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(54) **Title:** IMPELLER WITH STAKED BLADES AND TORQUE CONVERTER INCLUDING IMPELLER WITH STAKED BLADES

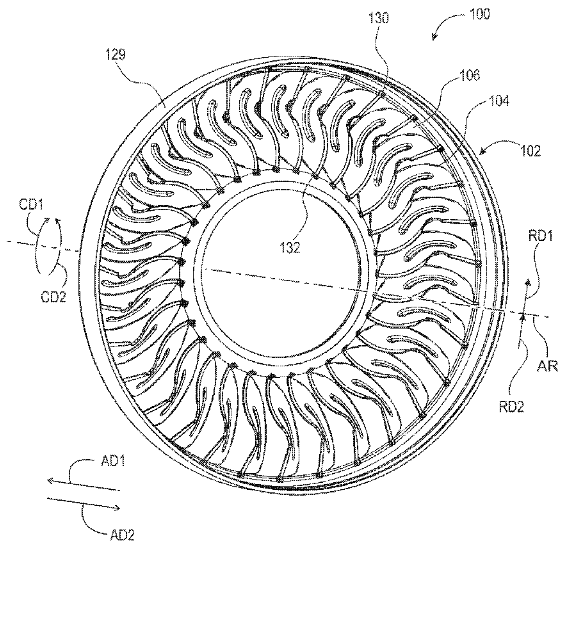

Fig. 1

(57) **Abstract:** A torque converter, including: a cover arranged to receive torque; an impeller and a turbine. The impeller includes an impeller shell non-rotatably connected to the cover and a plurality of impeller blades. The impeller shell includes an interior surface, and defines a plurality of first indentations in the interior surface. Each impeller blade in the plurality of impeller blades including a first tab disposed in a respective first indentation. The turbine is in fluid communication with the impeller and includes a turbine shell and turbine blades fixedly connected to the turbine shell. The first tab is fixedly secured to the impeller shell by a respective first portion of a material forming the impeller shell; or a respective first portion of a material forming the impeller shell contacts the first tab and overlaps the first tab in a first axial direction parallel to an axis of rotation of the torque converter.

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IMPELLER WITH STAKED BLADES AND TORQUE CONVERTER INCLUDING IMPELLER WITH STAKED BLADES

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Non-Provisional Application No. 17/325,336, filed May 20, 2021, the entire disclosure of which is incorporated herein by reference.

TECHNICAL FIELD

[0002] The present disclosure relates to an impeller with blades fixed by staking and a torque converter including the impeller with blades fixed by staking.

BACKGROUND

[0003] It is known to use brazing material to fix impeller blades to an impeller shell. However, brazing adds to the complexity of fabricating the impeller and can result in splatter of brazing material, which adversely impacts the performance and service life of the impeller.

SUMMARY

[0004] According to aspects illustrated herein, there is provided an impeller for a torque converter, including: an impeller shell including an interior surface and defining a first indentation in the interior surface; and a blade including a first tab disposed in the first indentation. The first tab is fixedly secured to the impeller shell by a first portion of a material forming the impeller shell.

[0005] According to aspects illustrated herein, there is provided a torque converter, including: a cover arranged to receive torque; an impeller and a turbine. The impeller includes an impeller shell non-rotatably connected to the cover and a plurality of impeller blades. The impeller shell includes an interior surface, and defines a plurality of first indentations in the interior surface. Each impeller blade in the plurality of impeller blades including a first tab disposed in a respective first indentation. The turbine is in fluid communication with the impeller and includes a turbine shell and at least one turbine blade fixedly connected to the turbine shell.

The first tab is fixedly secured to the impeller shell by a respective first portion of a material forming the impeller shell; or a respective first portion of a material forming the impeller shell contacts the first tab and overlaps the first tab in a first axial direction parallel to an axis of rotation of the torque converter.

[0006] According to aspects illustrated herein, there is provided a method of assembling an impeller, comprising: inserting a first tab of each blade, included in a plurality of blades of the impeller, in a respective first indentation defined by an interior surface of a shell of the impeller; contacting the interior surface with a first curved edge of said each blade, the first curved edge extending from the first tab; displacing a respective first portion of a material forming the impeller shell; overlapping the first tab with the respective first portion of the material; and fixing the first tab to the impeller shell with the respective first portion of the material.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Various examples are disclosed with reference to the accompanying schematic drawings in which corresponding reference symbols indicate corresponding parts, in which:

Figure 1 is a front isometric view of an example impeller with staked blades;

Figure 2 is a front view of the impeller shell shown in Figure 1 prior to staking the blades;

Figure 3 is a detail of a radially outer indentation shown in Figure 2;

Figure 4 is a detail of a radially inner indentation shown in Figure 2;

Figure 5 is a side view of a blade shown in Figure 1, prior to installation;

Figure 6 is an isometric view of a blade shown in Figure 1 prior to staking;

Figure 7 is a partial front isometric view of the impeller shown in Figure 1;

Figure 8 is a detail of a radially outer indentation and blade shown in Figure 1;

Figure 9 is a detail of a radially inner indentation and blade shown in Figure 1;

Figure 10 is a cross-sectional view generally along line 10-10 in Figure 6;

Figure 11 is a cross-section, cut by a circular arc centered on an axis of rotation of the impeller shown in Figure 1, of a middle indentation shown in Figure 2;

Figure 12 is a front isometric view of an example impeller with staked blades;

Figure 13 is a front view of the impeller shell shown in Figure 12 prior to insertion of blades;

Figure 14 is a rear isometric view of the impeller shown in Figure 12;

Figure 15 is a side view of a blade shown in Figure 12, prior to installation;

Figure 16 is a front isometric view of an example impeller with staked blades;

Figure 17 is a rear view of the impeller shell shown in Figure 16;

Figure 18 is an isometric view of a blade shown in Figure 16;

Figure 19 is a rear view of the impeller shown in Figure 16;

Figure 20 is a partial cross-sectional view of an example torque converter with the impeller shown in Figure 1;

Figure 21 is a partial cross-sectional view of an example torque converter with the impeller shown in Figure 12; and

Figure 22 is a partial cross-sectional view of an example torque converter with the impeller shown in Figure 16.

DETAILED DESCRIPTION

[0008] At the outset, it should be appreciated that like drawing numbers on different drawing views identify identical, or functionally similar, structural elements of the disclosure. It is to be understood that the disclosure as claimed is not limited to the disclosed aspects.

[0009] Furthermore, it is understood that this disclosure is not limited to the particular methodology, materials and modifications described and as such may, of course, vary. It is also understood that the terminology used herein is for the purpose of describing particular aspects only, and is not intended to limit the scope of the present disclosure.

[00010] Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood to one of ordinary skill in the art to which this disclosure belongs. It should be understood that any methods, devices, or materials similar or equivalent to those described herein can be used in the practice or testing of the disclosure

[0011] Figure 1 is a front isometric view of example impeller **100** with staked blades.

[0012] Figure 2 is a front view of impeller **100** shell shown in Figure 1 prior to staking the blades.

[0013] Figure 3 is a detail of a radially outer indentation shown in Figure 2.

