may be alternately formed with gaps in the circumferential direction Z when viewed in the axial direction.

[0034] As shown in FIGS. 5 and 6, the external fitting convex portion 21 includes a first tapered portion 21a which is linearly inclined in the circumferential direction Z of the lower steel-pipe pile 2 on the lower end surface in the inner side (lower side) in the axial direction X of the lower steel-pipe pile 2. Moreover, the external fitting engagement groove 23 includes a second tapered portion 23 a which is linearly inclined in the circumferential direction Z of the lower steel-pipe pile 2 to be approximately parallel with the first tapered portion 21 a at the portion facing the first tapered portion 21 a in the axial direction X of the lower steel-pipe pile 2. The external fitting engagement groove 23 includes a locking portion 23b extending in the axial direction X at the termination of the second tapered portion 23a.

[0035] The first tapered portion 21 a has a predetermined height h in the axial direction X of the lower steel-pipe pile 2. The second tapered portion 23a extends in a portion facing the first tapered portion 21a in the axial direction X of the lower steel-pipe pile 2 and extends to the entire portion positioned below the external fitting groove portion 22. In addition, the second tapered portion 23a is not limited to the above, and for example, as shown in FIG. 5, the second tapered portion may extend to an intermediate portion 23c positioned below the external fitting groove portion 22. Moreover, as described above, the first tapered portion 21a and the second tapered portion 23a are linearly formed on the external fitting convex portion 21 and the external fitting engagement groove 23. However, the first tapered portion 21a and the second tapered portion 23a may be formed to be inclined in an arc shape on the external fitting convex portion 21 and the external fitting engagement groove 23. In addition, the first tapered portion 21a and the second tapered portion 23a may be separately formed with respect to the external fitting convex portion 21 and the external fitting engagement groove 23.

[0036] In the internal fitting end portion 30, as shown in FIG. 7, an internal fitting edge 38, which is formed to protrude toward the outer side in the axis orthogonal direction Y of the upper steel-pipe pile 3, is formed on the inner side (upper side) in the axial direction X of the upper steel-pipe pile 3 from the two internal fitting step portions 39 (39a and 39b).

[0037] In each internal fitting step portion 39 (39a and 39b), the internal fitting end portion 30 includes a plurality of internal fitting convex portions 31 which are formed to protrude toward the outer side in an axis orthogonal direction Y of the upper steel-pipe pile 3 on an outer wall surface (outer circumferential surface) of the internal fitting end portion 30, a plurality of internal fitting groove portions 32 which are formed among the plurality of internal fitting convex portions 31, and an internal fitting engagement groove 33 which is formed on the inner side (upper side) in the axial direction X of the upper steel-pipe pile 3 from the plurality of internal fitting convex portions 31 and the plurality of internal fitting groove portions 32.

[0038] A plate thickness of the upper steel-pipe pile 3 is thickened in stages in the axial direction X and the internal fitting step portion 39 is formed so that the internal fitting groove portions 32 of the first internal fitting step portion 39a in the inner side (upper side) in the axial direction X of the upper steel-pipe pile 3, and the internal fitting convex portions 31 of the second internal fitting step portion 39b in the outer side (lower side) in the axial direction X of the upper steel-pipe pile 3 have approximately the same thickness in the axis orthogonal direction Y of the upper steel-pipe pile 3. The internal fitting engagement groove 33 of the first internal fitting step portion 39a has a space having a predetermined width t2 in the axis orthogonal direction Y of the upper steel-pipe pile 3.

[0039] In each internal fitting step portion 39 (39a and 39b), the internal fitting convex portion 31 is formed to protrude in an approximately rectangular shape in the axis orthogonal direction Y of the upper steel-pipe pile 3. In each internal fitting step portion 39 (39a and 39b), the internal fitting groove portions 32 are formed among the plurality of internal fitting convex portions 31, and each internal fitting groove portion has a predetermined width in a circumferential direction Z of the upper steel-pipe pile 3. The internal fitting engagement groove 33 is formed on the inner side (upper side) in the axial direction X of the upper steel-pipe pile 3 from the internal fitting convex portions 31 and the internal fitting groove portions 32, and is formed so that the width t2 (refer to FIG. 7) of the space between the internal fitting engagement grooves 33 in the first internal fitting step portion 39a is equal to or more than the width t1 (refer to FIG. 3) of the plate thickness of the external fitting convex portion 21 in the first external fitting step portion 29a. Moreover, in each internal fitting step portion 39, the internal fitting engagement groove 33 has a predetermined height in the axial direction X of the upper steel-pipe pile 3 and approximately the same thickness as the internal fitting groove portion 32 in the axis orthogonal direction Y.

[0040] The internal fitting convex portions 31 are formed on the first internal fitting step portion 39a on the inner side (upper side) in the axial direction X of the upper steel-pipe pile 3, and the second internal fitting step portion 39b adjacent to the first internal fitting step portion 39a on the outer side (lower side) in the axial direction X of the upper steel-pipe pile 3 from the first internal fitting step portion 39a. At this time, the internal fitting convex portions 31 of the first internal fitting step portion 39a and the internal fitting convex portions 31 of the second internal fitting step portion 39b are formed at positions which deviate in the axial direction X. In other words, the internal fitting convex portions 31 of the first internal fitting step portion 39a and the internal fitting convex portions 31 of the second internal fitting step portion 39b are formed at positions different from each other in the axial direction X.

[0041] As shown in FIG. 8A, the internal fitting convex portions 31 of the second internal fitting step portion 39b are formed at all positions adjacent to the internal fitting groove portions 32 formed on the first internal fitting step portion 39a in the axis orthogonal direction Y when viewed in the axial direction. Accordingly, the internal fitting convex portions 31 of the first internal fitting step portion 39a and the internal fitting convex portions 31 of the second internal fitting step portion 39b are alternately formed without gaps in the circumferential direction Z when viewed in the axial direction.

[0042] In addition, the internal fitting convex portions 31 are not limited to the above, and for example, as shown in FIG. 8B, the internal fitting convex portions 31 of the second internal fitting step portion 39b may be formed at partial positions adjacent to the internal fitting groove portions 32 formed on the first internal fitting step portion 39a in the axis orthogonal direction Y when viewed in the axial direction. In other words, the internal fitting convex portions 31 of the first internal fitting step portion 39a and the internal fitting convex portions 31 of the second internal fitting step portion 39b may be alternately formed with gaps in the circumferential direction Z when viewed in the axial direction.

[0043] As shown in FIGS. 9 and 10, the internal fitting convex portion 31 includes a third tapered portion 31a which is linearly inclined in the circumferential direction Z of the upper steel-pipe pile 3 to abut the first tapered portion 21a shown in FIG. 5 and to be approximately parallel with the first tapered portion 21a on the upper end surface in the inner side (upper side) in the axial direction X of the upper steel-pipe pile 3. Moreover, the internal fitting convex portion 31 includes a fourth tapered portion 31b which is linearly inclined in the circumferential direction Z of the upper steel-pipe pile 3 to abut the second tapered portion 23a shown in FIG. 5 and to be approximately parallel with the second tapered portion 23a and the third tapered portion 31a on the lower end surface in the outer side (lower side) in the axial direction X of the upper steel-pipe pile 3.

[0044] The third tapered portion 31a and the fourth tapered portion 31b have a predetermined height h in the axial direction X of the upper steel-pipe pile 3. Moreover, as described above, the third tapered portion 31a and the fourth tapered portion 31b are linearly formed on the internal fitting convex portion 31. However, the third tapered portion 31a and the fourth tapered portion 31b may be formed to be inclined in an arc shape on the internal fitting convex portion 31. In addition, the third tapered portion 31a and the fourth tapered portion 31b may be separately formed with respect to the internal fitting convex portion 31.

[0045] Next, a method for connecting the lower steel-pipe pile 2 and the upper steel-pipe pile 3 together using the joint structure 1 of a steel-pipe pile according to the first embodiment will be described in detail with reference to the drawings.

[0046] First, as shown in FIGS. 11 and 12, the internal fitting end portion 30 of the upper steel-pipe pile 3 is inserted into the external fitting end portion 20 of the lower steel-pipe pile 2 along the axial direction X. Here, FIG. 11 is a view showing a state where the internal fitting end portion 30 is inserted into the external fitting end portion 20, and FIG. 12 is a view showing a state where the internal fitting end portion 30 is further inserted into the external fitting end portion 20 from the state of FIG. 11. As shown in FIGS. 13 and 14A, the internal fitting end portion 30 is inserted into the external fitting end portion 20, and thus, the internal fitting convex portions 31 of the first internal fitting step portion 39a pass through the external fitting groove portions 22 of the first external fitting step portion 29a and abut the lower end surface of the external fitting engagement groove 23 of the first external fitting step portion 29a. Moreover, the internal fitting convex portions 31 of the second internal fitting step portion 39b pass through the external fitting groove portions 22 of the second external fitting step portion 29b and abut the lower end surface of the external fitting engagement groove 23 of the second external fitting step portion 29b. Moreover, FIG. 14B shows a state where the internal fitting convex portions 31 of the first internal fitting step portion 39a abut the lower end surface of the external fitting engagement groove 23 of the first external fitting step portion 29a when the second tapered portion 23a extends to the intermediate portion 23c (refer to FIG. 5).

[0047] Here, as described above, in the joint structure 1, the external fitting convex portions 21 of the first external fitting step portion 29a and the external fitting groove portions 22 of the second external fitting step portion 29b are formed to all have approximately the same thicknesses in the axis orthogonal direction Y of the lower steel-pipe pile 2, and the internal fitting groove portions 32 of the first internal fitting step portion 39a and the internal fitting convex portions 31 of the second internal fitting step portion 39b are formed to all have approximately the same thicknesses in the axis orthogonal direction Y of the upper steel-pipe pile 3. Accordingly, the internal fitting end portion 30 of the upper steel-pipe pile 3 can be inserted into the external fitting end portion 20 of the lower steel-pipe pile 2 without interference between the internal fitting convex portions 31 of the second internal fitting step portion 39b and the external fitting convex portions 21 of the first external fitting step portion 29a.

[0048] At this time, as shown in FIG. 14A, in the state where the internal fitting end portion 30 of the upper steel-pipe pile 3 is inserted into the external fitting end portion 20 of the lower steel-pipe pile 2, a gap d having a predetermined height in the axial direction X is formed between the tip portion 28 of the external fitting end portion 20 and the internal fitting edge 38 of the internal fitting end portion 30.

[0049] Next, as shown in FIG. 15, the lower steel-pipe pile 2 and the upper steel-pipe pile 3 are relatively rotated in the circumferential direction Z around the axis. Accordingly, as shown in FIGS. 16 and 17, the internal fitting convex portions 31 move to portions under the external fitting convex portions 21 along the circumferential direction Z and engage with the external fitting convex portions 21 in the axial direction X. In this way, the external fitting end portion 20 of the lower steel-pipe pile 2 and the internal fitting end portion 30 of the upper steel-pipe pile 3 are fitted together.

[0050] Here, the first tapered portion 21a and the second tapered portion 23 a shown in FIG. 5 and the third tapered portion 31a and the fourth tapered portion 31b shown in FIG. 9 have the predetermined height h in the axial direction X of the lower steel-pipe pile 2 and the upper steel-pipe pile 3. The height h is set to be approximately the same as the height of the gap d which is formed between the tip portion 28 of the external fitting end portion 20 and the internal fitting edge 38 of the internal fitting end portion 30.

[0051] At this time, as shown in FIG. 17, the third tapered portion 31a (refer to FIG. 9) abuts the first tapered portion 21a (refer to FIG. 5), and the fourth tapered portion 31b (refer to FIG. 9) abuts the second tapered portion 23a (refer to FIG. 5), and thus, the internal fitting convex portion 31 of the upper steel-pipe pile 3 moves in the circumferential direction Z on the external fitting engagement groove 23 of the lower steel-pipe pile 2. Accordingly, the lower steel-pipe pile 2 and the upper steel-pipe pile 3 approach each other in the axial direction X, and thus, the tip portion 28 of the external fitting end portion 20 and the internal fitting edge 38 of the internal fitting end portion 30 abut each other to fill the gap d.

[0052] Accordingly, in the joint structure 1, in the state where the external fitting convex portions 21 and the internal fitting convex portions 31 engage with each other in the axial direction X, the tip portion 28 of the external fitting end portion 20 and the internal fitting edge 38 of the internal fitting end portion 30 abut each other to fill the gap d. Accordingly, whether or not the external fitting end portion 20 of the lower steel-pipe pile 2 and the internal fitting end portion 30 of the upper steel-pipe pile 3 are completely fitted together can be determined by visually confirming the gap d from the outside.

[0053] Moreover, after the external fitting end portion 20 of the lower steel-pipe pile 2 and the internal fitting end portion 30 of the upper steel-pipe pile 3 are fitted together, a feeler gauge abuts the gap d, and the fitting between the external fitting end portion 20 and the internal fitting end portion 30 may be confirmed according to whether or not the feeler gauge passes through the gap d. In this case, compared to the above-described visual confirmation method, whether or not the external fitting end portion 20 and the internal fitting end portion 30 are fitted together can be more accurately determined.

[0054] In addition, as shown in FIG. 17, the third tapered portion 31a (refer to FIG. 9) abuts the first tapered portion 21a (refer to FIG. 5), and the fourth tapered portion 31b (refer to FIG. 9) abuts the second tapered portion 23 a (refer to FIG. 5), and thus, the internal fitting convex portion 31 of the upper steel-pipe pile 3 can smoothly move in the circumferential direction Z on the external fitting engagement groove 23 of the lower steel-pipe pile 2, and the external fitting end portion 20 of the lower steel-pipe pile 2 and the internal fitting end portion 30 of the upper steel-pipe pile 3 can be easily fitted together. In addition, in the joint structure 1, the internal fitting convex portion 31 of the upper steel-pipe pile 3 is locked to the locking portion 23b (refer to FIG. 5) of the external fitting engagement groove 23 of the lower steel-pipe pile 2. Accordingly, the external fitting end portion 20 of the lower steel-pipe pile 2 and the internal fitting end portion 30 of the upper steel-pipe pile 3 can be fitted together while the upper steel-pipe pile 3 is not rotated more than necessary.

[0055] In the joint structure 1, in the state where the external fitting end portion 20 of the lower steel-pipe pile 2 and the internal fitting end portion 30 of the upper steel-pipe pile 3 are fitted together, the internal fitting convex portions 31 formed on the first internal fitting step portion 39a engage with the external fitting convex portions 21 formed on the first external fitting step portion 29a, the internal fitting convex portions 31 formed on the second internal fitting step portion 39b engage with the external fitting convex portions 21 formed on the second external fitting step portion 29b, and thus, a bending load and a tension load are transmitted to the main body of the steel-pipe pile. Moreover, in the joint structure 1, the external fitting convex portions 21 formed on the first external fitting step portion 29a and the external fitting convex portions 21 formed on the second external fitting step portion 29b are provided at positions which deviate in the axial direction X. Accordingly, in the joint structure 1 of a steel-pipe pile, the lower steel-pipe pile 2 and the upper steel-pipe pile 3 can be connected together without a cross-sectional defect when viewed in the axial direction.

[0056] Accordingly, in the joint structure 1, in the state where the external fitting end portion 20 of the lower steel-pipe pile 2 and the internal fitting end portion 30 of the upper steel-pipe pile 3 are fitted together, it is possible to avoid a case where the bending load and the tension load which can be transmitted by the external fitting convex portions 21 and the internal fitting convex portions 31 are decreased by the cross-sectional defect when viewed in the axial direction. Accordingly, in the joint structure 1 of a steel-pipe pile, it is not necessary to enlarge the external fitting convex portions 21 and the internal fitting convex portions 31 by the cross-sectional defect to withstand the predetermined bending load and tension load, and it is not necessary to increase the number of steps of the external fitting step portion 29 and the internal fitting step portion 39 in the axial direction X. Accordingly, it is possible to avoid a case where the machining cost and the cost of materials of the joint structure between the lower steel-pipe pile 2 and the upper steel-pipe pile 3 are increased.

[0057] In the joint structure 1, since the external fitting convex portion 21 formed on the first external fitting step portion 29a and the external fitting convex portion 21 formed on the second external fitting step portion 29b are provided at positions which deviate in the axial direction X, the bending load and the tension load applied to the external fitting convex portions 21 and the internal fitting convex portions 31 can be uniform in the circumferential direction Z. Accordingly, in the joint structure 1, it is possible to avoid a case where the bending load and the tension load are concentrated on partial external fitting convex portions 21 and internal fitting convex portions 31 in the circumferential direction Z. Therefore, in the joint structure 1, the loads transmitted from the external fitting convex portion 21 and the internal fitting convex portion 31 to the main bodies of the lower steel-pipe pile 2 and the upper steel-pipe pile 3 can be uniform in the circumferential direction Z, and thus, increases in the plate thicknesses of the lower steel-pipe pile 2 and the upper steel-pipe pile 3 can be avoided. Accordingly, it is possible to avoid a case where the costs of materials of the joint structure between the lower steel-pipe pile 2 and the upper steel-pipe pile 3 is increased.

[0058] Here, in the joint structure 1, in the first external fitting step portion 29a and the first internal fitting step portion 39a, each of the external fitting convex portions 21 and the internal fitting convex portions 31 is formed in one step (one row), and the plate thicknesses of the lower steel-pipe pile 2 and the upper steel-pipe pile 3 are sufficient if the plate has load bearing capacity with respect to the bending load and the tension load by the one step. Meanwhile, in the second external fitting step portion 29b and the second internal fitting step portion 39b, the number of steps (the number of rows) of the external fitting convex portion 21 and the internal fitting convex portion 31 increases, and it is necessary to set the plate thicknesses of the lower steel-pipe pile 2 and the upper steel-pipe pile 3 according to the increase in the number of steps. In the joint structure 1, the plate thicknesses of the lower steel-pipe pile 2 and the upper steel-pipe pile 3 are thickened in stages from the outer side (upper side) toward the inner side (lower side) in the axial direction X of the lower steel-pipe pile 2 and from the outer side (lower side) toward the inner side (upper side) in the axial direction X of the upper steel-pipe pile 3, and the external fitting step portion 29 and the internal fitting step portion 39 are formed. Accordingly, in the joint structure 1, the structure in which the plate thicknesses of the lower steel-pipe pile 2 and the upper steel-pipe pile 3 increase in stages according to the number of steps of the external fitting convex portions 21 and the internal fitting convex portions 31 can be easily realized.

[0059] In addition, in the joint structure 1, the external fitting convex portions 21 formed on the first external fitting step portion 29a and the external fitting convex portions 21 formed on the second external fitting step portion 29b are provided at positions which deviate in the axial direction X. Accordingly, in the joint structure 1, even when the bending load is applied to the portion at which the lower steel-pipe pile 2 and the upper steel-pipe pile 3 are connected together, the external fitting convex portions 21 of either the first external fitting step portion 29a or the second external fitting step portion 29b and the internal fitting convex portions 31 of either the first internal fitting step portion 39a or the second internal fitting step portion 39b can be accurately disposed at the portions corresponding to the outermost edge ends of the lower steel-pipe pile 2 and the upper steel-pipe pile 3 at which the tensile stress is maximized. Therefore, in the joint structure 1, the bending load is accurately applied to any of the external fitting convex portions 21 and any of the internal fitting convex portions 31, and it is possible to avoid a case where the external fitting end portion 20 of the lower steel-pipe pile 2 and the internal fitting end portion 30 of the upper steel-pipe pile 3 are damaged.

