US 20250264132A1

(19) United States
(12) Patent Application Publication
(10) Pub. No.: US 2025/0264132 A1
MATSUI
(43) Pub. Date: Aug. 21, 2025

(54) **CROWN-TYPE RETAINER FOR BALL BEARING, AND BALL BEARING**

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(73) Assignee: **NSK Ltd.**, Tokyo (JP)

(21) Appl. No.: **18/857,716**

(22) PCT Filed: **Mar. 7, 2023**

(86) PCT No.: **PCT/JP2023/008682**

§ 371 (c)(1),
(2) Date: **Oct. 17, 2024**

(30) **Foreign Application Priority Data**

Apr. 20, 2022 (JP) 2022-069471

Publication Classification

(51) **Int. Cl.**
F16C 33/41 (2006.01)
F16C 19/06 (2006.01)

(52) **U.S. Cl.**
CPC ***F16C 33/418*** (2013.01); ***F16C 19/06*** (2013.01); *F16C 2240/70* (2013.01)

(57) **ABSTRACT**

A crown cage for a ball bearing includes an annular main portion, pillar portions protruding in an axial direction at predetermined intervals in a circumferential direction from the main portion, and a pocket formed between the adjacent pillar portions and having a spherical concave surface having a spherical shape capable of holding a ball. The pillar portion includes a pair of claw portions having tip end portions arranged at intervals therebetween and a connection portion connecting the claw portions. An inlet portion having a width shorter than a diameter of the ball and for inserting the ball is provided between the tip end portions of the two adjacent claw portions configuring the pocket. A distance from an inner circumferential surface of the pocket to a center of the crown cage for a ball bearing is smaller than a radius of an inner circumferential surface of the pillar portion.

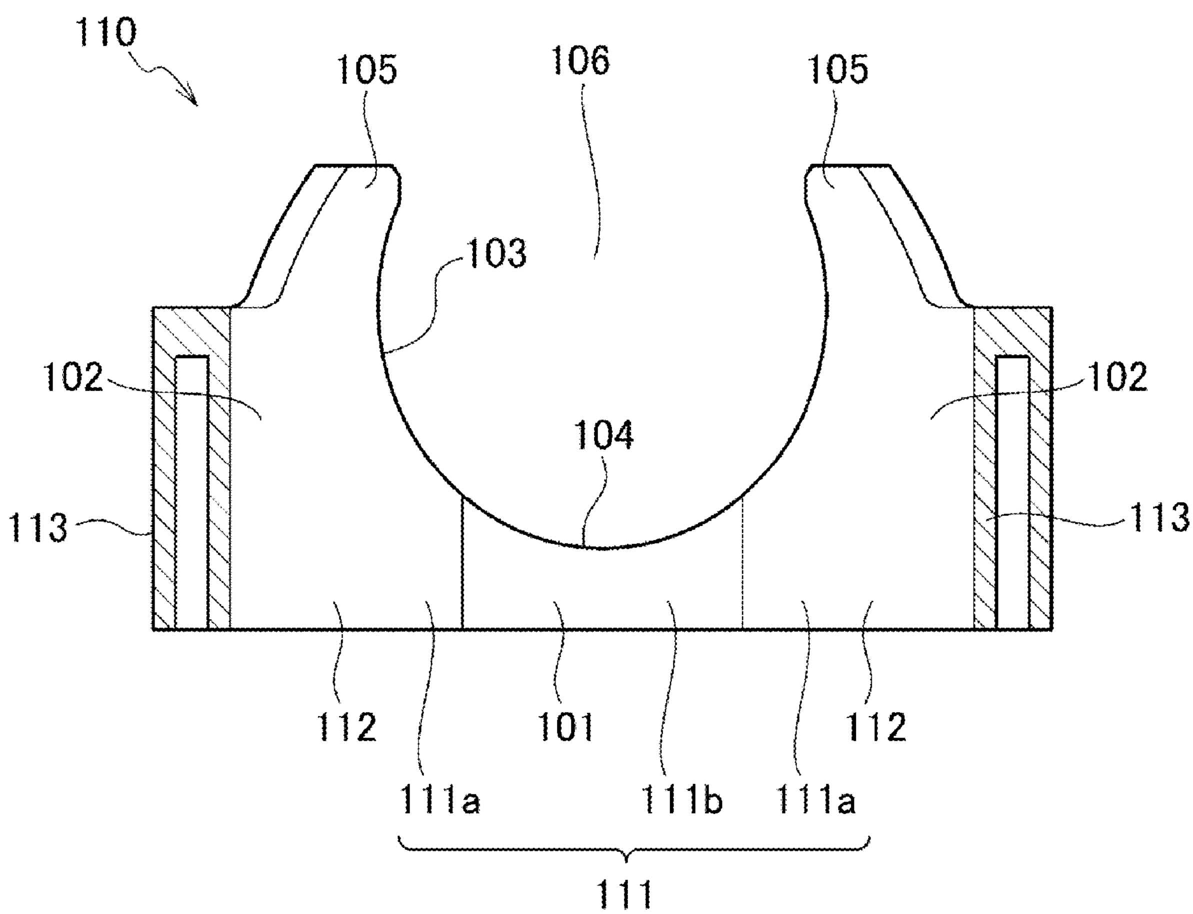
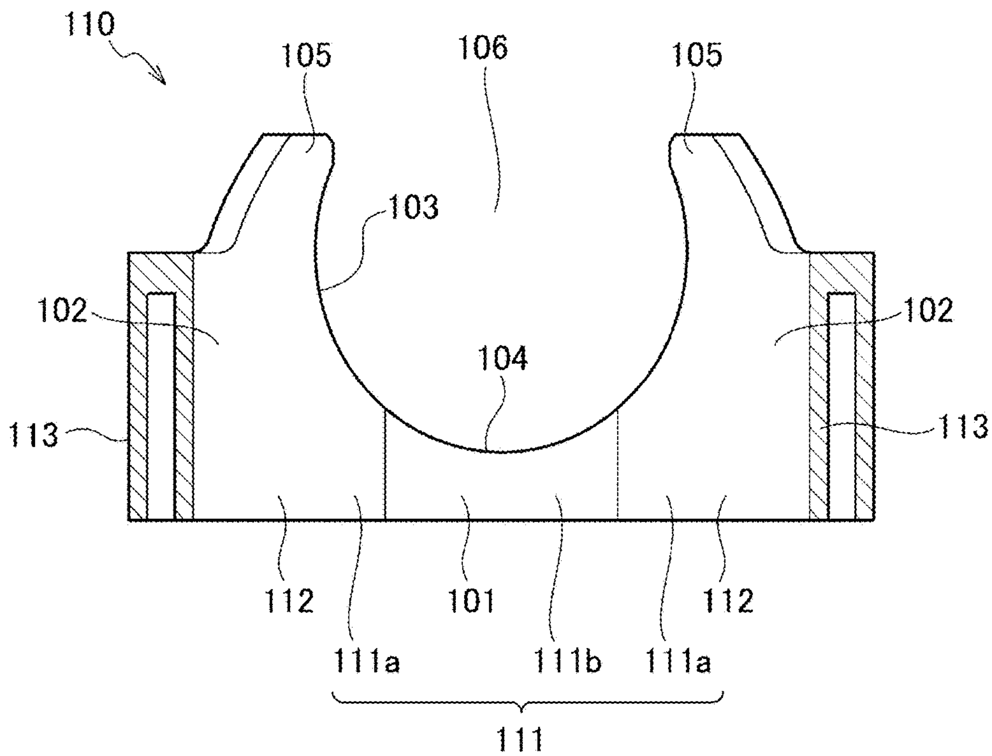


FIG. 1


110
105
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101
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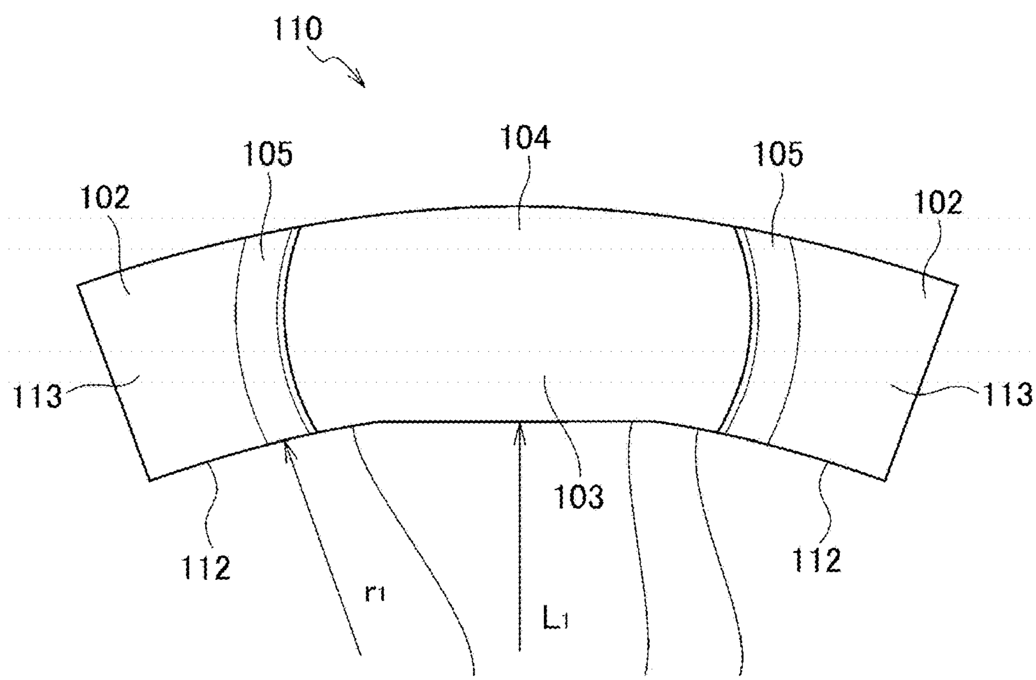
111a
111b
111a
111

FIG. 2


110
104
105
105
102
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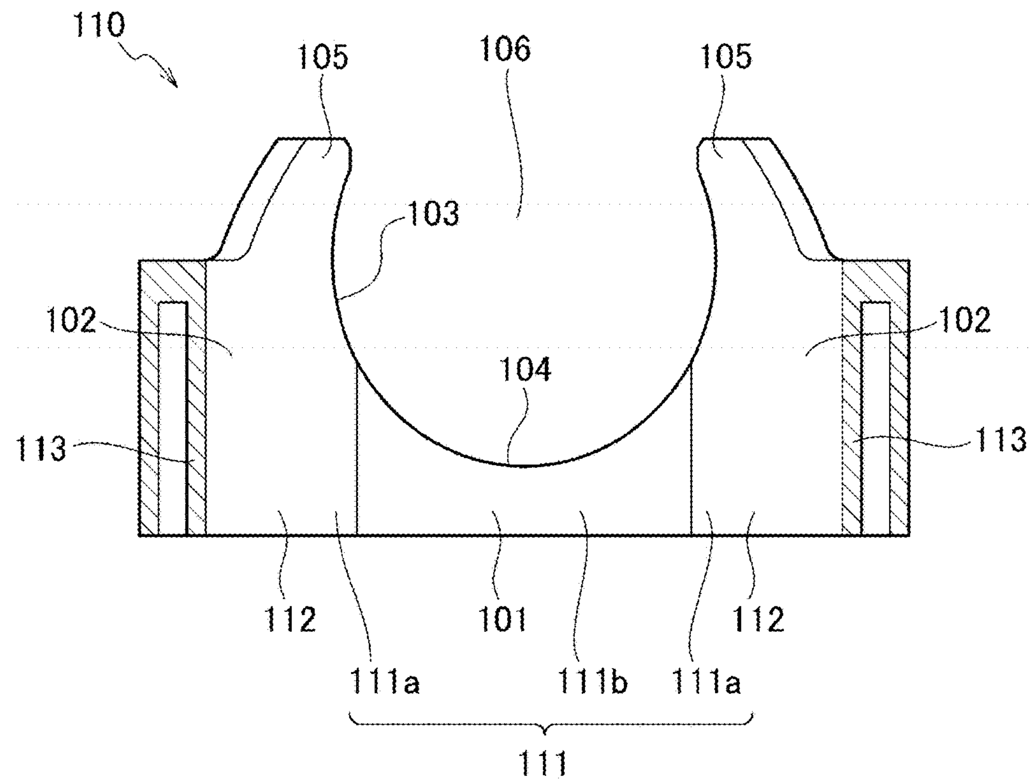
113
113
103
112
112
r1
L1
111a
111b
111a
111

FIG. 3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105
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111a
111b
111a
111