[0014] Figure 4 is a detail of a radially inner indentation shown in Figure 2. The following should be viewed in light of Figures 1 through 4. Impeller **100** for a torque converter includes impeller shell **102** and blades **104**. Impeller shell **102** includes interior surface **106**. Impeller shell **102** defines, in interior surface **106**: middle indentations **108**; radially outer indentations **110**, and radially inner indentations **112**. Indentations **110** are defined by impeller shell **102** as follows: in radially outer direction **RD1** (orthogonal to axis of rotation **AR** of impeller shell **100**) by wall **114**; in circumferential direction **CD1** (around axis **AR**) by wall **116**; in circumferential direction **CD2** (opposite direction **CD1**) by wall **118**; and in axial direction **AD1** (parallel to axis **AR**) by wall **120**. Indentations **112** are defined by impeller shell **102** as follows: in radially inner direction **RD2** (opposite direction **RD1**) by wall **122**; in circumferential direction **CD1** by wall **124**; in circumferential direction **CD2** by wall **126**; and in axial direction **AD1** by wall **128**.

[0015] Indentations **108**, **110**, and **112** do not extend through impeller shell **102** to exterior surface **129** of impeller shell **102**. For example: walls **114**, **116**, **118**, and **120** do not form protrusions in exterior surface **129**; and walls **122**, **124**, **126**, and **128** do not forms protrusions in surface **129**.

[0016] Figure 5 is a side view of a blade **104** shown in Figure 1, prior to installation.

[0017] Figure 6 is an isometric view of blade **104** shown in Figure 5, prior to staking. The following should be viewed in light of Figures 1 through 6. Blade **104** includes: tab **130**; tab **132**; tab **134**; curved edge **136**; and curved edge **138**. Tabs **130** are disposed in indentations **110**. Tabs **132** are disposed in indentations **112**. Tabs **134** are disposed in indentations **108**. Edge **136** connects tabs **130** and **134** and contacts interior surface **106**. Edge **138** connects tabs **132** and **134** and contacts interior surface **106**. Tabs **130** form the radially outermost portion of blade **104**

when installed in impeller **100**; and tabs **132** form the radially innermost portion of blade **104** when installed in impeller **100**.

[0018] Figure 7 is a partial isometric view of the impeller shown in Figure 1.

[0019] Figure 8 is a detail of a radially outer indentation **110** and blade tab **130** shown in Figure 1.

[0020] Figure 9 is a detail of a radially inner indentation **112** and blade tab **132** shown in Figure 1. The following should be viewed in light of Figures 1 through 9. Blades **104** are fixed to impeller shell **102** solely by material **M** forming impeller shell **102**. For example: tabs **130** are fixedly secured to impeller shell **102** solely by material **M** forming impeller shell **102**, for example solely by staked portions **140** of material **M**; and tabs **132** are fixedly secured to impeller shell **102** solely by material **M**, for example solely by staked portions **142** of material **M**. For example: a compressive contact of portions **140** with tabs **130** fixes tabs **130** to impeller shell **102**; and a compressive contact of portions **142** with tabs **132** fix tabs **132** to impeller shell **102**. Fixing tabs **130** and **132** to impeller shell **102** fixed blades **104** to impeller shell **102**. For example, impeller **100** is free of a brazing material contacting blades **104** and fixing blades **104**, tabs **130** or tabs **132** to impeller shell **102**.

[0021] Portions **140** overlap tabs **130** in axial direction **AD1**, and portions **142** overlap tabs **132** in direction **AD1**. In the example of Figure 1: each tab **130** is overlapped by a single portion **140**; and each tab **132** is overlapped by two portions **142**. It is understood that other configurations of portions **140** and **142** are possible including, but not limited to: each tab **130** and each tab **132** being overlapped by a single portion **140** and a single portion **142**, respectively; each tab **130** and each tab **132** being overlapped by a two portions **140** and two portions **142**, respectively; and each tab **130** and each tab **132** being overlapped by a two portions **140** and one portion **142**, respectively.

[0022] Figure 10 is a cross-sectional view generally along line 10-10 in Figure 6. The following should be viewed in light of Figures 1 through 10. Each tab **130** includes: surface **144** facing at least partly in axial direction **AD2**, opposite direction **AD1**; and surface **146** facing opposite surface **144** in direction **AD1**. Portions **140** are in compressive contact with surfaces **144** and urge surfaces **146** into contact with walls **120**.

[0023] Each tab **132** includes surface **148** facing at least partly in axial direction **AD2**. Portions **142** are in compressive contact with surfaces **148** and urge tabs **132** into contact with walls **128**.

[0024] In the example of Figure 1, hypothetical straight line **L1**, parallel to axis **AR**, passes through in sequence: wall **120**; surface **146**; surface **144**; and portion **140**. In the example of Figure 1, hypothetical straight line **L2**, parallel to axis **AR**, passes through in sequence: wall **120**; surface **146**; and surface **144**, without passing through portion **140**.

[0025] In the example of Figure 1, hypothetical circle segment **CS1**, centered on axis **AR**, passes through wall **118** and portion **140**, without passing through tab **130**. In the example of Figure 1, hypothetical circle segment **CS2**, centered on axis **AR**, passes through in sequence: wall **116**; surface **152** of tab **130** facing direction **CD1**; surface **154** of tab **130** facing direction **CD2**; and wall **118**, without passing through portion **140**.

[0026] Figure 11 is a cross-section, cut by a circular arc centered on an axis of rotation **AR** of impeller **100** shown in Figure 1, of a middle indentation **108** shown in Figure 2. The following should be viewed in light of Figures 1 through 11. Impeller shell **102** includes walls **156** defining indentations **108**. As seen in Figure 11, walls **156** do not result in protrusions or bulges in exterior surface **129**. For example, walls **156** do not extend far enough from interior surface **106** in direction **AD1** to cause bulging of surface **129**.

[0027] Figure 12 is a front isometric view of example impeller **100** with staked blades **104**.

[0028] Figure 13 is a front isometric view of impeller shell **102** shown in Figure 12.

[0029] Figure 14 is a rear isometric view of impeller **100** shown in Figure 12.

[0030] Figure 15 is a side view of a blade **104** shown in Figure 12, prior to installation. The discussion for impeller **100** shown in Figure 1 is applicable to impeller **100** shown in Figure 12, except as noted. In Figure 12, middle indentations **108** are replaced by indentations **160**, which form protrusions **162** extending outward from exterior surface **129** of impeller shell **102**. As shown in Figure 15, tabs **164** replace tabs **134** on blade **104**. In the example of Figures 1 and 12, extent **166** between edge **136** and **138** for blade **104** shown in Figure 5 is greater than extent **168** between edges **136** and **138** for blade **104** shown in Figure 15. In the example of Figure 12, blades **104** include core ring tabs **170** which are inserted through core ring **172** to fix blades **104** to core ring **172**.

[0031] Figure 16 is a front isometric view of example impeller **100** with staked blades **104**.

[0032] Figure 17 is a rear view of impeller shell **102** shown in Figure 16.

[0033] Figure 18 is an isometric view of a blade **104** shown in Figure 16.

[0034] Figure 19 is a rear view of impeller **100** shown in Figure 16. The discussion for impeller **100** shown in Figure 1 is applicable to impeller **100** shown in Figure 16, except as noted. In the example of Figure 16, middle indentations **108** are replaced by slots **174** passing through impeller shell **102** and connecting interior surface **106** and exterior surface **129**. As shown in Figure 18, tabs **176** replace tabs **134** on blade **104**. Portions **178** of tabs **176** are disposed in slots **174** and portions **180** of tabs **176** are pressed into contact with exterior surface **129**. In the example of Figures 1 and 16, extent **166** between edge **136** and **138** for blade **104** shown in Figure 5 is greater than extent **182** between edges **136** and **138** for blade **104** shown in Figure 18.

