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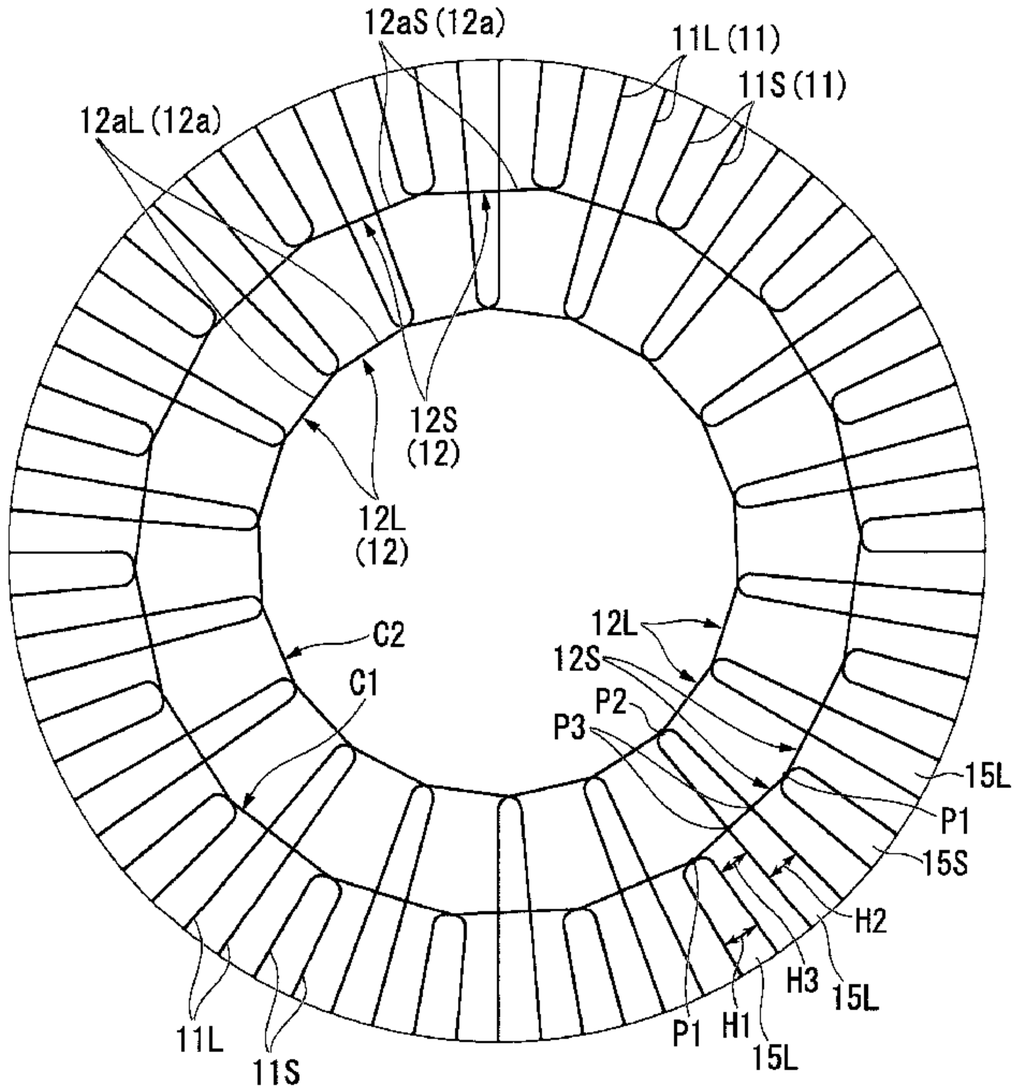
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(54) Titre : TOIT EN BETON PRECONTRAINT POUR RESERVOIR CYLINDRIQUE
(54) Title: PRESTRESSED CONCRETE ROOF FOR CYLINDRICAL TANK



(57) Abrégé/Abstract:
This prestressed concrete roof for a cylindrical tank is provided with a plurality of prestressed concrete (PC) steel members (11) which are arranged side by side in a peripheral direction, at an outer peripheral side of a discoid roof, and which each extend along a radial direction. The plurality of PC steel members (11) are configured from respective arm parts of bent-back PC steel members (12) which have been bent back so as to be open at the outer peripheral side of the roof in a planar view.

ABSTRACT

A prestressed concrete roof for a cylindrical tank is provided with a plurality of prestressed concrete (PC) steel members (11) which are disposed side by side in a circumferential direction at an outer circumferential side of a discoid roof and each of which extends in a radial direction, in which the plurality of PC steel members (11) are made up of both arm parts of folded PC steel members (12) that are folded so as to be open to the outer circumferential side of the roof in a plan view.

DESCRIPTION

Title of the Invention

PRESTRESSED CONCRETE ROOF FOR CYLINDRICAL TANK

Technical Field

[0001]

The present invention relates to a prestressed concrete roof for a cylindrical tank.