FIG. 4

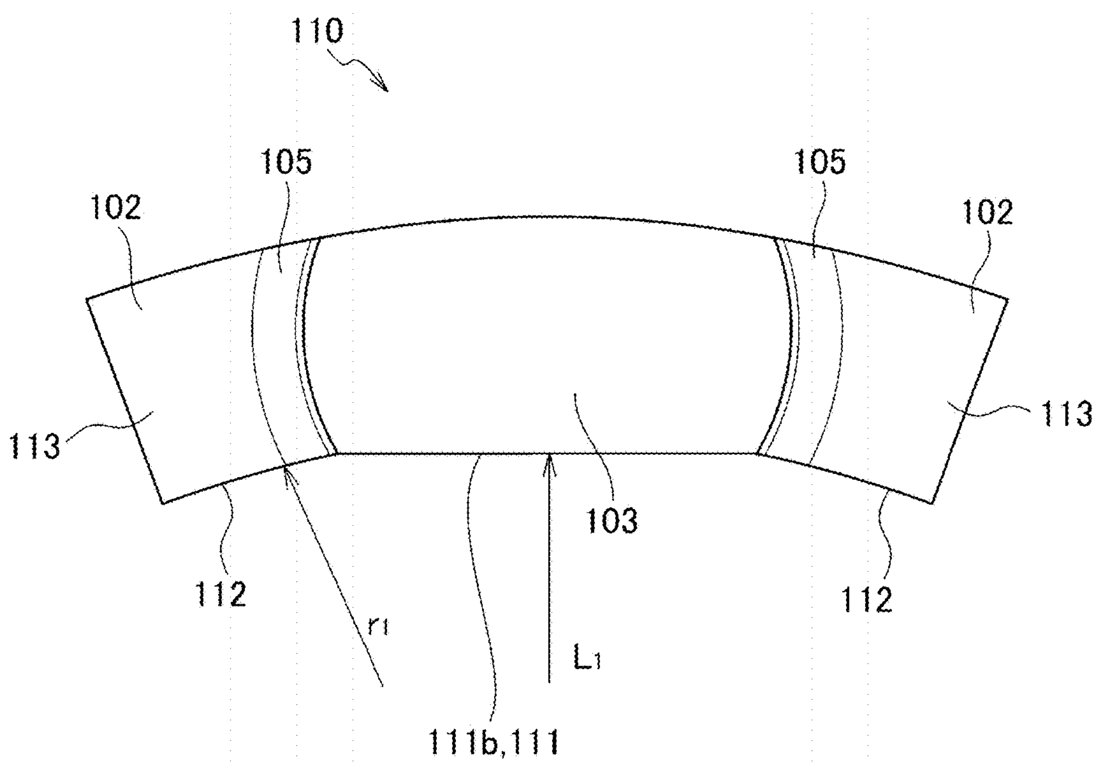

110
105
105
102
102
113
113
103
112
112
r1
L1
111b,111

FIG. 5

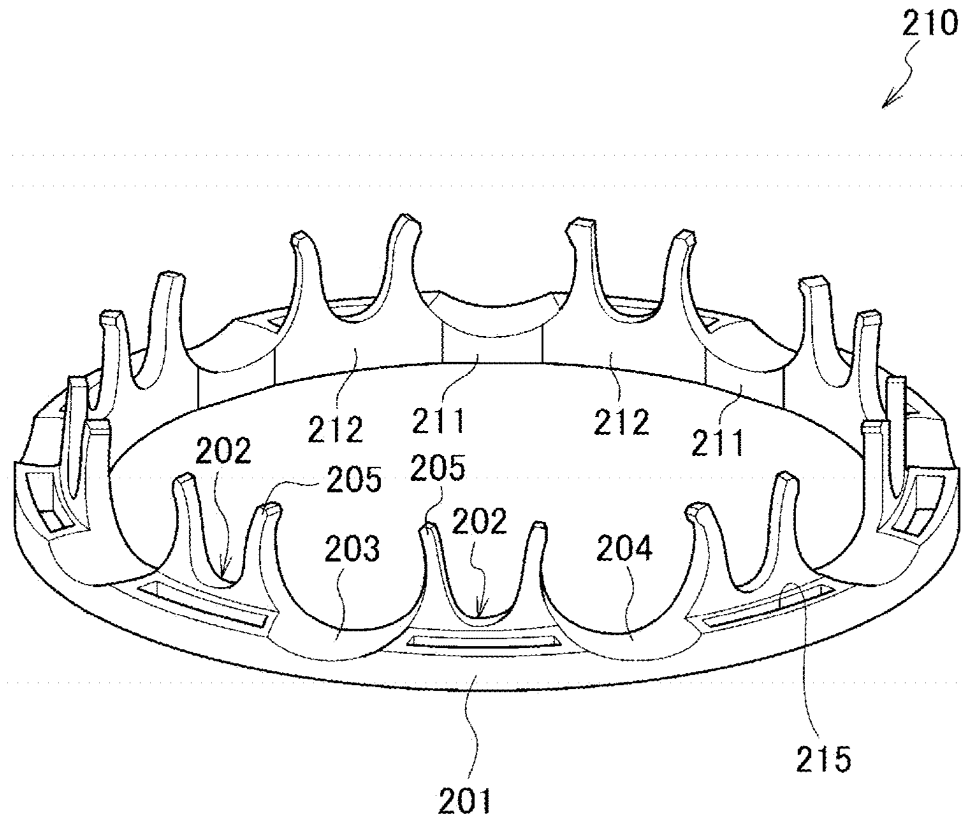


FIG. 6

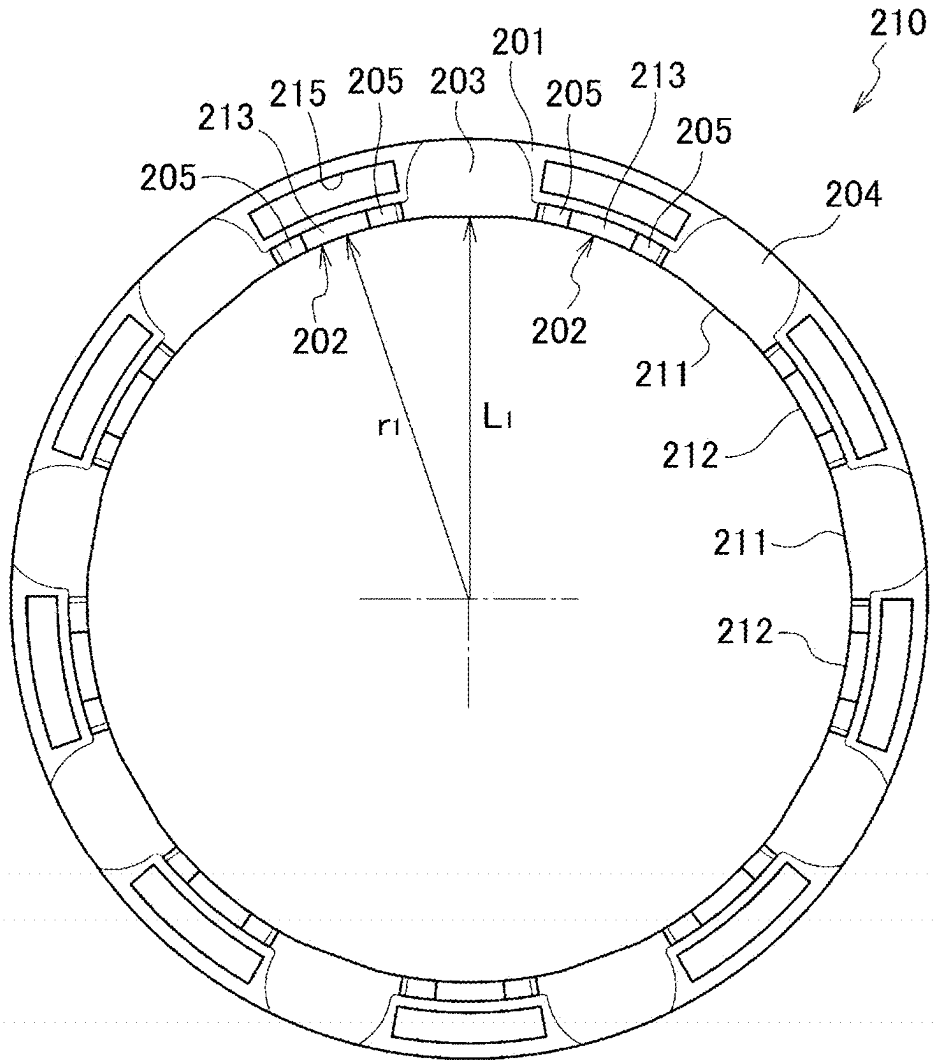

210
201
203
205
215
213
205
205
213
205
204
202
202
r1
L1
211
212
211
212

FIG. 7

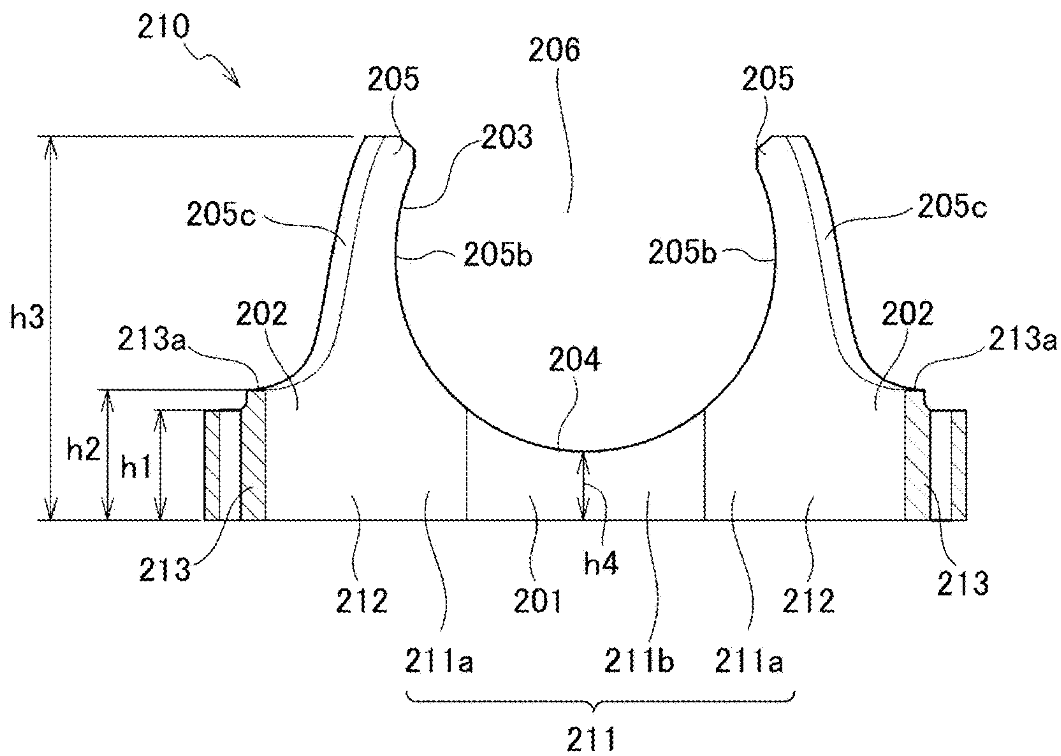

210
206
205
203
205
205c
205b
205b
205c
h3
213a
202
202
213a
204
h2
h1
213
212
211a
201
h4
211b
211a
212
213
211

FIG. 8

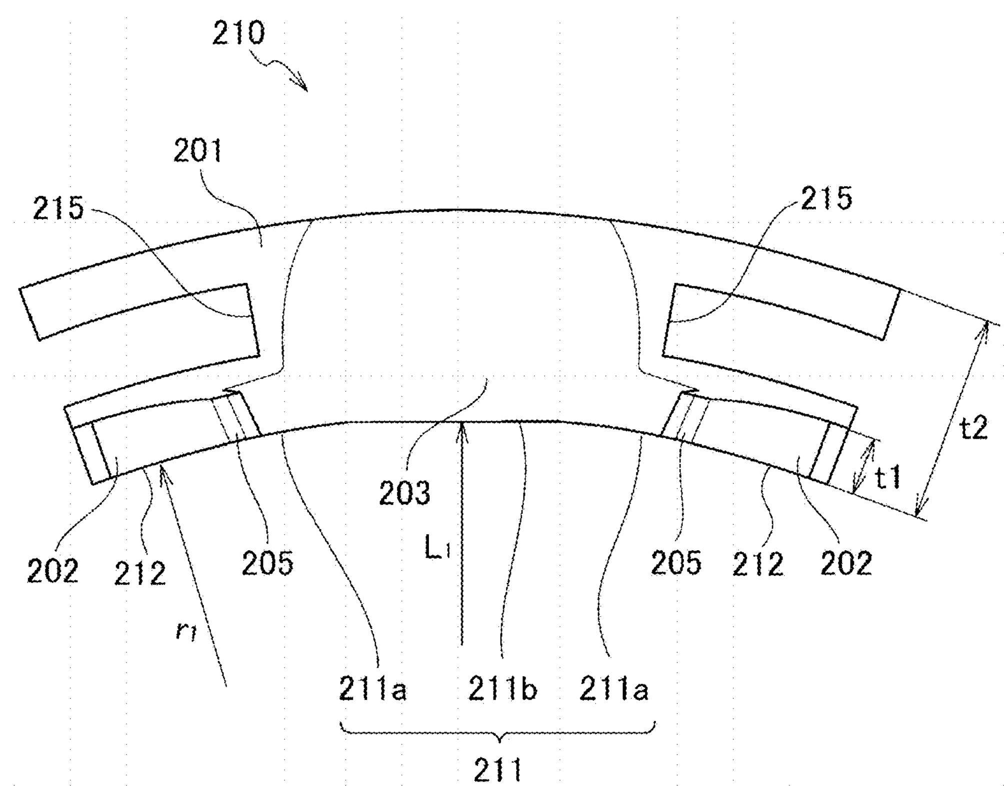

210
201
215
215
t2
t1
203
L1
202
212
205
205
212
202
r1
211a
211b
211a
211

FIG. 9

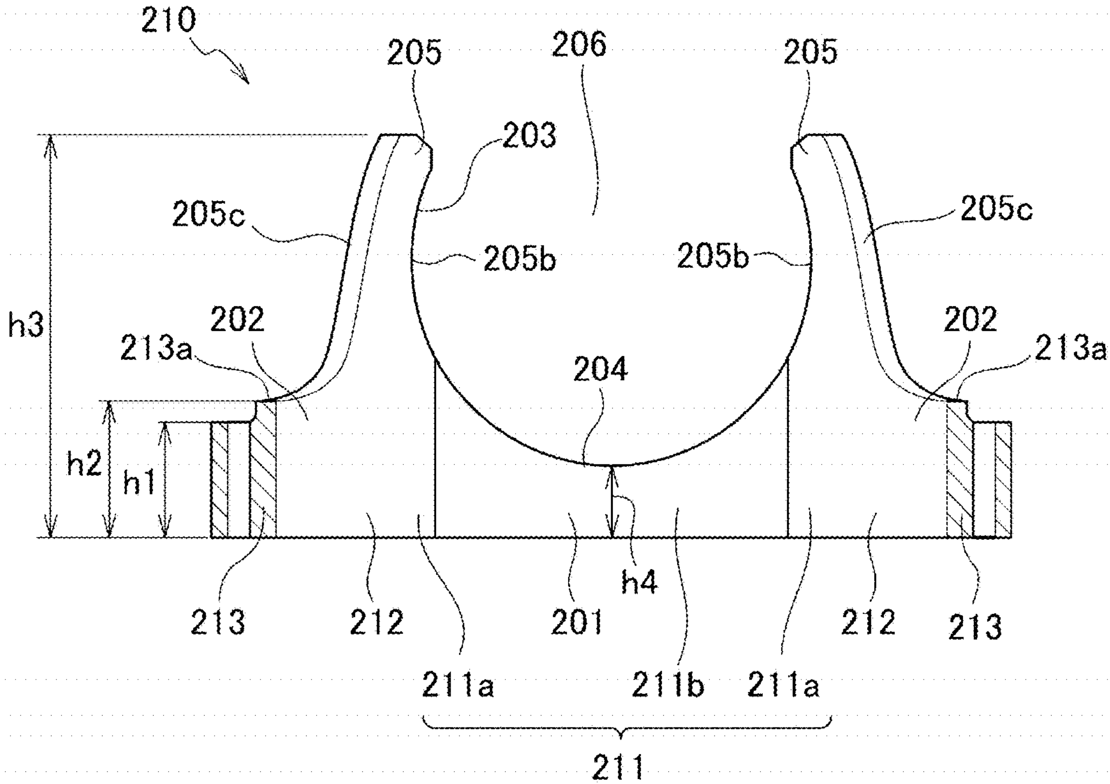

210
205
206
205
203
205c
205c
205b
205b
h3
202
202
213a
213a
204
h2
h1
h4
213
212
201
212
213
211a
211b
211a
211

FIG. 10

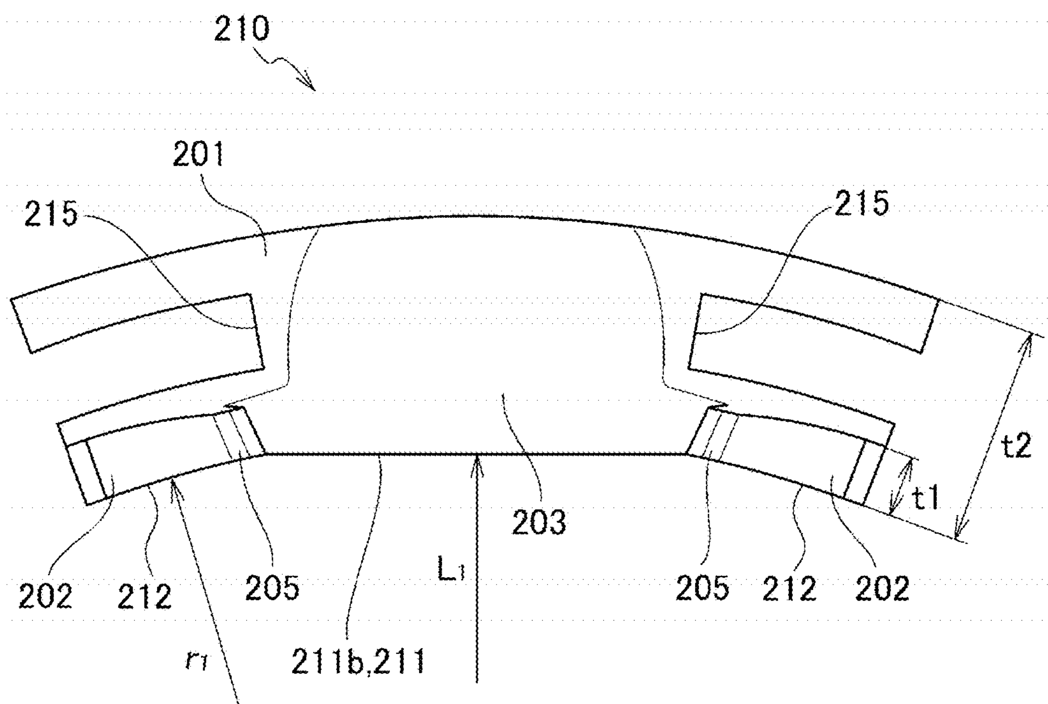

210
201
215
215
t2
203
t1
202
212
205
L_1
205
212
202
r_1
211b,211

FIG. 11

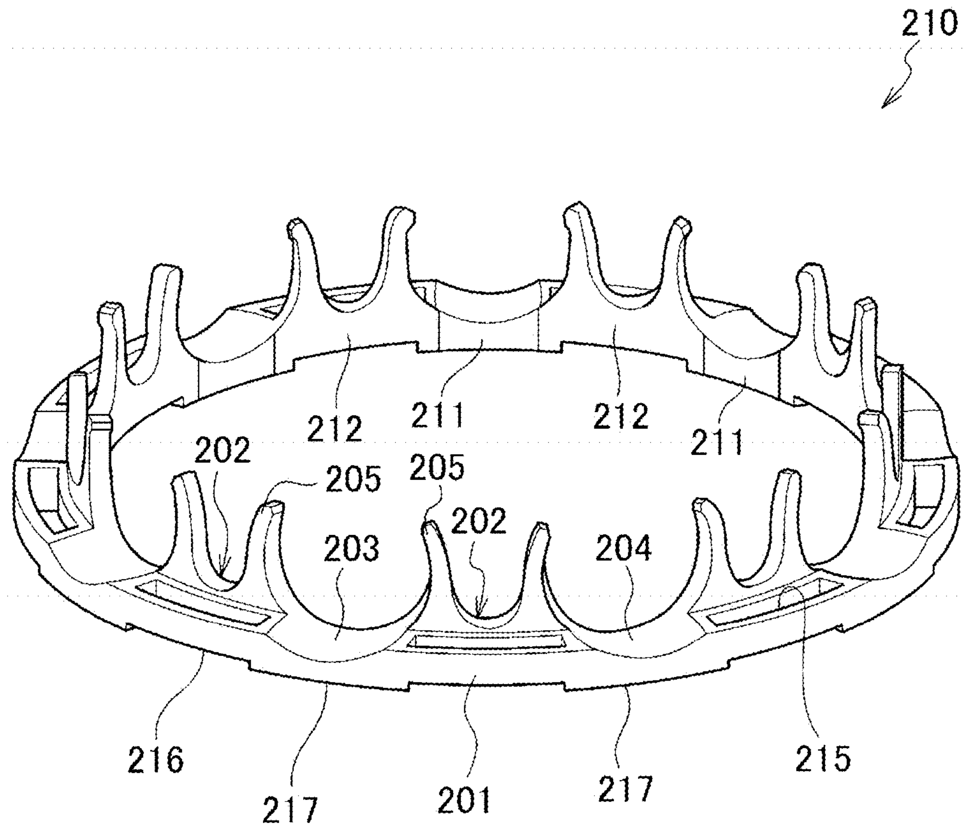
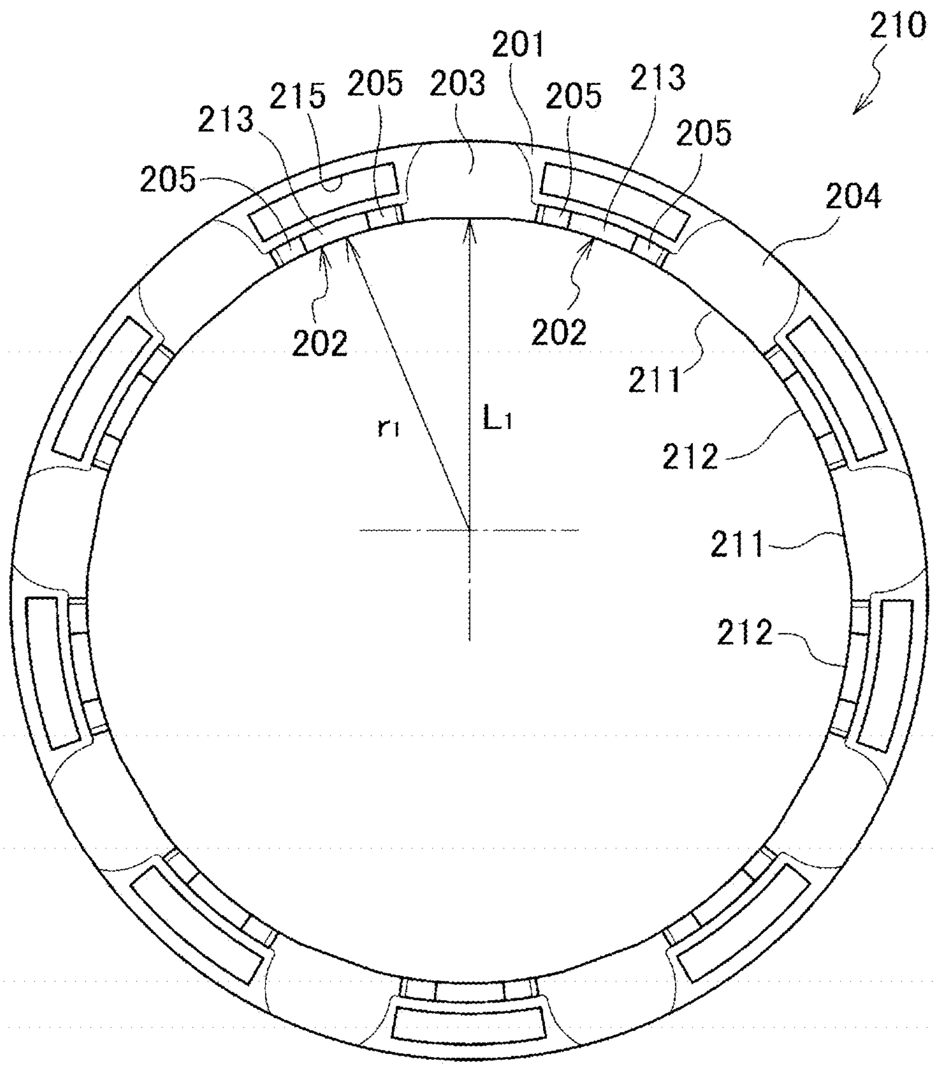


FIG. 12


210
201
203
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215
213
205
205
213
205
204
202
202
211
r_1
L_1
212
211
212