[0035] Figure 20 is a partial cross-sectional view of example torque converter **200** with impeller **100** shown in Figure 1. The following should be viewed in light of Figures 1 through 11 and 20. Torque converter **200** includes: impeller **100** as shown in Figure 1; cover **202** arranged to receive rotational torque and non-rotatably connected to impeller shell **102**; turbine **204**; lock-up clutch **206**; vibration damper **208**; stator **210** located between impeller **100** and turbine **204**; and output **212** arranged to non-rotatably connect to a transmission input shaft (not shown). Turbine **204** includes turbine shell **214** and at least one turbine blade **216** fixedly connected to shell **214**. Clutch **206** includes axially displaceable piston plate **218** and clutch plate **220**. Damper **208** includes: non-rotatably connected cover plates **222**; output flange **224** non-rotatably connected to output **212**; and at least one spring **226** engaged with plates **222** and flange **224**. Cover plates **222** are non-rotatably connected to clutch plate **220** and turbine shell **214**.

[0036] By "non-rotatably connected" components, we mean that components are connected so that whenever one of the components rotates, all the components rotate; and relative rotation between the components is precluded. Radial and/or axial movement of non-rotatably connected components with respect to each other is possible. Components connected by tabs, gears, teeth, or splines are considered as non-rotatably connected despite possible lash inherent in the connection. The input and output elements of a closed clutch are considered non-rotatably connected despite possible slip in the clutch. The input and output parts of a vibration damper, engaged with springs for the vibration damper, are not considered non-rotatably connected due to the compression and unwinding of the springs. Without a further modifier, the non-rotatable connection between or among components is assumed for rotation in any direction. However, the non-rotatable connection can be limited by use of a modifier. For example, "non-rotatably connected for rotation in circumferential direction CD1," defines the connection for rotation only in circumferential direction CD1.

[0037] For a torque converter mode of torque converter **200**, in which torque from cover **202** is transmitted to impeller **100**, plate **218** is displaceable, by fluid pressure in chamber **228**, in direction **AD1** to disengage clutch plate **220** from cover **202**. For a lock-up mode of torque converter **200**, in which torque from cover **202** is transmitted to damper **208** through clutch **206**, plate **218** is displaceable, by fluid pressure in chamber **230**, in direction **AD2** to non-rotatably connect cover **202**, clutch plate **220** and cover plates **222**.

[0038] Figure 21 is a partial cross-sectional view of example torque converter **200** with impeller **100** shown in Figure 12. The following should be viewed in light of Figures 12 through 15 and 21. Torque converter **200** includes: impeller **100** as shown in Figure 1; cover **202** arranged to receive rotational torque and non-rotatably connected to impeller shell **102**; turbine **204**; lock-up clutch **206**; vibration damper **208**; stator **210** located between impeller **100** and turbine **204**; and output **212** arranged to non-rotatably connect to a transmission input shaft (not shown). Turbine **204** includes turbine shell **214** and at least one turbine blade **216** fixedly connected to shell **214**. Clutch **206** includes axially displaceable piston plate **218** and clutch plate **220**. Damper

208 includes: non-rotatably connected cover plates **222**; output flange **224** non-rotatably connected to output **212**; and at least one spring **226** engaged with plates **222** and flange **224**. Cover plates **222** are non-rotatably connected to clutch plate **220** and turbine shell **214**.

[0039] For a torque converter mode of example torque converter **200**, in which torque from cover **202** is transmitted to impeller **100**, plate **218** is displaceable, by fluid pressure in chamber **228**, in direction **AD1** to disengage clutch plate **220** from cover **202**. For a lock-up mode of torque converter **200**, in which torque from cover **202** is transmitted to damper **208** through clutch **206**, plate **218** is displaceable, by fluid pressure in chamber **230**, in direction **AD2** to non-rotatably connect cover **202**, clutch plate **220** and cover plates **222**.

[0040] Figure 22 is a partial cross-sectional view of torque converter **200** with impeller **100** shown in Figure 16. The following should be viewed in light of Figures 16 through 19 and 22. Torque converter **200** includes: impeller **100** as shown in Figure 1; cover **202** arranged to receive rotational torque and non-rotatably connected to impeller shell **102**; turbine **204**; lock-up clutch **206**; vibration damper **208**; stator **210** located between impeller **100** and turbine **204**; and output **212** arranged to non-rotatably connect to a transmission input shaft (not shown). Turbine **204** includes turbine shell **214** and at least one turbine blade **216** fixedly connected to shell **214**. Clutch **206** includes axially displaceable piston plate **218** and clutch plate **220**. Damper **208** includes: non-rotatably connected cover plates **222**; output flange **224** non-rotatably connected to output **212**; and at least one spring **226** engaged with plates **222** and flange **224**. Cover plates **222** are non-rotatably connected to clutch plate **220** and turbine shell **214**.

[0041] For a torque converter mode of torque converter **200**, in which torque from cover **202** is transmitted to impeller **100**, plate **218** is displaceable, by fluid pressure in chamber **228**, in direction **AD1** to disengage clutch plate **220** from cover **202**. For a lock-up mode of torque converter **200**, in which torque from cover **202** is transmitted to damper **208** through clutch **206**, plate **218** is displaceable, by fluid pressure in chamber **230**, in direction **AD2** to non-rotatably connect cover **202**, clutch plate **220** and cover plates **222**.

[0042] The following should be viewed in light of Figures 1 through 19. The following describes a method of assembling impeller **100** for a torque converter. Although the method is presented as a sequence of steps for clarity, no order should be inferred from the sequence unless explicitly stated. A first step inserts tabs **130** of blades **104** into indentations **110** in shell **102**. A second step contacts interior surface **106** of shell **102** with curved edges **136** of blades **104**. A third step displaces material **M** to form portions **140**. A fourth step overlaps tabs **130** with portions **140** and contacts tabs **130** with portions **140**. A fifth step fixedly connects tabs **130** to impeller shell **102** with portions **140**.

[0043] A sixth step inserts tabs **132** of blades **104** into indentations **112** in shell **102**. A seventh step contacts interior surface **106** with curved edge **138**. An eighth step displaces material **M** to form portions **142**. A ninth step overlaps tabs **132** with portions **142** and contacts tabs **132** with portions **142**. A tenth step fixedly connects tabs **132** to impeller shell **102** with portions **142**.

[0044] In an example embodiment, an eleventh step connects blades **104** to each other solely with shell **102**. In an example embodiment, a twelfth step: inserts tabs **134** into indentations **108**; or inserts tabs **164** into indentations **160** and connects tabs **170** to core ring **172**; or passes tabs **176** through slots **174** and contacts surface **129** with portions **180**.

[0045] In an example embodiment, displacing material **M** to form portions **140** includes forming divots **184**, continuous with portions **140**, in material **M**. In an example embodiment, displacing material **M** to form portions **142** includes forming divots **186**, continuous with portions **142**, in material **M**.

[0046] In an example embodiment, fixedly connecting tabs **130** to impeller shell **102** with portions **140** includes fixedly connecting tabs **132** to impeller shell **102** solely with portions **140**. In an example embodiment, fixedly connecting tabs **132** to impeller shell **102** with portions **142** includes fixedly connecting tabs **132** to impeller shell **102** solely with portions **142**.

[0047] In an example embodiment, fixedly connecting tabs **130** to impeller shell **102** with portions **140** and fixedly connecting tabs **132** to impeller shell **102** with portions **142** includes fixedly connecting blades **104** to impeller shell **102** solely with portions **140** and **142**.

[0048] It will be appreciated that various of the above-disclosed and other features and functions, or alternatives thereof, may be desirably combined into many other different systems or applications. Various presently unforeseen or unanticipated alternatives, modifications, variations, or improvements therein may be subsequently made by those skilled in the art which are also intended to be encompassed by the following claims.