Background Art

[0002]

As is well known, prestressed concrete (PC) construction methods for introducing prestress are used in large cylindrical concrete structures such as ground tanks for storing liquefied natural gas (LNG) or liquefied petroleum gas (LPG). The PC construction methods include methods of using bonded PC steel members as PC steel members and methods of using unbonded PC steel members as PC steel members. The PC construction method using the bonded PC steel members has the following processes. First, sheaths are arranged before concrete is poured. Bonded PC steel members such as PC steel rods, PC steel wires, or PC steel stranded wires (PC steel strands), are inserted into the sheaths before or after the concrete is cured, and are strained when the concrete reaches the desired strength. Afterwards, a material such as cement milk enters the sheaths under pressure in order to perform an anti-corrosion treatment and to bind and integrate the bonded PC steel members and the concrete. On the other hand, in the PC

construction method using the unbonded PC steel members, grease is applied to PC steel members, and their surroundings are covered with sheaths.

As a prestressed concrete roof for a cylindrical tank, as disclosed in, for instance, Patent Documents 1 and 2, a technique for arranging PC steel members at an outer circumferential side of a discoid roof in a radial direction and thereby supporting strength against bending moment generated adjacent to the outer circumference side of the roof is known.

Citation List

Patent Documents

[0003]

Patent Document 1: Japanese Unexamined Patent Application, First Publication No. 2011-251741

Patent Document 2: Japanese Unexamined Patent Application, First Publication No. H07-4111

Summary of Invention

Technical Problem

[0004]

In the related art, a radial compressive force caused by PC steel members may be applied to an outer circumferential side of the roof, whereas a radial tensile force opposite to the radial compressive force may be applied to an inner circumferential side positioned inside of the PC steel members in the roof. Since the opposite force is applied in this way, stress tends to be concentrated around inner circumferential ends of the PC steel members in the roof. To relieve the concentration of the stress, a technique

for alternately arranging long PC steel members and short PC steel members in a circumferential direction is known.

However, since the stress is still concerned on an anchoring part of the inner circumferential end of each PC steel member, there is a need to use large anchoring tools or form thick wall parts or reinforced parts around the anchoring parts. As a result, the weight and manufacturing cost of the roof are increased.

[0005]

The present invention has been made in view of the aforementioned problems, and an object of the present invention is to provide a prestressed concrete roof for a cylindrical tank, which minimizes increases in the weight and manufacturing cost of the roof and inhibits stress from being concentrated on anchoring parts of PC steel members arranged at an outer circumferential side of the roof.

[0006]

According to first aspect of the present invention, there is provided a prestressed concrete roof for a cylindrical tank comprising:

a plurality of PC steel members which are disposed side by side in a circumferential direction at an outer circumferential side of a discoid roof and each of which extends in a radial direction,

wherein the plurality of PC steel members are made up of both arm parts of folded PC steel members that are folded so as to be open to the outer circumferential side of the roof in a plan view, each folded PC steel member having the both arm parts and a folded part extending between the both arm parts, and

the folded parts of the folded PC steel members are arranged to stand in line so as to form at least one circle in the plan view.

[0007]

According to this constitution, by using the folded parts extending between inner circumferential ends of both of the arm parts of the folded PC steel members as

anchoring parts of inner circumferential ends of the PC steel members formed by both the arm parts of the folded PC steel members, the tension load of the PC steel members may be dispersed to all the folded parts. For this reason, stress concentration at the anchoring parts of the inner circumferential ends of the PC steel members may be limited. As a result, there may be no need to use large anchoring tools or form thick wall parts or reinforced parts around the anchoring parts, and increases in the weight and manufacturing cost of the roof 6 may be minimized.

[0008]

According to a second aspect of the present invention, in the prestressed concrete roof for a cylindrical tank according to the first aspect, the PC steel members includes a short PC steel member and a long PC steel member that are different in radial length; and the folded PC steel members includes a short folded PC steel member which constitutes the short PC steel member and a long folded PC steel member which constitutes the long PC steel member.

In this case, radial positions of the anchoring parts of the inner circumferential ends of the short PC steel members (i.e., folded parts of the short folded PC steel members) and radial positions of the anchoring parts of the inner circumferential ends of the long PC steel members (i.e., folded parts of the long folded PC steel members) are out of alignment with each other, and therefore the stress concentration on the anchoring parts of the inner circumferential ends of the PC steel members may be more effectively limited.

[0009]

According to a third aspect of the present invention, in the prestressed concrete roof for a cylindrical tank according to the second aspect, lateral portions of the short folded PC steel members including the short PC steel members form short overlap

portions that overlap the short folded PC steel members adjacent in the circumferential direction; lateral portions of the long folded PC steel members including the long PC steel members form long overlap portions that overlap the long folded PC steel members adjacent in the circumferential direction; the short overlap portions and the long overlap portions are alternately arranged in the circumferential direction; and all of the plurality of PC steel members including the short PC steel members at both sides of the short overlap portions and the long PC steel members at both sides of the long overlap portions are arranged at regular intervals in the circumferential direction.

In this case, the short folded PC steel members adjacent in the circumferential direction and the long folded PC steel members adjacent in the circumferential direction overlap each other in the circumferential direction. Thereby, it may be possible to give prestress to the entire region in the circumferential direction. Also, the short overlap portions and the long overlap portions are alternately arranged, and all the PC steel members are arranged at regular intervals in the circumferential direction. Thereby, the prestress may be uniformly given.

[0010]

According to the present invention, in the prestressed concrete roof for a cylindrical tank, it may be possible to limit an increase in the weight and manufacturing cost of the roof and inhibit stress from being concentrated on the anchoring parts of the PC steel members arranged at the outer circumferential side of the roof.