FIG. 13

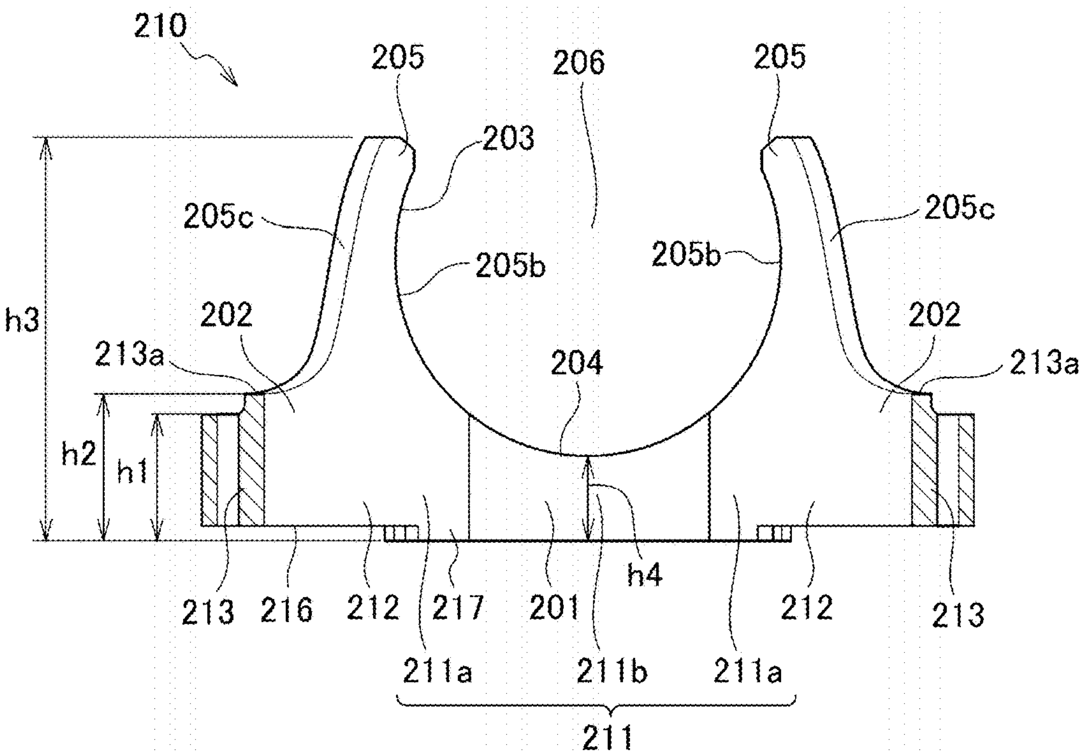

210
205
206
205
203
205c
205c
205b
205b
h3
202
202
213a
213a
204
h2
h1
h4
213
216
212
217
201
212
213
211a
211b
211a
211

FIG. 14

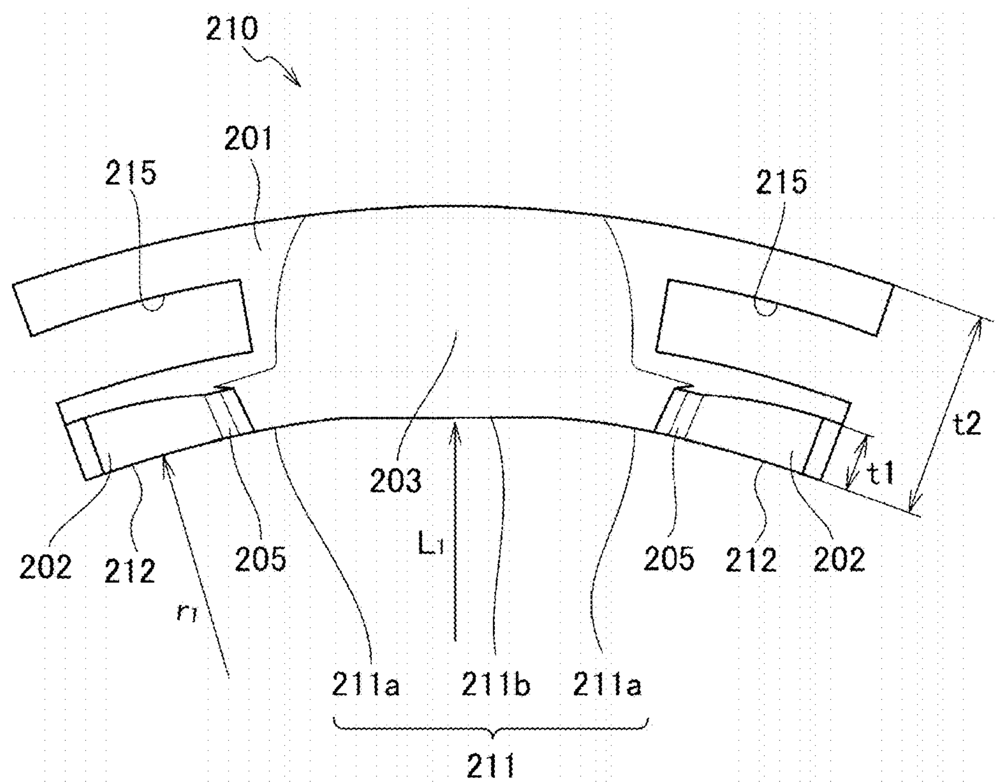

210
201
215
215
t2
t1
203
L1
202
212
205
205
212
202
r1
211a
211b
211a
211

FIG. 15

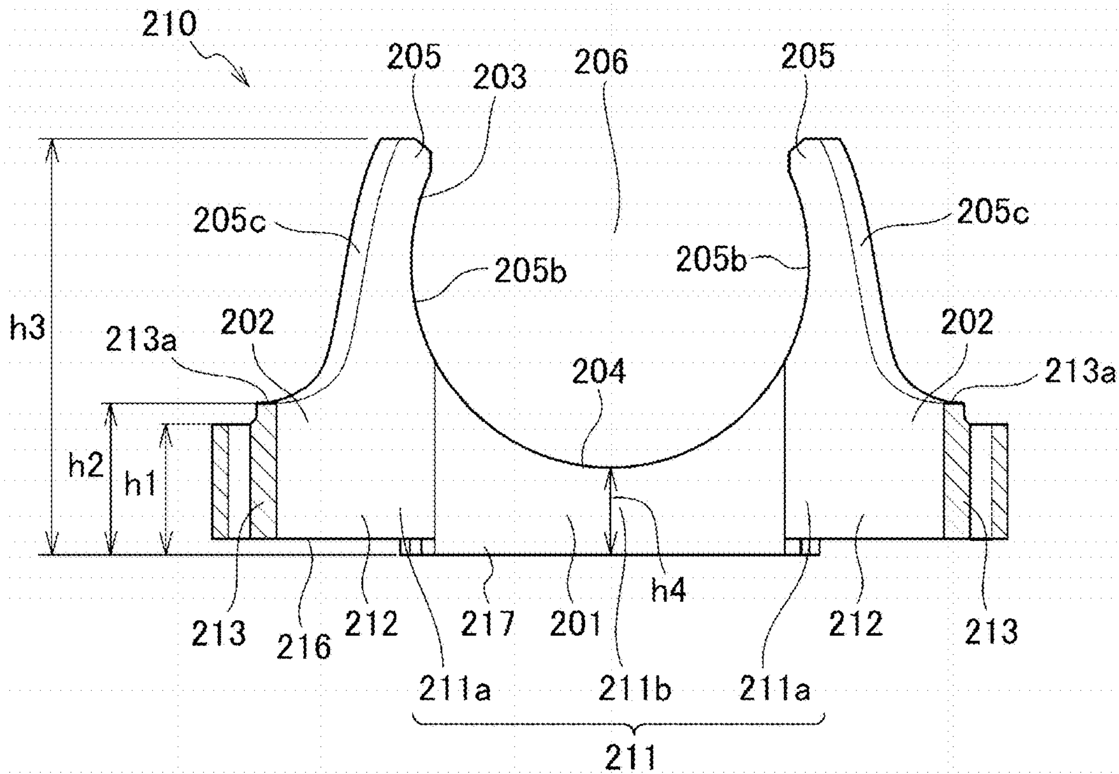

210
205
203
206
205
205c
205b
205b
205c
h3
213a
202
202
213a
204
h2
h1
h4
213
216
212
217
201
212
213
211a
211b
211a
211

FIG. 16

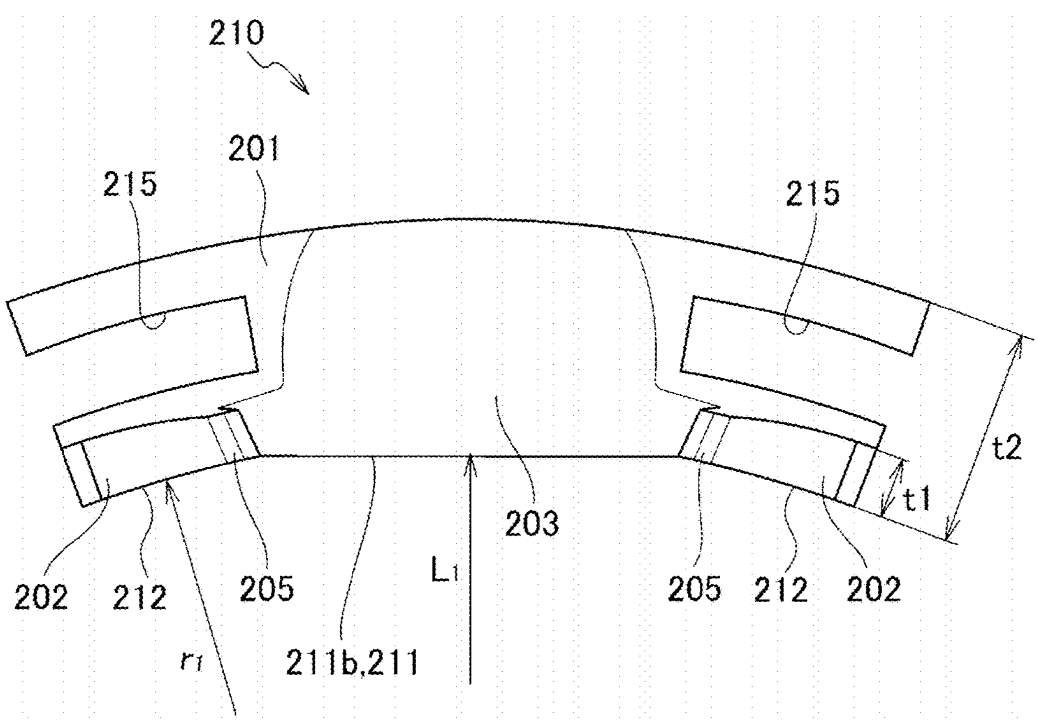

210
201
215
215
t2
203
t1
202
212
205
L1
205
212
202
r1
211b,211

FIG. 17

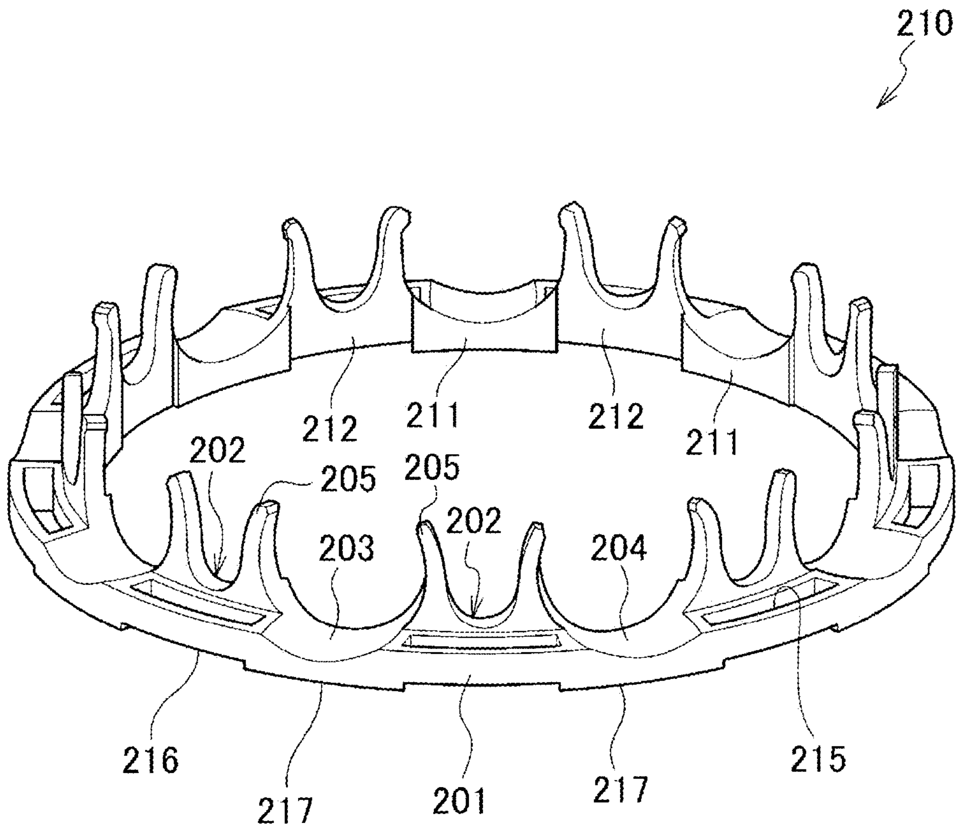


FIG. 18

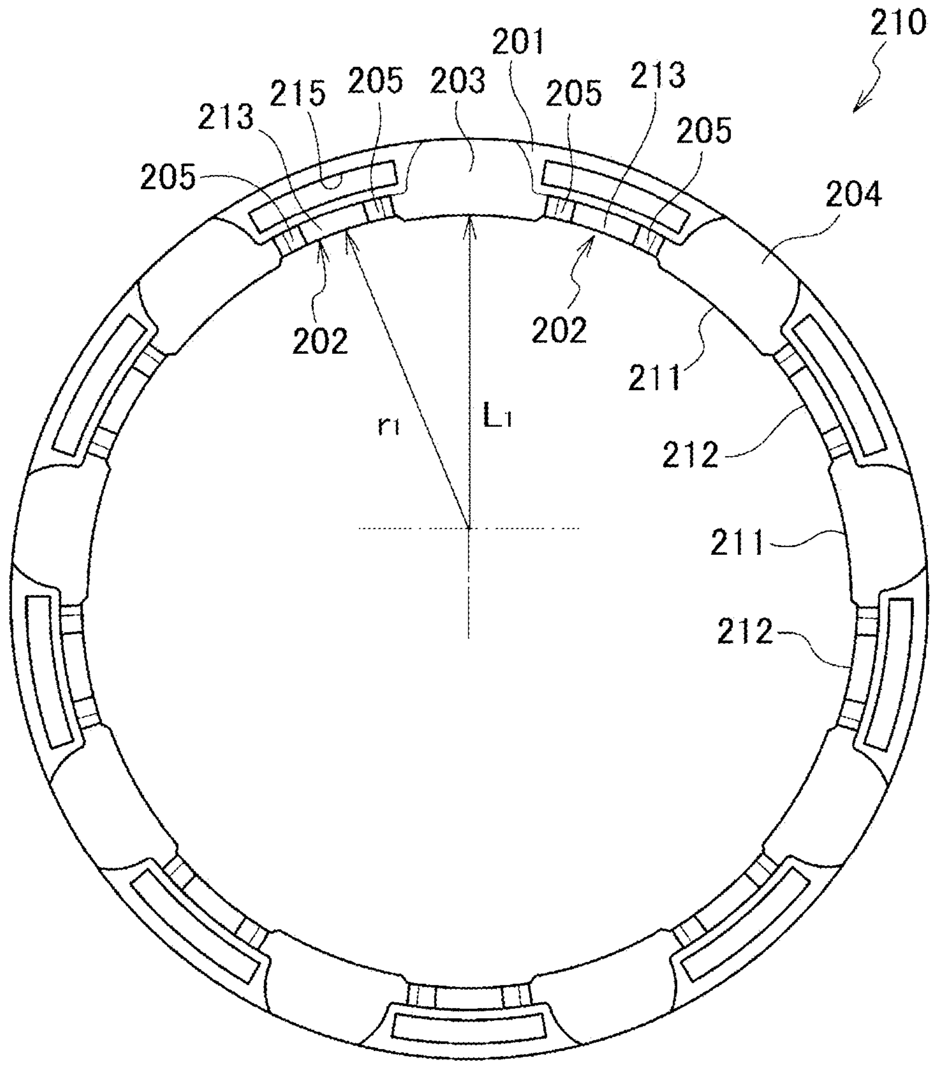

210
201
213
215
205
203
205
213
205
205
204
202
202
211
r1
L1
212
211
212

FIG. 19

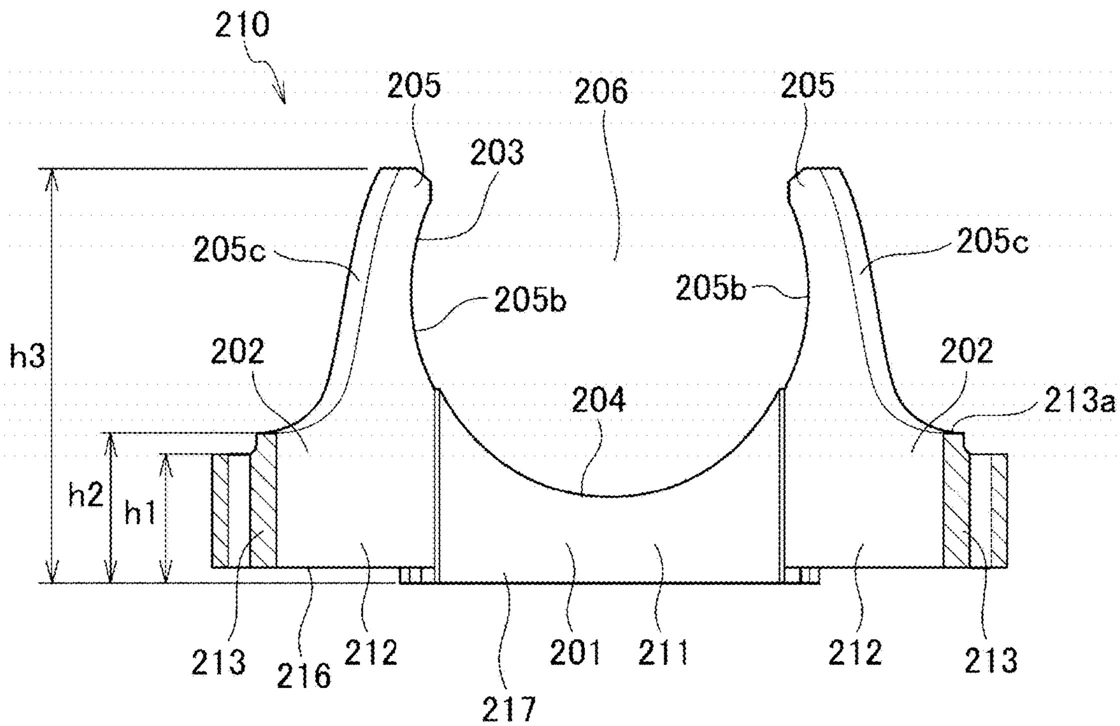

210
205
206
205
203
205c
205c
205b
205b
h3
202
202
213a
204
h2
h1
213
216
212
217
201
211
212
213