List of Reference Characters:

AD1	**axial direction**
AD2	**axial direction**
AR	**axis of rotation**
CD1	**circumferential direction**
CD2	**circumferential direction**
CS1	**circle segment**
CS2	**circle segment**
L1	**line**
L2	**line**
M	**material, shell**
100	**impeller**
102	**impeller shell**
104	**impeller blade**
106	**interior surface, impeller shell**
108	**indentation, impeller shell**
110	**indentation, impeller shell**
112	**indentation, impeller shell**
114	**wall**
116	**wall**
118	**wall**
120	**wall**
122	**wall**
124	**wall**
126	**wall**
128	**wall**
130	**tab**

132 tab

134 tab

136 curved edge

138 curved edge

140 portion, shell

142 portion, shell

144 surface, tab

146 surface, tab

148 surface, tab

152 surface, tab

154 surface, tab

156 wall, shell

160 indentation

162 protrusion

164 tab

166 extent

168 extent

170 core ring tab

172 core ring

174 slot

176 tab

178 portion, tab 176

180 portion, tab 176

182 extent

184 divot

186 divot

CLAIMS

1. An impeller for a torque converter, comprising:

an impeller shell:

including an interior surface; and,

defining a first indentation in the interior surface; and,

a blade including a first tab disposed in the first indentation, the first tab fixedly secured to the impeller shell by a first portion of a material forming the impeller shell.

2. The impeller of claim 1, wherein:

the first tab is fixedly secured to the impeller shell solely by a contact of the first portion of the material forming the impeller shell with the first tab; or,

the impeller shell defines a central opening through which an axis of rotation of the impeller passes, and the first portion of the material forming the impeller shell overlaps the first tab in an axial direction parallel to the axis of rotation.

3. The impeller of claim 1, wherein:

the impeller shell defines a second indentation in the interior surface;

the blade includes a second tab disposed in the second indentation; and,

the second tab is fixedly secured to the impeller shell solely by a contact of a second portion of the material forming the impeller shell with the second tab; or,

the impeller shell defines a central opening through which an axis of rotation of the impeller passes, and the second portion of the material forming the impeller shell overlaps the second tab in an axial direction parallel to the axis of rotation.

4. The impeller of claim 1, wherein:

the impeller shell defines a central opening through which an axis of rotation of the impeller passes;

the impeller shell includes a first wall defining the first indentation in a first axial direction parallel to the axis of rotation;

the first tab includes:

a second wall in contact with the first wall; and,

a third wall facing at least partly in a second axial direction, opposite the first axial direction; and,

the first portion of the material forming the impeller shell is in contact with the third wall.

5. The impeller of claim 4, wherein:

a first hypothetical straight line, parallel to the axis of rotation, passes through, in sequence: the first wall, the second wall, the third wall, and the first portion of the material forming the impeller shell; and,

a second hypothetical straight line, parallel to the axis of rotation, passes through, in sequence: the first wall, the second wall, and the third wall without passing through the first portion of the material forming the impeller shell.

6. The impeller of claim 1, wherein:

the impeller shell defines a central opening through which an axis of rotation of the impeller passes;

the impeller shell includes:

a first wall defining the first indentation in a first circumferential direction around the axis of rotation; and, a second wall defining the first indentation in a second circumferential direction, opposite the first circumferential direction;

a first hypothetical circle segment, centered on the axis of rotation, passes through the first wall and the first portion of the material forming the impeller shell without passing through the first tab; and,

a second hypothetical circle segment, centered on the axis of rotation, passes through in sequence, the first wall, the first tab, and the second wall without passing through the first portion of the material forming the impeller shell.

7. The impeller of claim 1, wherein:

the impeller shell:

includes an exterior surface; and,

defines a second indentation in the interior surface and a third indentation in the interior surface; and,

the blade includes:

a second tab disposed in the second indentation and fixedly connected to the impeller shell with a second portion of the material forming the impeller shell;

a third tab disposed in the third indentation;

a first curved edge connecting the first tab and the third tab and in contact with the interior surface; and,

a second curved edge connecting the third tab and the second tab and in contact with the interior surface.

8. The impeller of claim 7, wherein:

the impeller shell includes:

an exterior surface; and,

a wall defining the third indentation in the interior surface; and, the wall does not define a protrusion extending from the exterior surface of the impeller shell.

9. The impeller of claim 1, wherein the impeller is free of a brazing material in contact with the blade and the impeller shell.

10. A torque converter, comprising:

a cover arranged to receive torque;

an impeller including:

an impeller shell non-rotatably connected to the cover, the impeller shell:

including an interior surface; and,

defining a plurality of first indentations in the interior surface; and,

a plurality of impeller blades, each impeller blade in the plurality of impeller blades including a first tab disposed in a respective first indentation; and,

a turbine in fluid communication with the impeller and including a turbine shell and at least one turbine blade fixedly connected to the turbine shell, wherein:

the first tab is fixedly secured to the impeller shell by a respective first portion of a material forming the impeller shell; or,

a respective first portion of a material forming the impeller shell contacts the first tab and overlaps the first tab in a first axial direction parallel to an axis of rotation of the torque converter.

11. The torque converter of claim 10, wherein:

the impeller shell defines a plurality of second indentations in the interior surface of the impeller shell;

said each impeller blade includes a second tab disposed in a respective second indentation; and, the second tab is fixedly secured to the impeller shell solely by a contact of a respective second portion of the material forming the impeller shell with the second tab; or,

a respective second portion of the material forming the impeller shell contacts the second tab and overlaps the second tab in in a first axial direction parallel to an axis of rotation of the torque converter.

12. The impeller of claim 10, wherein:

the impeller shell includes an exterior surface; and,

said each blade includes:

a second tab; and,

a first curved edge in contact with the interior surface of the impeller shell and connecting the first tab and the second tab; and,

the impeller shell defines a plurality of second indentations, and the second tab is disposed in a respective second indentation; or,

the impeller shell defines a plurality of slots connecting the interior surface of the impeller shell with the exterior surface of the impeller shell, and the second tab passes through a respective slot and is in contact with the exterior surface of the impeller shell.

13. The torque converter of claim 12, wherein:

the impeller shell defines the plurality of second indentations;

the impeller shell includes:

an exterior surface; and,

a plurality of walls, each wall defining a respective second indentation; and,

said each wall fails to define a protrusion extending from the exterior surface of the impeller shell.

14. The torque converter of claim 10, wherein:

the impeller shell defines:

a plurality of second indentations in the interior surface of the impeller shell; and,

a plurality of third indentation in the interior surface of the impeller shell; and,

said each impeller blade includes

a second tab disposed in a respective second indentation and fixedly secured to the impeller shell solely by a contact of a respective second portion of the material forming the impeller shell with the second tab;

a third tab disposed in a respective third indentation;

a first curved edge in contact with the interior surface and connecting the first tab and the third tab; and,

a second curved edge in contact with the interior surface and connecting the third tab and the second tab.

15. The torque converter of claim 10, wherein the plurality of impeller blades are connected to each other solely by the impeller shell.

16. The torque converter of claim 10, wherein:

a first hypothetical straight line, parallel to the axis of rotation, passes through the first tab and the respective first portion of the material forming the impeller shell; and,

a second hypothetical straight line, parallel to the axis of rotation, passes through the first tab without passing through the respective first portion of the material forming the impeller shell.

17. A method of assembling an impeller, comprising:

inserting a first tab of each blade, included in a plurality of blades of the impeller, in a respective first indentation, the respective first indentation defined by a shell of the impeller, in an interior surface of the shell of the impeller;

contacting the interior surface with a first curved edge of said each blade, the first curved edge extending from the first tab;

displacing a respective first portion of a material forming the impeller shell;

overlapping the first tab with the respective first portion of the material; and,

fixing the first tab to the impeller shell with the respective first portion of the material.