[0060] In the first embodiment, the case is shown, in which the external fitting end portion 20 includes the plurality of step portions (first external fitting step portion 29a and second external fitting step portion 29b), and the internal fitting end portion 30 includes the plurality of step portions (first internal fitting step portion 39a and second internal fitting step portion 39b). However, for example, as shown in FIG. 18, each of the external fitting end portion 20 and the internal fitting end portion 30 may include one step portion (external fitting step portion 29 or internal fitting step portion 39), and the external fitting convex portions 21 and the internal fitting convex portions 31 may be formed at positions which deviate in the axial direction X.

[0061] Also in this case, the cross-sectional defect does not occur when viewed in the axial direction, and the loads transmitted from the external fitting convex portions 21 and the internal fitting convex portions 31 to the main bodies of the lower steel-pipe pile 2 and the upper steel-pipe pile 3 can be uniform in the circumferential direction.

[0062] In addition, in this case, since the plurality of step portions are not formed on the external fitting end portion 20 and the internal fitting end portion 30, compared to the first embodiment, it is possible to decrease the machining costs.

[0063] In addition, in the first embodiment, the case is shown, in which the external fitting convex portions 21 are formed in one step (one row) on each of the first external fitting step portion 29a and the second external fitting step portion 29b and the internal fitting convex portions 31 are formed in one step (one row) on each of the first internal fitting step portion 39a and the second internal fitting step portion 39b. However, for example, as shown in FIG. 19, the external fitting convex portions 21 may be formed in two steps (two rows) on the first external fitting step portion 29a, and the external fitting convex portions 21 may be formed in one step (one row) on the second external fitting step portion 29b.

[0064] Also in this case, the cross-sectional defect does not occur when viewed in the axial direction, and the loads transmitted from the external fitting convex portions 21 and the internal fitting convex portions 31 to the main bodies of the lower steel-pipe pile 2 and the upper steel-pipe pile 3 can be uniform in the circumferential direction.

[0065] In addition, in this case, compared to the first embodiment, the number of the external fitting convex portions 21 and the internal fitting convex portions 31 can be increased, and thus, the loads applied to one external fitting convex portion 21 and one internal fitting convex portion 31 can be decreased.

[0066] Moreover, in FIG. 19, the case is shown, in which the external fitting convex portions 21 are formed in two steps (two rows) on the first external fitting step portion 29a and the internal fitting convex portions 31 are formed in two steps (two rows) on the first internal fitting step portion 39a. However, the external fitting convex portions 21 and the internal fitting convex portions 31 may be formed in a plurality of step portions (a plurality of rows) on the second external fitting step portion 29b and the second internal fitting step portion 39b.

[0067] As described above, from the viewpoint that the cross-sectional defect does not occur when viewed in the axial direction, the external fitting convex portions 21 and the external fitting groove portions 22 are formed in the plurality of rows in the axial direction X, and among the plurality of rows adjacent to one another along the axial direction X, in at least (one set of) two rows adjacent to each other, the external fitting convex portions 21 of one row and the external fitting groove portions 22 of the other row may be formed to be adjacent to each other in the axis orthogonal direction Y when viewed in the axial direction.

(Second Embodiment)

[0068] Next, a joint structure 100 of a steel-pipe pile according to a second embodiment of the present invention will be described. Moreover, the same numeral references are assigned to the same components as the above-described components, and descriptions thereof are omitted below.

[0069] In the joint structure 100 of a steel-pipe pile according to the second embodiment, as shown in FIG. 20, three external fitting step portions 29 (29a, 29b, and 29c) arranged in the axial direction X of the lower steel-pipe pile 2 are provided on the external fitting end portion 20. Moreover, three internal fitting step portions 39 (39a, 39b, and 39c) arranged in the axial direction X of the upper steel-pipe pile 3 are provided on the internal fitting end portion 30.

[0070] The plate thickness of the lower steel-pipe pile 2 is thickened in stages in the axial direction X and the external fitting step portion 29 is formed so that the external fitting convex portions 21 of the first external fitting step portion 29a in the outer side (upper side) in the axial direction X of the lower steel-pipe pile 2, and the external fitting groove portions 22 of the second external fitting step portion 29b in the inner side (lower side) in the axial direction X of the lower steel-pipe pile 2 from the first external fitting step portion 29a have approximately the same thickness in the axis orthogonal direction Y of the lower steel-pipe pile 2, and the external fitting convex portions 21 of the second external fitting step portion 29b, and the external fitting groove portions 22 of the third external fitting step portion 29c in the inner side (lower side) in the axial direction X of the lower steel-pipe pile 2 from the second external fitting step portion 29b have approximately the same thickness in the axis orthogonal direction Y of the lower steel-pipe pile 2.

[0071] The external fitting convex portions 21 formed on the first external fitting step portion 29a and the external fitting convex portions 21 formed on the second external fitting step portion 29b are provided at positions which deviate in the axial direction X. In addition, the external fitting convex portions 21 formed on the second external fitting step portion 29b and the external fitting convex portions 21 formed on the third external fitting step portion 29c are provided at positions which deviate in the axial direction X.

[0072] As shown in FIG. 21A, the external fitting convex portions 21 of the second external fitting step portion 29b are formed at all positions adjacent to the external fitting groove portions 22 formed on the first external fitting step portion 29a in the axis orthogonal direction Y when viewed in the axial direction. In addition, the external fitting convex portions 21 of the third external fitting step portion 29c are formed at all positions adjacent to the external fitting groove portions 22 formed on the second external fitting step portion 29b in the axis orthogonal direction Y when viewed in the axial direction. Accordingly, the external fitting convex portions 21 of the first external fitting step portion 29a and the external fitting convex portions 21 of the second external fitting step portion 29b are alternately formed without gaps in the circumferential direction Z when viewed in the axial direction, and the external fitting convex portions 21 of the second external fitting step portion 29b and the external fitting convex portions 21 of the third external fitting step portion 29c are alternately formed without gaps in the circumferential direction Z when viewed in the axial direction.

[0073] In addition, the external fitting convex portions 21 are not limited to the above, and as shown in FIG. 21B, the external fitting convex portions 21 of the second external fitting step portion 29b may be formed at partial positions adjacent to the external fitting groove portions 22 formed on the first external fitting step portion 29a in the axis orthogonal direction Y when viewed in the axial direction, and the external fitting convex portions 21 of the third external fitting step portion 29c may be formed at partial positions adjacent to the external fitting groove portions 22 formed on the second external fitting step portion 29b in the axis orthogonal direction Y when viewed in the axial direction. At this time, the external fitting convex portions 21 of the first external fitting step portion 29a and the external fitting convex portions 21 of the second external fitting step portion 29b are alternately formed with gaps in the circumferential direction Z when viewed in the axial direction, and the external fitting convex portions 21 of the second external fitting step portion 29b and the external fitting convex portions 21 of the third external fitting step portion 29c are alternately formed with gaps in the circumferential direction Z when viewed in the axial direction.

[0074] The plate thickness of the upper steel-pipe pile 3 is thickened in stages in the axial direction X and the internal fitting step portion 39 is formed so that the internal fitting groove portions 32 of the first internal fitting step portion 39a in the inner side (upper side) in the axial direction X of the upper steel-pipe pile 3, and the internal fitting convex portions 31 of the second internal fitting step portion 39b in the outer side (lower side) in the axial direction X of the upper steel-pipe pile 3 from the first internal fitting step portion 39a have approximately the same thickness in the axis orthogonal direction Y of the upper steel-pipe pile 3, and the internal fitting groove portions 32 of the second internal fitting step portion 39b, and the internal fitting convex portions 31 of the third internal fitting step portion 39c in the outer side (lower side) in the axial direction X from the second internal fitting step portion 39b have approximately the same thickness in the axis orthogonal direction Y.

[0075] The internal fitting convex portions 31 formed on the first internal fitting step portion 39a and the internal fitting convex portions 31 formed on the second internal fitting step portion 39b are provided at positions which deviate in the axial direction X. In addition, the internal fitting convex portions 31 formed on the second internal fitting step portion 39b and the internal fitting convex portions 31 formed on the third internal fitting step portion 39c are provided at positions which deviate in the axial direction X.

[0076] As shown in FIG. 22A, the internal fitting convex portions 31 of the second internal fitting step portion 39b are formed at all positions adjacent to the internal fitting groove portions 32 formed on the first internal fitting step portion 39a in the axis orthogonal direction Y when viewed in the axial direction. In addition, the internal fitting convex portions 31 of the third internal fitting step portion 39c are formed at all positions adjacent to the internal fitting groove portions 32 formed on the second internal fitting step portion 39b in the axis orthogonal direction Y when viewed in the axial direction. Accordingly, the internal fitting convex portions 31 of the first internal fitting step portion 39a and the internal fitting convex portions 31 of the second internal fitting step portion 39b are alternately formed without gaps in the circumferential direction Z when viewed in the axial direction, and the internal fitting convex portions 31 of the second internal fitting step portion 39b and the internal fitting convex portions 31 of the third internal fitting step portion 39c are alternately formed without gaps in the circumferential direction Z when viewed in the axial direction.

[0077] In addition, the internal fitting convex portions 31 are not limited to the above, and as shown in FIG. 22B, the internal fitting convex portions 31 of the second internal fitting step portion 39b may be formed at partial positions adjacent to the internal fitting groove portions 32 formed on the first internal fitting step portion 39a in the axis orthogonal direction Y when viewed in the axial direction. Moreover, the internal fitting convex portions 31 of the third internal fitting step portion 39c may be formed at partial positions adjacent to the internal fitting groove portions 32 formed on the second internal fitting step portion 39b in the axis orthogonal direction Y when viewed in the axial direction. At this time, in the internal fitting convex portions 31, the internal fitting convex portions 31 of the first internal fitting step portion 39a and the internal fitting convex portions 31 of the second internal fitting step portion 39b are alternately formed with gaps in the circumferential direction Z when viewed in the axial direction, and the internal fitting convex portions 31 of the second internal fitting step portion 39b and the internal fitting convex portions 31 of the third internal fitting step portion 39c are alternately formed with gaps in the circumferential direction Z when viewed in the axial direction.

[0078] Next, a method for connecting the lower steel-pipe pile 2 and the upper steel-pipe pile 3 together using the joint structure 100 of a steel-pipe pile according to the second embodiment will be described in detail with reference to the drawings.

[0079] First, the internal fitting end portion 30 of the upper steel-pipe pile 3 is inserted into the external fitting end portion 20 of the lower steel-pipe pile 2 in the axial direction X. Accordingly, as shown in FIGS. 23 and 24, the internal fitting convex portions 31 of the first internal fitting step portion 39a pass through the external fitting groove portions 22 of the first external fitting step portion 29a and abut the lower end surface of the external fitting engagement groove 23 of the first external fitting step portion 29a. Moreover, the internal fitting convex portions 31 of the second internal fitting step portion 39b pass through the external fitting groove portions 22 of the second external fitting step portion 29b and abut the lower end surface of the external fitting engagement groove 23 of the second external fitting step portion 29b. In addition, the internal fitting convex portions 31 of the third internal fitting step portion 39c pass through the external fitting groove portions 22 of the third external fitting step portion 29c and abut the lower end surface of the external fitting engagement groove 23 of the third external fitting step portion 29c.

[0080] Here, in the joint structure 100, the external fitting convex portions 21 of the first external fitting step portion 29a and the external fitting groove portions 22 of the second external fitting step portion 29b are formed to all have approximately the same thicknesses in the axis orthogonal direction Y of the lower steel-pipe pile 2, and the internal fitting groove portions 32 of the first internal fitting step portion 39a and the internal fitting convex portions 31 of the second internal fitting step portion 39b are formed to all have approximately the same thicknesses in the axis orthogonal direction Y of the upper steel-pipe pile 3. In addition, the external fitting convex portions 21 of the second external fitting step portion 29b and the external fitting groove portions 22 of the third external fitting step portion 29c are formed to all have approximately the same thicknesses in the axis orthogonal direction Y of the lower steel-pipe pile 2, and the internal fitting groove portions 32 of the second internal fitting step portion 39b and the internal fitting convex portions 31 of the third internal fitting step portion 39c are formed to all have approximately the same thicknesses in the axis orthogonal direction Y of the upper steel-pipe pile 3. Accordingly, the internal fitting end portion 30 of the upper steel-pipe pile 3 is inserted into the external fitting end portion 20 of the lower steel-pipe pile 2 without interference between the internal fitting convex portions 31 of the third internal fitting step portion 39c and the external fitting convex portions 21 of the first external fitting step portion 29a and the second external fitting step portion 29b, and without interference between the internal fitting convex portions 31 of the second internal fitting step portion 39b and the external fitting convex portions 21 of the first external fitting step portion 29a.

[0081] At this time, in the joint structure 100, as shown in FIG. 24, in the state where the internal fitting end portion 30 of the upper steel-pipe pile 3 is inserted into the external fitting end portion 20 of the lower steel-pipe pile 2, the gap d having a predetermined height in the axial direction X is formed between the tip portion 28 of the external fitting end portion 20 and the internal fitting edge 38 of the internal fitting end portion 30.

[0082] Next, in the joint structure 100, as shown in FIG. 25, the lower steel-pipe pile 2 and the upper steel-pipe pile 3 are relatively rotated in the circumferential direction Z around the axis. Accordingly, as shown in FIGS. 26 and 27, the internal fitting convex portions 31 move in the circumferential direction Z in the external fitting engagement groove 23 to portions under the external fitting convex portions 21. Moreover, the internal fitting convex portions 31 engage with the external fitting convex portions 21 in the axial direction X, and the external fitting end portion 20 of the lower steel-pipe pile 2 and the internal fitting end portion 30 of the upper steel-pipe pile 3 are fitted together.

[0083] At this time, in the joint structure 100, as shown in FIG. 27, the third tapered portion 31a (refer to FIG. 9) abuts the first tapered portion 21a (refer to FIG. 5), the fourth tapered portion 31 b (refer to FIG. 9) abuts the second tapered portion 23 a (refer to FIG. 5), and thus, the internal fitting convex portion 31 moves in the circumferential direction Z on the external fitting engagement groove 23. Accordingly, the lower steel-pipe pile 2 and the upper steel-pipe pile 3 approach each other in the axial direction X, and thus, the tip portion 28 of the external fitting end portion 20 and the internal fitting edge 38 of the internal fitting end portion 30 abut each other to fill the gap d.

[0084] Similar to the first embodiment, as described above, in the second embodiment, in the state where the external fitting convex portions 21 and the internal fitting convex portions 31 engage with each other in the axial direction X, the tip portion 28 of the external fitting end portion 20 and the internal fitting edge 38 of the internal fitting end portion 30 abut each other to fill the gap d. Accordingly, whether or not the external fitting end portion 20 of the lower steel-pipe pile 2 and the internal fitting end portion 30 of the upper steel-pipe pile 3 are completely fitted together can be determined by visually confirming the gap d from the outside.

[0085] In addition, similar to the first embodiment, also in the second embodiment, after the external fitting end portion 20 of the lower steel-pipe pile 2 and the internal fitting end portion 30 of the upper steel-pipe pile 3 are fitted together, the feeler gauge abuts the gap d, and the fitting between the external fitting end portion 20 and the internal fitting end portion 30 may be confirmed according to whether or not the feeler gauge passes through the gap d. In this case, compared to the above-described visual confirmation method, whether or not the external fitting end portion 20 and the internal fitting end portion 30 are fitted together can be more accurately determined.

[0086] Moreover, similar to the first embodiment, in the second embodiment, as shown in FIG. 27, the third tapered portion 31a (refer to FIG. 9) abuts the first tapered portion 21a (refer to FIG. 5), and the fourth tapered portion 31b (refer to FIG. 9) abuts the second tapered portion 23a (refer to FIG. 5), and thus, the internal fitting convex portion 31 of the upper steel-pipe pile 3 can smoothly move in the circumferential direction Z on the external fitting engagement groove 23 of the lower steel-pipe pile 2. Accordingly, the external fitting end portion 20 of the lower steel-pipe pile 2 and the internal fitting end portion 30 of the upper steel-pipe pile 3 can be easily fitted together. In addition, the internal fitting convex portion 31 is locked to the locking portion 23b (refer to FIG. 5) of the external fitting engagement groove 23, and thus, it is possible to prevent the upper steel-pipe pile 3 from being rotated more than necessary.

[0087] In the joint structure 100 of a steel-pipe pile according to the second embodiment, in the state where the external fitting end portion 20 of the lower steel-pipe pile 2 and the internal fitting end portion 30 of the upper steel-pipe pile 3 are fitted together, the internal fitting convex portions 31 of the first internal fitting step portion 39a engage with the external fitting convex portions 21 of the first external fitting step portion 29a, the internal fitting convex portions 31 of the second internal fitting step portion 39b engage with the external fitting convex portions 21 of the second external fitting step portion 29b, and the internal fitting convex portions 31 of the third internal fitting step portion 39c engage with the external fitting convex portions 21 of the third external fitting step portion 29c. In addition, the bending load and the tension load are transmitted to the main body of the steel-pipe pile. Moreover, the external fitting convex portions 21 of the first external fitting step portion 29a and the external fitting convex portions 21 of the second external fitting step portion 29b are provided at positions which deviate in the axial direction X, and the external fitting convex portions 21 of the second external fitting step portion 29b and the external fitting convex portions 21 of the third external fitting step portion 29c are provided at positions which deviate in the axial direction X. Accordingly, in the joint structure 100 of a steel-pipe pile according to the second embodiment, and the lower steel-pipe pile 2 and the upper steel-pipe pile 3 can be connected together without the cross-sectional defect when viewed in the axial direction.

[0088] Therefore, similar to the first embodiment, also in the second embodiment, in the state where the external fitting end portion 20 of the lower steel-pipe pile 2 and the internal fitting end portion 30 of the upper steel-pipe pile 3 are fitted together, it is possible to avoid a case where the bending load and the tension load which can be transmitted by the external fitting convex portions 21 and the internal fitting convex portions 31 are decreased by the cross-sectional defect when viewed in the axial direction. Accordingly, it is not necessary to enlarge the external fitting convex portions 21 and the internal fitting convex portions 31 by the cross-sectional defect to withstand predetermined bending load and tension load, and it is not necessary to increase the number of steps of the external fitting step portion 29 and the internal fitting step portion 39 in the axial direction X, and thus, it is possible to avoid a case where the machining cost and the cost of materials of the joint structure of a steel-pipe pile are increased.

[0089] In the second embodiment, the external fitting convex portion 21 of the first external fitting step portion 29a and the external fitting convex portion 21 of the second external fitting step portion 29b are provided at positions which deviate in the axial direction X, the external fitting convex portion 21 of the second external fitting step portion 29b and the external fitting convex portion 21 of the third external fitting step portion 29c are provided at positions which deviate in the axial direction X, and thus, the bending load and the tension load applied to the external fitting convex portions 21 and the internal fitting convex portions 31 can be uniform in the circumferential direction Z. Accordingly, it is possible to avoid a case where the bending load and the tension load are concentrated on partial external fitting convex portions 21 and internal fitting convex portions 31 in the circumferential direction Z. Therefore, also in the second embodiment, the loads transmitted from the external fitting convex portion 21 and the internal fitting convex portion 31 to the main bodies of the lower steel-pipe pile 2 and the upper steel-pipe pile 3 can be uniform in the circumferential direction Z, and thus, increases in the plate thicknesses of the lower steel-pipe pile 2 and the upper steel-pipe pile 3 can be avoided. Accordingly, it is possible to avoid a case where the cost of materials of the joint structure between the lower steel-pipe pile 2 and the upper steel-pipe pile 3 is increased.