FIG. 20

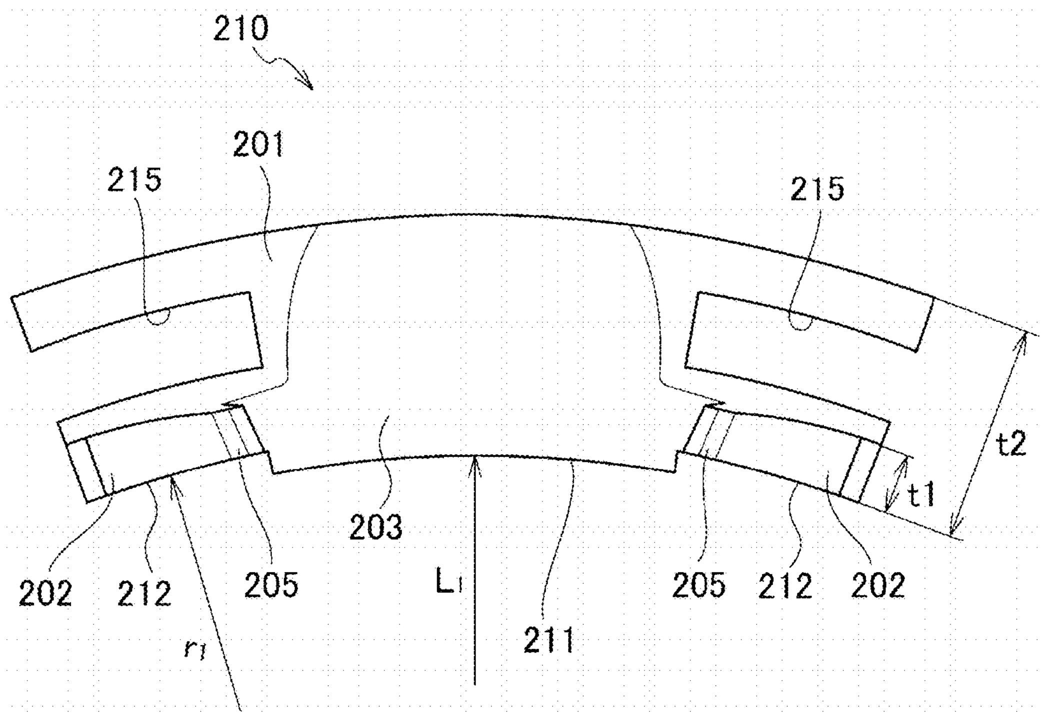

210
201
215
215
t2
t1
202
212
205
203
L1
211
205
212
202
r1

FIG. 21A

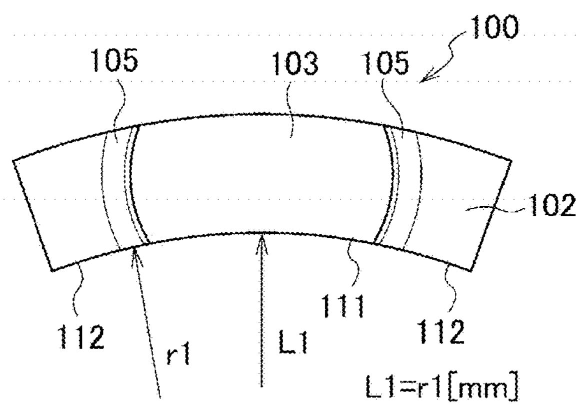


FIG. 21B

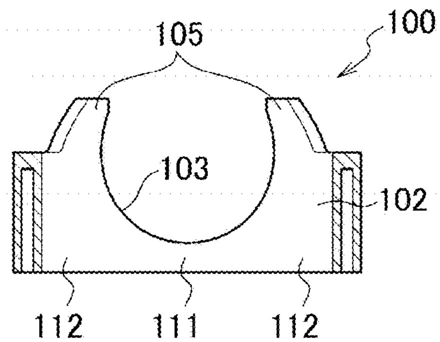


FIG. 21C

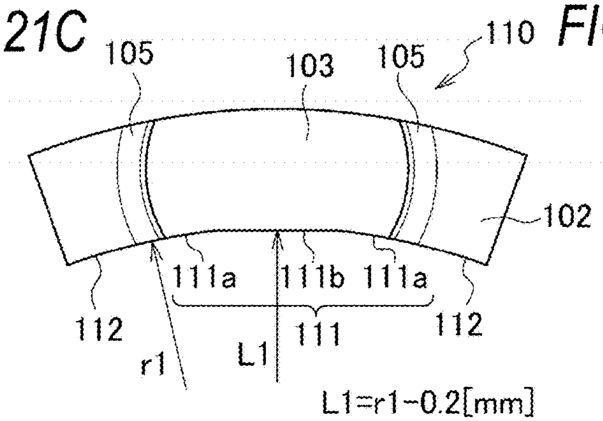


FIG. 21D

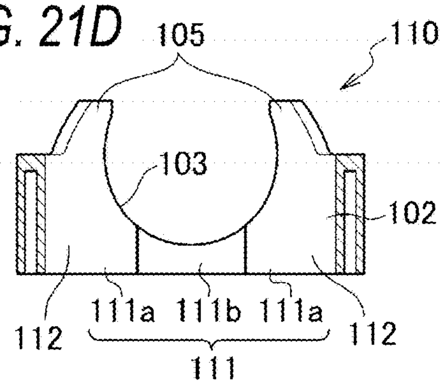


FIG. 21E

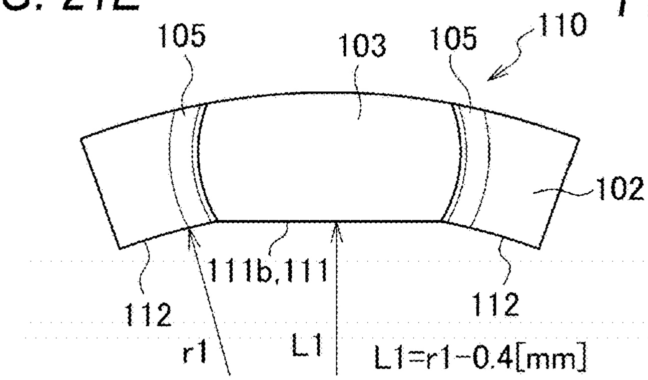


FIG. 21F

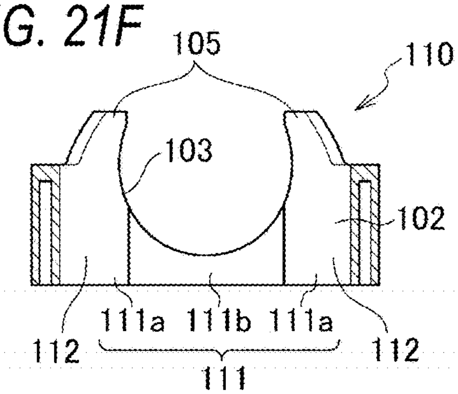


FIG. 21G

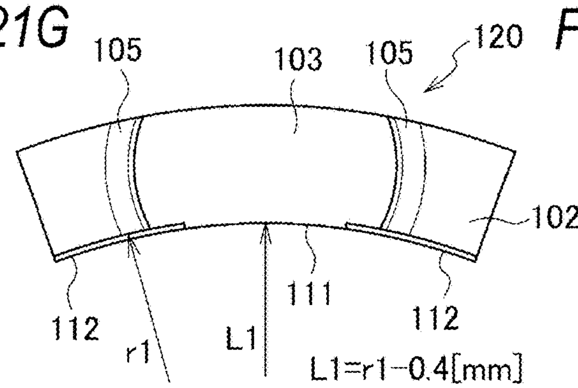


FIG. 21H

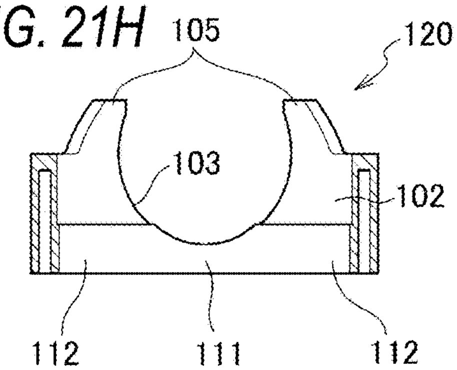


FIG. 22A

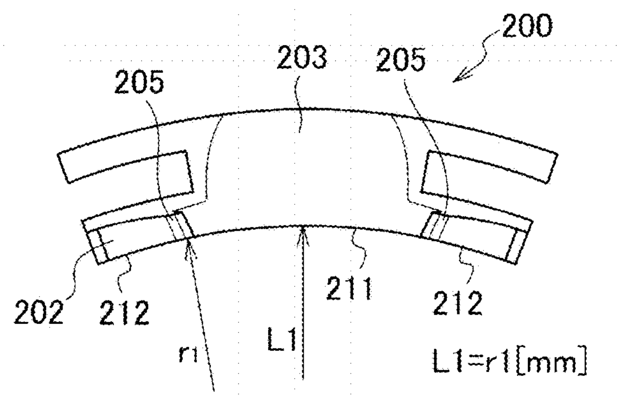


FIG. 22B

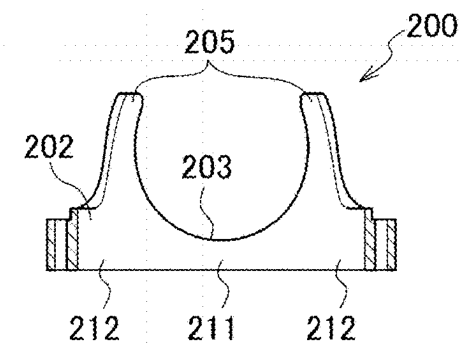


FIG. 22C

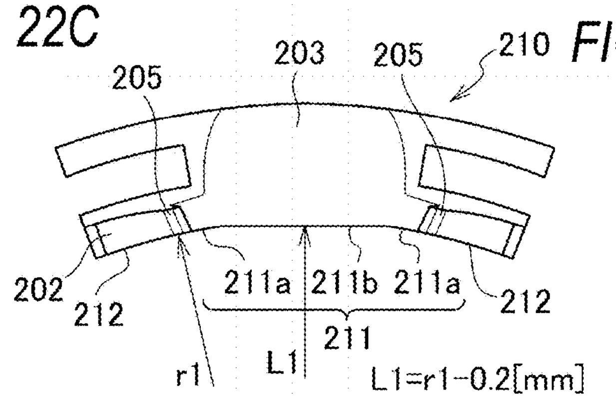


FIG. 22D

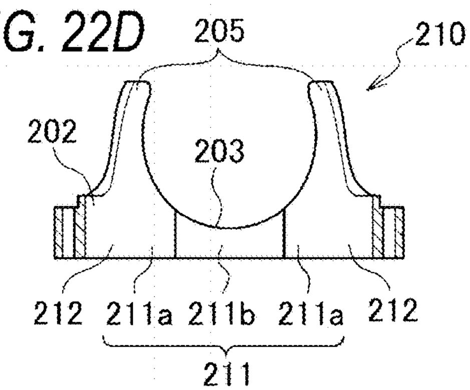


FIG. 22E

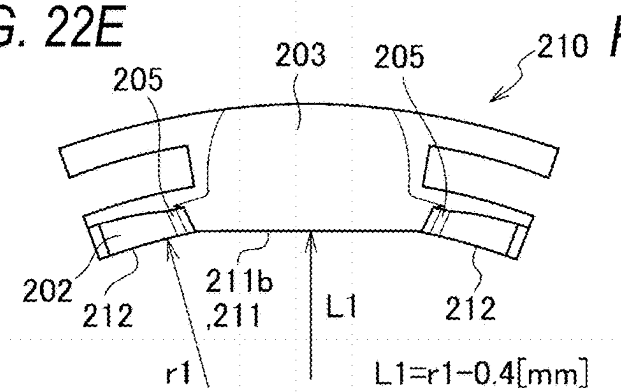


FIG. 22F

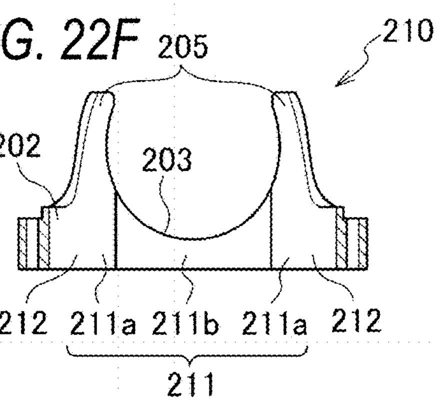


FIG. 22G

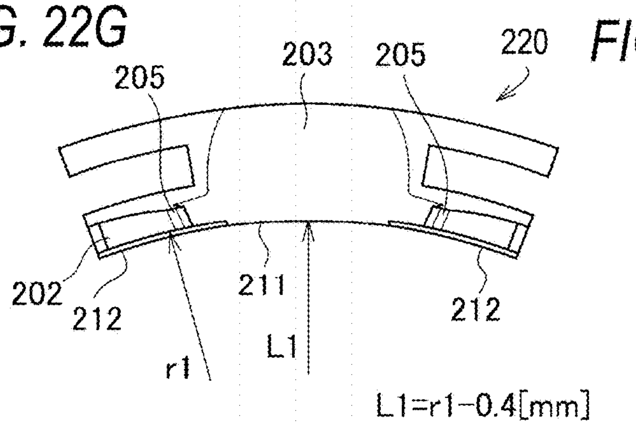


FIG. 22H

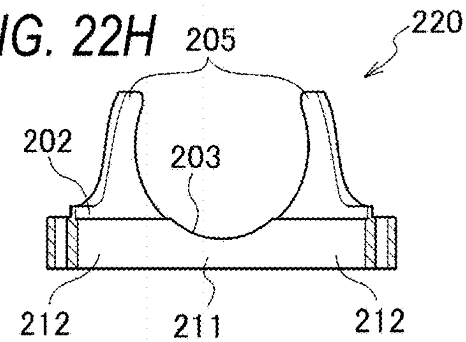


FIG. 23A

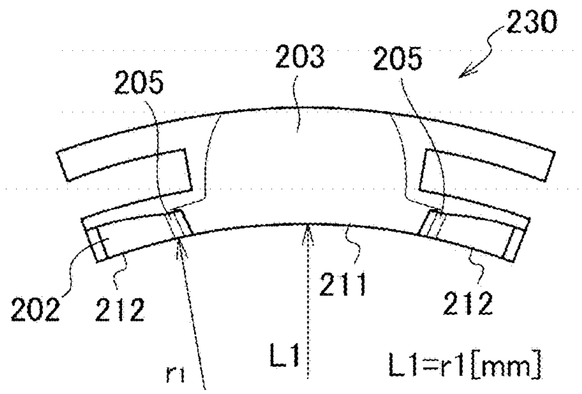


FIG. 23B

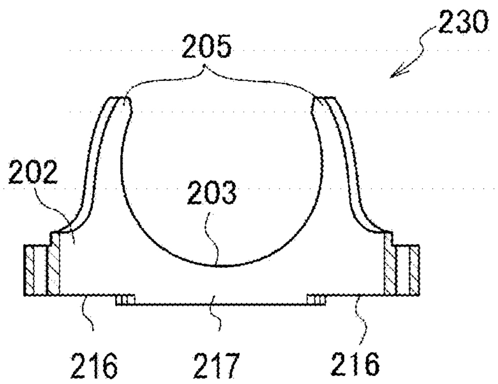


FIG. 23C