18. The method of claim 17, further comprising:

inserting a second tab of said each blade in a respective second indentation in the interior surface of the shell of the impeller, the respective second indentation defined by the shell of the impeller;

contacting the interior surface with a second curved edge of said each blade, the second curved edge extending from the second tab;

displacing a respective second portion of the material forming the impeller shell;

overlapping the second tab with the respective second portion of the material; and,

fixing the second tab to the impeller shell with the respective second portion of the material.

19. The method of claim 18, further comprising:

inserting a third tab of said each blade in a respective third indentation in the interior surface of the shell of the impeller, the respective third indentation defined by the shell of the impeller, wherein:

the third tab is directly connected to the first curved edge and to the second curved edge;

the respective third indentation is defined, in an axial direction parallel to an axis of rotation of the impeller, by a respective wall of the shell; and,

the respective wall of the shell fails to define a protrusion in an exterior surface of the shell.

20. The method of claim 17, further comprising:

connecting the plurality of blades to each other solely by the impeller shell.

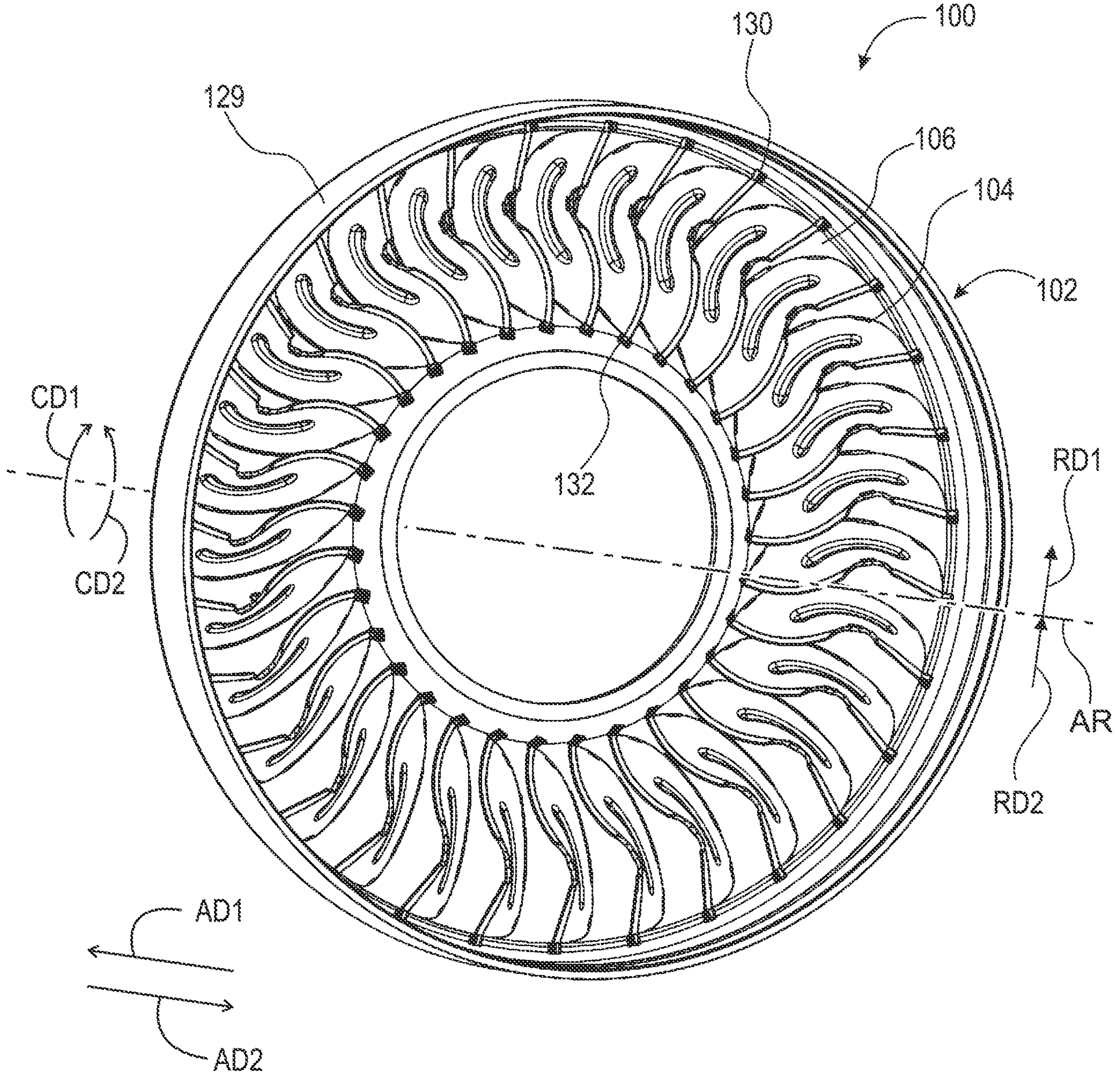


Fig. 1

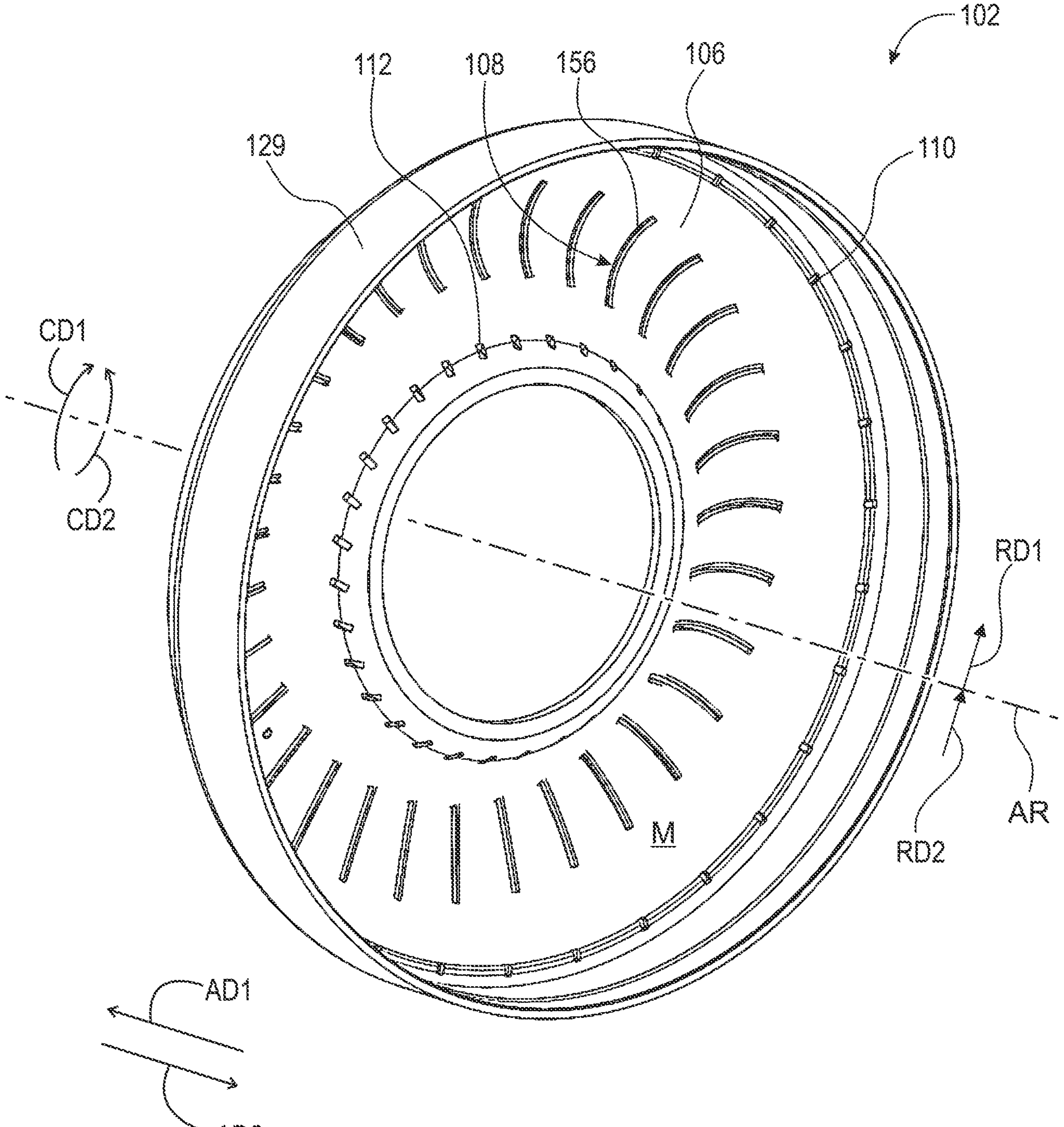
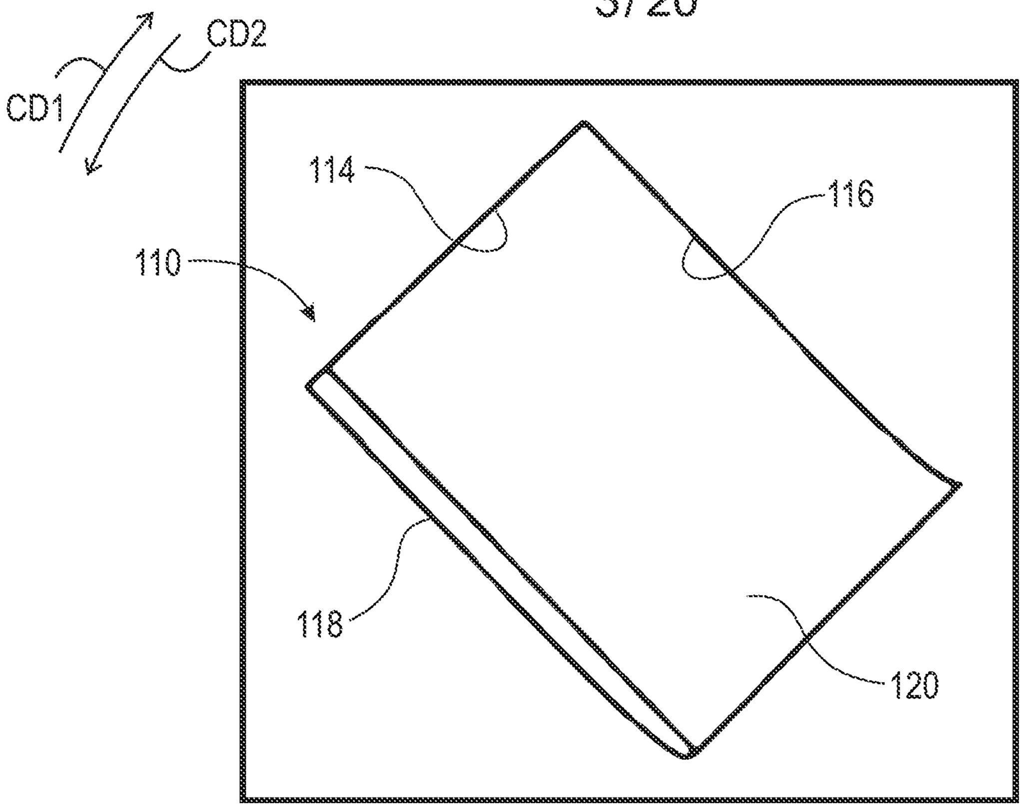


Fig. 2



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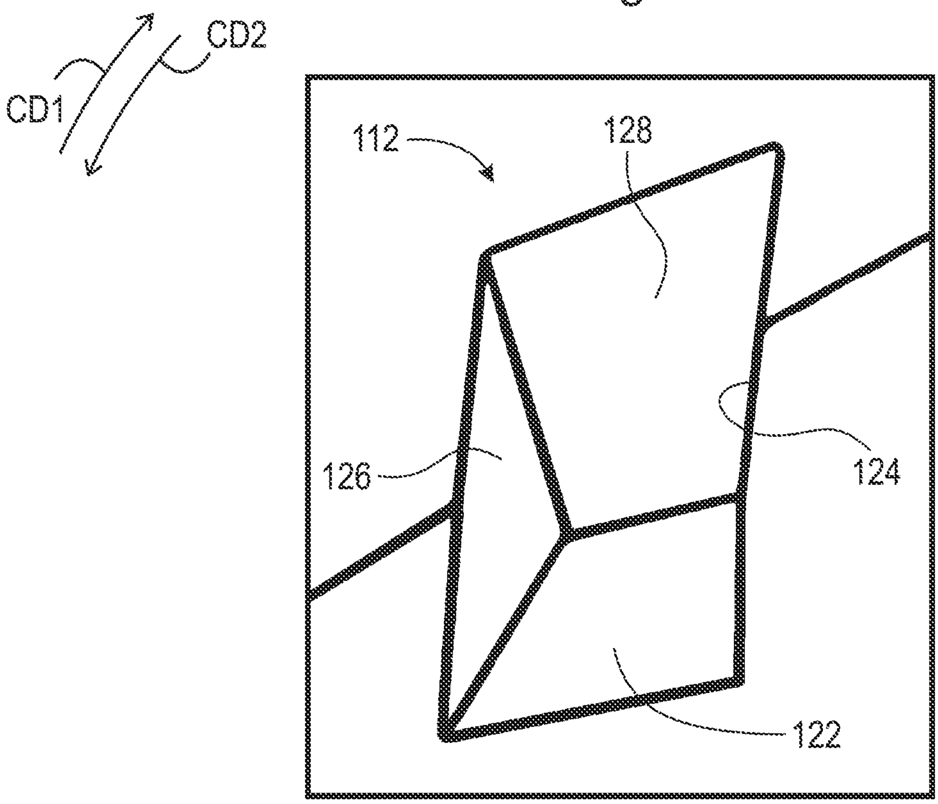