Brief Description of Drawings

[0011]

FIG. 1 is a vertical sectional view of a cylindrical tank in an embodiment of the present invention.

FIG. 2 is an enlarged view of a part A of FIG. 1.

FIG. 3 is a plan view showing an arrangement of prestressed concrete (PC) steel members in a prestressed concrete roof of the cylindrical tank in the embodiment of the present invention.

FIG. 4 is a partially enlarged view of FIG. 3.

Description of Embodiments

[0012]

Hereinafter, an embodiment of the present invention will be described with reference to the drawings. In the present embodiment, a cylindrical prestressed concrete (PC) double shell storage tank for storing liquefied natural gas (LNG) will be described as an example.

The construction of the cylindrical tank (PC structure) of the present invention will be described with reference to FIG. 1. First, a discoid base (bottom part of an outer tank) 1 is laid, and a base part 3 for building a PC wall (sidewall of the outer tank) 2 is provided to protrude at an outer circumferential edge of the base 1.

[0013]

Next, lateral liners (outer tank lateral plates) 2a are built on the base 1 along an inner side of the base part 3 and up to an uppermost level of the cylindrical tank. Concrete is poured and cured on the base part 3 along the built lateral liners 2a, and the PC wall 2 is built sequentially from a lowermost level to an uppermost level according to the number of levels of the lateral liner 2a.

An inner tank sidewall 4, an inner tank roof 5, and an outer tank roof 6 are

appropriately assembled, and thereby the cylindrical tank acting as the double shell storage tank having an inner tank made of a metal and an outer tank made of prestressed concrete is constructed. In the drawings, a reference sign 2b indicates a ring-shaped beam part formed at an upper end of the PC wall 2, and a reference sign 7 indicates a cold insulator filled between the inner tank and the outer tank.

[0014]

As shown in FIG. 2, a thickness of the outer tank roof (hereinafter referred to simply as a "roof") 6, which has an approximate disc shape and bulges upward, increases toward an outer circumferential side. Thus, resistance to bending moment caused by a dead load of the roof 6 is increased. Reinforcing bars are appropriately arranged in the roof 6 in radial and circumferential directions of the roof 6.

Hereinafter, FIG. 3 is also referred. A plurality of PC steel members 11, each of which extends in a radial direction, are arranged in a circumferential direction at an outer circumferential side excluding a predetermined region of an inner circumferential side in the roof 6. Thus, compressive prestress in the radial direction is applied to the outer circumferential side of the roof 6. Each of the PC steel members 11 is inserted into the outer circumferential side of the roof 6 so as to pass an intermediate portion of the roof 6 in a thickness direction of the roof 6. Each of the PC steel members 11 is inclined relative to a horizontal direction to follow a slope of the outer circumferential side of the roof 6. It is preferable to arrange the PC steel members 11 closer to an upper surface of the roof 6 since compressive prestress against the bending moment cause by a dead load of the roof 6 can be efficiently given.

[0015]

An inner circumferential end 11a of each PC steel member 11 is anchored by a folded part 12a to be described below. An outer circumferential end 11b of each PC

steel member 11 is fixed at an outer circumferential side of the beam part 2b of the PC wall 2 using an anchoring tool 11c.

The PC steel members 11 are formed, for instance, by inserting PC steel wires into sheaths. After the inner circumferential end 11a of each PC steel wire is anchored, the outer circumferential end 11b of each PC steel wire is pulled and tensioned by, for instance, a jack, and each PC steel wire is held and fixed in a tensed state using an anchoring tool 11c with a predetermined tension applied. Afterwards, the interiors of the sheaths are grouted to stick the PC steel wires to the roof 6, and thereby compressive prestress is given to the roof 6. A tendon is not limited to the PC steel wire, and may be a PC steel rod, a PC steel stranded wire, or the like.

[0016]

The PC steel members 11 are made up of both arm parts of folded PC steel members 12 that are folded so as to be open to the outer circumferential side of the roof 6 in a plan view. To be specific, the folded PC steel members 12 are bent in a U shape in a plan view. A pair of PC steel members 11 formed by both the arm parts of the folded PC steel member 12 and a folded part 12a extending between both the arm parts (that is, between the inner circumferential ends 11a of the pair of the PC steel members 11) are integrally formed. The folded part 12a anchors the inner circumferential ends 11a of the pair of the PC steel members 11 continuing with the folded part 12a. The outer circumferential ends 11b of the pair of PC steel members 11 pass through the beam part 2b, and are fixed in a state in which they are pulled toward the outer circumference.

[0017]

The type of the PC steel member 11 includes a short PC steel member 11S and a long PC steel member 11L which are different in length in a radial direction. Also, the type of the folded PC steel member 12 includes a short folded PC steel member 12S

constituting the short PC steel members 11S, and a long folded PC steel member 12L constituting the long PC steel members 11L. The radial length of the long folded PC steel member 12L (i.e., long PC steel member 11L) is about twice that of the short folded PC steel member 12S (i.e., short PC steel member 11S).

[0018]

Among the plurality of short folded PC steel members 12S, the short folded PC steel members 12S that are adjacent to each other in a circumferential direction are disposed such that lateral portions thereof including the short PC steel members 11S overlap each other. Hereinafter, the overlap portion between the short folded PC steel members 12S that are adjacent to each other in the circumferential direction is referred to as a short overlap portion 15S.