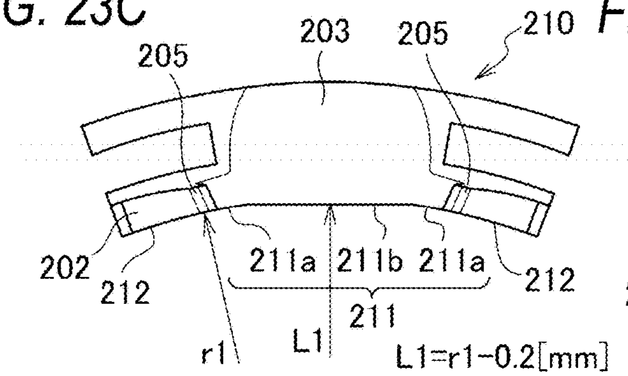


FIG. 23D

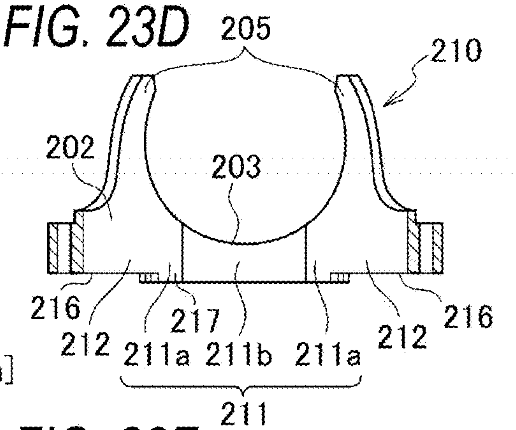


FIG. 23E

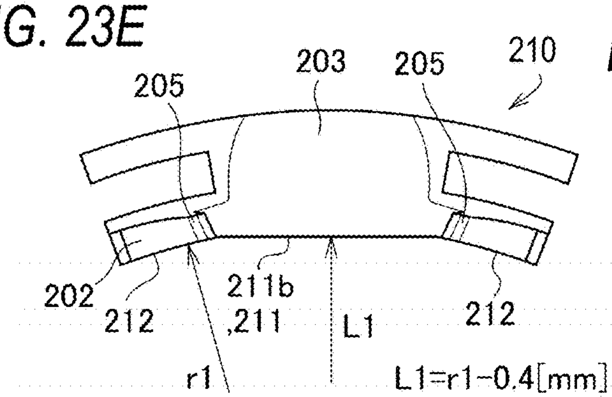


FIG. 23F

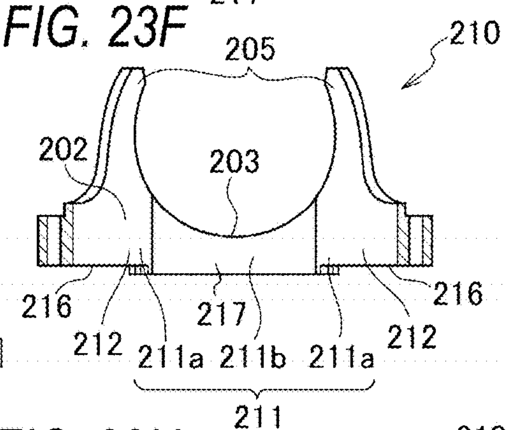


FIG. 23G

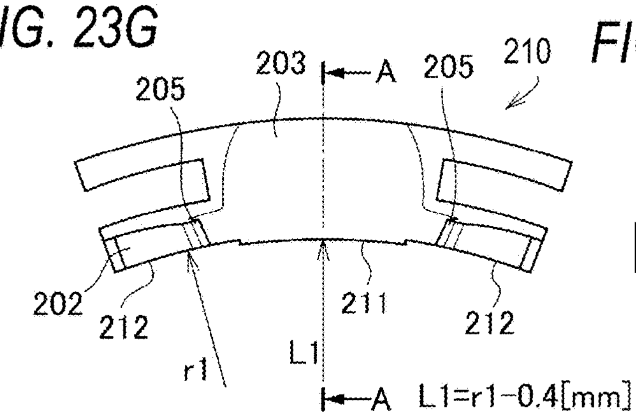


FIG. 23H

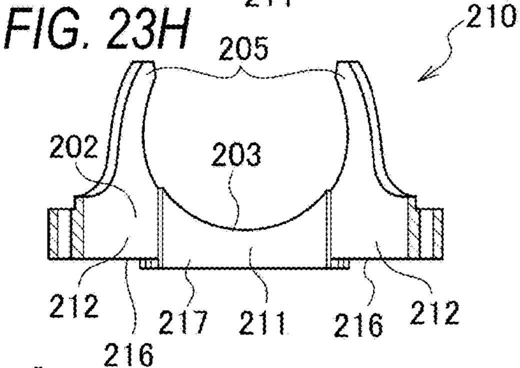


FIG. 24

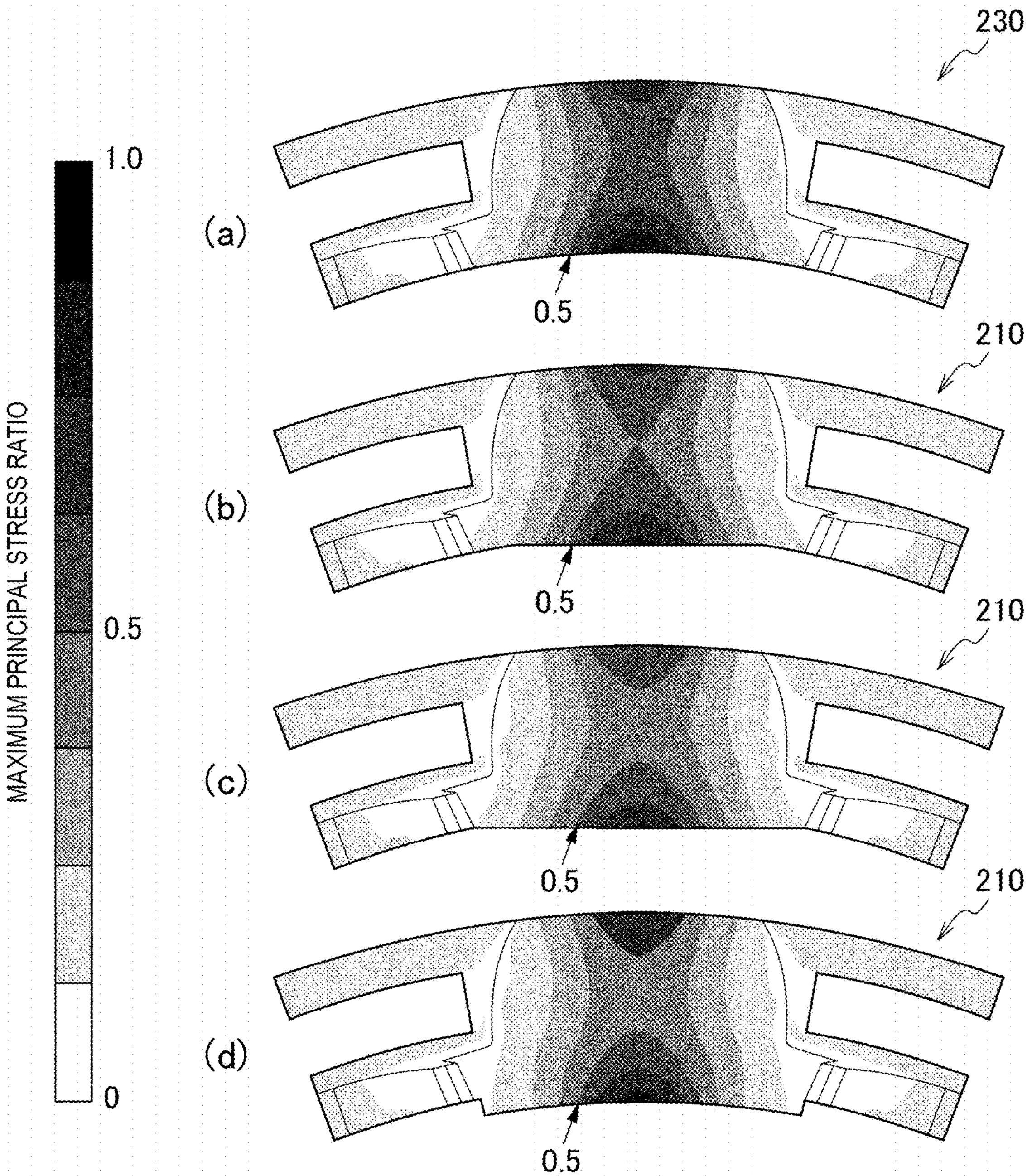

MAXIMUM PRINCIPAL STRESS RATIO
1.0
0.5
0
230
(a)
0.5
210
(b)
0.5
210
(c)
0.5
210
(d)
0.5

FIG. 25

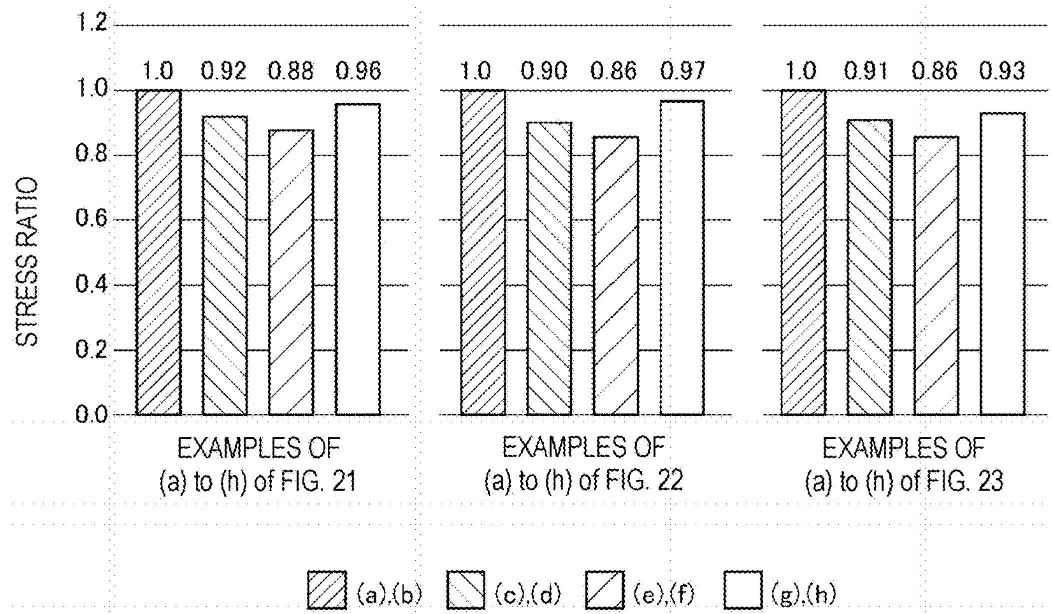

1.2
1.0
0.8
0.6
0.4
0.2
0.0
STRESS RATIO
1.0
0.92
0.88
0.96
0.90
0.86
0.97
0.91
0.93
EXAMPLES OF
(a) to (h) of FIG. 21
EXAMPLES OF
(a) to (h) of FIG. 22
EXAMPLES OF
(a) to (h) of FIG. 23
(a),(b)
(c),(d)
(e),(f)
(g),(h)

FIG. 26

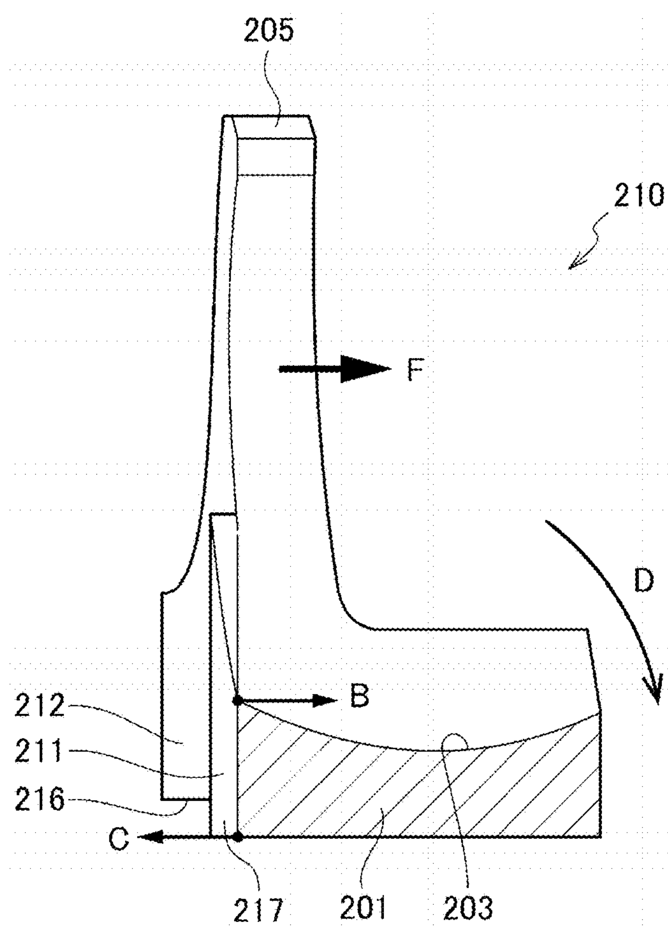

205
210
F
D
B
212
211
216
C
217
201
203

FIG. 27

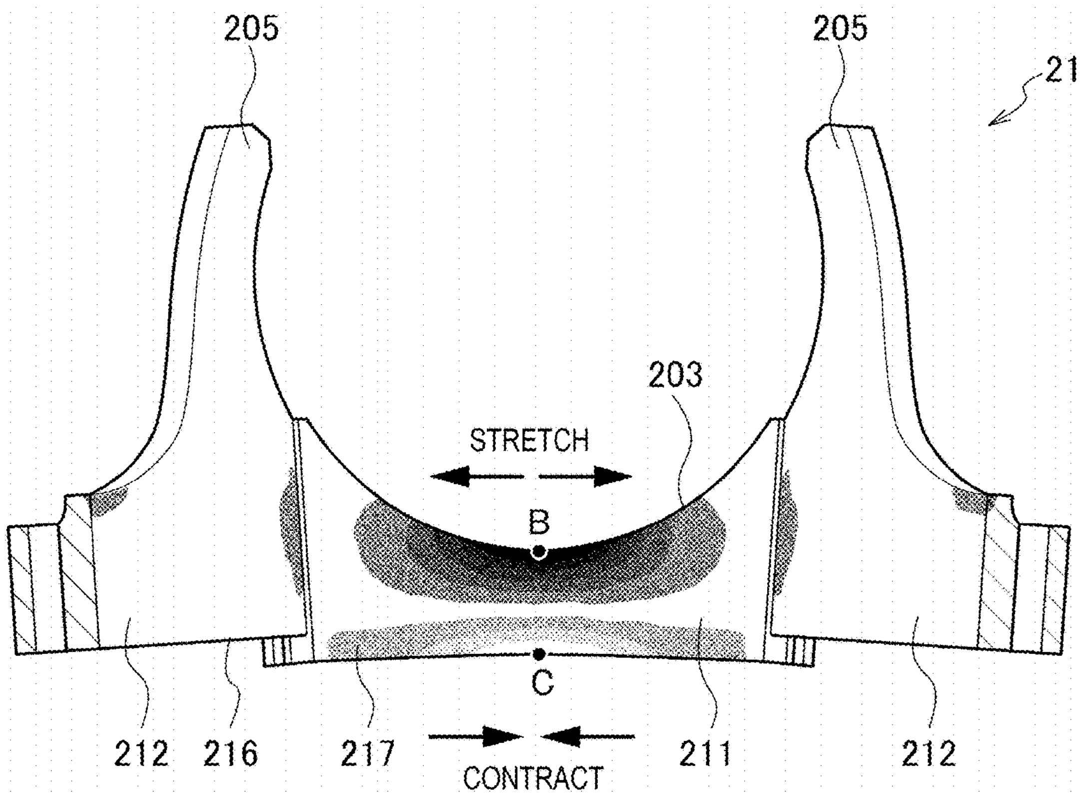


FIG. 28

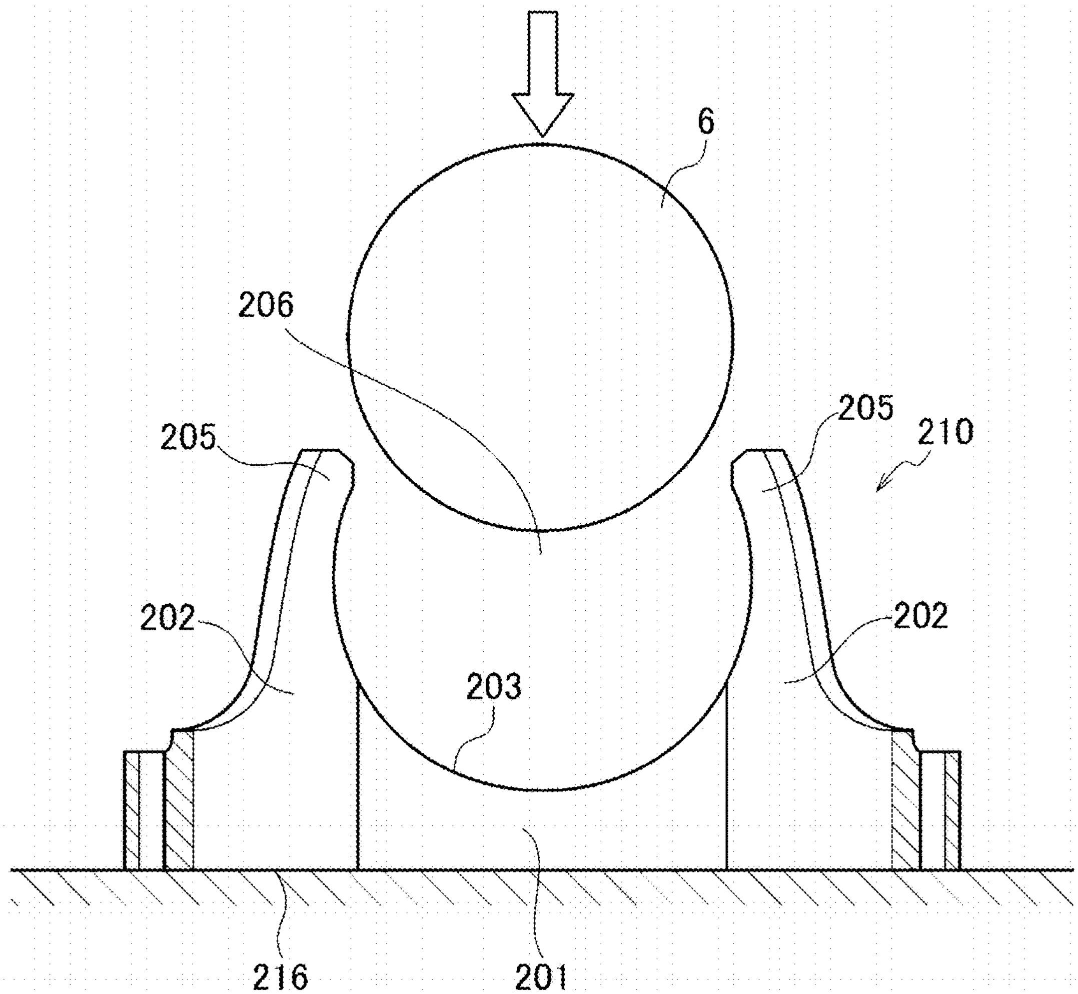


FIG. 29

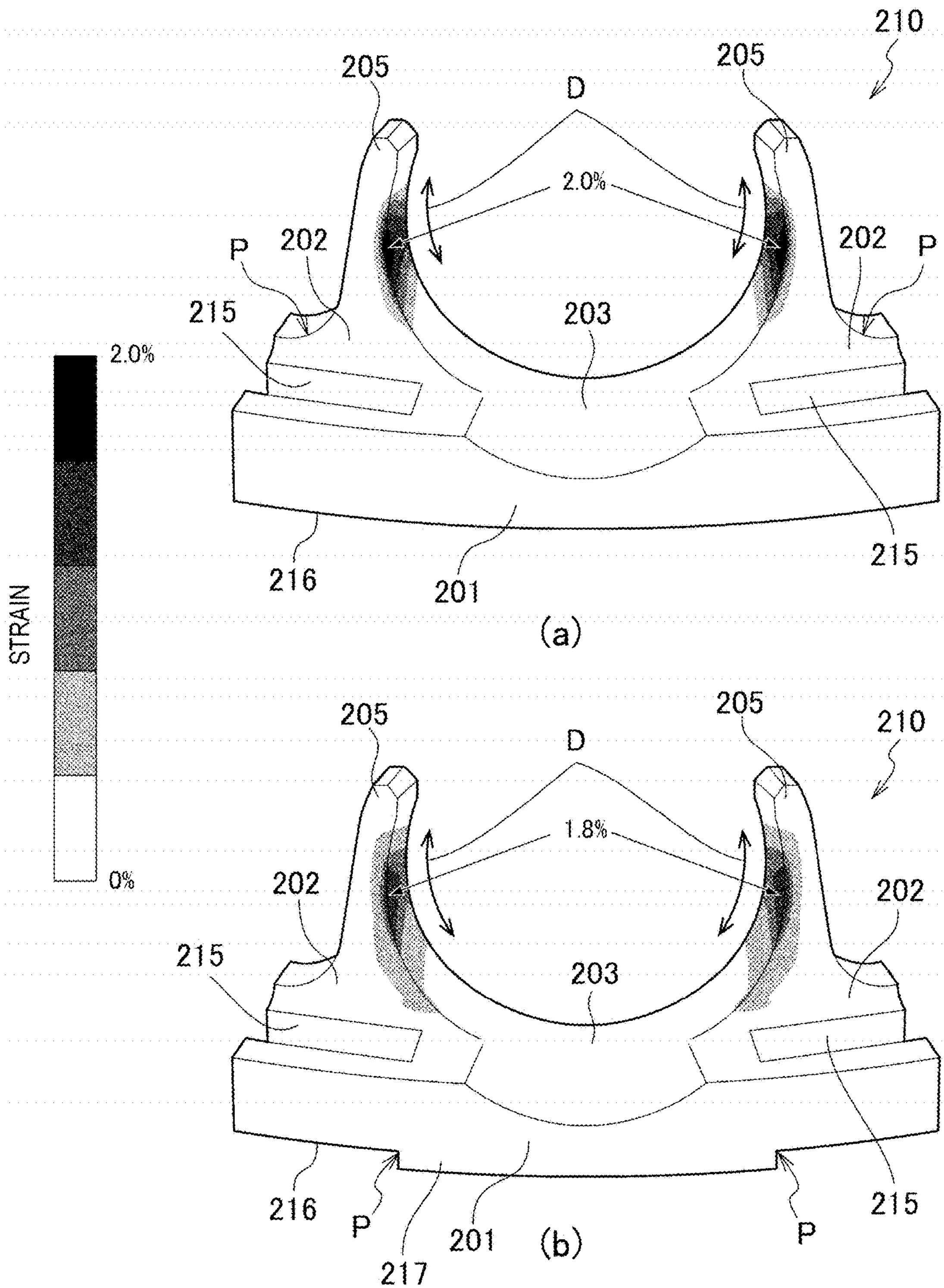

210
205
205
D
2.0%
P
202
202
P
215
203
2.0%
STRAIN
0%
215
216
201
(a)
205
205
210
D
1.8%
202
202
215
203
216
P
217
201
(b)
P
215