[0090] Here, in the first external fitting step portion 29a and the first internal fitting step portion 39a, the external fitting convex portions 21 and the internal fitting convex portions 31 are formed in one step (one row), and the plate thicknesses of the lower steel-pipe pile 2 and the upper steel-pipe pile 3 are sufficient if the plate has load bearing capacity with respect to the bending load and the tension load by the one step. Meanwhile, the number of steps (the number of rows) of the external fitting convex portion 21 and the internal fitting convex portion 31 increases in the second external fitting step portion 29b and the second internal fitting step portion 39b, the number of steps of the external fitting convex portion 21 and the internal fitting convex portion 31 increases in the third external fitting step portion 29c and the third internal fitting step portion 39c, and thus, it is necessary to set the plate thicknesses of the lower steel-pipe pile 2 and the upper steel-pipe pile 3 according to the increase in the number of steps. In the joint structure 100, the plate thicknesses of the lower steel-pipe pile 2 and the upper steel-pipe pile 3 are thickened in stages from the outer side (upper side) toward the inner side (lower side) in the axial direction X of the lower steel-pipe pile 2 and from the outer side (lower side) toward the inner side (upper side) in the axial direction X of the upper steel-pipe pile 3, and the external fitting step portion 29 and the internal fitting step portion 39 are formed. Accordingly, also in the second embodiment, the structure in which the plate thicknesses of the lower steel-pipe pile 2 and the upper steel-pipe pile 3 increase in stages according to the number of steps of the external fitting convex portions 21 and the internal fitting convex portions 31 can be easily realized.

[0091] In addition, in the joint structure 100, the external fitting convex portions 21 of the first external fitting step portion 29a and the external fitting convex portions 21 of the second external fitting step portion 29b are provided at positions which deviate in the axial direction X, and the external fitting convex portions 21 of the second external fitting step portion 29b and the external fitting convex portions 21 of the third external fitting step portion 29c are provided at positions which deviate in the axial direction X. Accordingly, even when the bending load is applied to the portion at which the lower steel-pipe pile 2 and the upper steel-pipe pile 3 are connected together, the external fitting convex portions 21 of any of the first external fitting step portion 29a, the second external fitting step portion 29b, and the third external fitting step portion 29c, and the internal fitting convex portions 31 of any of the first internal fitting step portion 39a, the second internal fitting step portion 39b, and the third internal fitting step portion 39c can be accurately disposed at the portions corresponding to the outermost edge ends of the lower steel-pipe pile 2 and the upper steel-pipe pile 3 at which the tensile stress is maximized. Therefore, also in the second embodiment, the bending load is accurately applied to any of the external fitting convex portions 21 and any of the internal fitting convex portions 31, and it is possible to avoid a case where the external fitting end portion 20 of the lower steel-pipe pile 2 and the internal fitting end portion 30 of the upper steel-pipe pile 3 are damaged.

[0092] In the second embodiment, the case is shown, in which the number of steps in each of the external fitting step portion 29 and the internal fitting step portion 39 is three, the external fitting convex portions 21 of the first external fitting step portion 29a and the external fitting convex portions 21 of the second external fitting step portion 29b are provided at positions which deviate in the axial direction X, and the external fitting convex portions 21 of the second external fitting step portion 29b and the external fitting convex portions 21 of the third external fitting step portion 29c are provided at positions which deviate in the axial direction X.

[0093] However, the present invention is not limited to the above, and for example, the external fitting convex portions 21 of the first external fitting step portion 29a and the external fitting convex portions 21 of the second external fitting step portion 29b may be provided at positions which deviate in the axial direction X, and the external fitting convex portions 21 of the second external fitting step portion 29b and the external fitting convex portions 21 of the third external fitting step portion 29c are provided at positions matched in the axial direction X. Also in this case, the cross-sectional defect does not occur when viewed in the axial direction, and the loads transmitted from the external fitting convex portions 21 and the internal fitting convex portions 31 to the main body of a steel-pipe pile can be uniform in the circumferential direction.

[0094] Accordingly, in the plurality of external fitting step portions 29 formed on the external fitting end portion 20 along the axial direction X, the external fitting convex portions 21 of the external fitting step portion 29 positioned at the outermost side (upper side) in the axial direction X and the external fitting convex portions 21 of at least one external fitting step portion 29 positioned at the inner side (lower side) in the axial direction X may be provided at positions which deviate in the axial direction X. In other words, in at least (one set of) the external fitting step portions 29 adjacent to each other among the plurality of external fitting step portions 29 adjacent to one another, the external fitting convex portions 21 of one external fitting step portion 29 and the external fitting groove portion 22 of the other external fitting step portion 29 may be provided to be adjacent in the axis orthogonal direction Y when viewed in the axial direction X.

[0095] The first embodiment shows the case in which the number of steps in each of the external fitting step portion 29 and the internal fitting step portion 39 is two, and the second embodiment shows the case in which the number of steps in each of the external fitting step portion 29 and the internal fitting step portion 39 is three. However, preferably, the number of steps is two. When the number of steps is increased, the thicknesses of the tip portions (the outer side in the axial direction X) of the external fitting step portion and the internal fitting step portion in the steel-pipe pile are inevitably decreased. The damage by the loads easily occurs as the thickness of the tip portion is decreased. As a result, the joint structure is easily damaged. On the other hand, if the number of steps is two, the thicknesses in the inner sides in the axial direction X can be thinned while the thicknesses of the tip portions (the outer sides in the axial direction X) of the external fitting step portion and the internal fitting step portion are maintained in certain thicknesses or more. Accordingly, the increase in the cost of materials due to the increase in the plate thickness of the steel-pipe pile can be prevented.

[0096] As the above, embodiments of the present invention are described in detail. However, the above-described embodiments are only specific examples for embodying the present invention, and the technical scope of the present invention should not be interpreted as being limited by the embodiments.

[0097] For example, a joint structure may be adopted in which the lower steel-pipe pile 2 (first steel-pipe pile) includes the internal fitting end portion 30, and the upper steel-pipe pile 3 (second steel-pipe pile) includes the external fitting end portion 20.

[0098] In addition, a joint structure may be adopt, which includes a rotation prevention unit (not shown) for preventing reverse rotations of the lower steel-pipe pile 2 and the upper steel-pipe pile 3 connected together in the axial direction X. For example, as the rotation prevention unit, in the state where the lower steel-pipe pile 2 and the upper steel-pipe pile 3 are connected together in the axial direction X, a screw may be inserted into the lower steel-pipe pile 2 to prevent the reverse rotation.

[0099] Moreover, the external fitting step portion 29 having any number of steps may be arranged in the axial direction X of the lower steel-pipe pile 2 on the external fitting end portion 20, and the internal fitting step portion 39 having any number of steps may be arranged in the axial direction X of the upper steel-pipe pile 3 on the internal fitting end portion 30.

[Industrial Applicability]

[0100] It is possible to provide a joint structure of a steel-pipe pile and a steel-pipe pile in which an increase in labor for rotation of a steel-pipe pile at a work site is prevented, an excessive increase in a plate thickness of the steel-pipe pile is avoided, and there is no concern of damage even when the bending load is applied.

[Brief Description of the Reference Symbols]

[0101]

1: joint structure of steel-pipe pile
2: lower steel-pipe pile (first steel-pipe pile)
20: external fitting end portion
21: external fitting convex portion
21a: first tapered portion
22: external fitting groove portion
23: external fitting engagement groove
23a: second tapered portion
23b: locking portion
28: tip portion
29: external fitting step portion
29a: first external fitting step portion
29b: second external fitting step portion
29c: third external fitting step portion
3: upper steel-pipe pile (second steel-pipe pile)
30: internal fitting end portion
31: internal fitting convex portion

31a: third tapered portion
31b: fourth tapered portion
32: internal fitting groove portion
33: internal fitting engagement groove
38: internal fitting edge
39: internal fitting step portion
39a: first internal fitting step portion
39b: second internal fitting step portion
39c: third internal fitting step portion
100: joint structure of steel-pipe pile
X: axial direction
Y: axis orthogonal direction
Z: circumferential direction
d: gap
h: height of tapered portion

Claims

1. A joint structure of a steel-pipe pile, which connects a first steel-pipe pile and a second steel-pipe pile in series, the joint structure comprising:

an external fitting end portion which is an opening end of the first steel-pipe pile; and
a column shaped internal fitting end portion which configures a portion inserted into the external fitting end portion on one end of the second steel-pipe pile,
wherein the external fitting end portion includes a plurality of external fitting convex portions which protrude from an inner circumferential surface of the external fitting end portion toward an inner side in a radial direction of the first steel-pipe pile, and are provided along a circumferential direction of the first steel-pipe pile;
an external fitting groove portion which is formed between the external fitting convex portions adjacent to each other in the circumferential direction of the first steel-pipe pile; and
an external fitting engagement groove which is formed along the circumferential direction at a position of an inner side in an axial direction of the first steel-pipe pile from the external fitting convex portion and the external fitting groove portion on the inner circumferential surface,
the internal fitting end portion includes a plurality of internal fitting convex portions which protrude from an outer circumferential surface of the internal fitting end portion toward an outer side in a radial direction of the second steel-pipe pile, and are provided along a circumferential direction of the second steel-pipe pile,
each of the internal fitting convex portions engages with each of the external fitting convex portions in the external fitting engagement groove after the internal fitting end portion is inserted into the external fitting end portion and the first steel-pipe pile and the second steel-pipe pile are relatively rotated around an axis of the first steel-pipe pile,
the external fitting convex portions and the external fitting groove portions are formed in a plurality of rows along the axial direction of the first steel-pipe pile, and
in at least one set of two rows adjacent to each other among the plurality of rows adjacent to one another, the external fitting convex portions of one row and the external fitting groove portions of the other row are provided to be adjacent in the radial direction of the first steel-pipe pile when viewed in the axial direction of the first steel-pipe pile.

2. The joint structure of a steel-pipe pile according to Claim 1,
wherein the external fitting end portion includes a plurality of step portions formed along the axial direction of the first steel-pipe pile,
the external fitting convex portions and the external fitting groove portions by at least one row are provided in each of the plurality of step portions, and
in two step portions adjacent to each other, the external fitting convex portions of one step portion and the external fitting groove portions of the other step portion are provided to be adjacent in the radial direction of the first steel-pipe pile when viewed in the axial direction of the first steel-pipe pile.

3. The joint structure of a steel-pipe pile according to Claim 2,
wherein in the two step portions adjacent to each other, the external fitting convex portions of the one step portion are provided at all positions adjacent to the external fitting groove portions of the other step portion in the radial direction of the first steel-pipe pile when viewed in the axial direction of the first steel-pipe pile, and
the external fitting convex portions are provided without gaps along the circumferential direction of the first steel-pipe pile when viewed in the axial direction of the first steel-pipe pile.

4. The joint structure of a steel-pipe pile according to Claim 2 or 3,
wherein the first steel-pipe pile is thickened in stages along the axial direction of the first steel-pipe pile, and the plurality of step portions adjacent to one another in the axial direction of the first steel-pipe pile are formed so that the external fitting convex portions of the step portion positioned at an outer side in the axial direction of the first steel-pipe pile and the external fitting groove portions of the step portion positioned at the inner side in the axial direction of the first steel-pipe pile all have approximately the same thickness.

5. The joint structure of a steel-pipe pile according to any one of Claims 1 to 4,
wherein the internal fitting end portion includes an internal fitting edge which forms a gap between a tip portion of the external fitting end portion and the internal fitting end portion, at the inner side in the axial direction of the second steel-pipe pile, in a state where the internal fitting end portion is inserted into the external fitting end portion,
the external fitting convex portion includes a first tapered portion which is inclined along the circumferential direction of the first steel-pipe pile on an end surface in the inner side in the axial direction of the first steel-pipe pile so that a height in the axial direction of the first steel-pipe pile is approximately the same as a height of the gap,
the external fitting engagement groove includes a second tapered portion which is inclined in the circumferential direction of the first steel-pipe pile to be approximately parallel with the first tapered portion at a portion facing the first tapered portion in the axial direction of the first steel-pipe pile,
the internal fitting convex portion includes a third tapered portion which is inclined along the circumferential direction of the second steel-pipe pile to abut the first tapered portion on an end surface in the inner side in the axial direction of the second steel-pipe pile, and a fourth tapered portion which is inclined along the circumferential direction of the second steel-pipe pile to abut the second tapered portion on an end surface in the outer side in the axial direction of the second steel-pipe pile, and
the first steel-pipe pile and the second steel-pipe pile relatively rotate around the axis of the first steel-pipe pile, the first tapered portion and the third tapered portion abut each other, the second tapered portion and the fourth tapered portion abut each other, the plurality of external fitting convex portions and the plurality of internal fitting convex portions engage with each other, the internal fitting edge and the tip portion abut each other to fill the gap, and the external fitting end portion and the internal fitting end portion are fitted together.

6. A steel-pipe pile comprising the joint structure of a steel-pipe pile according to any one of Claims 1 to 5.

FIG. 1

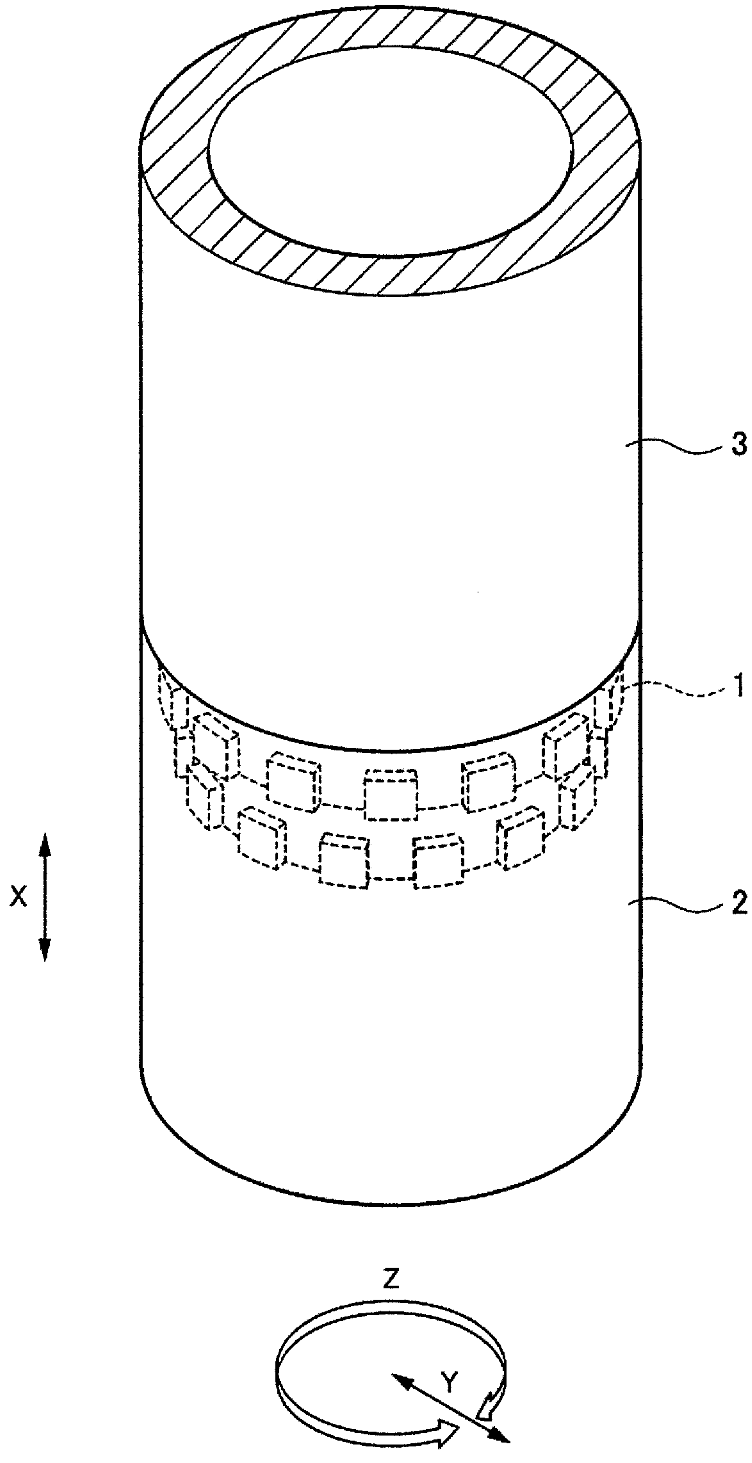
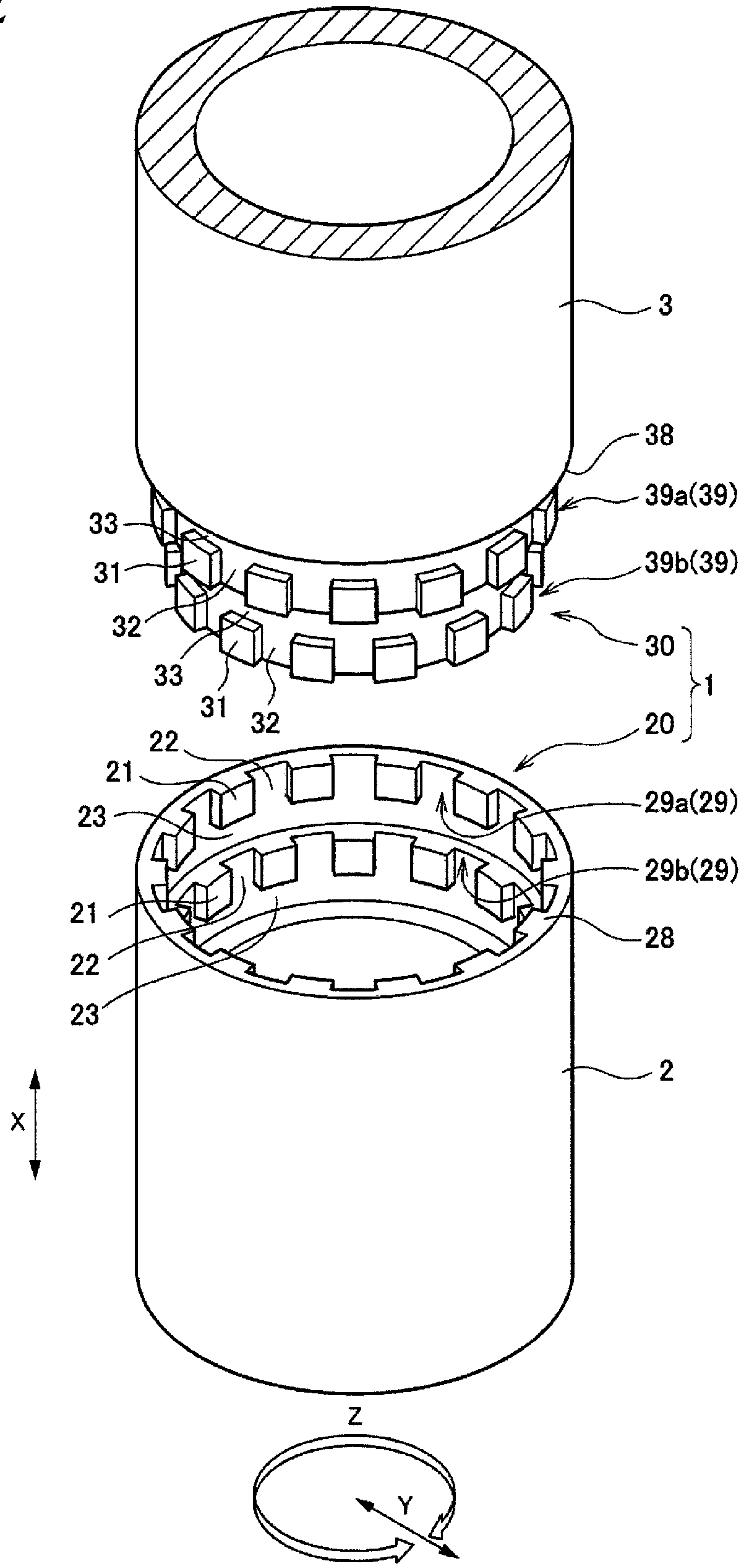