The folded parts 12a (hereinafter referred to as "folded parts 12aS") of the plurality of short folded PC steel members 12S are disposed to be arranged on the same circumference of the roof 6 in a plan view. Thus, a first circle C1 on which the plurality of folded parts 12aS stand in line at positions of the inner circumferential ends of the plurality of the short PC steel members 11S is formed.

[0019]

Among the plurality of long folded PC steel members 12L, the long folded PC steel members 12L that are adjacent to each other in a circumferential direction are disposed such that lateral portions thereof including the long PC steel members 11L overlap each other. Hereinafter, the overlap portion between the long folded PC steel members 12L that are adjacent to each other in the circumferential direction is referred to as a long overlap portion 15L.

The folded parts 12a (hereinafter referred to as "folded parts 12aL") of the plurality of long folded PC steel members 12L are disposed to be arranged on the same

circumference of the roof 6 in a plan view. Thus, a second circle C2 on which the plurality of folded parts 12aL stand in line at positions of the inner circumferential ends of the plurality of the long PC steel members 11L is formed.

[0020]

FIG. 4 is also referred. The short overlap portions 15S and the long overlap portions 15L are disposed to be alternately arranged in the circumferential direction. Circumferential widths (i.e., angles in FIGS. 3 and 4) H1 of the short overlap portions 15S are uniform, and circumferential widths (i.e., angles in FIGS. 3 and 4) H2 of the long overlap portions 15L are uniform. Also, the widths H1 and H2 are the same as each other. Also, the widths H1 and H2 and an interval (i.e., angle in FIGS. 3 and 4) H3 in a circumferential direction between the long and short overlap portions 15L and 15S that are adjacent are the same as each other. Thus, at the outer circumferential side positioned outside of the second circle C2, all of the PC steel members 11 are disposed so as to be arranged at regular intervals in the circumferential direction. To be specific, the short PC steel members 11S at both sides of the short overlap portions 15S and the outer circumferential sides of the long PC steel members 11L at both sides of the long overlap portions 15L are disposed to be arranged at regular intervals in the circumferential direction.

[0021]

A first intersection P1 at which bent portions of the short folded PC steel members 12S adjacent in the circumferential direction intersect each other in a plan view is present at the inner circumferential side of each short overlap portion 15S. A second intersection P2 at which bent portions of the long folded PC steel members 12L adjacent in the circumferential direction intersect each other in a plan view is present at the inner circumferential side of each long overlap portion 15L. A pair of third intersections P3

at which the folded parts 12aS and the pair of long PC steel members 11L intersect each other in a plan view are present at the inner circumferential side of each short folded PC steel member 12S. Two PC steel members 11 intersect each other at the intersections P1, P2 and P3 in a state in which positions thereof are different in a thickness direction of the roof 6.

The pair of third intersections P3 and the first intersections P1 at both sides thereof are out of alignment in a circumferential direction. The second intersection P2 is out of alignment to the first intersection P1 and the third intersection P3 in a radial direction. That is, three or more of the PC steel members 11 do not intersect one another at each of the intersections P1, P2 and P3. Therefore, an increase in thickness of the roof 6 at each of the intersections P1, P2 and P3 can be limited.

[0022]

As described above, according to the present embodiment, the plurality of PC steel members 11 extending in the radial direction are disposed at the outer circumferential side of the discoid roof 6 side by side in the circumferential direction. The plurality of PC steel members 11 are made up of both the arm parts of the folded PC steel members 12 that are folded so as to be open to the outer circumferential side of the roof 6 in a plan view. Thus, by using the folded parts 12a extending between both the arm parts of the folded PC steel members 12 as the anchoring parts of the inner circumferential ends 11a of the PC steel members 11 formed by both the arm parts of the folded PC steel members 12, tension load of the PC steel members 11 can be dispersed to all the folded parts 12a. For this reason, stress concentration at the anchoring parts of the inner circumferential ends 11a of the PC steel members 11 can be limited. As a result, there is no need to use large anchoring tools or form thick wall parts or reinforced parts around the anchoring parts, and an increase in the weight and manufacturing cost of

the roof 6 can be minimized.

[0023]

The present invention is not limited to the above embodiment. All the shapes and combinations of the means and components represented in the aforementioned embodiment are only examples, and can be variously modified based on design requirements without departing from the spirit and scope of the present invention.

For example, in the above embodiment, the application to the LNG tank has been described as an example. However, the present invention may be applied to various prestressed concrete structures such as an LPG tank in addition to the LNG tank.

Industrial Applicability

[0024]

According to the present invention, in the prestressed concrete roof for a cylindrical tank, an increase in weight and manufacturing cost of the roof can be minimized, and stress concentration at the anchoring parts of the PC steel members arranged at the outer circumferential side of the roof can be limited.

Reference Signs List

[0025]

6	outer tank roof (roof)
11	PC steel member
11S	short PC steel member
11L	long PC steel member
12	folded PC steel member
12S	short folded PC steel member

12L long folded PC steel member

15S short overlap portion

15L long overlap portion

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A prestressed concrete roof for a cylindrical tank comprising:

a plurality of PC steel members which are disposed side by side in a circumferential direction at an outer circumferential side of a discoid roof and each of which extends in a radial direction,

wherein the plurality of PC steel members are made up of both arm parts of folded PC steel members that are folded so as to be open to the outer circumferential side of the roof in a plan view, each folded PC steel member having the both arm parts and a folded part extending between the both arm parts, and

the folded parts of the folded PC steel members are arranged to stand in line so as to form at least one circle in the plan view.