FIG. 30

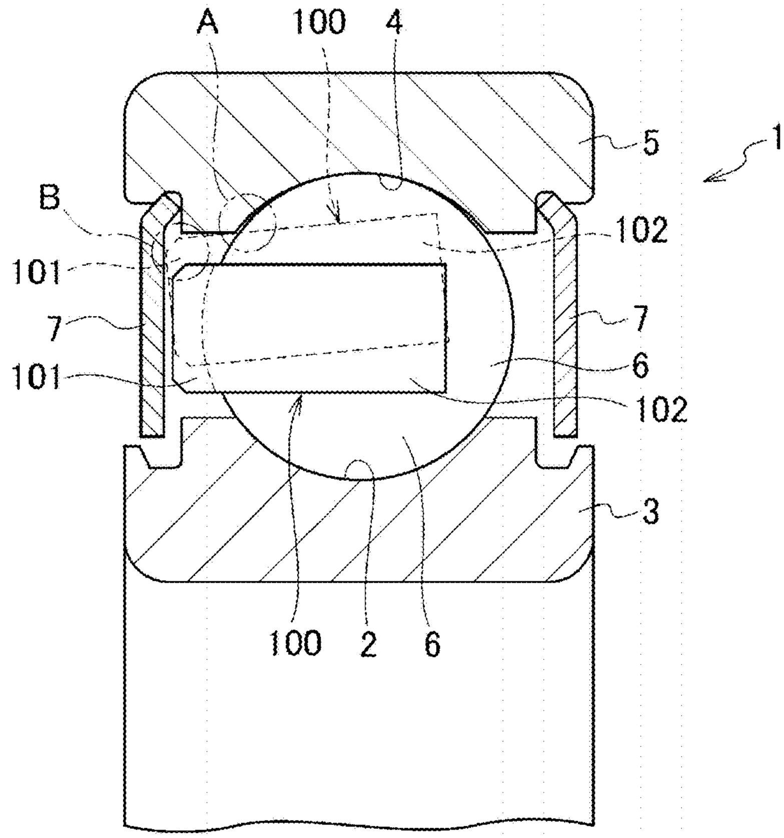

A
100
4
5
1
B
102
101
7
7
6
101
102
3
100
2
6

FIG. 31

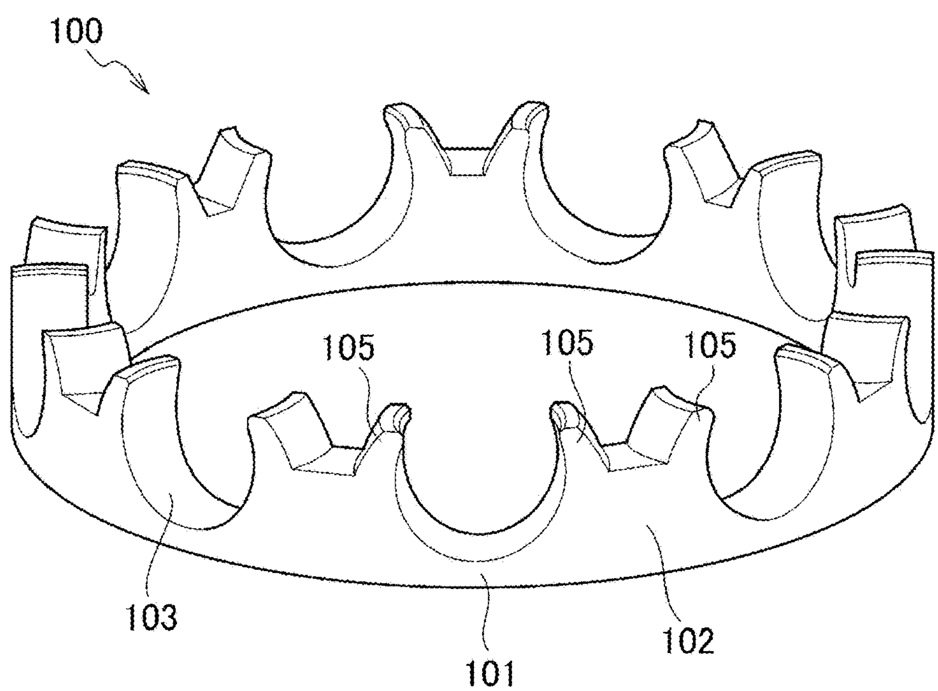

100
105
105
105
103
101
102

FIG. 32

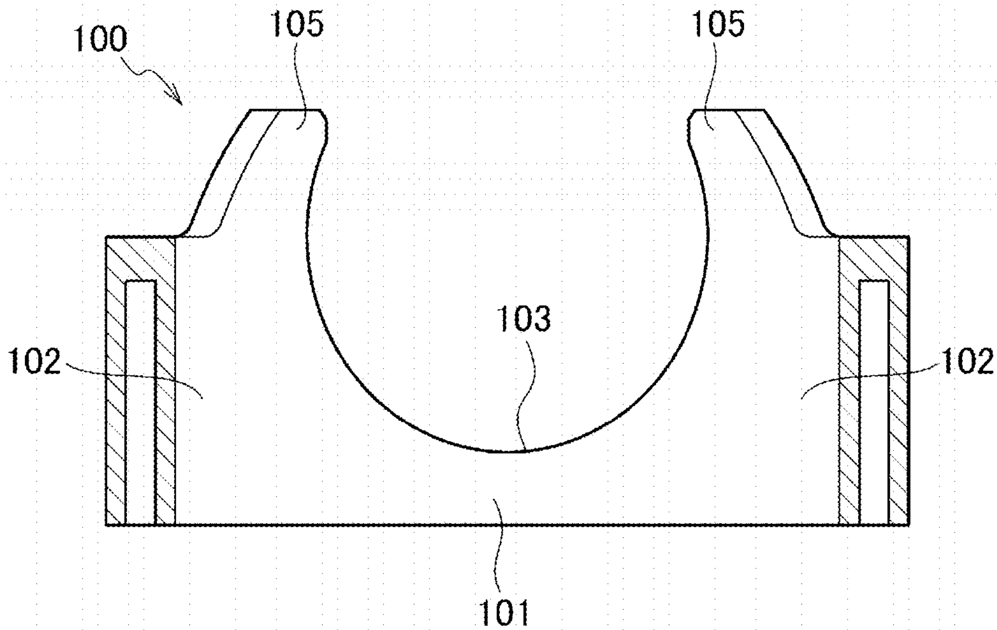
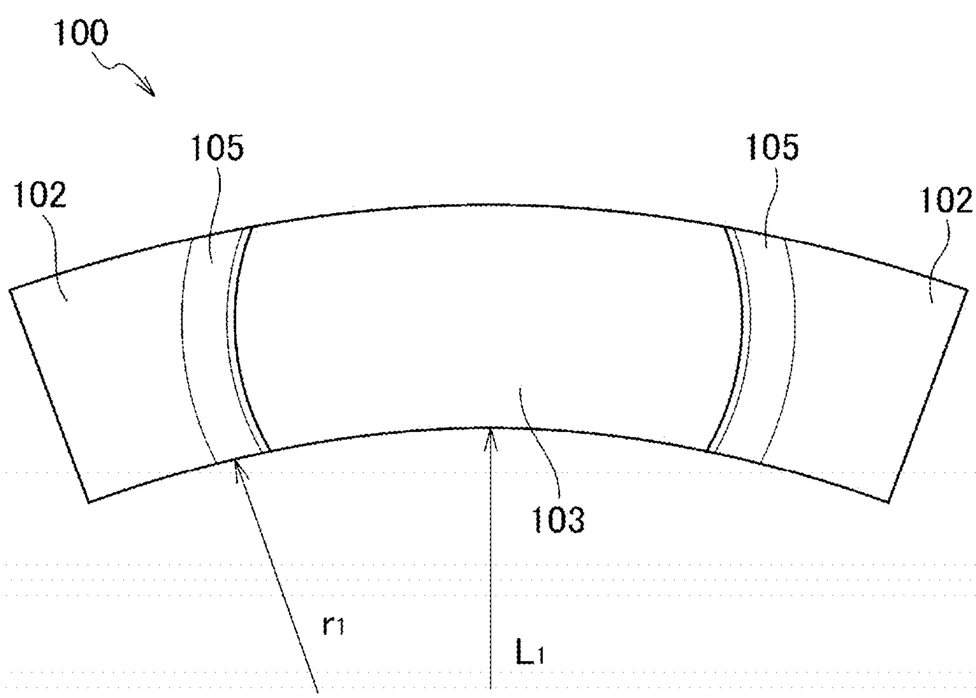


FIG. 33



CROWN-TYPE RETAINER FOR BALL BEARING, AND BALL BEARING

TECHNICAL FIELD

[0001] The present invention relates to a crown cage for a ball bearing and a ball bearing.

BACKGROUND ART

[0002] FIG. **30** is a cross-sectional view of a ball bearing **1** according to an example in the related art. Generally, the ball bearing **1** as shown in FIG. **30** is used to support a rotating portion of various rotary machines. The ball bearing **1** includes an inner ring **3** having an inner ring raceway **2** on an outer circumferential surface thereof, an outer ring **5** disposed concentrically with the inner ring **3** and having an outer ring raceway **4** on an inner circumferential surface thereof, and a plurality of balls **6** rollably disposed between the inner ring raceway **2** and the outer ring raceway **4**.

[0003] Each ball **6** is rollably held by the cage **100**. Outer circumferential edges of a pair of circular ring-shaped shield plates **7**, **7** are respectively engaged with both axial end portions of the inner circumferential surface of the outer ring **5**. The pair of shield plates **7**, **7** prevent a lubricant such as grease present in a bearing space from leaking to the outside or prevent dust floating outside from entering the bearing space. Instead of the non-contact type shield plates **7**, **7**, a contact type seal may be used as a sealing device.

[0004] The cage **100** is a crown cage made of a resin. FIG. **31** is a perspective view of the cage **100** according to the example in the related art. FIG. **32** is a view of a portion of the cage **100** according to the example in the related art as viewed from a radially inner side. FIG. **33** is a top view of the portion of the cage **100** according to the example in the related art. As shown in FIGS. **31** to **33**, the cage **100** includes an annular main portion **101**, a plurality of pillar portions **102** protruding in an axial direction at predetermined intervals in a circumferential direction from the main portion **101**, and pockets **103** each having a spherical shape formed between the adjacent pillar portions **102** and capable of holding the ball **6**.

[0005] The pillar portion **102** has a pair of claw portions **105**, **105** whose tip end portions are arranged at intervals. Since the two adjacent claw portions **105** and **105** configuring the pocket **103** hold the ball **6**, the cage **100** is prevented from falling off in the axial direction from between the outer ring **5** and the inner ring **3**. In the cage **100**, as shown in FIG. **33**, a distance L**1** from the inner circumferential surface of the pocket **103** to the center of the cage **100** (the radius of the inner circumferential surface of the pocket **103**) is equal to a radius r**1** of the inner circumferential surface of the pillar portion **102** (the claw portion **105**) (L**1**=r**1**).

[0006] In recent years, a rolling bearing (in particular, a ball bearing) that supports a rotating shaft of a motor has been required to be rotated at a high speed with the motorization of an automobile. To achieve the high-speed rotation, it is necessary to (i) prevent fatigue failure by suppressing centrifugal force expansion of the cage and reducing a stress generated at the bottom portion of the pocket, and (ii) avoid contact of the cage with the outer ring and the seal by suppressing deformation of the cage, thereby suppressing wear, vibration, and heat generation of the cage.

[0007] In the cage **100** in the related art as shown in FIGS. **31** to **33**, the stress may act on the cage **100** by the centrifugal force during the high-speed rotation, and the cage **100** may be deformed toward an outer diameter side. In FIG. **30**, a state in which the cage **100** is deformed is shown by a dashed line. In this case, the cage **100** may come into contact with the outer ring **5** (refer to a portion A in FIG. **30**), the cage **100** may come into contact with the shield plate **7** (refer to a portion B in FIG. **30**), and the cage **100** may wear, vibrate, or generate heat.

[0008] A cage described in Patent Literature 1 includes an annular base portion and an axial portion extending in an axial direction from the base portion. An outer diameter of the axial portion is smaller than an outer diameter of the base portion. The base portion is formed with a hole that communicates with a recessed area of the axial portion and penetrates in the axial direction. Accordingly, the amount of a material (that is, the mass of the cage) is reduced, and deformation in a radial direction induced during high-speed rotation is suppressed.

CITATION LIST

Patent Literature

[0009] Patent Literature 1: JP5436204B

SUMMARY OF INVENTION

Technical Problem

[0010] However, in order to meet the demand for higher-speed rotation, it is not enough to simply suppress deformation by reducing the weight of the cage or reduce the stress generated in the pockets, and it is necessary to suppress deformation of the cage caused by centrifugal force and further suppress stress by changing the shape which takes rigidity into amount. Accordingly, it is possible to avoid loss of the life at a high-stress portion generated in the pocket.

[0011] The present invention has been made in view of the above circumstances, and an object thereof is to provide a crown cage for a ball bearing and a ball bearing capable of suppressing deformation of the cage and capable of reducing stress.

Solution to Problem

[0012] The above object of the present invention is achieved by the following configuration.

[0013] [1] A crown cage for a ball bearing includes:

- **[0014]** an annular main portion;
- **[0015]** a plurality of pillar portions protruding in an axial direction at predetermined intervals in a circumferential direction from the main portion; and
- **[0016]** a pocket formed between the adjacent pillar portions and having a spherical concave surface having a spherical shape capable of holding a ball, wherein
- **[0017]** the pillar portion includes a pair of claw portions having tip end portions arranged at intervals therebetween and a connection portion connecting the pair of claw portions,
- **[0018]** an inlet portion having a width shorter than a diameter of the ball and for inserting the ball is provided between the tip end portions of the two adjacent claw portions configuring the pocket, and

[0019] a distance from an inner circumferential surface of the pocket to a center of the crown cage for a ball bearing is smaller than a radius of an inner circumferential surface of the pillar portion.

[0020] [2] A ball bearing includes:

[0021] an outer ring;

[0022] an inner ring;

[0023] a plurality of balls arranged between the outer ring and the inner ring; and

[0024] the crown cage for a ball bearing according to [1].

Advantageous Effects of Invention

[0025] According to the crown cage for a ball bearing and the ball bearing of the present invention, deformation of the cage can be suppressed, and stress can be reduced.

BRIEF DESCRIPTION OF DRAWINGS

[0026] FIG. **1** is a view of a portion of a cage according to a first embodiment as viewed from a radially inner side.

[0027] FIG. **2** is a top view of the portion of the cage according to the first embodiment.

[0028] FIG. **3** is a view of a portion of a cage according to a modification of the first embodiment as viewed from a radially inner side.

[0029] FIG. **4** is a top view of the portion of the cage according to the modification of the first embodiment.

[0030] FIG. **5** is a perspective view of a cage according to a second embodiment.

[0031] FIG. **6** is a top view of the cage according to the second embodiment.

[0032] FIG. **7** is a view of a portion of the cage according to the second embodiment as viewed from a radially inner side.

[0033] FIG. **8** is a top view of the portion of the cage according to the second embodiment.

[0034] FIG. **9** is a view of a portion of a cage according to a modification of the second embodiment as viewed from a radially inner side.

[0035] FIG. **10** is a top view of the portion of the cage according to the modification of the second embodiment.

[0036] FIG. **11** is a perspective view of a cage according to a third embodiment.

[0037] FIG. **12** is a top view of the cage according to the third embodiment.

[0038] FIG. **13** is a view of a portion of the cage according to the third embodiment as viewed from a radially inner side.

[0039] FIG. **14** is a top view of the portion of the cage according to the third embodiment.

[0040] FIG. **15** is a view of a portion of a cage according to a modification of the third embodiment as viewed from a radially inner side.

[0041] FIG. **16** is a top view of the portion of the cage according to the modification of the third embodiment.

[0042] FIG. **17** is a perspective view of a cage according to a fourth embodiment.

[0043] FIG. **18** is a top view of the cage according to the fourth embodiment.

[0044] FIG. **19** is a view of a portion of the cage according to the fourth embodiment as viewed from a radially inner side.

[0045] FIG. **20** is a top view of the portion of the cage according to the fourth embodiment.

[0046] FIGS. **21**A, **21**C, **21**E and **21**G are top views each showing a portion of a cage, and FIGS. **21**B, **21**D, **21**F and **21**H are views each showing the portion of the cage as viewed from the radially inner side. FIGS. **21**A and **21**B are a comparative example and show a cage shown in FIGS. **31** to **33** as a product in the related art, FIGS. **21**C and **21**D are an example and show the cage of the first embodiment shown in FIGS. **1** and **2**, FIGS. **21**E and **21**F are an example and show the cage according to the modification of the first embodiment shown in FIGS. **3** and **4**, and FIGS. **21**G and **21**H show a cage according to a comparative example.

[0047] FIGS. **22**A, **22**C, **22**E and **22**G are top views each showing a portion of a cage, and FIGS. **22**B, **22**D, **22**F and **22**H are views each showing the portion of the cage as viewed from the radially inner side. FIGS. **22**A and **22**B show a cage according to a comparative example, FIGS. **22**C and **22**D are an example and show the cage according to the second embodiment shown in FIGS. **5** to **8**, FIGS. **22**E and **22**F are an example and show the cage according to the modification of the second embodiment shown in FIGS. **9** and **10**, and FIGS. **22**G and **22**H show a cage according to a comparative example.

[0048] FIGS. **23**A, **23**C, **23**E and **23**G are top views each showing a portion of a cage, and FIGS. **23**B, **23**D, **23**F and **23**H are views each showing the portion of the cage as viewed from the radially inner side. FIGS. **23**A and **23**B show a cage according to a comparative example, FIGS. **23**C and **23**D are an example and show the cage according to the third embodiment shown in FIGS. **11** to **14**, FIGS. **23**E and **23**F are an example and show the cage according to the modification of the third embodiment shown in FIGS. **15** and **16**, and FIGS. **23**G and **23**H are an example and show the cage according to the fourth embodiment shown in FIGS. **17** to **20**.

[0049] FIG. **24**, including Sections (a) to (d), shows a maximum principal stress distribution generated in the cages by a centrifugal force. The cages shown in Sections (a) to (d) of FIG. **24** correspond to the cages shown in FIGS. **23**A, **23**C, **23**E and **23**G, respectively.

[0050] FIG. **25** shows results of relative comparison of a maximum value of a maximum principal stress generated by a centrifugal force in each cage shown in FIG. **21**A to FIG. **23**H.

[0051] FIG. **26** is a cross-sectional view taken along a line A-A of FIG. **23**G.

[0052] FIG. **27** shows a stress distribution when a centrifugal force is applied in the example of FIG. **23**H.

[0053] FIG. **28** is a diagram for illustrating a model for analysis.

[0054] FIG. **29**, including Sections (a) and (b), shows analysis results of a strain distribution of the cages.

[0055] FIG. **30** is a cross-sectional view of a ball bearing **1** according to an example in the related art.

[0056] FIG. **31** is a perspective view of a cage **100** according to the example in the related art.

[0057] FIG. **32** is a view of a portion of the cage **100** according to the example in the related art as viewed from a radially inner side.

[0058] FIG. **33** is a top view of the portion of the cage **100** according to the example in the related art.

DESCRIPTION OF EMBODIMENTS

[0059] A crown cage for a ball bearing and a ball bearing according to an embodiment of the present invention will be described below with reference to the drawings.

First Embodiment

[0060] FIG. **1** is a view of a portion of a cage according to a first embodiment as viewed from a radially inner side. FIG. **2** is a top view of the portion of the cage according to the first embodiment. As shown in FIGS. **1** and **2**, similarly to a cage **100** in the related art shown in FIGS. **31** to **33**, a crown cage for a ball bearing (hereinafter, referred to as a "crown cage" or also simply referred to as a "cage") **110** of the present embodiment can be applied to a ball bearing **1** shown in FIG. **30**.