FIG. 2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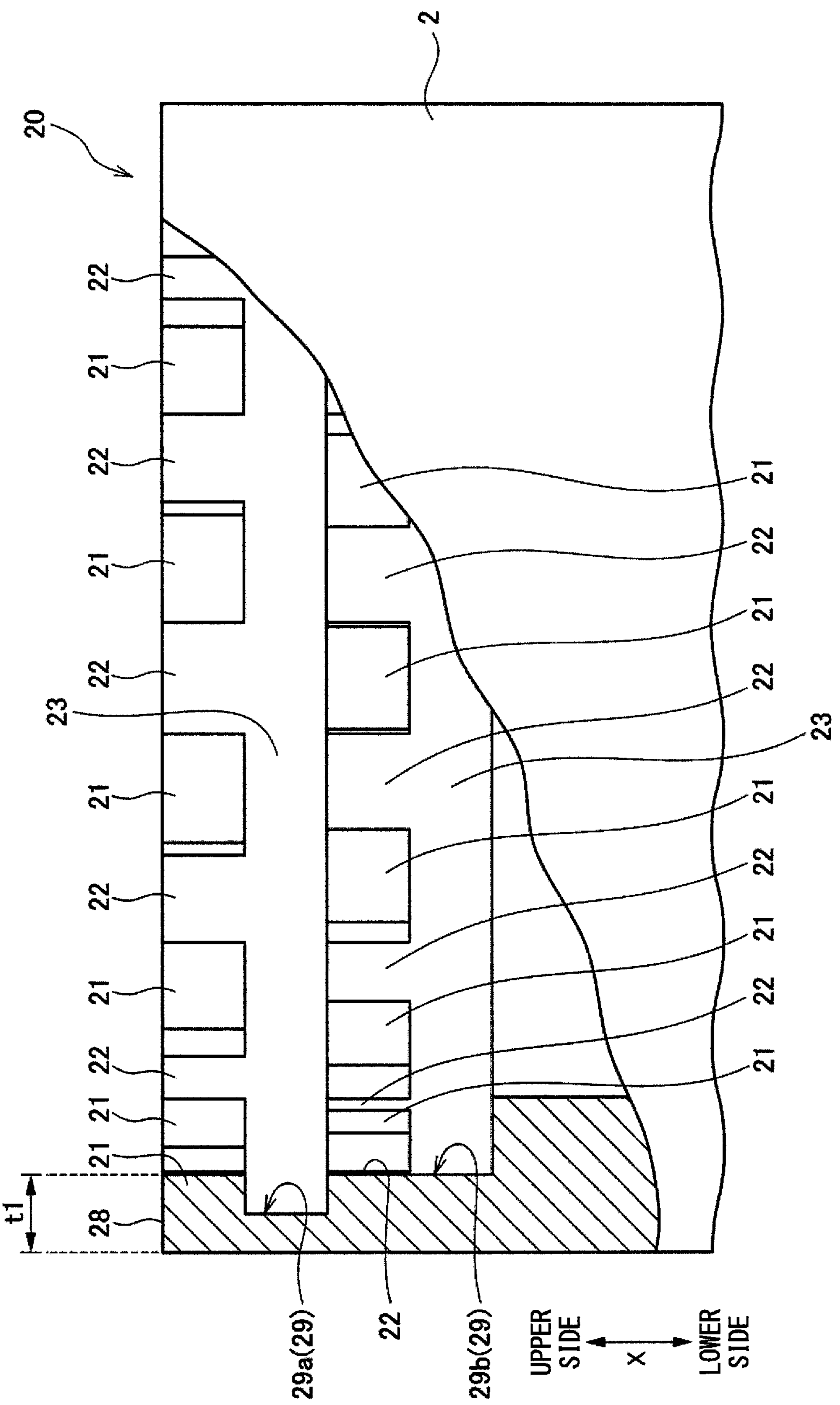

FIG. 3

FIG. 4A

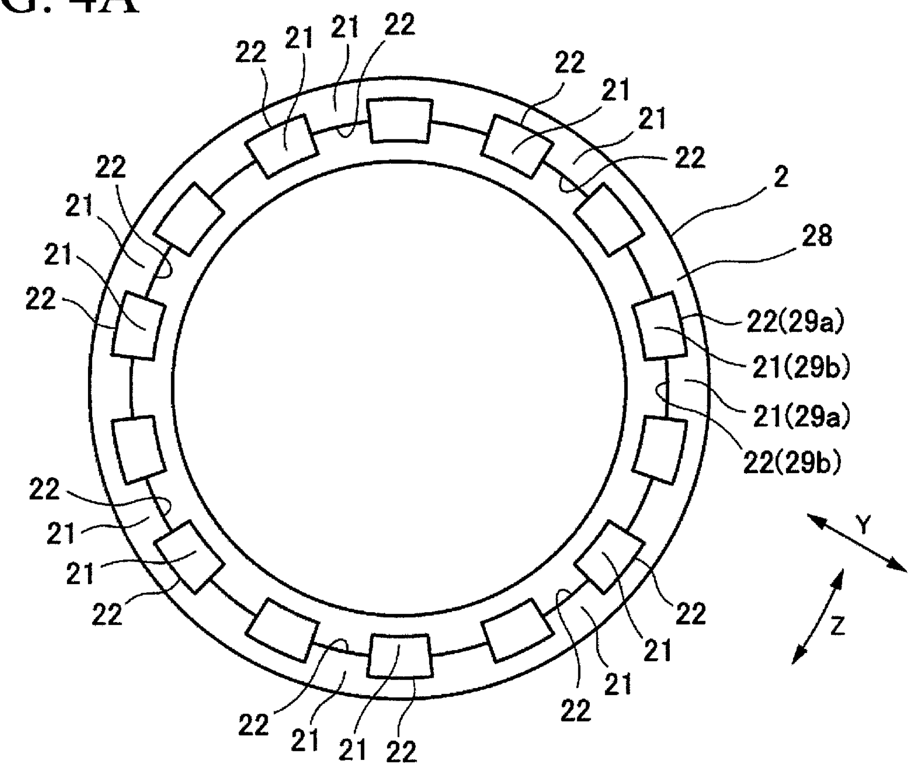
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FIG. 4B

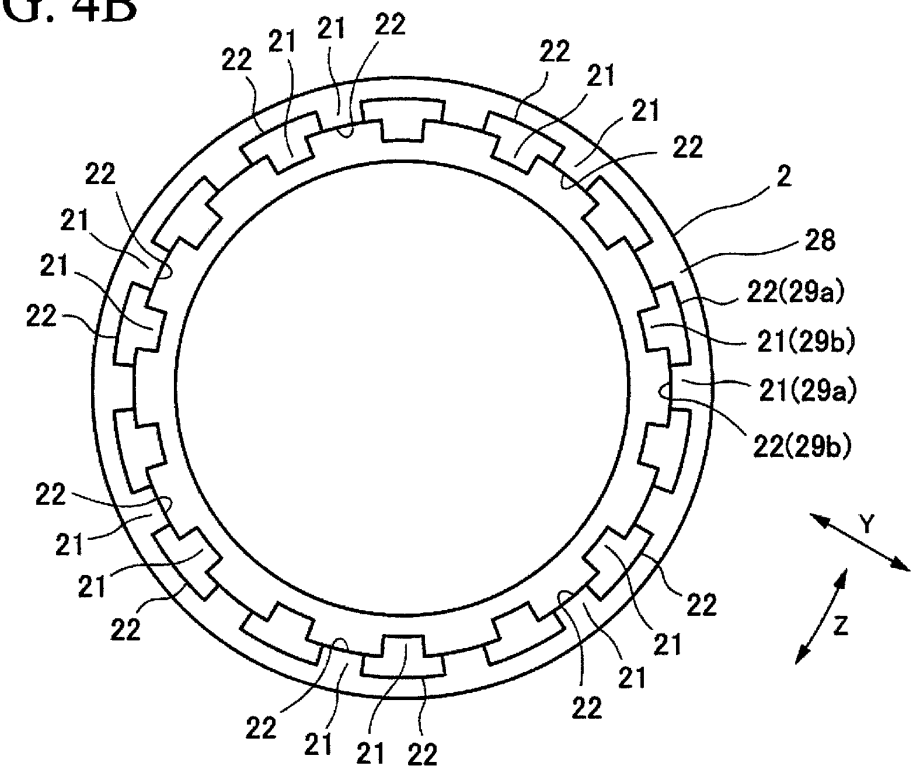
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FIG. 5

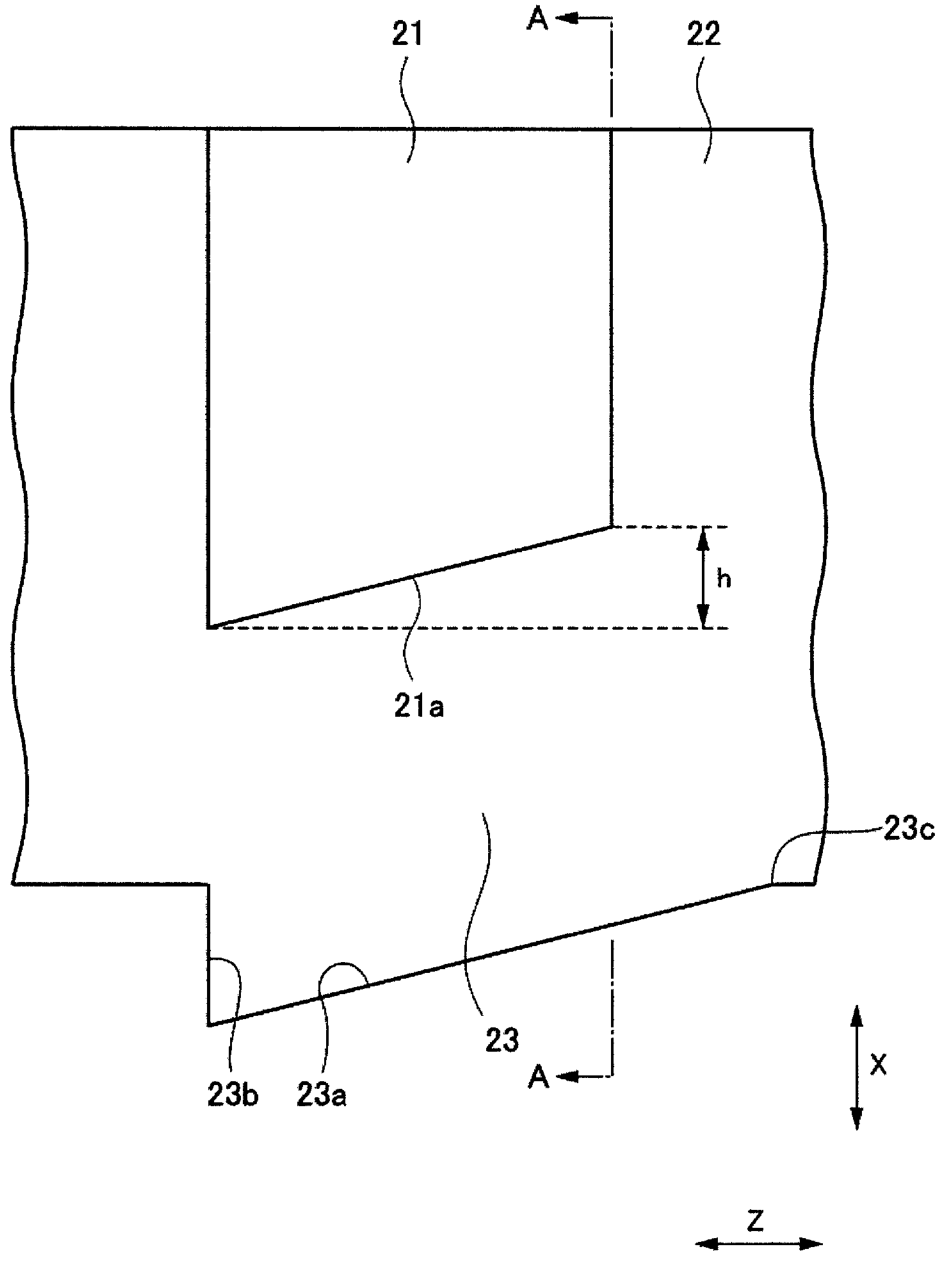
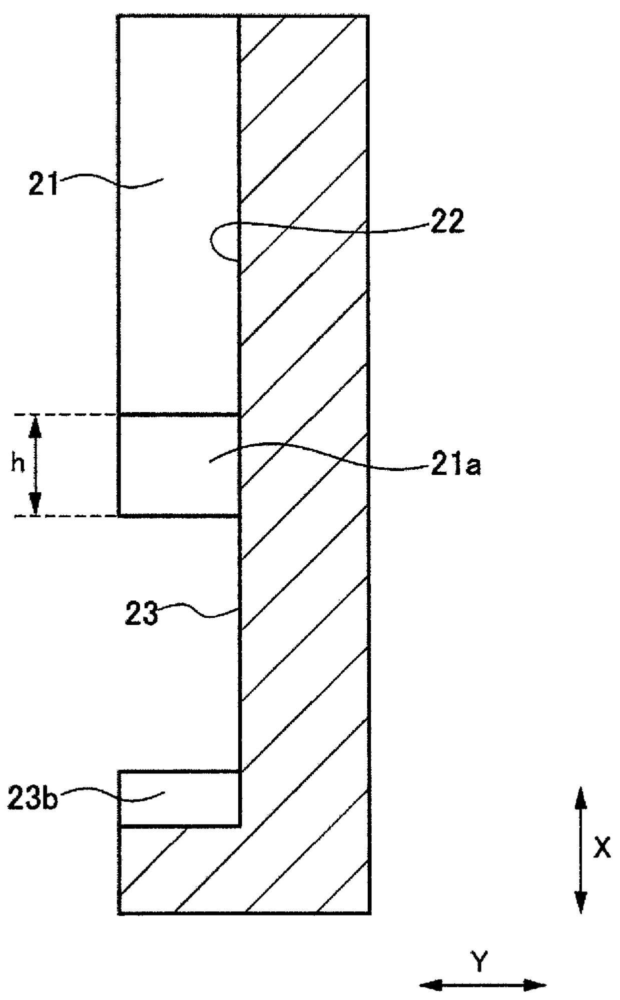