2. The prestressed concrete roof for a cylindrical tank according to claim 1, wherein:

the PC steel members include a short PC steel member and a long PC steel member that are different in radial length; and

the folded PC steel members include a short folded PC steel member which constitutes the short PC steel member and a long folded PC steel member which constitutes the long PC steel member.

3. The prestressed concrete roof for a cylindrical tank according to claim 2, wherein:

lateral portions of the short folded PC steel members including the short PC steel members form short overlap portions that overlap the short folded PC steel members adjacent in the circumferential direction;

lateral portions of the long folded PC steel members including the long PC steel members form long overlap portions that overlap the long folded PC steel members adjacent in the circumferential direction;

the short overlap portions and the long overlap portions are alternately arranged in the circumferential direction; and

all of the plurality of PC steel members including the short PC steel members at both sides of the short overlap portions and the long PC steel members at both sides of the long overlap portions are arranged at regular intervals in the circumferential direction.

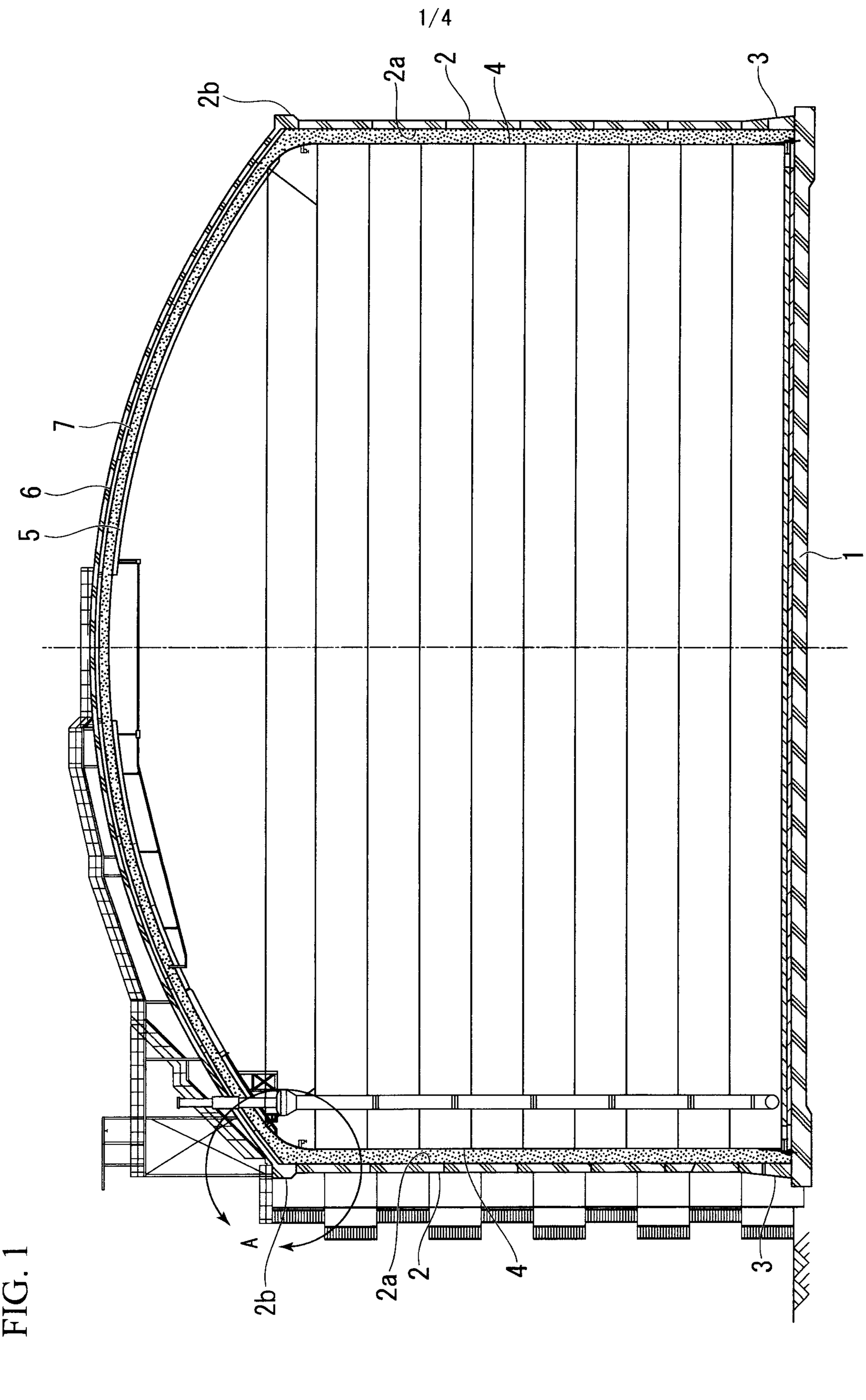


FIG. 1

FIG. 2

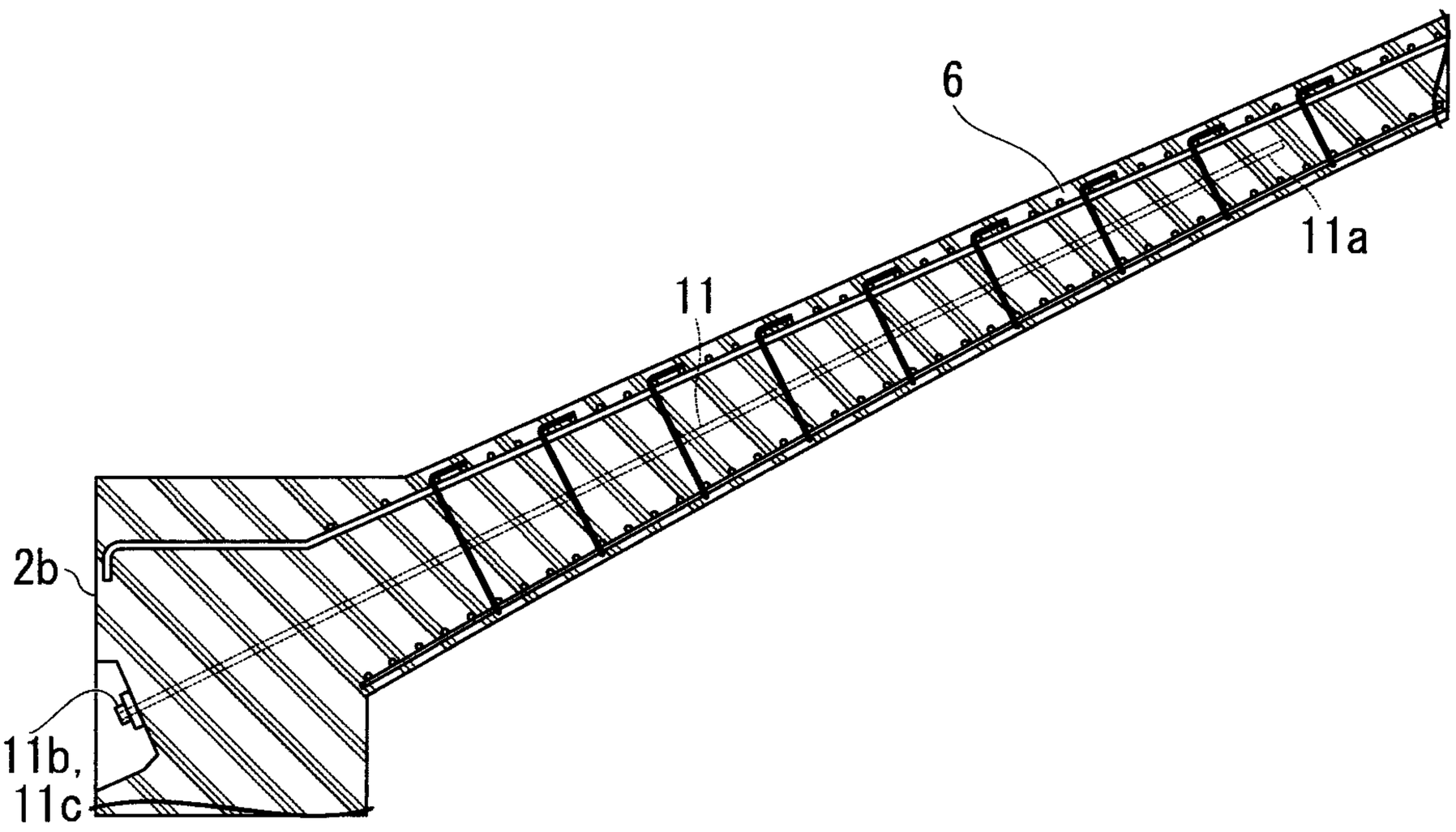


FIG. 3