[0061] The crown cage **110** is made of a resin material such as nylon 46 (polyamide 46, PA46), nylon 66 (polyamide 66, PA66), polyamide 9T (PA9T), polyamide 10T (PA10T), L-PPS, PEEK, or the like, or another resin material. In order to improve the strength of the cage **110**, a resin composition in which a fiber reinforcing material (carbon fiber, glass fiber, aramid fiber, or the like) is added in a number of 10% (for example, 10 to 50 wt %) may be used. Examples of a method for manufacturing the cage **110** include a method of injection molding using a mold, and a method of manufacturing with a 3D printer.

[0062] The crown cage **110** includes a substantially annular main portion **101**, a plurality of pillar portions **102** protruding in an axial direction at predetermined intervals in a circumferential direction from the main portion **101**, and pockets **103** each having a spherical shape formed between the adjacent pillar portions **102**, **102** and capable of holding a ball **6** (see FIG. **30**).

[0063] A plurality of spherical concave surfaces **104** each having a spherical shape are formed in the main portion **101** at predetermined intervals in the circumferential direction. The spherical concave surface **104** is formed over an entire radial width of the main portion **101**, and configures the pocket **103**.

[0064] The pillar portion **102** protrudes in the axial direction from the entire radial width of the main portion **101**. The pillar portion **102** includes a pair of claw portions **105**, **105** and a connection portion **113** connecting the pair of claw portions **105**, **105**.

[0065] Tip end portions of the pair of claw portions **105** and **105** are arranged at intervals in the circumferential direction. Further, an inlet portion **106** having a width shorter than the diameter of the ball **6** (see FIG. **30**) and for inserting the ball **6** is provided between the tip end portions of the two adjacent claw portions **105**, **105** configuring the pocket **103**.

[0066] Circumferential surfaces of the two adjacent claw portions **105**, **105** and the spherical concave surface **104** of the main portion **101** configures the pocket **103**. The two circumferential surfaces and the spherical concave surface **104** are smoothly connected to each other to form a spherical concave surface of the pocket **103**. A radius of curvature of the spherical concave surface of the pocket **103** is set to be larger than a radius of curvature of a rolling surface of the ball **6** (see FIG. **30**).

[0067] As described above, since the plurality of pockets **103** are connected to each other by the main portion **101**, when a centrifugal force is applied to the cage **110** during high-speed rotation or the like, the cage **110** falls to a radially outer side with the main portion **101** as a center.

[0068] In order to suppress the fall, an inner circumferential side of the pocket **103**, where a high stress is generated (an inner circumferential side of the main portion **101** configuring the pocket **103**), is formed to be thickened to the radially inner side. That is, as shown in FIG. **2**, the distance L1 from an inner circumferential surface (inner circumferential surface of the main portion **101** configuring the pocket **103**) **111** of the pocket **103** to a center of the cage **110** is smaller than the radius **r1** of an inner circumferential surface **112** of the pillar portion **102** (L1<**r1**). Accordingly, the rigidity of the pocket **103** on the main portion **101** side is improved, and deformation of the crown cage **110** can be suppressed. On the other hand, in the cage **100** according to an example in the related art, as shown in FIG. **33**, a distance from an inner circumferential surface of the pocket **103** to a center of the cage **100** is equal to the radius **r1** of an inner circumferential surface of the pillar portion **102** (L1=**r1**).

[0069] In the illustrated example, the inner circumferential surface (inner circumferential surface of the main portion **101** configuring the pocket **103**) **111** of the pocket **103** includes a pair of connection surfaces **111***a*, **111***a* positioned on both sides of the inner circumferential surface **111** in the circumferential direction and connected to the inner circumferential surface **112** of the pillar portion **102**, and a convex surface **111***b* connecting inner side end portions of the pair of connection surfaces **111***a*, **111***a* in the circumferential direction to each other.

[0070] The pair of connection surfaces **111***a*, **111***a* are curved surfaces having substantially the same curvature as the inner circumferential surface **112** of the pillar portion **102**. A distance from the pair of connection surfaces **111***a*, **111***a* to the center of the cage **110** is substantially equal to the radius **r1** of the inner circumferential surface **112** of the pillar portion **102**.

[0071] The convex surface **111***b* is a plane that protrudes to the radially inner side from the connection surface **111***a* and the inner circumferential surface **112** of the pillar portion **102**. The shape of the convex surface **111***b* is not limited to a plane, and may be any shape, for example, an arc surface connecting the insides of the connection surfaces **111***a*, **111***a*, or a cylindrical surface shape as described below. The distance L1 from an inner circumferential surface of the convex surface **111***b* to the center of the cage **110** is smaller than the radius **r1** of the inner circumferential surface **112** of the pillar portion **102**.

[0072] A circumferential width of the convex surface **111***b* of the inner circumferential surface **111** is preferably set to a range in which the stress is particularly high when the centrifugal force is applied. That is, a range from about half an inner diameter of the pocket to a diameter position of the pocket is preferable.

[0073] As described above, according to the cage **110** of the present embodiment, deformation of the cage **110** is suppressed and the stress is reduced by thickening the inner circumferential side of the pocket **103**, where a high stress is generated, to the radially inner side. As a result, the cage **110** can be prevented from coming into contact with the outer ring **5**, the shield plate **7**, or the like, and wear, vibration, heat generation, or the like of the cage **10** can be suppressed.

Modification of First Embodiment

[0074] FIG. **3** is a view of a portion of a cage according to a modification of the first embodiment as viewed from a radially inner side. FIG. **4** is a top view of the portion of the cage according to the modification of the first embodiment. As shown in FIGS. **3** and **4**, in the present modification, a circumferential width of the convex surface **111***b* of the inner circumferential surface **111** of the pocket **103** is set larger than that in the example of FIGS. **1** and **2**. Specifically, both end portions in the circumferential direction of the convex surface **111***b* are arranged at substantially the same position in the circumferential direction with respect to tip end portions (inner side end portions in the circumferential direction) of the pair of claw portions **105**, **105**. Accordingly, the rigidity around the pocket **103** of the cage **110** can be further increased.

Second Embodiment

[0075] Next, a crown cage for a ball bearing according to a second embodiment of the present invention will be described with reference to the drawings.

[0076] FIG. **5** is a perspective view of the cage according to the second embodiment. FIG. **6** is a top view of a cage according to the second embodiment. FIG. **7** is a view of a portion of the cage according to the second embodiment as viewed from a radially inner side. FIG. **8** is a top view of the portion of the cage according to the second embodiment.

[0077] A crown cage **210** of the present embodiment includes an annular main portion **201**, a plurality of pillar portions **202** protruding in an axial direction at predetermined intervals in the circumferential direction from an upper surface of the main portion **201**, and pockets **203** each having a spherical shape formed between the adjacent pillar portions **202**, **202** and capable of holding the ball **6** (see FIG. **30**).

[0078] A plurality of spherical concave surfaces **204** each having a spherical shape are formed at predetermined intervals in the circumferential direction on the upper surface of the main portion **201**. The spherical concave surface **204** is formed over an entire radial width of the main portion **201**, and configures the pocket **203**.

[0079] The pillar portion **202** protrudes from a radially inner side portion of the upper surface of the main portion **201** in the axial direction. In addition, the upper surface of the main portion **201** is exposed to a radially outer side of the pillar portion **202**. In the crown cage **110** (see FIGS. **1** to **4**) of the first embodiment, since the pillar portion **102** protrudes in the axial direction from the entire radial width of the upper surface of the main portion **101**, the pillar portion **202** of the second embodiment differs in this respect. That is, in the second embodiment, a configuration in which a region on the radially outer side of the pillar portion **202** (claw portions **205**) is scraped is employed. That is, the pillar portion **202** of the second embodiment protrudes in the axial direction from only the radially inner side portion of the upper surface of the main portion **201**, and is removed from a radially intermediate portion and a radially outer side portion of the upper surface of the main portion **201**. Accordingly, the weight of the pillar portion **202**, that is, the weight of the cage **210** is reduced, and deformation of the claw portion **205** due to the centrifugal force is suppressed even during high-speed rotation.

[0080] The pillar portion **202** includes the pair of claw portions **205**, **205** and a connection portion **213** connecting the pair of claw portions **205**, **205**.

[0081] Tip end portions of the pair of claw portions **205**, **205** are arranged at intervals in the circumferential direction.

[0082] An inlet portion **206** having a width shorter than the diameter of the ball **6** (see FIG. **30**) and for inserting the ball **6** is provided between the tip end portions of the two adjacent claw portions **205**, **205** configuring the pocket **203**.

[0083] The claw portion **205** includes a circumferential first surface **205***b* of a spherical shape configuring the pocket **203** and a circumferential second surface **205***c* opposite the circumferential first surface **205***b*.

[0084] The circumferential second surfaces **205***c*, **205***c* of the pair of claw portions **205**, **205** have curved shapes respectively and are smoothly connected to each other on an upper surface **213***a* of the connection portion **213**. The upper surface **213***a* of the connection portion **213** corresponds to a substantially U-shaped bottom portion formed by the upper surface **213***a* and the pair of circumferential second surfaces **205***c*, **205***c*. The upper surface **213***a* (a bottom portion of the pair of circumferential second surfaces **205***c*, **205***c*) of the connection portion **213** is positioned slightly above (one side in the axial direction) the upper surface of the main portion **201**. Accordingly, the bottom portion (the upper surface **213***a* of the connection portion **213**) of the pair of circumferential second surfaces **205***c*, **205***c* is positioned below a center of the cage **210** in the axial direction (the other side in the axial direction), and forms a substantially U-shaped recessed portion. As shown in FIG. **32**, in the crown cage **100** in the related art, an upper surface of a connection portion (a bottom portion of a pair of circumferential second surfaces) is positioned much higher than an upper surface of the main portion **101**, and is positioned above a center of the cage **100** in the axial direction (one side in the axial direction).

[0085] As shown in FIG. **8**, an outer diameter of the claw portion **205** is set to be smaller than an outer diameter of the main portion **201**.

[0086] Further, a radial width t**1** of the claw portion **205** is set to ½ or less of a radial width t**2** of the main portion **201** $\{t1 \leq (t2)/2\}$.

[0087] As shown in FIG. **7**, an axial width h**2** from the upper surface **213***a* of the connection portion **213** of the pillar portion **202** to a bottom surface of the main portion **201** is set to ½ or less of an axial width h**3** of the cage **210** $\{h2 \leq (h3)/2\}$. Further, an axial width h**1** on a side of the connection portion **213** where the pillar portion **202** (the claw portion **205**) is not present, that is, on the radially outer side, is also set to ½ or less of the axial width h**3** $\{h1 \leq (h3)/2\}$. The axial width h**1** is smaller than the axial width h**2** $(h1<h2)$.

[0088] If the axial widths h**1**, h**2** are too small, the strength of the cage **210** may decrease, and thus the axial widths h**1**, h**2** are preferably larger than an axial width h**4** of the main portion **201** in a bottom portion of the pocket **203** $(h1>h4, h2>h4)$.

[0089] The main portion **201** is provided with an opening portion **215** that opens in the axial direction between the adjacent pockets **203**, **203**. The opening portion **215** penetrates the bottom surface from the upper surface of the main portion **201** in the axial direction. The opening portion **215** is positioned on the radially outer side of the pillar portion

202 (the pair of claw portions **205**, **205**). That is, at least a portion of the opening portion **215** overlaps the pillar portion **202** (the pair of claw portions **205**, **205**) in the circumferential direction. Further, the claw portion **205** and the opening portion **215** are provided to be offset in the radial direction, and the opening portion **215** is positioned on the radially outer side of the claw portion **205**. By providing the opening portion **215** in this way, the weight of the cage **210** is reduced.

[0090] When a width of the pillar portion **202** or the claw portion **205** of the cage **210** is reduced, there is a possibility that the strength will decrease, and there is a possibility that a resin does not flow and voids are generated when the cage **210** is manufactured by injection molding. A width of each portion of the cage **210** is preferably 1 mm or more.

[0091] As described above, since the plurality of pockets **203** are connected to each other by the main portion **201**, when the centrifugal force is applied to the cage **210** at the time of high-speed rotation or the like, the cage **210** falls to the radially outer side with the main portion **201** as a center. In order to suppress the fall, an inner circumferential side of the pocket **203**, where a high stress is generated (an inner circumferential side of the main portion **201** configuring the pocket **203**), is formed to be thickened to the radially inner side.

[0092] That is, as shown in FIG. **8**, the distance L**1** from an inner circumferential surface **211** of the pocket **203** (an inner circumferential surface of the main portion **201** configuring the pocket **203**) to a center of the cage **210** is smaller than the radius r**1** of the inner circumferential surface **212** of the pillar portion **202**.

[0093] In the illustrated example, the inner circumferential surface (inner circumferential surface of the main portion **201** configuring the pocket **203**) **211** of the pocket **203** includes a pair of connection surfaces **211***a*, **211***a* positioned on both sides of the inner circumferential surface **211** in the circumferential direction and connected to the inner circumferential surface **212** of the pillar portion **202**, and a convex surface **211***b* connecting inner side end portions of the pair of connection surfaces **211***a*, **211***a* in the circumferential direction to each other.

[0094] The pair of connection surfaces **211***a*, **211***a* are curved surfaces having substantially the same curvature as the inner circumferential surface **212** of the pillar portion **202**. A distance from the pair of connection surfaces **211***a*, **211***a* to the center of the cage **210** is substantially equal to the radius r**1** of the inner circumferential surface **212** of the pillar portion **202**.

[0095] The convex surface **211***b* is a plane that protrudes to the radially inner side from the connection surface **211***a* and the inner circumferential surface **212** of the pillar portion **202**. The shape of the convex surface **211***b* is not limited to a plane, and may be any shape, for example, a cylindrical surface shape as described below. The distance L**1** from an inner circumferential surface of the convex surface **211***b* to the center of the cage **210** is smaller than the radius r**1** of the inner circumferential surface **212** of the pillar portion **202** (L**1**<r**1**).

[0096] A circumferential width of the convex surface **211***b* of the inner circumferential surface **211** is preferably set to a range in which the stress is particularly high when the centrifugal force is applied. That is, a range from about half an inner diameter of the pocket to a diameter position of the pocket is preferable.

[0097] As described above, according to the cage **210** of the present embodiment, the weight of the cage **210** is reduced, the rigidity of the pocket **203** is improved, and the deformation and the stress caused by the centrifugal force during the high-speed rotation can be suppressed. As a result, the cage **210** can be prevented from coming into contact with the outer ring **5**, the shield plate **7**, or the like, and wear, vibration, heat generation, or the like of the cage **210** can be suppressed.

Modification of Second Embodiment

[0098] FIG. **9** is a view of a portion of a cage according to a modification of the second embodiment as viewed from a radially inner side. FIG. **10** is a top view of the portion of the cage according to the modification of the second embodiment. As shown in FIGS. **9** and **10**, in the present modification, a circumferential width of the convex surface **211***b* of the inner circumferential surface **211** of the pocket **203** is set larger than that in the example of FIGS. **5** to **8**. Specifically, both end portions in the circumferential direction of the convex surface **211***b* are arranged at substantially the same position in the circumferential direction with respect to tip end portions (inner side end portions in the circumferential direction) of the pair of claw portions **205**, **205**. Accordingly, the rigidity around the pocket **203** of the cage **210** can be further increased.

Third Embodiment

[0099] Next, a crown cage for a ball bearing according to a third embodiment of the present invention will be described with reference to the drawings.

[0100] FIG. **11** is a perspective view of the cage according to the third embodiment. FIG. **12** is a top view of the cage according to the third embodiment. FIG. **13** is a view of a portion of the cage according to the third embodiment as viewed from a radially inner side. FIG. **14** is a top view of the portion of the cage according to the third embodiment.

[0101] The cage **210** of the present embodiment is different from the cage **210** of the second embodiment (see FIGS. **5** to **10**) in that convex portions **217** are provided on a bottom surface **216** of the main portion **201**. Since other configurations are the same as those of the second embodiment, the same reference numerals are given to the same components, and description thereof will be omitted or simplified.

[0102] The convex portion **217** protrudes from the bottom surface **216** of the main portion **201** in the axial direction (a direction opposite to the direction in which the claw portion **205** extends in an upper-lower direction in FIG. **11**) between the opening portions **215**, **215** adjacent to each other in the circumferential direction. That is, the bottom surface **216** of the main portion **201** has the plurality of convex portions **217** formed at predetermined intervals in the circumferential direction below the plurality of pockets **203**.

[0103] A portion of the convex portion **217** preferably overlaps the pocket **203** in the circumferential direction and the radial direction. That is, a circumferential range and a radial range in which the convex portion **217** is provided are preferably substantially the same as a circumferential range and a radial range in which the spherical concave surface **204** of the main portion **201** configuring the pocket **203** is provided. A radial width and a circumferential width of the convex portion **217** of the present embodiment are substantially the same as a radial width (the radial width t**2** of the main portion **201**) and a circumferential width of the pocket **203**.

[0104] According to the cage **210** of the third embodiment, the effect of suppressing the stress and the deformation generated by centrifugal force compared to the second embodiment is not significantly different if an axial width h**4** of the main portion **201** at a bottom portion of the pocket **203** is the same dimension, but the effect is exerted when the cage **210** is incorporated into the bearing **1** consisting of the inner ring **3**, the outer ring **5**, and the balls **6**. That is, as described later, strain generated in the claw portions **205** of the cage **210** is reduced.

Modification of Third Embodiment

[0105] FIG. **15** is a view of a portion of a cage according to a modification of the third embodiment as viewed from a radially inner side. FIG. **16** is a top view of the portion of the cage according to the modification of the third embodiment. As shown in FIGS. **15** and **16**, in the present modification, a circumferential width of the convex surface **211***b* of the inner circumferential surface **211** of the pocket **203** is set larger than that in the example of FIGS. **11** to **14**. Specifically, both end portions in the circumferential direction of the convex surface **211***b* are arranged at substantially the same position in the circumferential direction with respect to tip end portions (inner side end portions in the circumferential direction) of the pair of claw portions **205**, **205**. Accordingly, the rigidity around the pocket **203** of the cage **210** can be further increased.

Fourth Embodiment

[0106] Next, a crown cage for a ball bearing according to a fourth embodiment of the present invention will be described with reference to the drawings.

[0107] FIG. **17** is a perspective view of the cage according to the fourth embodiment. FIG. **18** is a top view of the cage according to the fourth embodiment. FIG. **19** is a view of a portion of the cage according to the fourth embodiment as viewed from a radially inner side. FIG. **20** is a top view of the portion of the cage according to the fourth embodiment.

[0108] A shape of the inner circumferential surface (an inner circumferential surface of the main portion **201** configuring the pocket **203**) **211** of the pocket **203** in the cage **210** of the present embodiment is different from a shape thereof in the cage **210** (see FIGS. **11** to **16**) of the third embodiment. Since other configurations are the same as those of the third embodiment, the same reference numerals are given to the same components, and description thereof will be omitted or simplified.

[0109] In the present embodiment, similarly to the above-described embodiment, the distance L1 from the inner circumferential surface **211** of the pocket **203** to a center of the cage **210** is smaller than the radius **r1** of the inner circumferential surface **212** of the pillar portion **202** (L**1**<r**1**).

[0110] In the illustrated example, the inner circumferential surface **211** of the pocket **203** is a cylindrical surface protruding to the radially inner side from the inner circumferential surface **212** of the pillar portion **202**. The distance L1 from the inner circumferential surface **211** of the pocket **203** to the center of the cage **210** (that is, a radius of the inner circumferential surface **211** of the pocket **203**) is smaller than the radius **r1** of the inner circumferential surface **212** of the pillar portion **202**.