Fig. 4

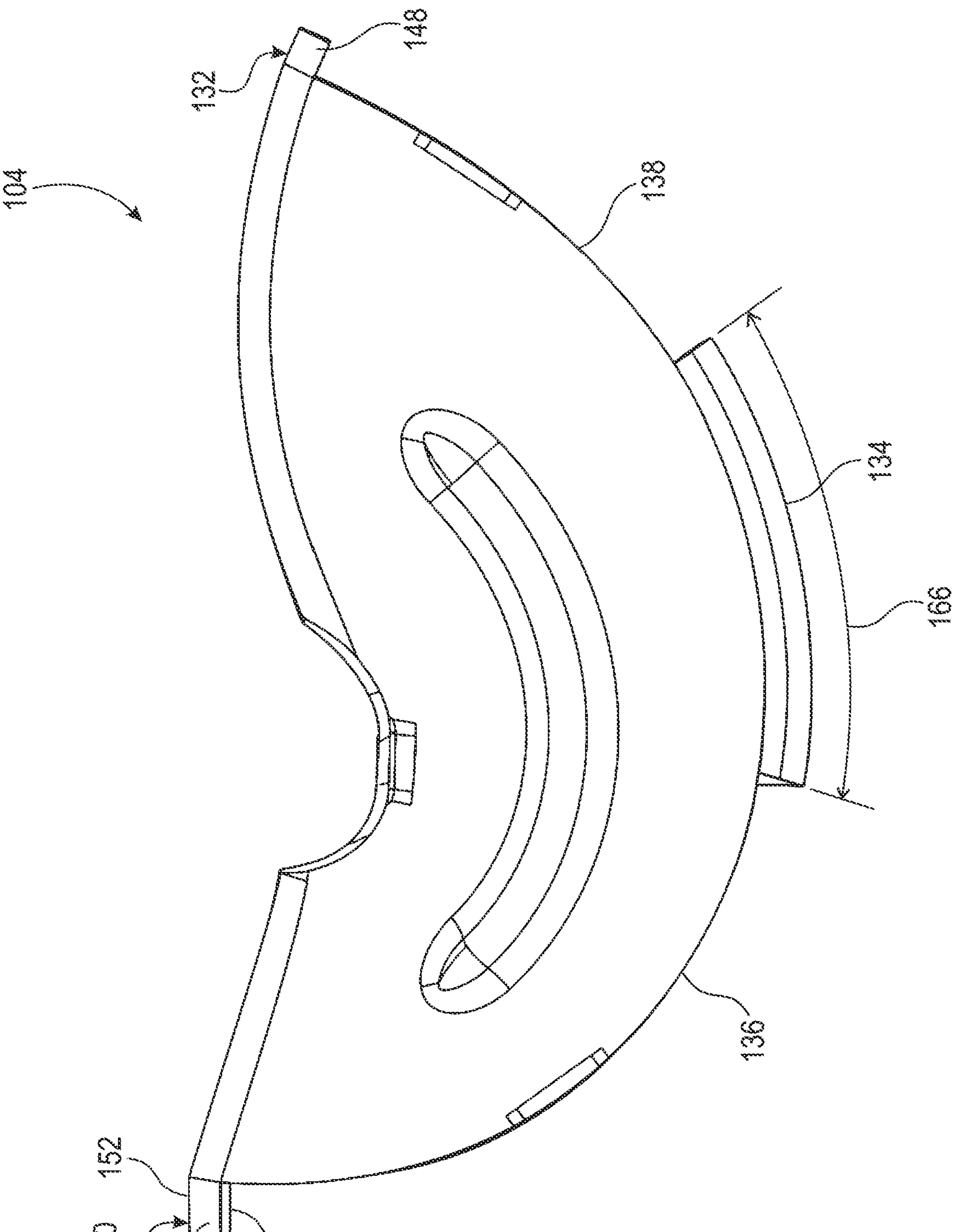
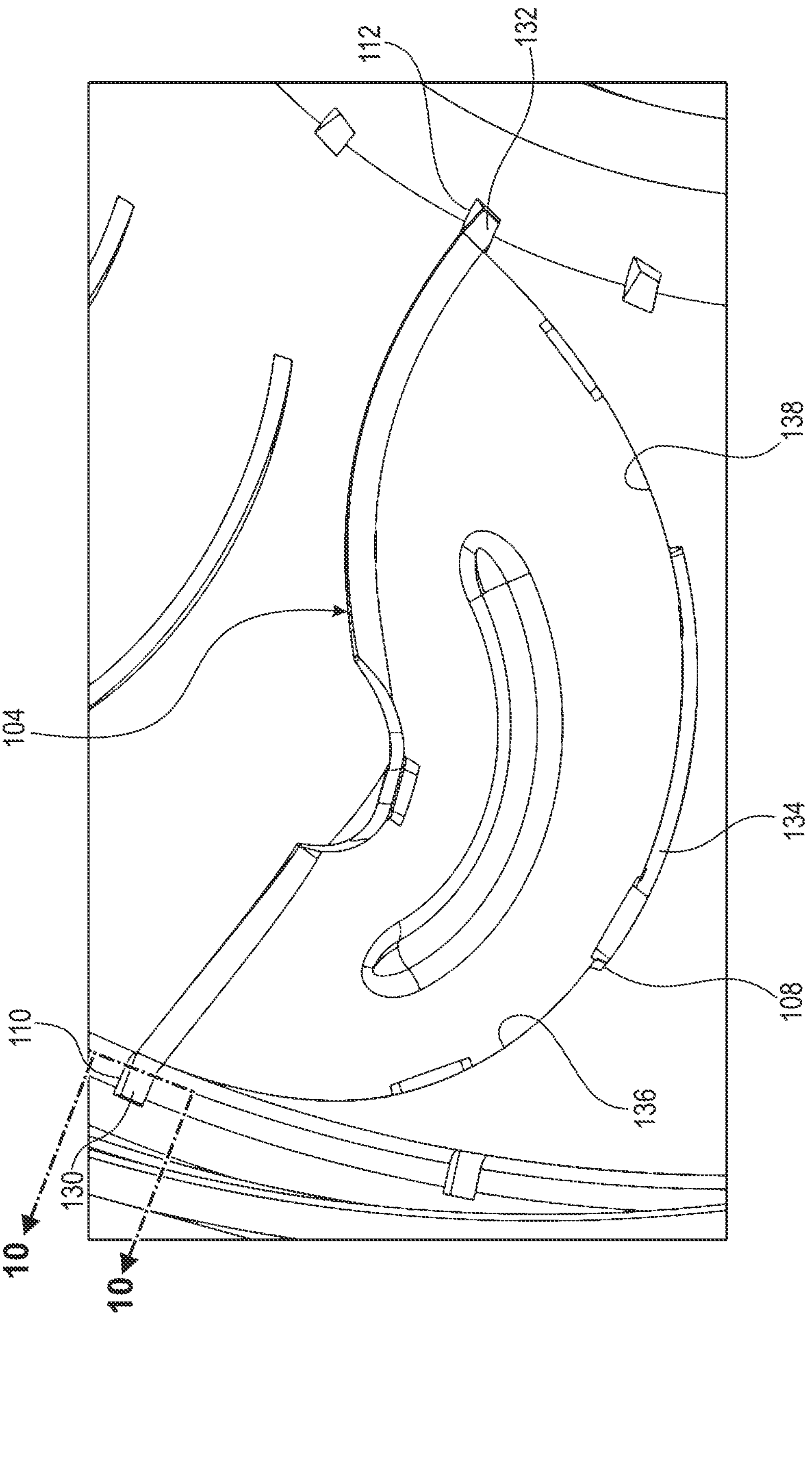