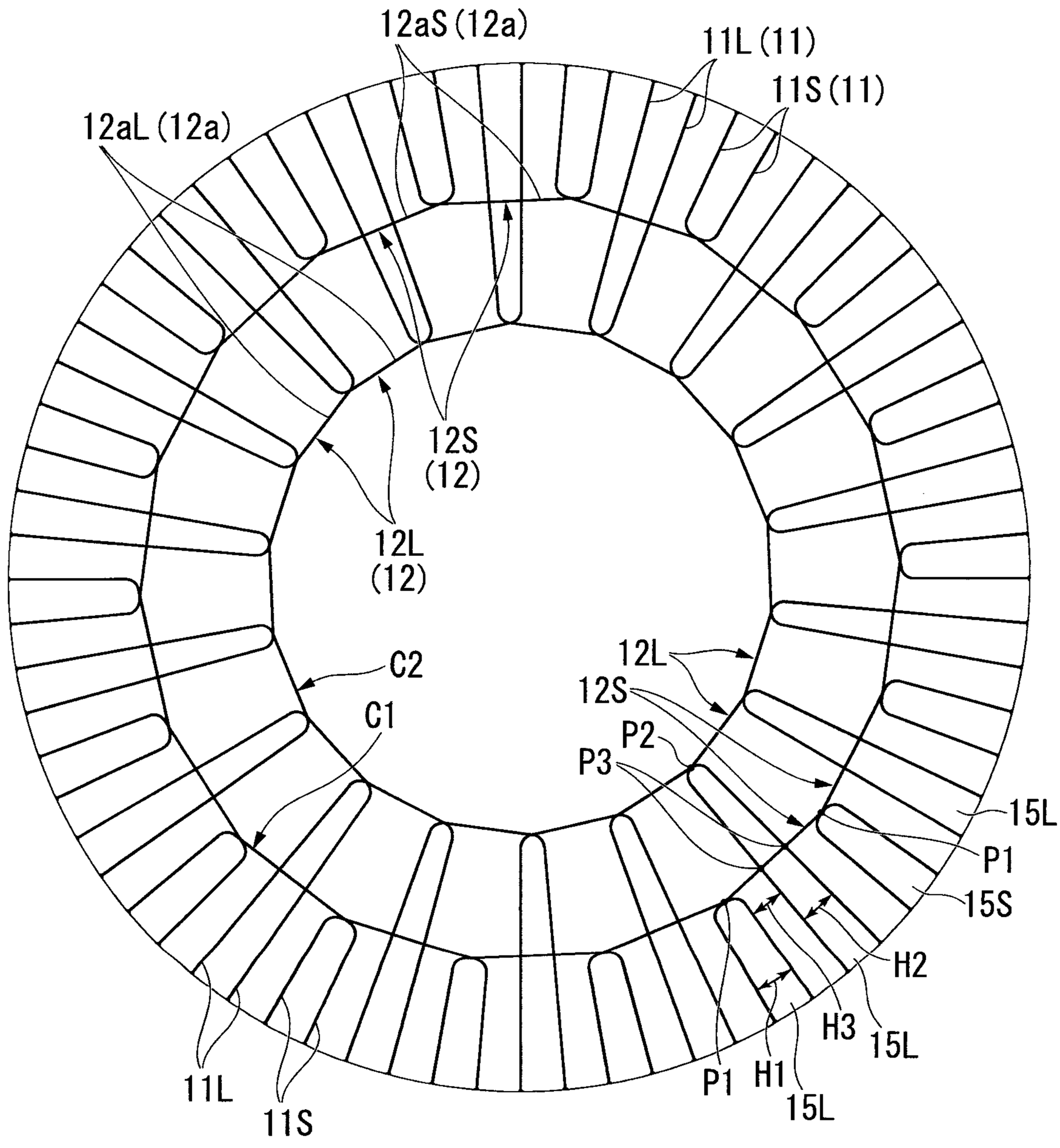
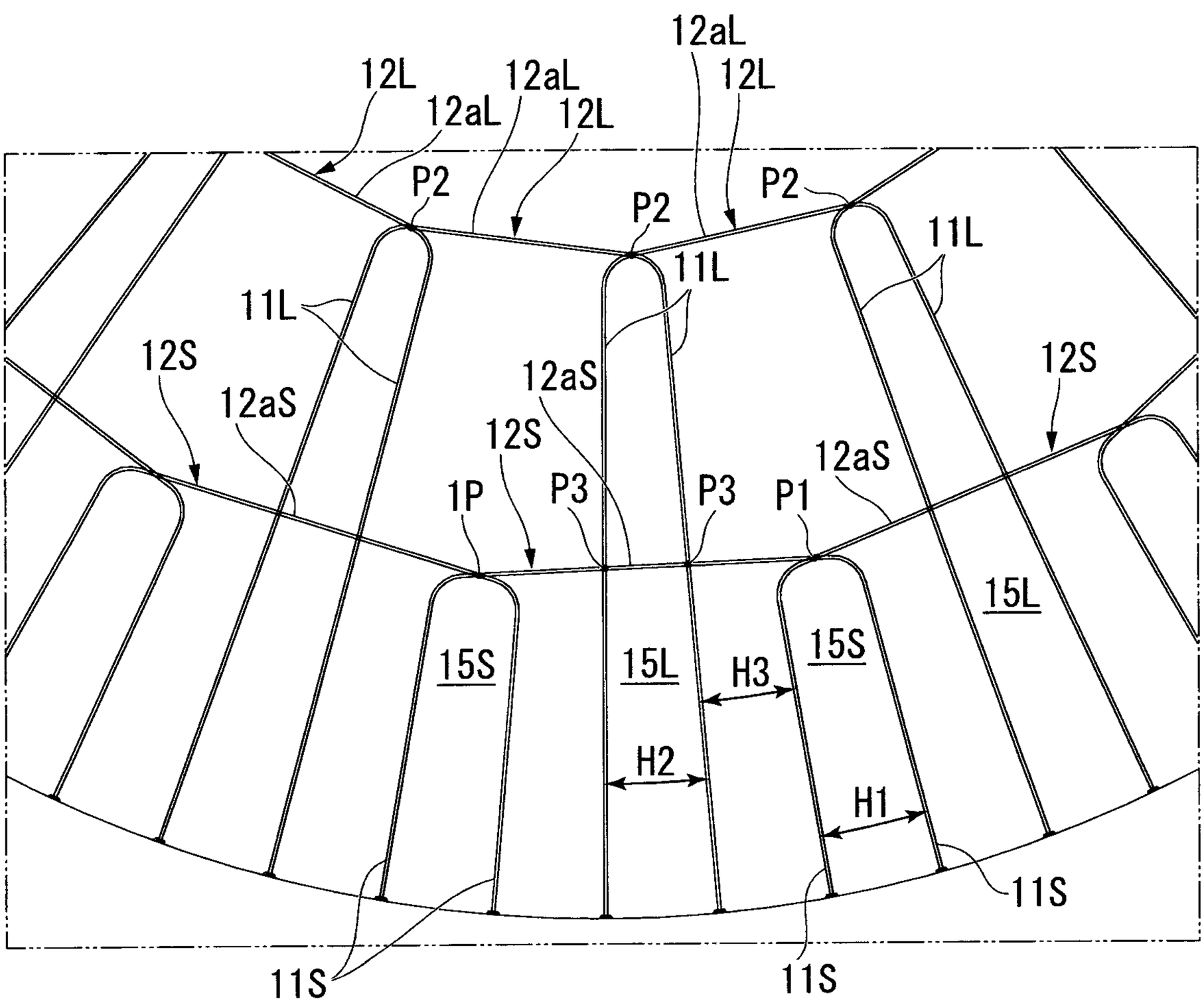
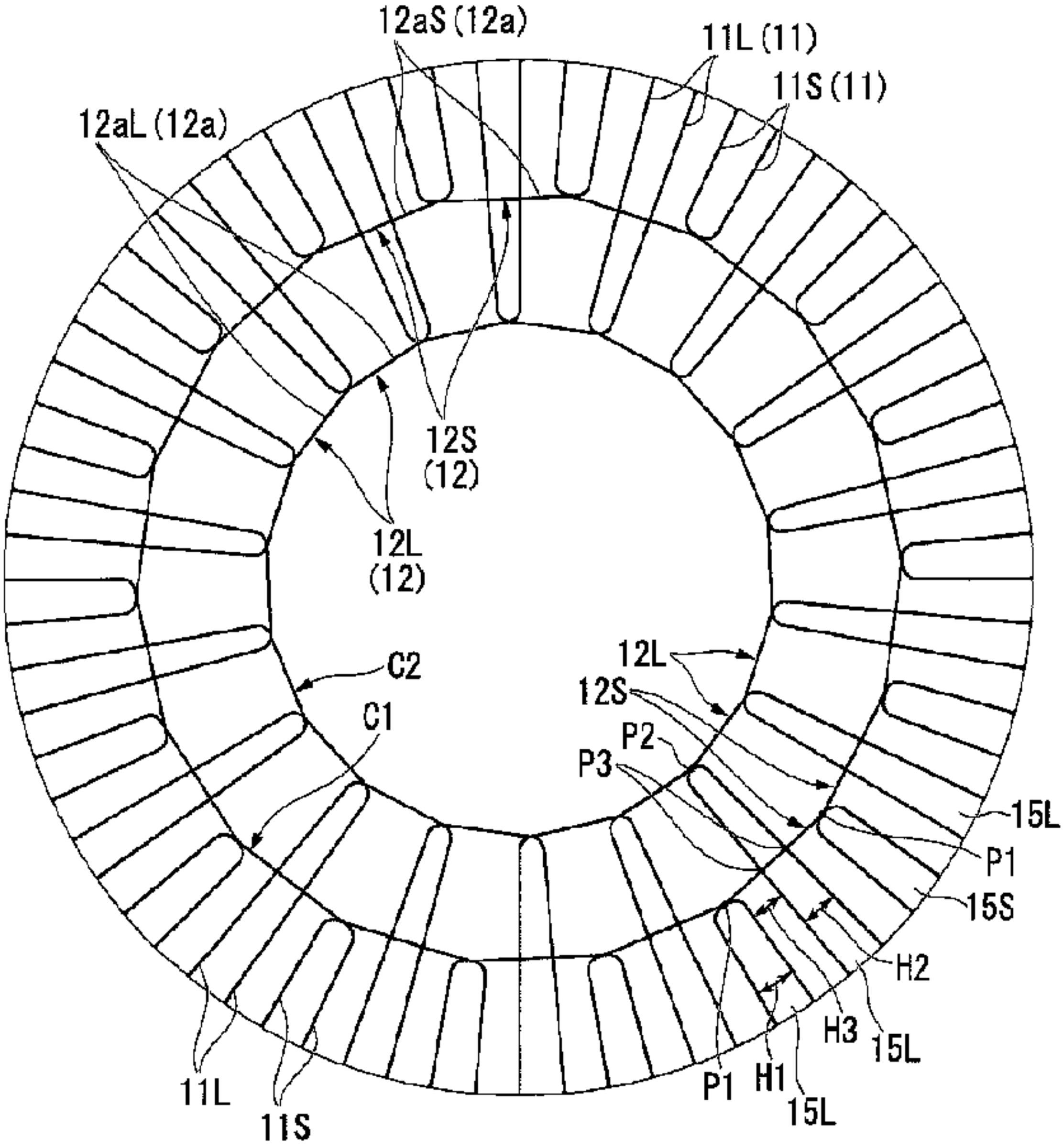

12aS (12a)
11L (11)
11S (11)
12aL (12a)
12S (12)
12L (12)
C2
C1
12L
12S
P2
P3
15L
P1
15S
H2
H3
15L
11L
11S
P1
H1
15L

FIG. 4


12L
12aL
12aL
12L
12aL
12L
P2
P2
P2
11L
11L
11L
12S
12aS
12S
12aS
12S
12aS
1P
P3
P3
P1
15L
15S
15L
15S
H3
H2
H1
11S
11S
11S


12aS (12a)
11L (11)
11S (11)
12aL (12a)
12S (12)
12L (12)
C2
C1
12L
12S
P2
P3
15L
P1
15S
H2
H3
15L
11L
11S
P1
H1
15L