FIG. 6



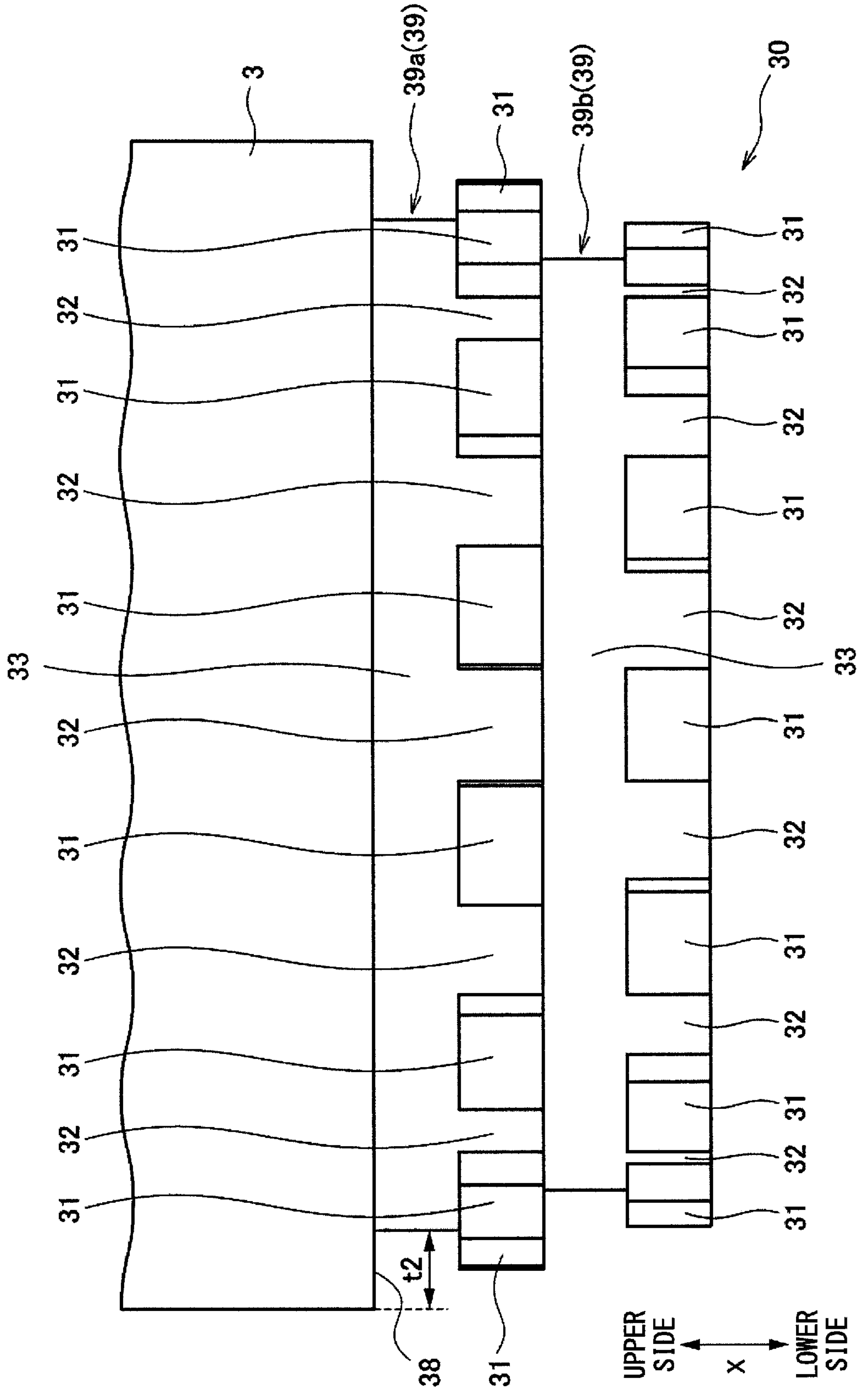


FIG. 7

FIG. 8A

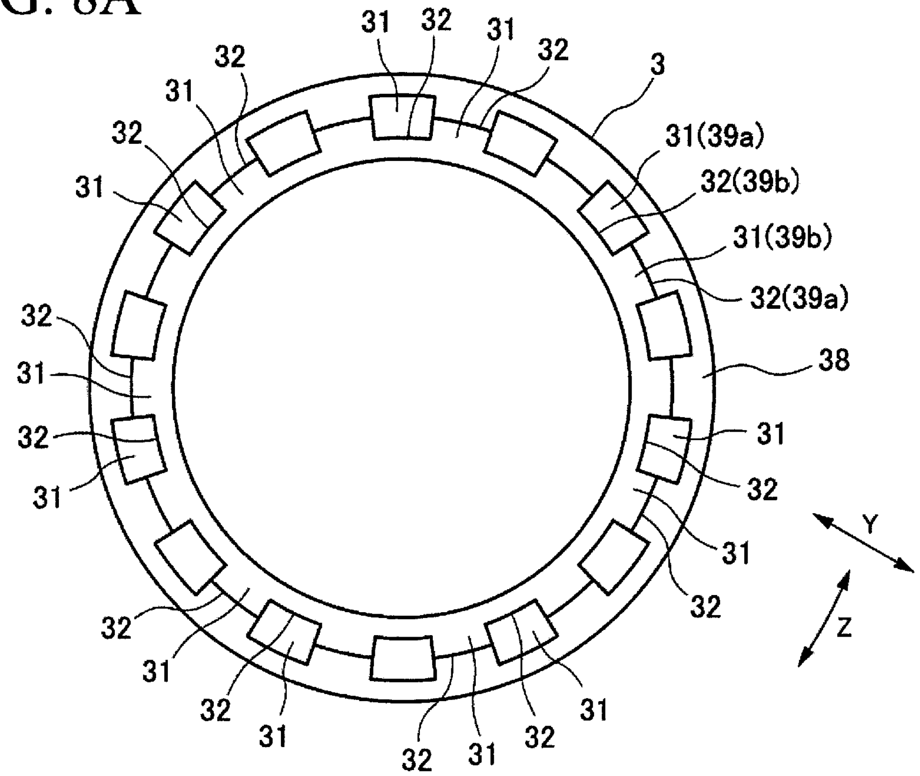

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FIG. 8B

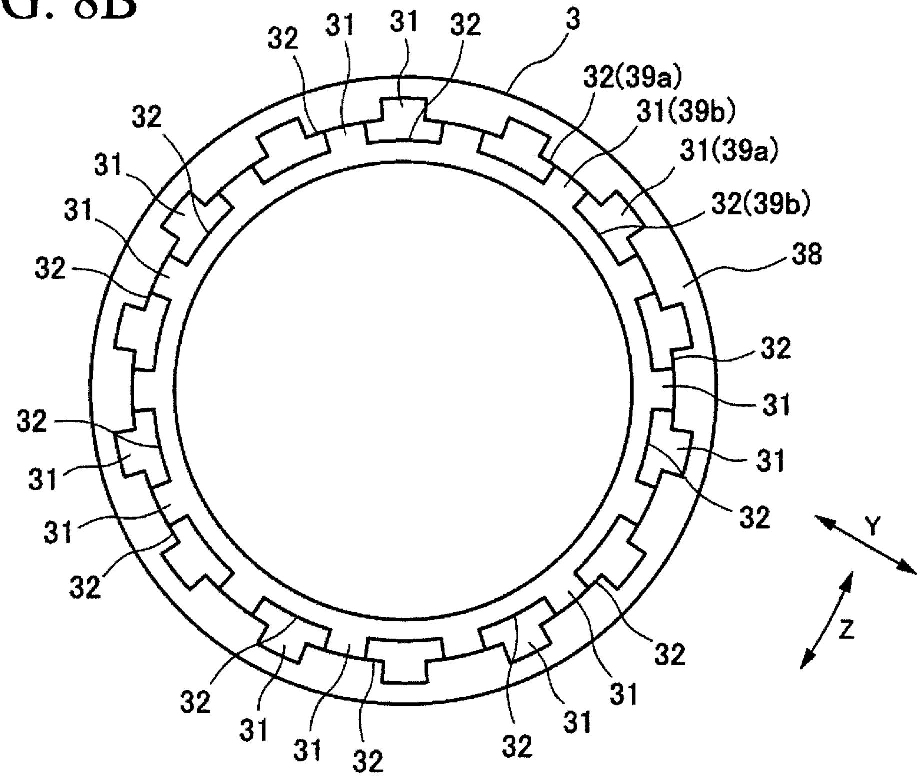
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FIG. 9

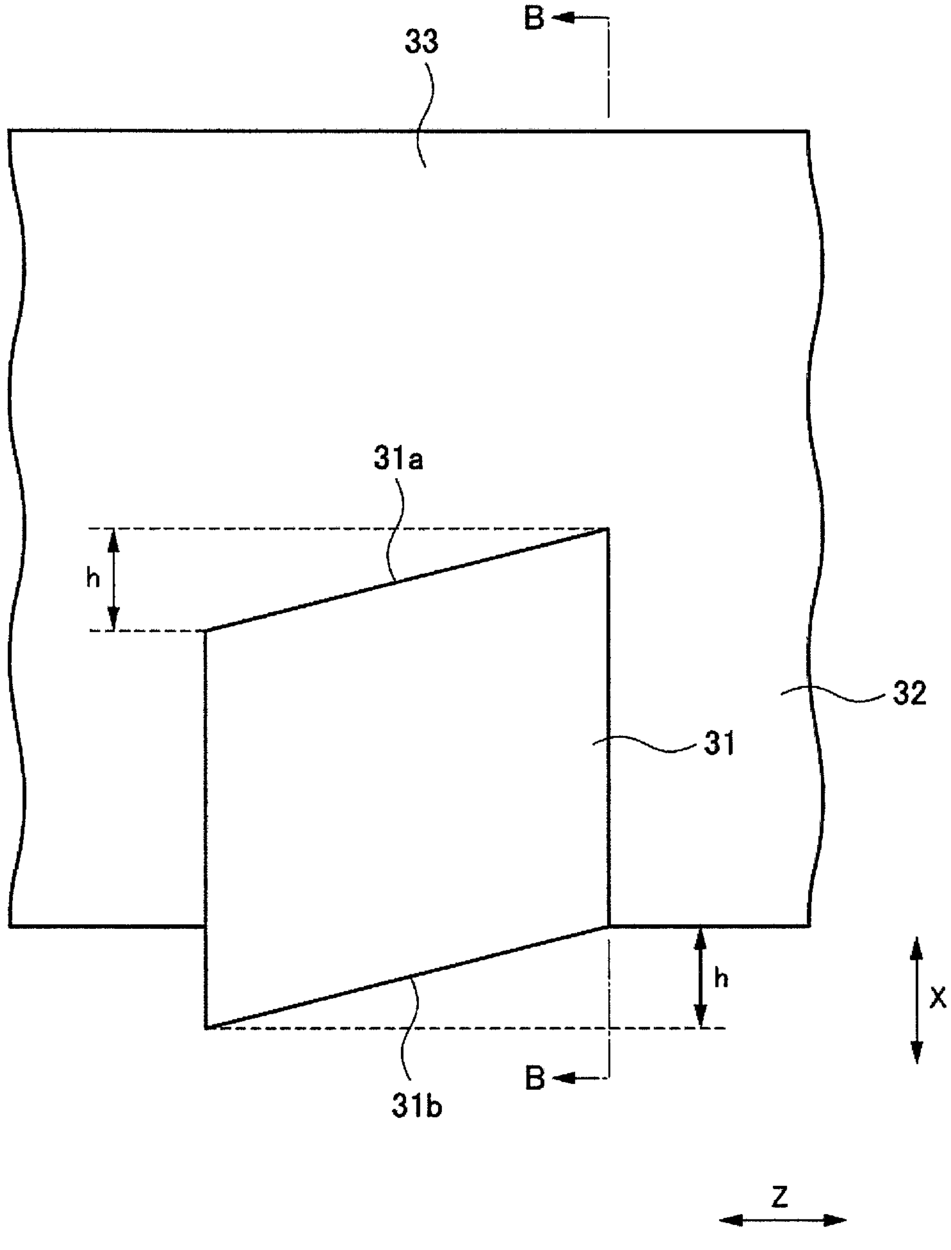


FIG. 10

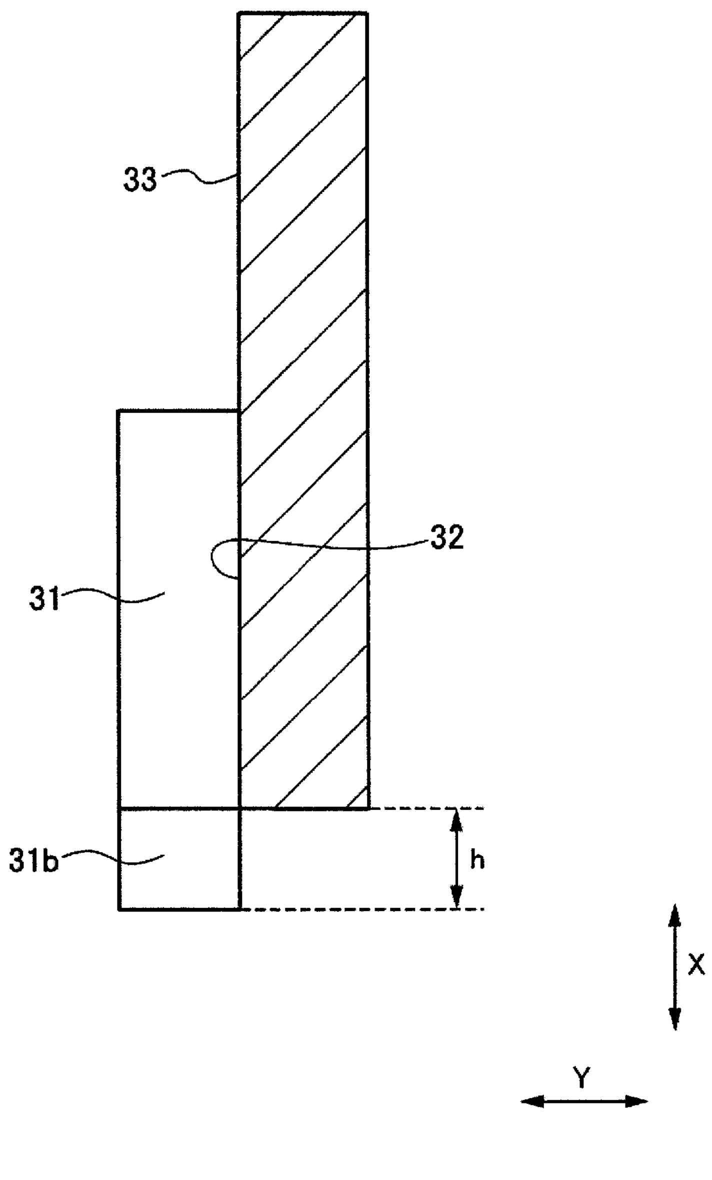


FIG. 11

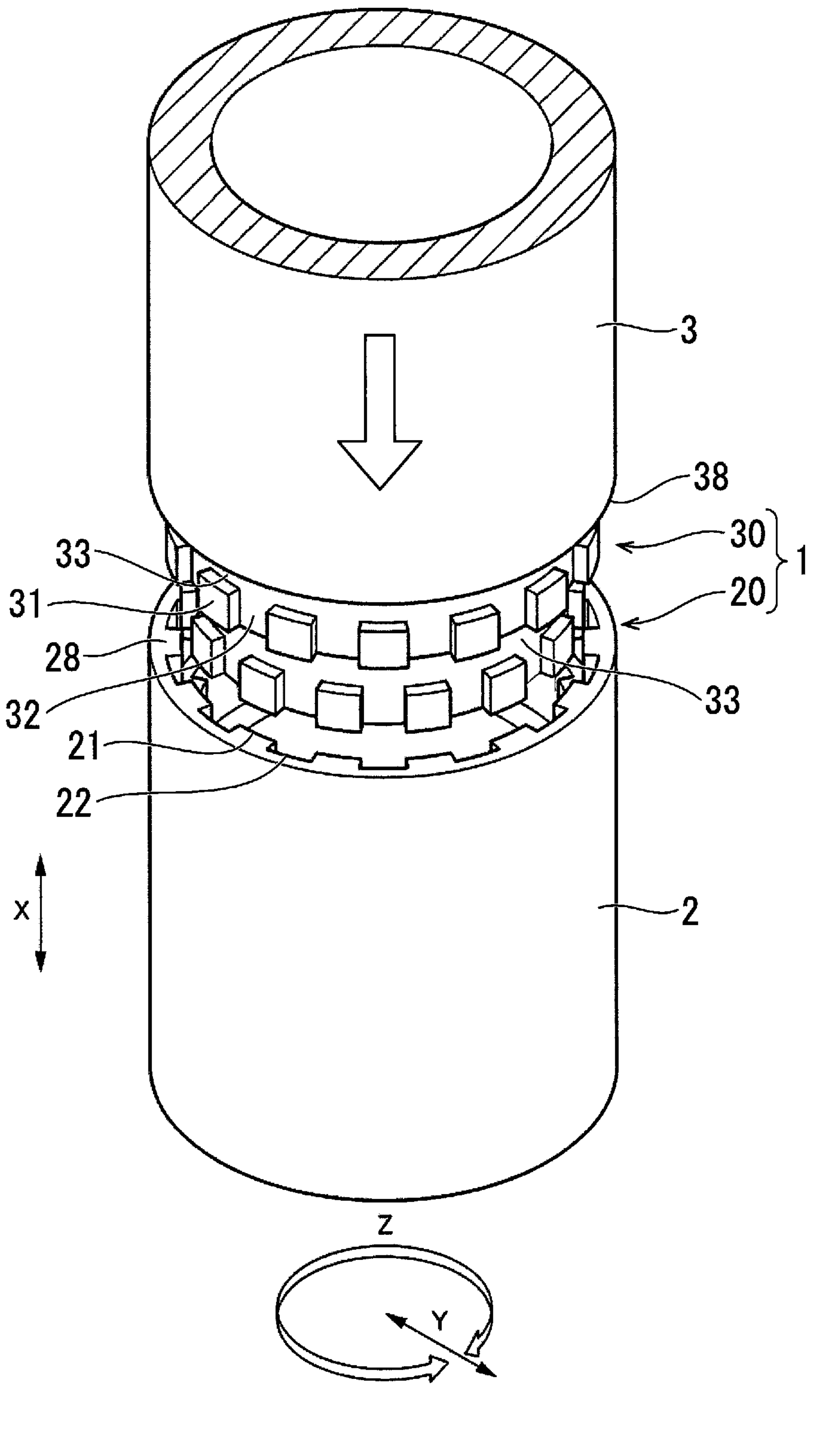


FIG. 12

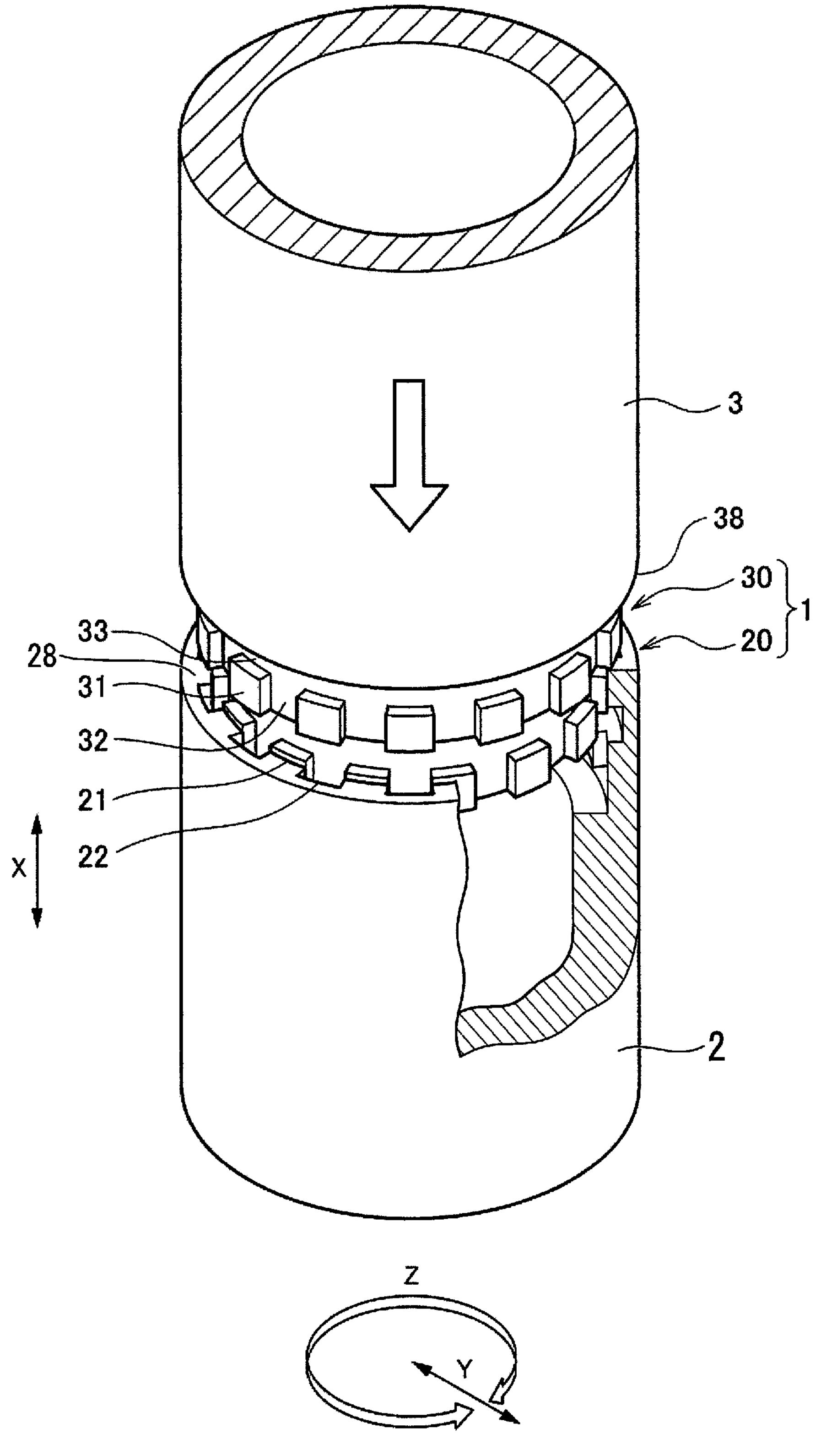
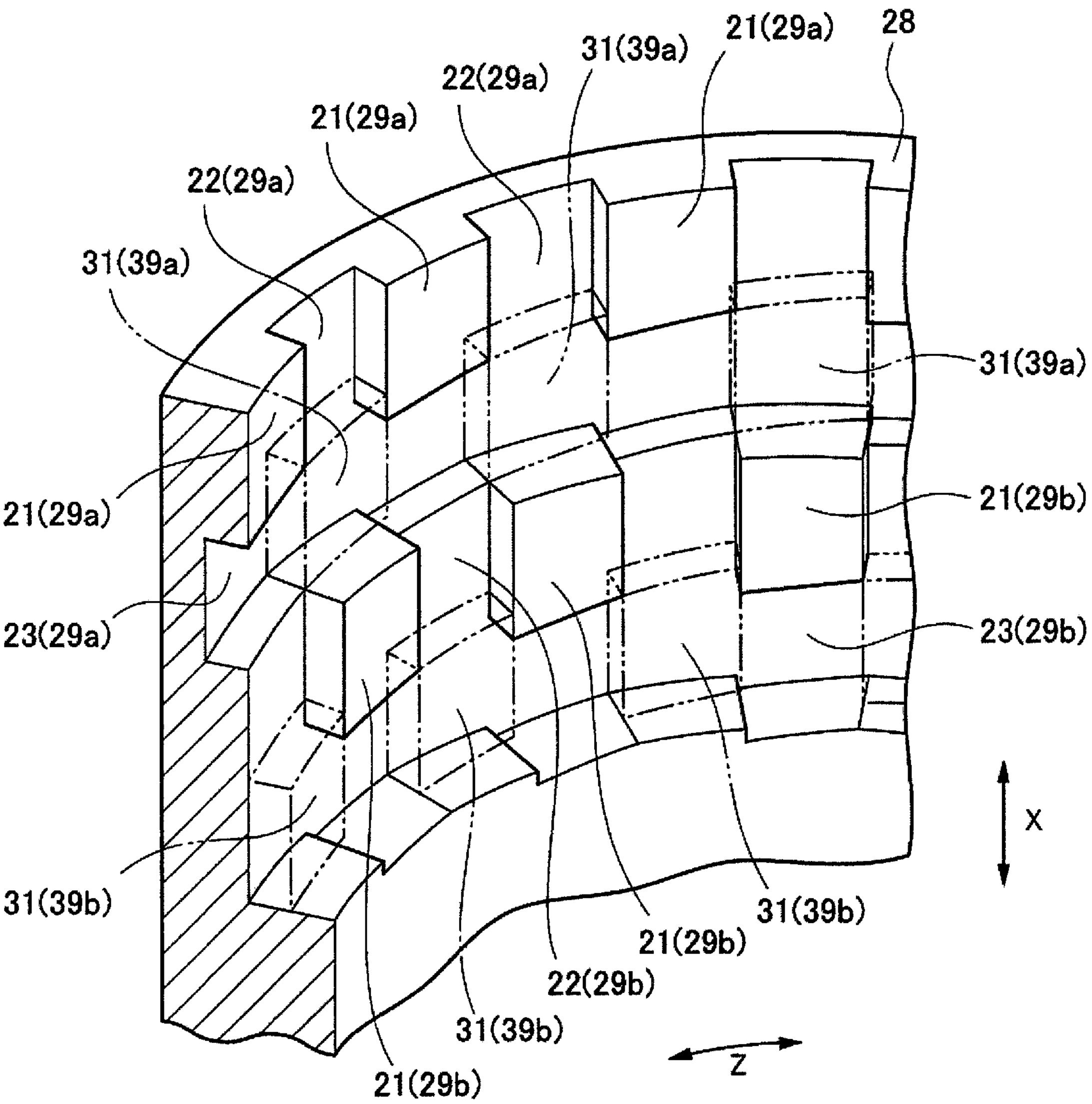