[0111] According to such a configuration, the rigidity of the pocket **203** is improved, and deformation and stress caused by a centrifugal force during high-speed rotation can be suppressed. As a result, the cage **210** can be prevented from coming into contact with the outer ring **5**, the shield plate **7**, or the like, and wear, vibration, heat generation, or the like of the cage **210** can be suppressed.

[0112] The shape of the inner circumferential surface **211** of the pocket **203** of the present embodiment can be applied not only to the third embodiment but also to the inner circumferential surfaces **111**, **211** of the pockets **103**, **203** in the cage according to the first and second embodiments.

Example 1

[0113] In order to confirm the effect of the present invention, analysis according to a finite element method was performed. The cage to be analyzed is a resin crown cage used for a bearing having an inner diameter of 35 mm. A shape of the cage was set based on each embodiment of the present invention on the basis of the resin crown cage **100** in the related art and the like.

[0114] In order to confirm the effect of the first embodiment, shapes of the cages shown in FIGS. **21**A to **21**H are employed. FIGS. **21**A, **21**C, **21**E, and **21**G are top views each showing a portion of a cage, and FIGS. **21**B, **21**D, **21**F and **21**H are views each showing the portion of the cage as viewed from the radially inner side. FIGS. **21**A and **21**B are a comparative example and show the cage **100** shown in FIGS. **31** to **33** as a product in the related art, (FIGS. **21**C and **21**D are an example and show the cage **110** of the first embodiment shown in FIGS. **1** and **2**, FIGS. **21**E and **21**F are an example and show the cage **110** according to the modification of the first embodiment shown in FIGS. **3** and **4**, and FIGS. **21**G and **21**H show a cage **120** according to a comparative example.

[0115] In the cage **120** according to the comparative example of FIGS. **21**G and **21**H, as compared with the example of FIGS. **21**A and **21**B, not only the inner circumferential surface **111** of the pocket **103** but also the inner circumferential surface **112** on the main portion side of the pillar portion **102** protrudes to the radially inner side.

[0116] The distance L1 from the inner circumferential surface **111** of the pocket **103** to a center of the cage was reduced by 0.2 mm (L**1**=**r1**−0.2 mm) in FIGS. **21**C and **21**D, reduced by 0.4 mm in FIGS. **21**E and **21**F (L**1**=**r1**−0.4 mm), and reduced by 0.4 mm in FIGS. **21**G and **21**H (L**1**=**r1**−0.4 mm) based on the example of FIGS. **21**A and **21**B (L**1**=**r1**).

[0117] In order to confirm the effect of the second embodiment, shapes of the cages shown in FIGS. **22**A to **22**H are employed. FIGS. **22**A, **22**C, **22**E, and **22**G are top views each showing a portion of a cage, and FIGS. **22**B, **22**D, **22**F and **22**H are views each showing the portion of the cage as viewed from the radially inner side. FIGS. **22**A and **22**B show a cage **200** according to a comparative example, FIGS. **22**C and **22**D are an example and show the cage **210** according to the second embodiment shown in FIGS. **5** to **8**, FIGS. **22**E and **22**F are an example and show the cage **210** according to the modification of the second embodiment shown in FIGS. **9** and **10**, FIGS. **22**G and **22**H show a cage **220** according to a comparative example.

[0118] Different from the examples of FIGS. **22**C to **22**F, in the cage **200** according to the comparative example of FIGS. **22**A and **22**B, the distance L**1** from the inner circumferential surface **211** of the pocket **203** to the center of the cage is set to be equal to the radius **r1** of the inner circumferential surface **212** of the pillar portion **202** (L**1**=**r1**).

[0119] In the cage **220** according to the comparative example of FIGS. **22**G and **22**H, as compared with the example of FIGS. **22**A and **22**B, not only the inner circumferential surface **211** of the pocket **203** but also the inner circumferential surface **212** on the main portion side of the pillar portion **202** protrudes to the radially inner side.

[0120] The distance L**1** from the inner circumferential surface **211** of the pocket **203** to a center of the cage was reduced by 0.2 mm (L**1**=**r1**−0.2 mm) in FIGS. **22**C and **22**D, reduced by 0.4 mm in FIGS. **22**E and **22**F (L**1**=**r1**−0.4 mm), and reduced by 0.4 mm in FIGS. **22**G and **22**H (L**1**=**r1**−0.4 mm) based on the example of FIGS. **22**A and **22**B (L**1**=**r1**).

[0121] In order to confirm the effects of the third and fourth embodiments, shapes of the cages shown in FIGS. **23**A to **23**H are employed. FIGS. **23**A, **23**C, **23**E, and **23**G are top views each showing a portion of a cage, and FIGS. **23**B, **23**D, **23**F and **23**H are views each showing the portion of the cage as viewed from the radially inner side. FIGS. **23**A and **23**B show a cage **230** according to a comparative example, FIGS. **23**C and **23**D are an example and show the cage **210** according to the third embodiment shown in FIGS. **11** to **14**, FIGS. **23**E and **23**F are an example and show the cage **210** according to the modification of the third embodiment shown in FIGS. **15** and **16**, and FIGS. **23**G and **23**H are an example and show the cage **210** according to the fourth embodiment shown in FIGS. **17** to **20**.

[0122] Different from the examples of FIGS. **23**C to **23**F, in the cage **230** according to the comparative example of FIGS. **23**A and **23**B, the distance L**1** from the inner circumferential surface **211** of the pocket **203** to the center of the cage is set to be equal to the radius **r1** of the inner circumferential surface **212** of the pillar portion **202** (L**1**=**r1**).

[0123] The distance L**1** from the inner circumferential surface **211** of the pocket **203** to a center of the cage was reduced by 0.2 mm (L**1**=**r1**−0.2 mm) in FIGS. **23**C and **23**D, reduced by 0.4 mm in FIGS. **23**E and **23**F (L**1**=**r1**−0.4 mm), and reduced by 0.4 mm in FIGS. **23**G and **23**H (L**1**=**r1**−0.4 mm) based on the example of FIGS. **23**A and **23**B (L**1**=**r1**).

[0124] Dimensions of each cage were set such that the inner circumferential radius r1 of the cage (the radius of the inner circumferential surface **212** of the pillar portion **202**) was 24.5 mm and a height in the axial direction was 10 mm. Material property values of each cage were a Young's modulus of 7210 MPa, a Poisson's ratio of 0.4, and a density of 1.27 g/cm^3. As conditions, a rotation speed of the cage was 15,000 rpm when a rotation speed of the inner ring (rotating ring) was 38,000 rpm.

[0125] Sections (a) to (d) of FIG. **24** show a maximum principal stress distribution generated in the cages by the centrifugal force. The cages shown in Sections (a) to (d) of FIG. **24** correspond to the cages shown in FIGS. **23**A, **23**C, **23**E, and **23**G, respectively. Here, a stress value was a relative value.

[0126] It can be seen that a largest stress is generated in the cage **230** of the comparative example of Section (a) of FIG. **24**. On the other hand, it can be seen that in the cages **210** of Sections (b), (c), and (d) of FIG. **24**, the generation of stress is suppressed as compared with the cage **230** of Section (a) of FIG. **24**.

[0127] FIG. **25** shows results of relative comparison of a maximum value of a maximum principal stress generated by a centrifugal force in each cage shown in FIGS. **21**A to **23**H.

[0128] In the examples of FIGS. **21**A to **21**H in FIG. **25**, the maximum value of the maximum principal stress generated in the cage **100** according to the example in the related art shown in FIGS. **21**A and **21**B is set to 1.0, and a ratio of the maximum value of the maximum principal stress generated in each of the cages **110** shown in FIGS. **21**C to **21**H is shown. As shown in FIGS. **21**C to **21**F, when only the pocket **103** is thickened to the radially inner side, the stress ratios become 0.92 and 0.88, respectively, which shows that the stress is reduced. On the other hand, as shown in FIGS. **21**G and **21**H, when the entire inner circumference of the cage **120** is thickened, the stress ratio becomes 0.96, which shows that there is little effect.

[0129] In the examples of FIGS. **22**A to **22**H in FIG. **25**, the maximum value of the maximum principal stress generated in the cage **200** according to the comparative example shown in FIGS. **22**A and **22**B is set to 1.0, and a ratio of the maximum value of the maximum principal stress generated in each of the cages **210**, **220** shown in FIGS. **22**C to **22**H is illustrated. As shown in FIGS. **22**C to **22**F, when only the pocket **203** is thickened in the radially inner side, the stress ratios become 0.90 and 0.86, respectively, which shows that the stress is lower than when the entire inner circumference of the cage **220** is thickened as shown in FIGS. **22**G and **22**H (stress ratio: 0.97).

[0130] In the examples of FIGS. **23**A to **23**H in FIG. **25**, the maximum value of the maximum principal stress generated in the cage **230** according to the comparative example shown in **23**A and **23**B is set to 1.0, and a ratio of the maximum value of the maximum principal stress generated in each of the cages **210** shown in FIGS. **23**C to **23**H is illustrated. As shown in FIGS. **23**C to **23**H, when only the pocket **203** is thickened in the radially inner side, the stress ratios become 0.91, 0.86, and 0.93, respectively, which shows that there is a stress reduction effect.

[0131] Here, the stress when the centrifugal force is applied to the cage **210** will be described using the example of FIGS. **23**G and **23**H (fourth embodiment). FIG. **26** is a cross-sectional view taken along a line A-A of FIG. **23**G. FIG. **27** shows a stress distribution when a centrifugal force is applied in the example of FIG. **23**H.

[0132] In FIG. **27**, the deformation of the cage is exaggerated for about 10 times.

[0133] As shown in FIG. **26**, when a centrifugal force F is applied to the cage **210**, the claw portion **205** falls toward a direction of an arrow D in FIG. **26** with the annular main portion **201** as a center. Therefore, a point B on an inner diameter side of the pocket **203** moves to the radially outer side, and a point C moves to the radially inner side. Then, as shown in FIG. **27**, the point B extends in the circumferential direction, and the point C contracts in the circumferential direction. Since the thickness of the bottom portion of the pocket **203** is the thinnest, the highest tensile stress in the circumferential direction is generated in the portion of the point B. Since the larger a cross-sectional area of the thinnest part of the bottom of the pocket **203**, the less likely the claw portion **205** falls, the stress in the examples of FIGS. **23**C to **23**H can be reduced as compared to the example of FIGS.

23A and **23**B. In the example of FIGS. **23**G and **23**H, although the volume of the main portion **201** is slightly larger than those in the examples of FIGS. **23**C to **23**F, a larger centrifugal force is applied, and a stress (stress ratio: 0.93) higher than those in the examples of FIGS. **23**C to **23**F (stress ratio: 0.91, 0.86) is generated.

[0134] Similarly, in the example of FIGS. **21**G and **21**H, since the volume of the main portion **101** is larger than those in the examples of FIGS. **21**C to **21**F, a larger centrifugal force is applied, and a stress (stress ratio: 0.96) higher than those in the examples of FIGS. **21**C to **21**F (stress ratio: 0.92, 0.88) is generated.

[0135] Similarly, in the example of FIGS. **22**G and **22**H, since the volume of the main portion **201** is larger than those in the examples of FIGS. **22**C to **22**F, a larger centrifugal force is applied, and a stress (stress ratio: 0.97) higher than those in the examples of FIGS. **21**C to **21**F (stress ratio: 0.90, 0.86) is generated.

Example 2

[0136] The strain generated in the claw portion **205** when the cage **210** having no convex portion **217** on the bottom surface **216** of the main portion **201** and the cage **210** having the convex portions **217** on the bottom surface **216** of the main portion **201** are incorporated into the bearing **1** including the inner ring **3**, the outer ring **5**, and the balls **6** is analyzed by the finite element method and calculated.

[0137] Sections (a) and (b) of FIG. **29** are analysis results of a strain distribution of the cages. The cage **210** of Section (a) of FIG. **29** is the cage according to the modification of the second embodiment shown in FIGS. **9** and **10**, and does not have the convex portions **217** on the bottom surface **216** of the main portion **201**. The cage **210** of Section (b) of FIG. **29** is the cage according to the modification of the third embodiment shown in FIG. **15** and FIG. **16**, and has the convex portions **217** on the bottom surface **216** of the main portion **201**.

[0138] In the analysis, as shown in FIG. **28**, the model in which one portion of the cage **210** was taken out and the ball **6** was pushed little by little was used. In actual bearing assembly, the ball is fixed and the cage is moved, but in the present analysis, the model in which the cage is fixed and the ball is moved is used since an overall movement remains the same. The strain distribution when the strain becomes maximum at this time is shown in Sections (a) and (b) of FIG. **29**.

[0139] The maximum value of the strain generated in the claw portion **205** of the cage **210** of Section (a) of FIG. **29** was 2.0%. On the other hand, the maximum value of strain generated in the claw portion **205** of the cage **210** in (b) of FIG. **29** is 1.8%, which is 10% lower than the example in Section (a) of FIG. **29**, which shows that providing the convex portions **217** has a strain reduction effect.

[0140] This is because, as shown in Sections (a) and (b) of FIG. **29**, when the ball **6** is pushed into the pocket **203** of the cage **210**, the claw portion **205** is widened in the circumferential direction with a portion having low rigidity as a fulcrum P. That is, it is considered that the farther the fulcrum P is positioned from the tip end portion of the claw portion **205**, the wider a strain generation region D, and since the generated strain is dispersed, the maximum value is reduced.

[0141] In the cage **210** according to the modification of the third embodiment shown in Section (b) of FIG. **29** compared with the cage **210** according to the modification of the second embodiment shown in Section (a) of FIG. **29**, the strain generation region D is widened and the maximum value of the strain is further reduced as a distance from the tip end portion of the claw portion **205** to the fulcrum P increases.

[0142] When the present invention is applied to a cage using a resin material such as polyamide 9T (PA9T) or polyamide 10T (PA10T) having a smaller elongation than nylon 46 or nylon 66, strain can be reduced.

[0143] The present specification discloses the following contents.

[0144] (1) A crown cage for a ball bearing includes:

- **[0145]** an annular main portion;
- **[0146]** a plurality of pillar portions protruding in an axial direction at predetermined intervals in a circumferential direction from the main portion; and
- **[0147]** a pocket formed between the adjacent pillar portions and having a spherical concave surface having a spherical shape capable of holding a ball, wherein
- **[0148]** the pillar portion includes a pair of claw portions having tip end portions arranged at intervals therebetween and a connection portion connecting the pair of claw portions,
- **[0149]** an inlet portion having a width shorter than a diameter of the ball and for inserting the ball is provided between the tip end portions of the two adjacent claw portions configuring the pocket, and
- **[0150]** a distance from an inner circumferential surface of the pocket to a center of the crown cage for a ball bearing is smaller than a radius of an inner circumferential surface of the pillar portion.

[0151] (2) The crown cage for a ball bearing according to (1), in which

- **[0152]** a convex portion protruding in the axial direction is provided on a bottom surface of the main portion, and
- **[0153]** at least a portion of the convex portion overlaps the pocket in the circumferential direction and a radial direction.

[0154] (3) The crown cage for a ball bearing according to (1) or (2), in which

- **[0155]** the claw portion protrudes in the axial direction from a radially inner side portion of an upper surface of the main portion, and
- **[0156]** the upper surface of the main portion is exposed to a radially outer side of the pillar portion.

[0157] (4) The crown cage for a ball bearing according to (3), in which

- **[0158]** an opening portion opened in the axial direction is provided between the adjacent pockets in the main portion.

[0159] (5) The crown cage for a ball bearing according to any one of (1) to (4), in which

- **[0160]** the inner circumferential surface of the pocket is a cylindrical surface protruding to a radially inner side from the inner circumferential surface of the pillar portion.

[0161] (6) A ball bearing includes:

- **[0162]** an outer ring;
- **[0163]** an inner ring;
- **[0164]** a plurality of balls arranged between the outer ring and the inner ring; and
- **[0165]** the crown cage for a ball bearing according to any one of (1) to (5).

[0166] Although various embodiments have been described above with reference to the drawings, the present invention is not limited to these examples. It is apparent to those skilled in the art that various variations or modifications can be conceived within the scope described in the claims, and it is understood that the variations or modifications naturally fall within the technical scope of the present invention. In addition, the components in the above embodiments may be combined in any manner within the scope not departing from the gist of the invention.

[0167] The present application is based on a Japanese Patent Application (No. 2022-069471) filed on Apr. 20, 2022, the contents of which are incorporated herein by reference.

REFERENCE SIGNS LIST

[0168] **1** ball bearing
[0169] **2** inner ring raceway
[0170] **3** inner ring
[0171] **4** outer ring raceway
[0172] **5** outer ring
[0173] **6** ball
[0174] **7** shield plate
[0175] **100**, **110**, **120** cage
[0176] **101** main portion
[0177] **102** pillar portion
[0178] **103** pocket
[0179] **104** spherical concave surface
[0180] **105** claw portion
[0181] **106** inlet portion
[0182] **111** inner circumferential surface of pocket
[0183] **111***a* connection surface
[0184] **111***b* convex surface
[0185] **112** inner circumferential surface of pillar portion
[0186] **113** connection portion
[0187] **201** main portion
[0188] **202** pillar portion
[0189] **203** pocket
[0190] **204** spherical concave surface
[0191] **205** claw portion
[0192] **205***b* circumferential first surface
[0193] **205***c* circumferential second surface
[0194] **206** inlet portion
[0195] **200**, **210**, **220**, **230** cage
[0196] **211** inner circumferential surface of pocket
[0197] **211***a* connection surface
[0198] **211***b* convex surface
[0199] **212** inner circumferential surface of pillar portion
[0200] **213** connection portion
[0201] **213***a* upper surface
[0202] **215** opening portion
[0203] **216** bottom surface
[0204] **217** convex portion

1. A crown cage for a ball bearing comprising:
an annular main portion;
a plurality of pillar portions protruding in an axial direction at predetermined intervals in a circumferential direction from the main portion; and
a pocket formed between the adjacent pillar portions and having a spherical concave surface having a spherical shape capable of holding a ball, wherein:
the pillar portion includes a pair of claw portions having tip end portions arranged at intervals therebetween and a connection portion connecting the pair of claw portions;
an inlet portion having a width shorter than a diameter of the ball and for inserting the ball is provided between the tip end portions of the two adjacent claw portions configuring the pocket; and
a distance from an inner circumferential surface of the pocket to a center of the crown cage for a ball bearing is smaller than a radius of an inner circumferential surface of the pillar portion.

2. The crown cage for a ball bearing according to claim **1**, wherein:
a convex portion protruding in the axial direction is provided on a bottom surface of the main portion; and
at least a portion of the convex portion overlaps the pocket in the circumferential direction and a radial direction.

3. The crown cage for a ball bearing according to claim **1**, wherein:
the claw portion protrudes in the axial direction from a radially inner side portion of an upper surface of the main portion; and
the upper surface of the main portion is exposed to a radially outer side of the pillar portion.

4. The crown cage for a ball bearing according to claim **3**, wherein
an opening portion opened in the axial direction is provided between the adjacent pockets in the main portion.

5. The crown cage for a ball bearing according to claim **1**, wherein
the inner circumferential surface of the pocket is a cylindrical surface protruding to a radially inner side from the inner circumferential surface of the pillar portion.

6. A ball bearing comprising:
an outer ring;
an inner ring;
a plurality of balls arranged between the outer ring and the inner ring; and
the crown cage for a ball bearing according to claim **1**.

* * * * *