FIG. 13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21(29b)

FIG. 14A

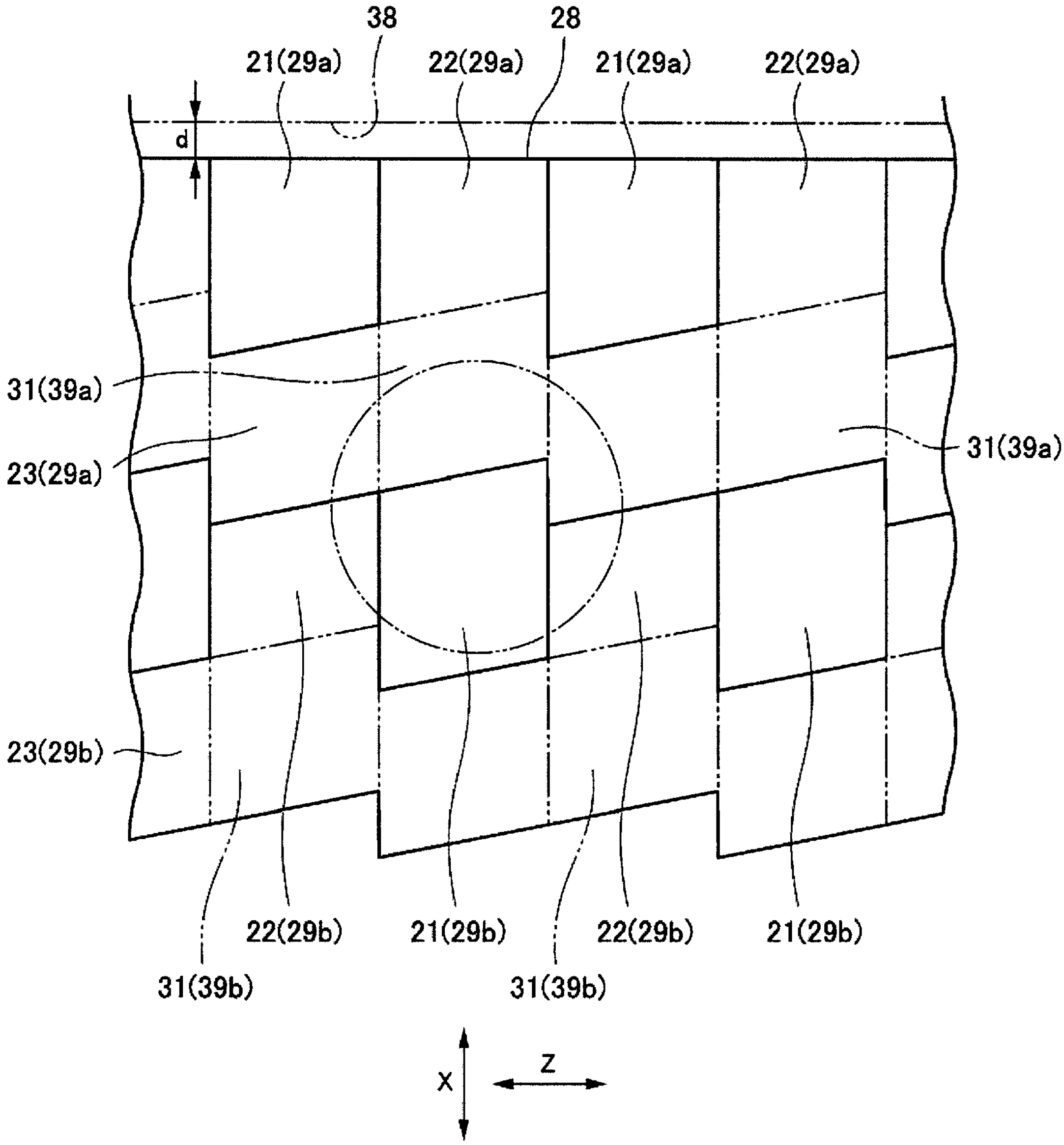


FIG. 14B

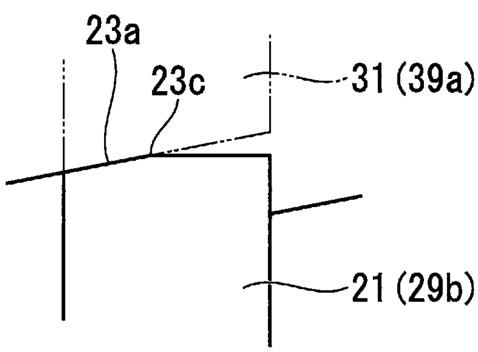


FIG. 15

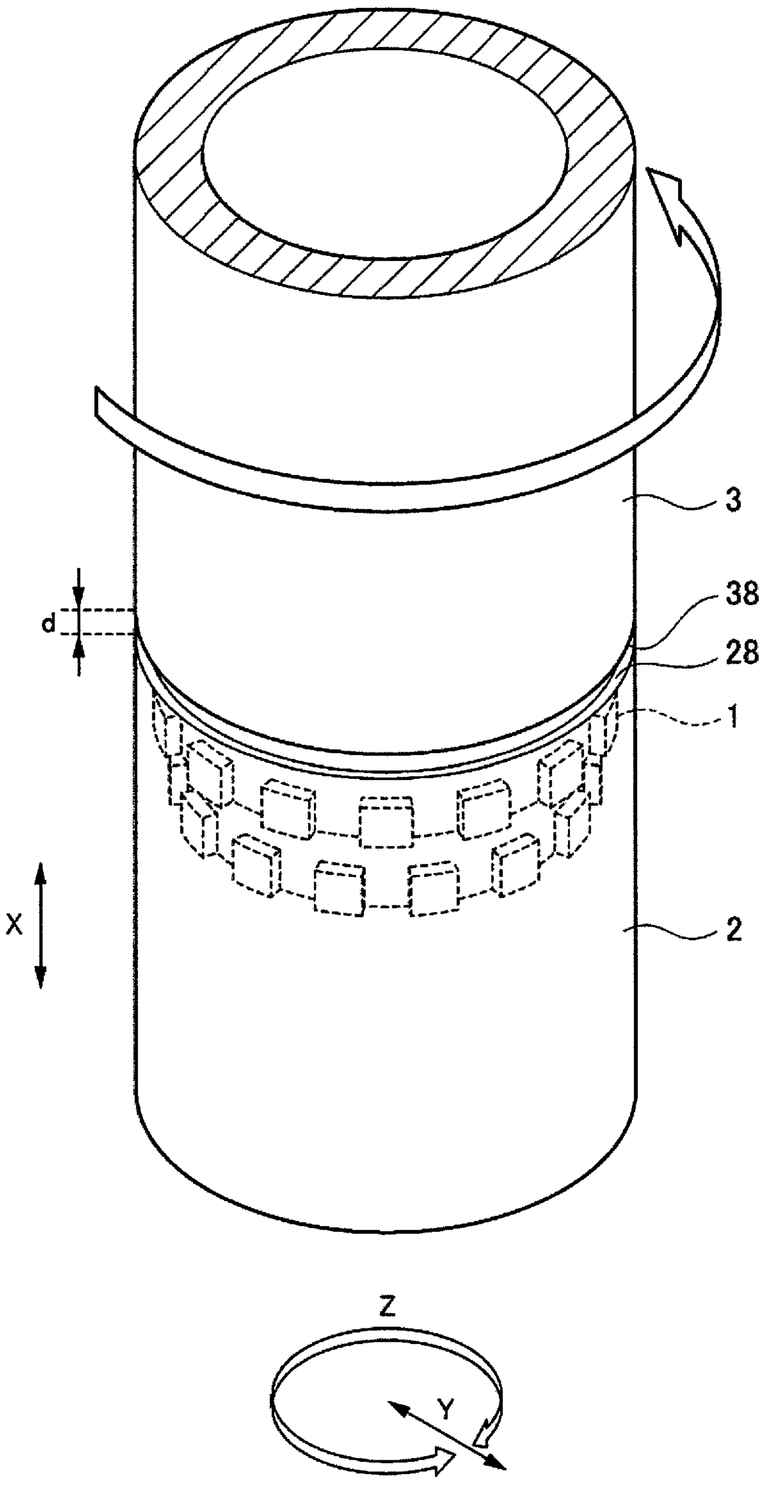
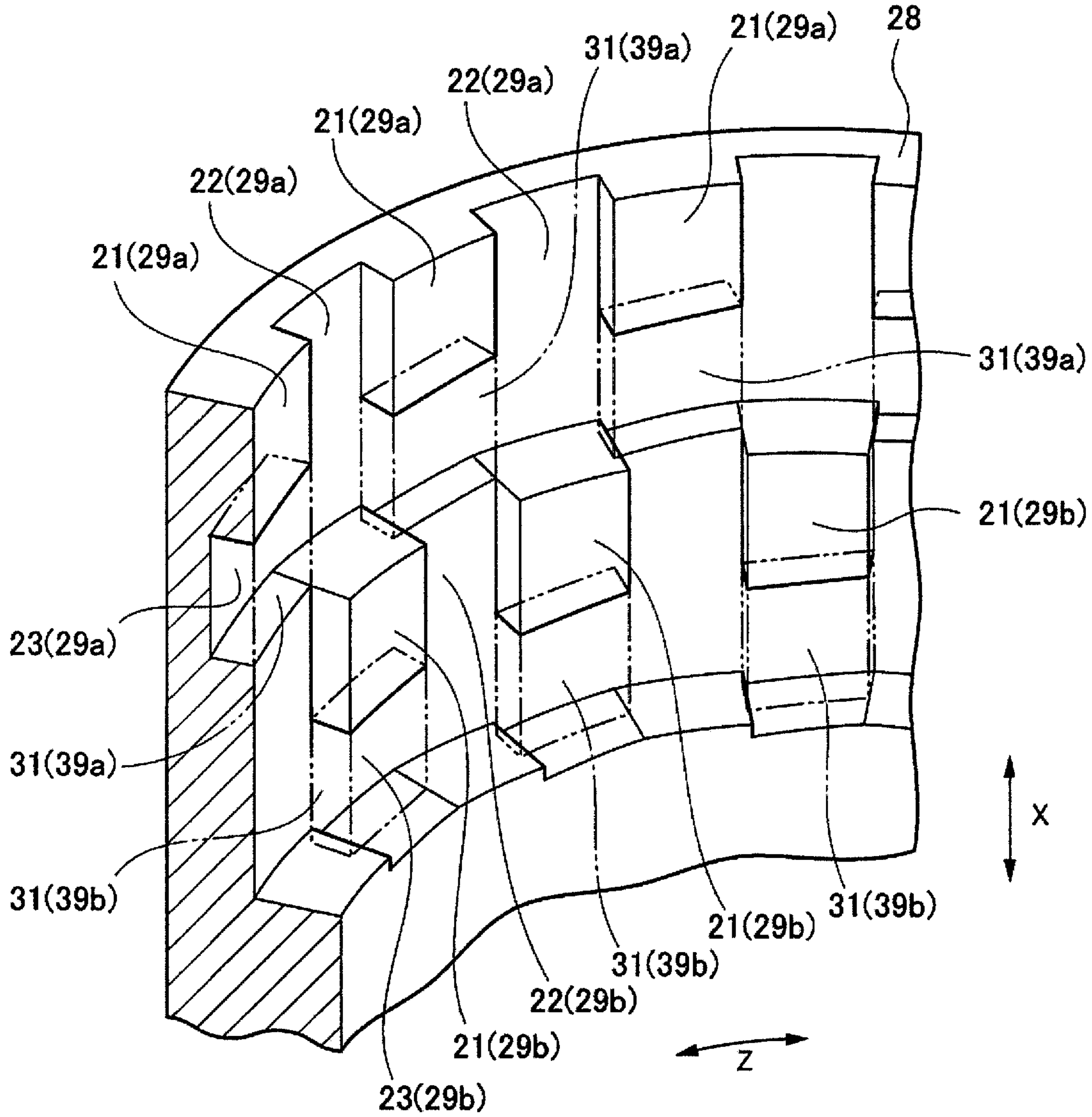


FIG. 16



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31(39a)
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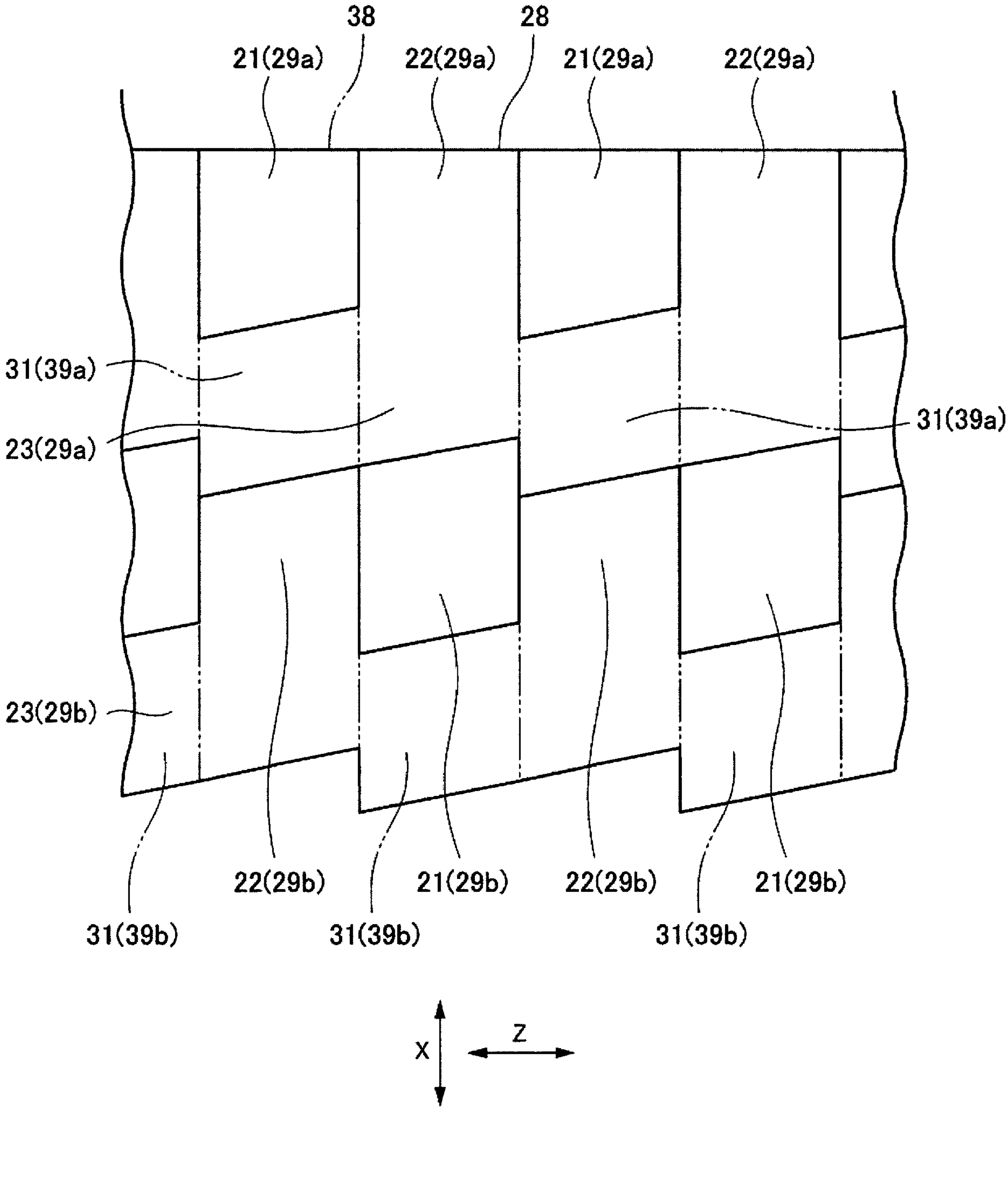
31(39b)
22(29b)
21(29b)
23(29b)
Z

FIG. 17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31(39b)
31(39b)
31(39b)
X
Z

FIG. 18

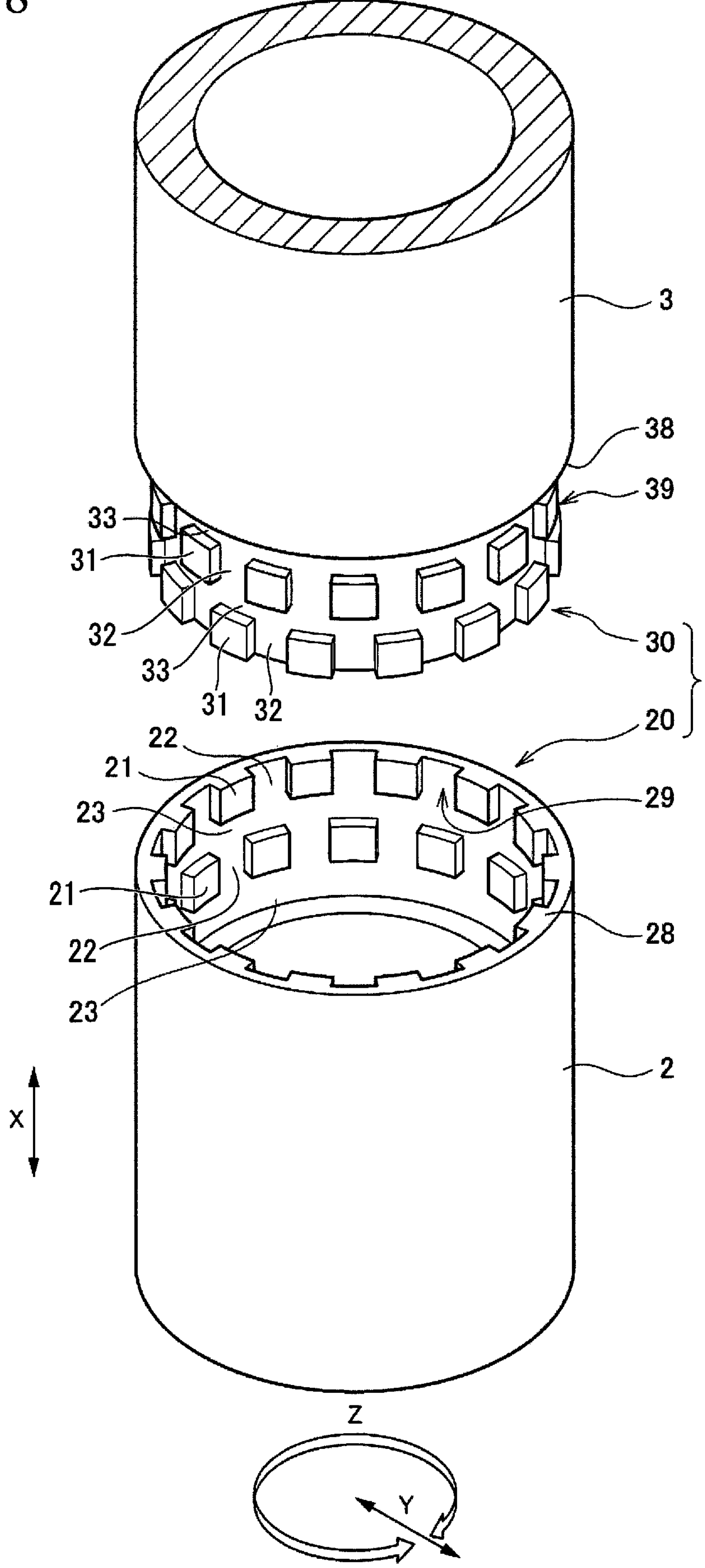
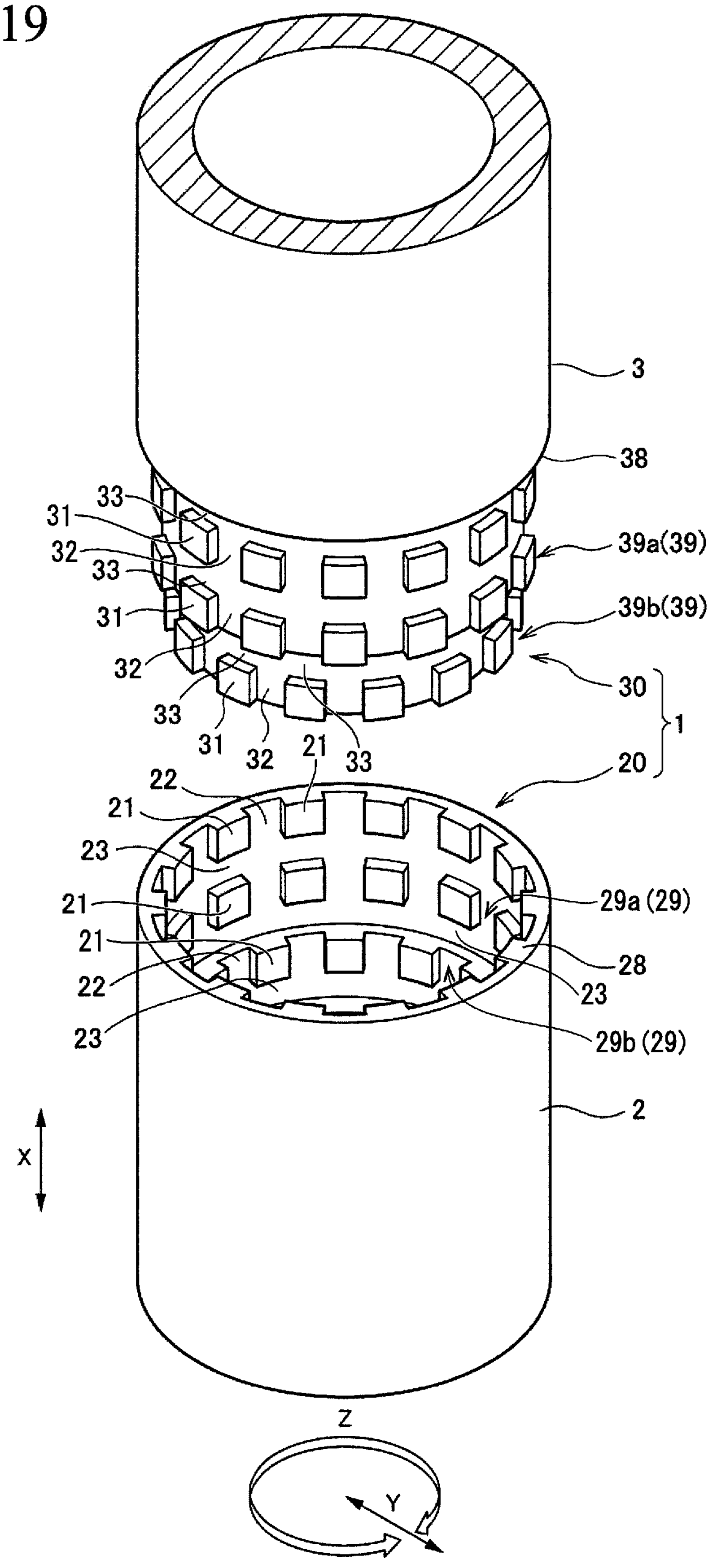


FIG. 19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29b (29)
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FIG. 20

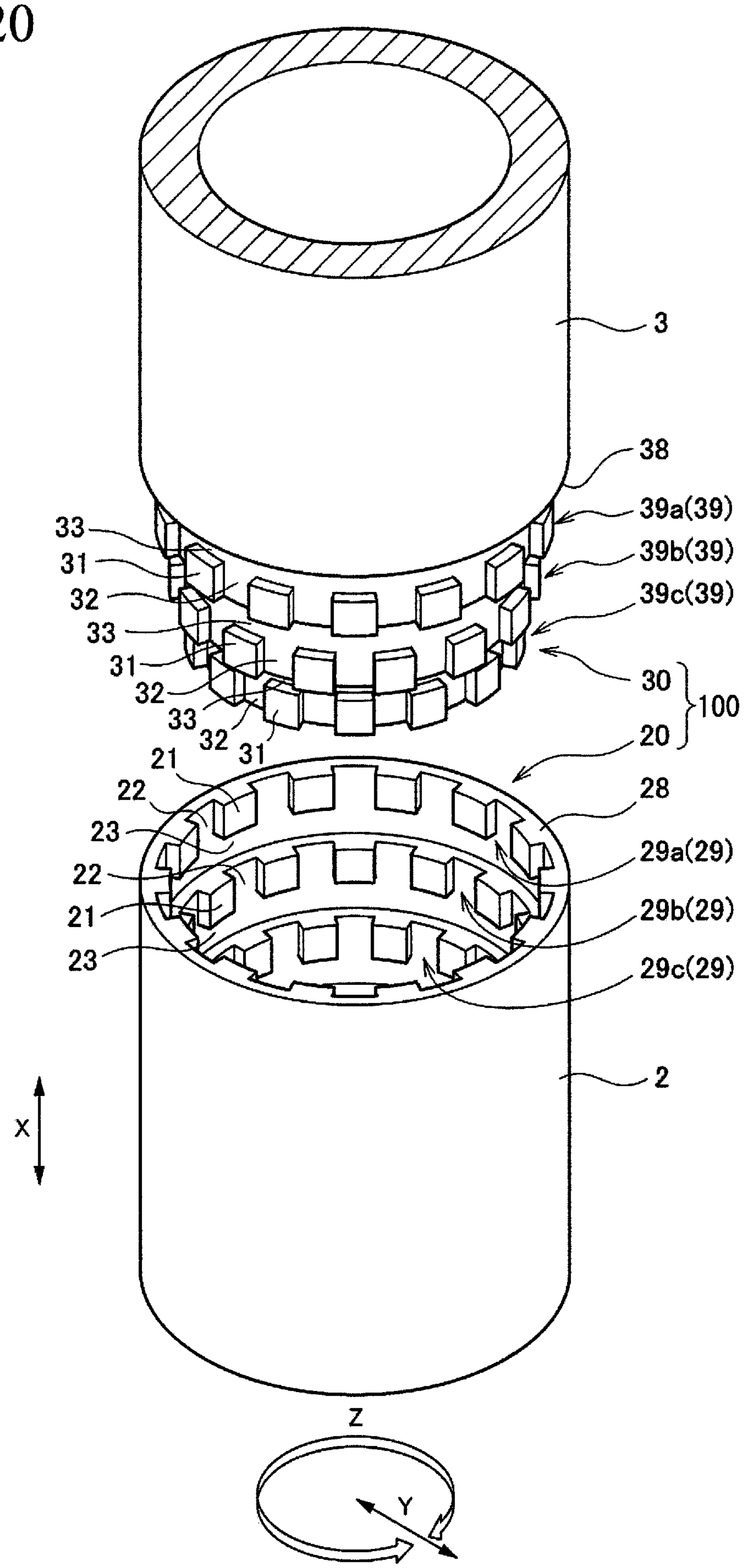
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FIG. 21A

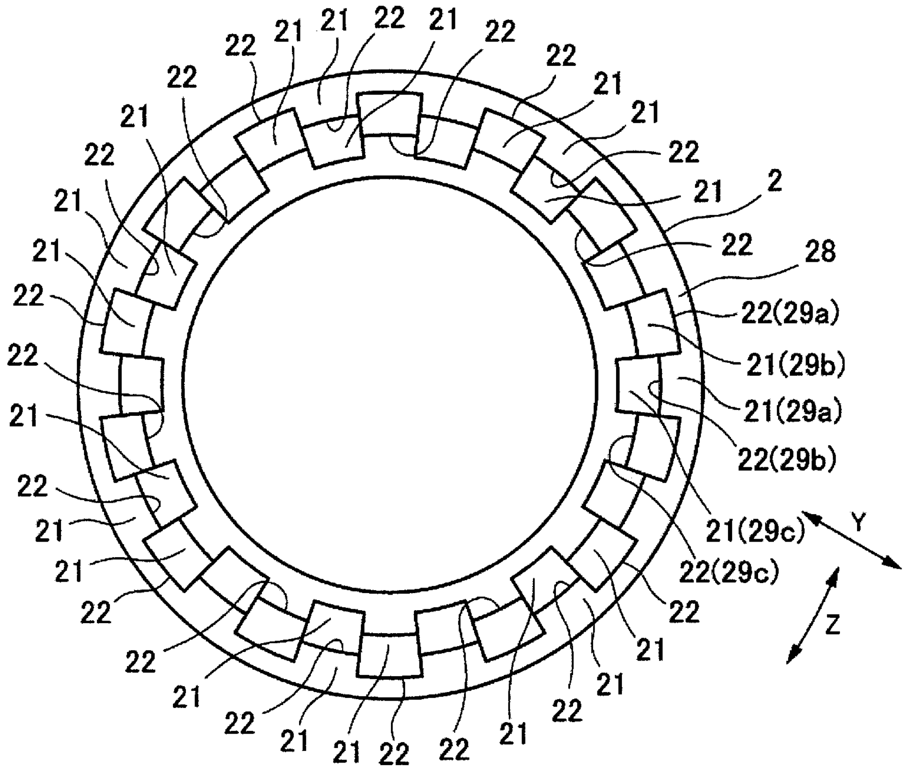


FIG. 21B

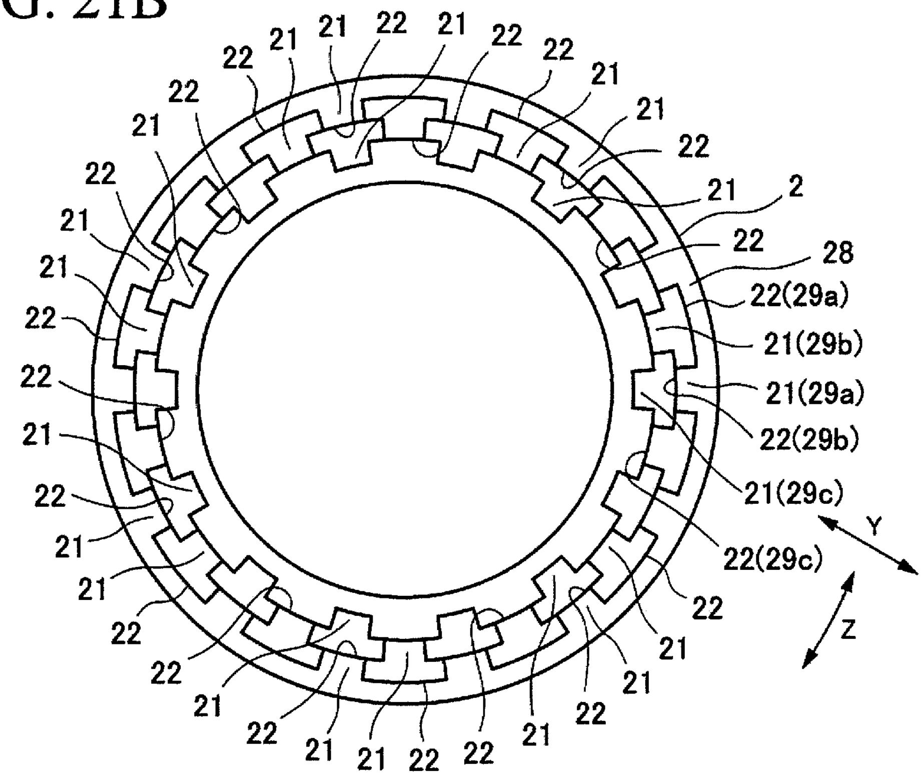


FIG. 22A

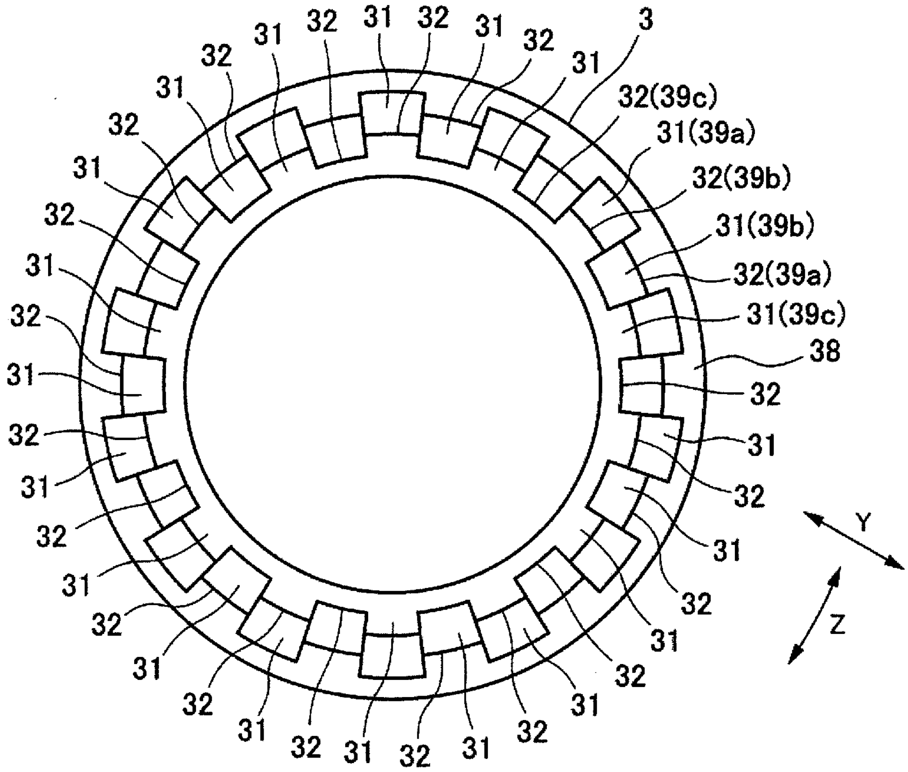


FIG. 22B

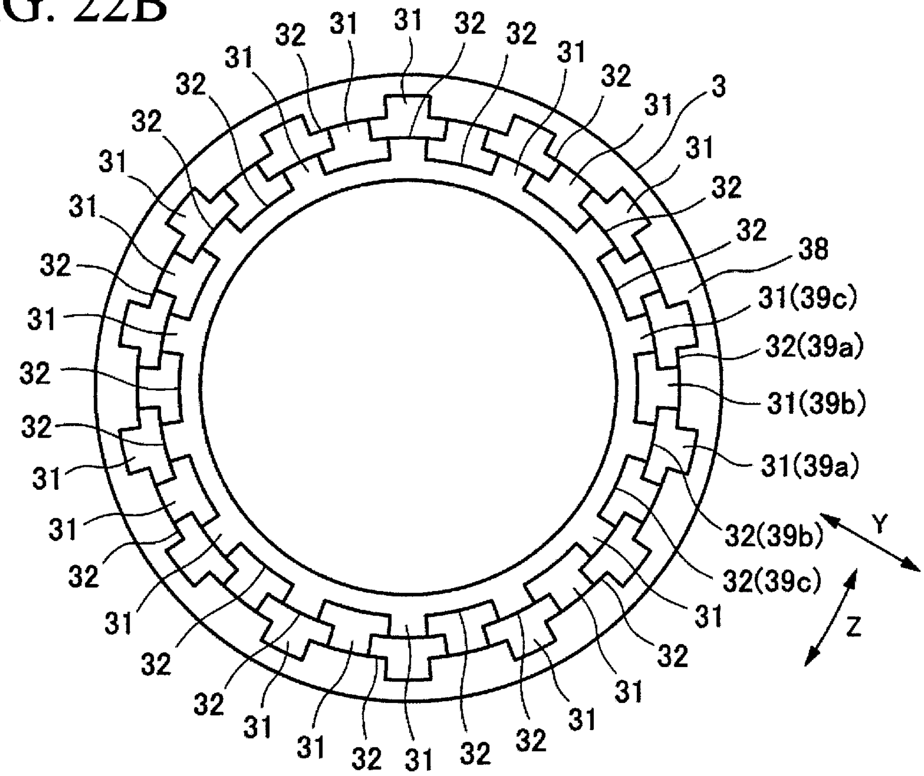
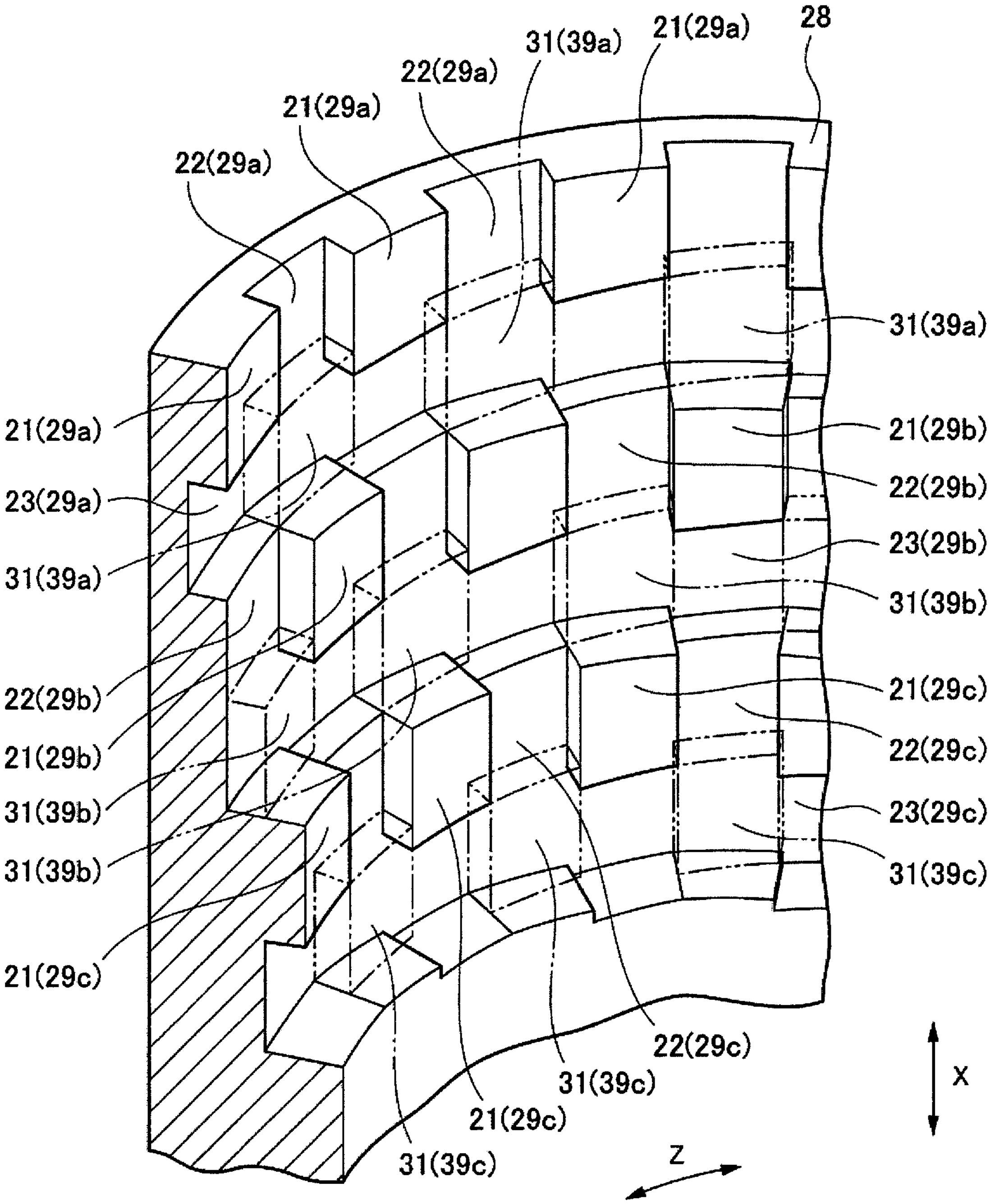


FIG. 23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31(39c)
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31(39a)
22(29b)
21(29b)
31(39b)
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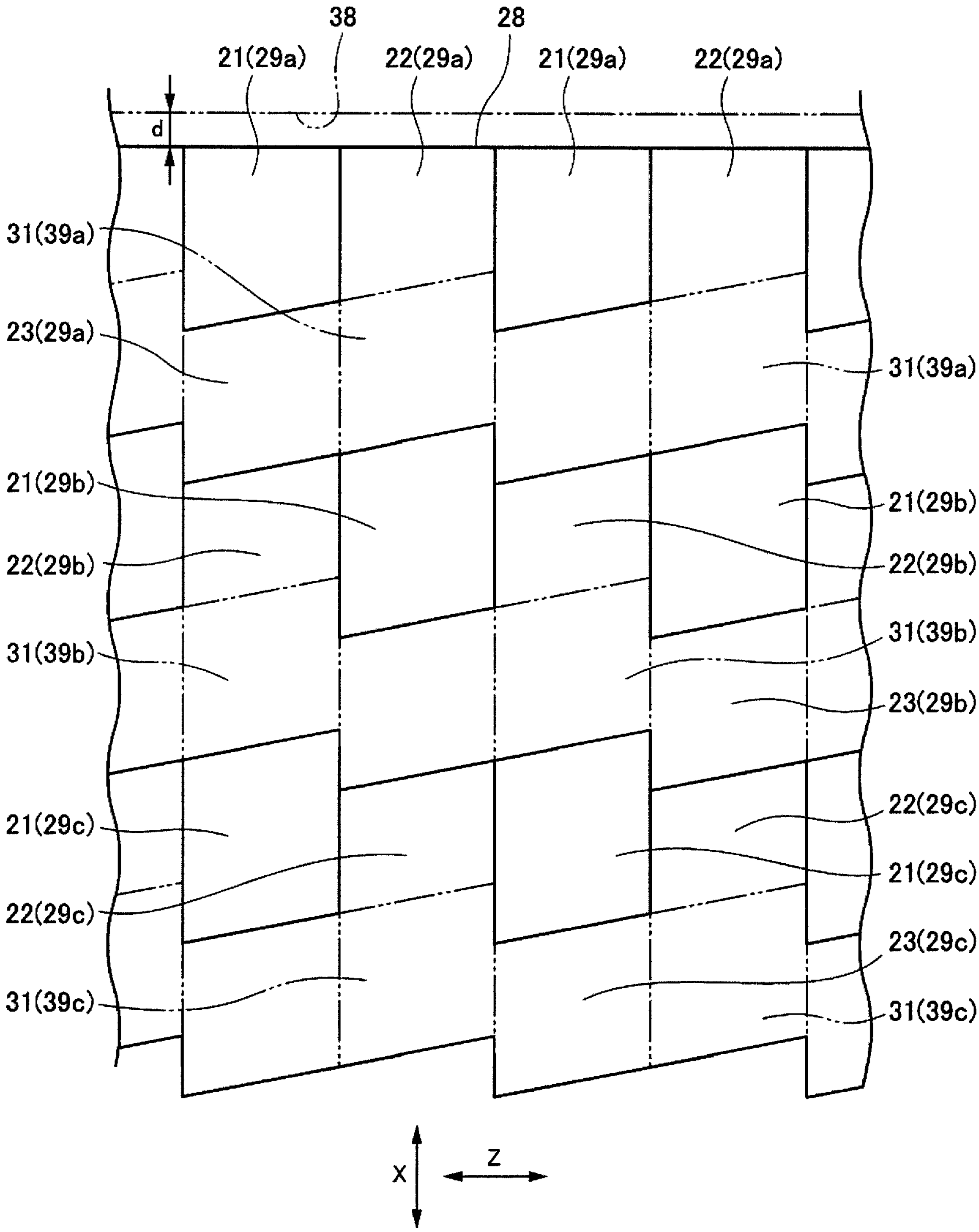
21(29c)
22(29c)
31(39c)
21(29c)
31(39c)
X
Z

FIG. 24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31(39b)
31(39b)
23(29b)
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21(29c)
22(29c)
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31(39c)
31(39c)
X
Z

FIG. 25

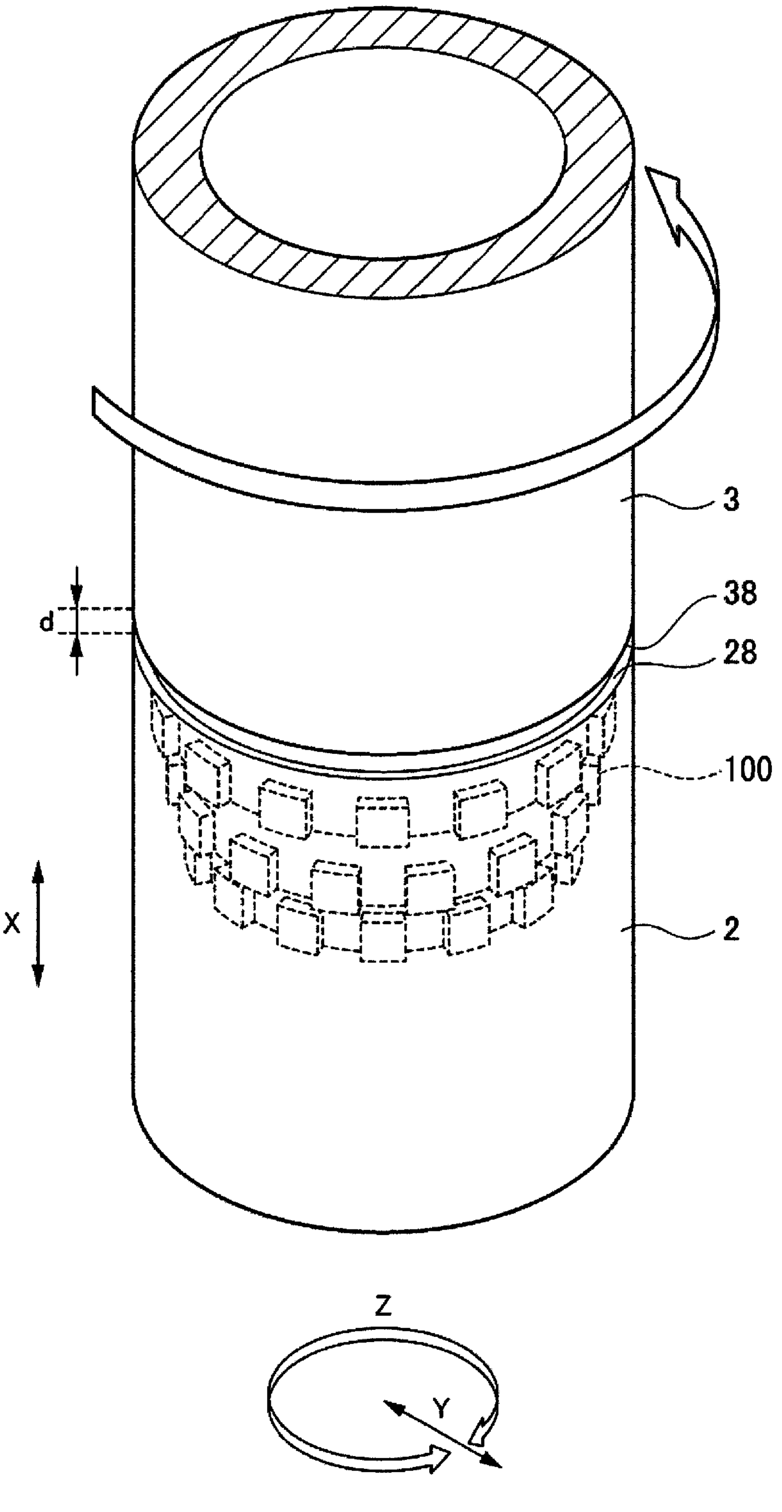
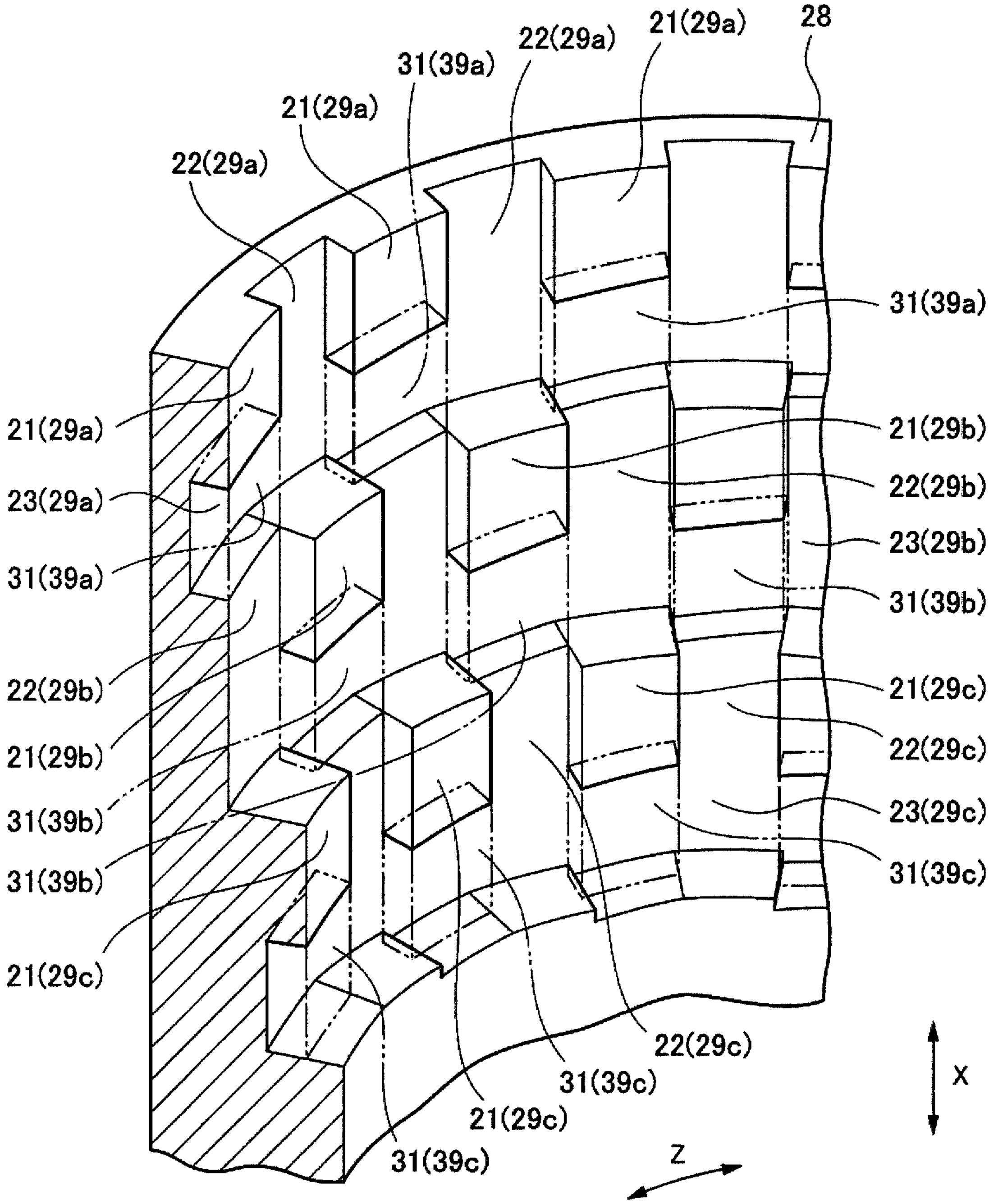


FIG. 26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21(29b)
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23(29b)
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31(39c)
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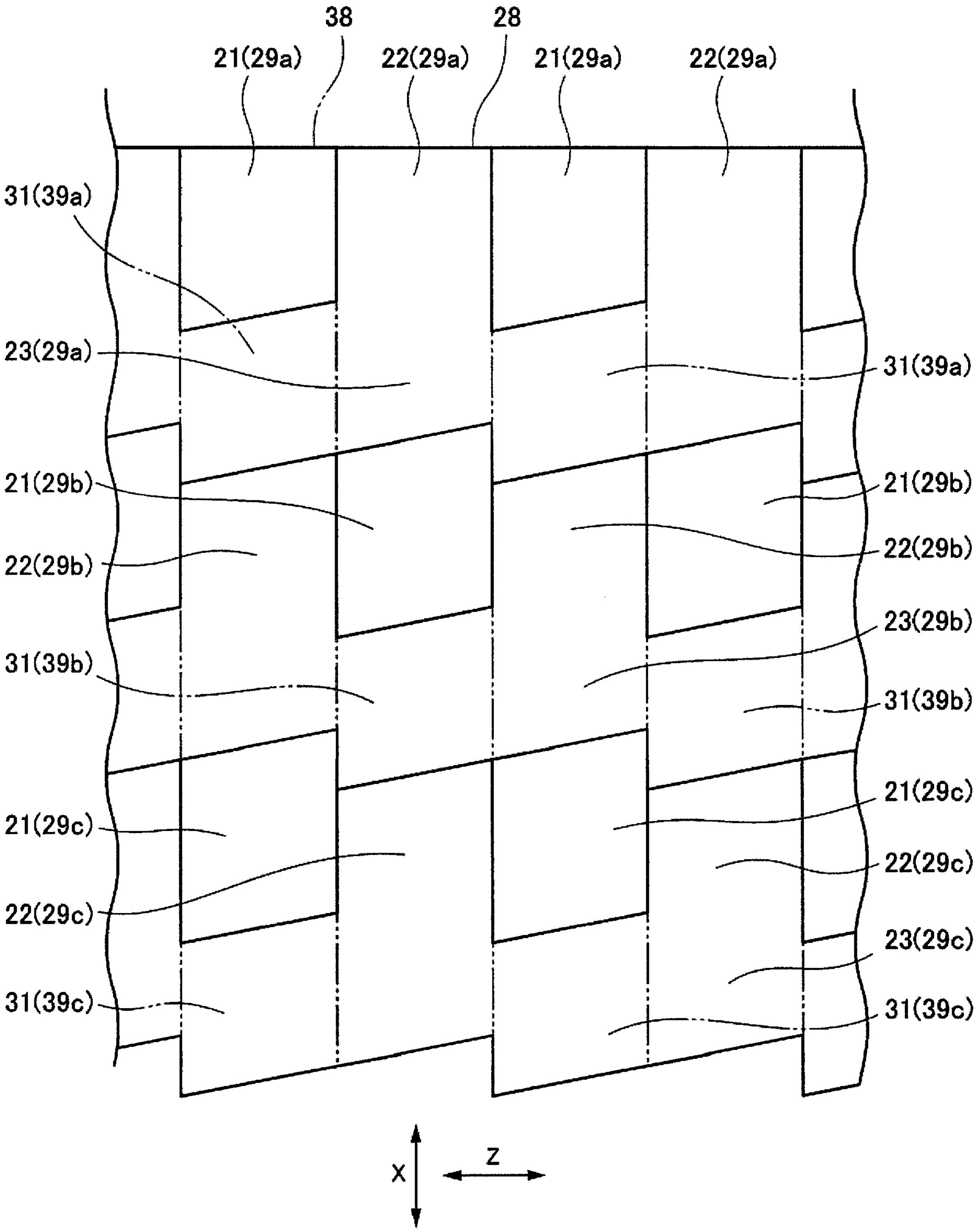
FIG. 27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21(29c)
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/080748

A. CLASSIFICATION OF SUBJECT MATTER
E02D5/24(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)
E02D5/24

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	1996-2014
Kokai Jitsuyo Shinan Koho	1971-2014	Toroku Jitsuyo Shinan Koho	1994-2014

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 11-43936 A (Kubota Corp.), 16 February 1999 (16.02.1999), paragraphs [0009] to [0017]; fig. 1 to 5 (Family: none)	1-4,6 5
Y A	WO 2011/078661 A1 (IHC HOLLAND IE B.V.), 30 June 2011 (30.06.2011), page 6, line 31 to page 8, line 33; fig. 2, 6a to 6e & JP 2013-515924 A & US 2012/0325335 A1 & EP 2516915 A & NL 2004010 C & AU 2010335103 A & CA 2785442 A & SG 181918 A & CN 102812280 A & KR 10-2012-0137471 A & MX 2012007374 A	1-4,6 5

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 January, 2014 (21.01.14)	28 January, 2014 (28.01.14)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

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- JP H0782738 B **[0008]**
- JP 2000257058 A **[0008]**
- JP H1143937 B **[0008]**