Fig. 5



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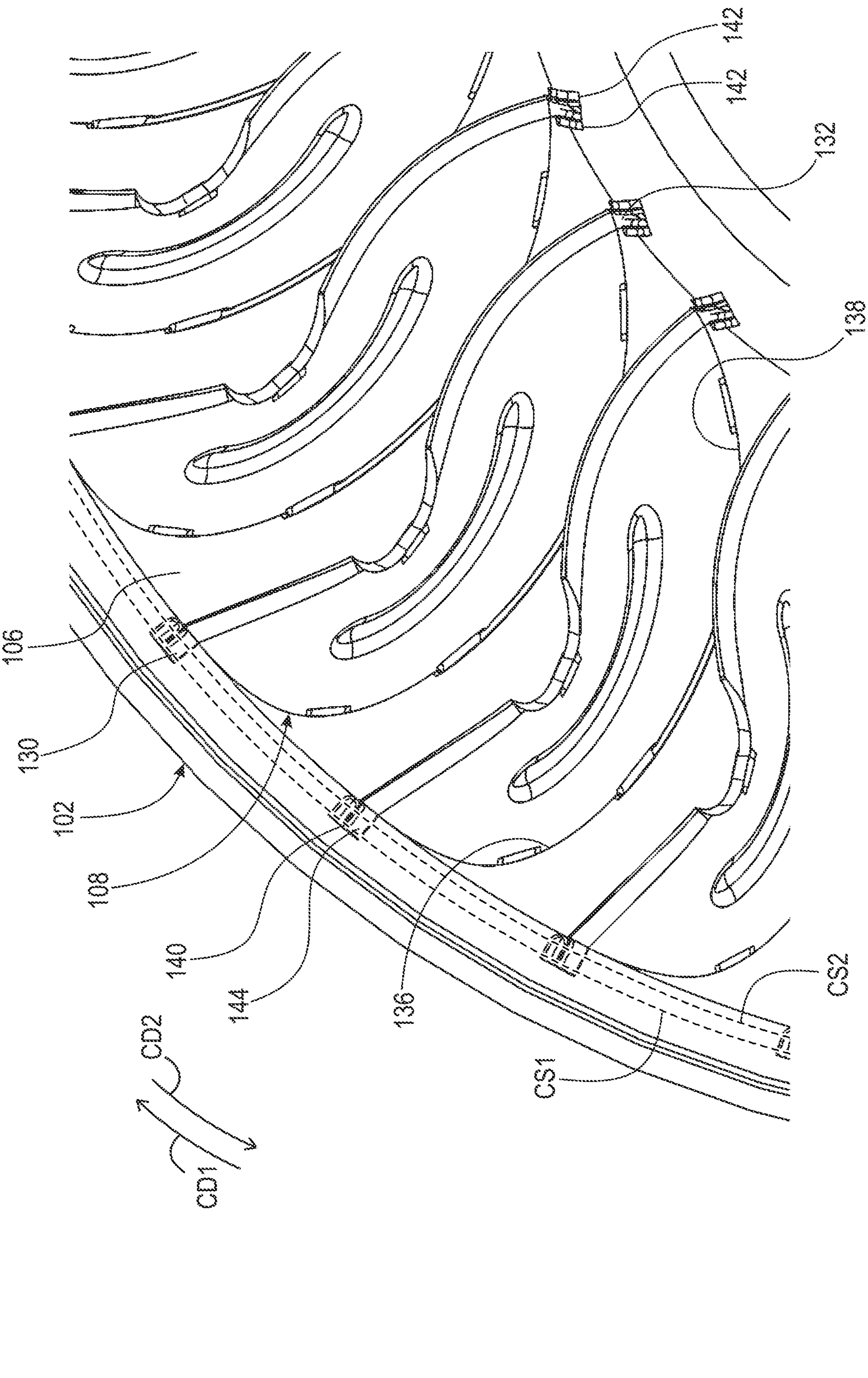


Fig. 7

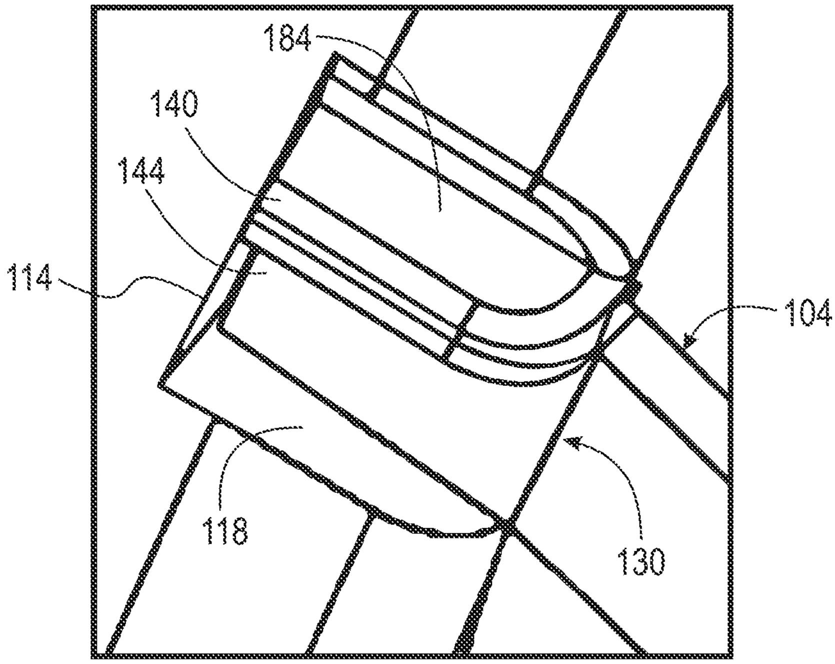
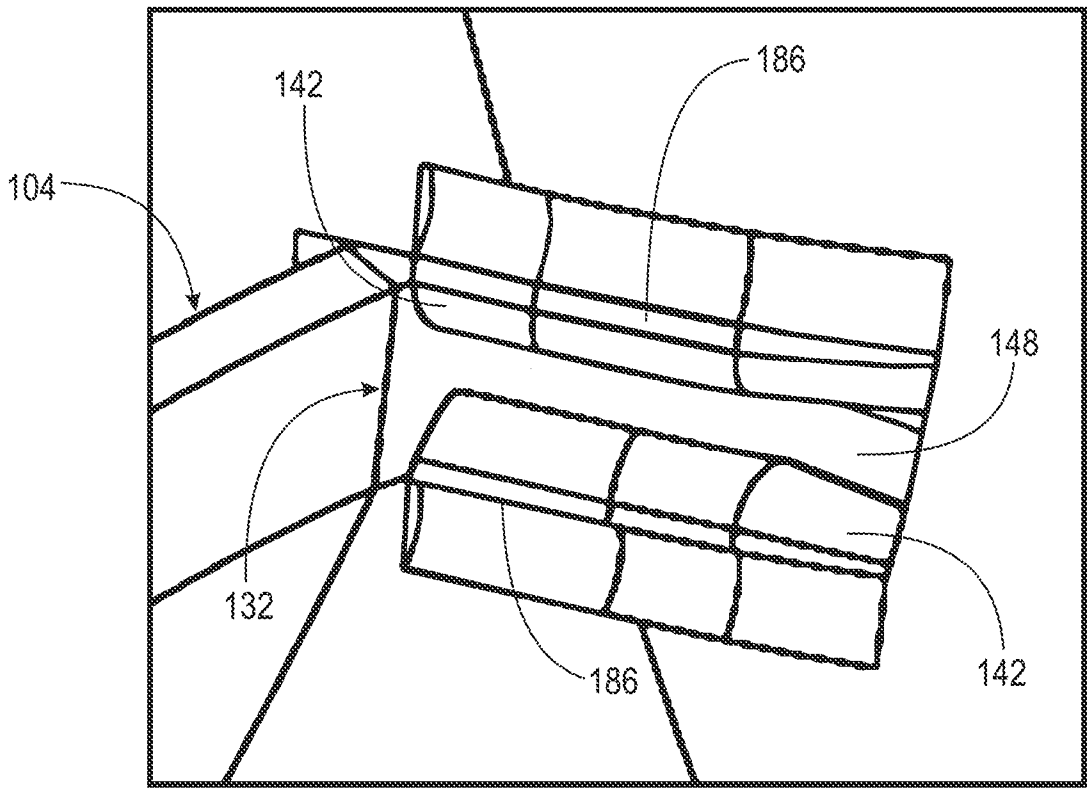


Fig. 8



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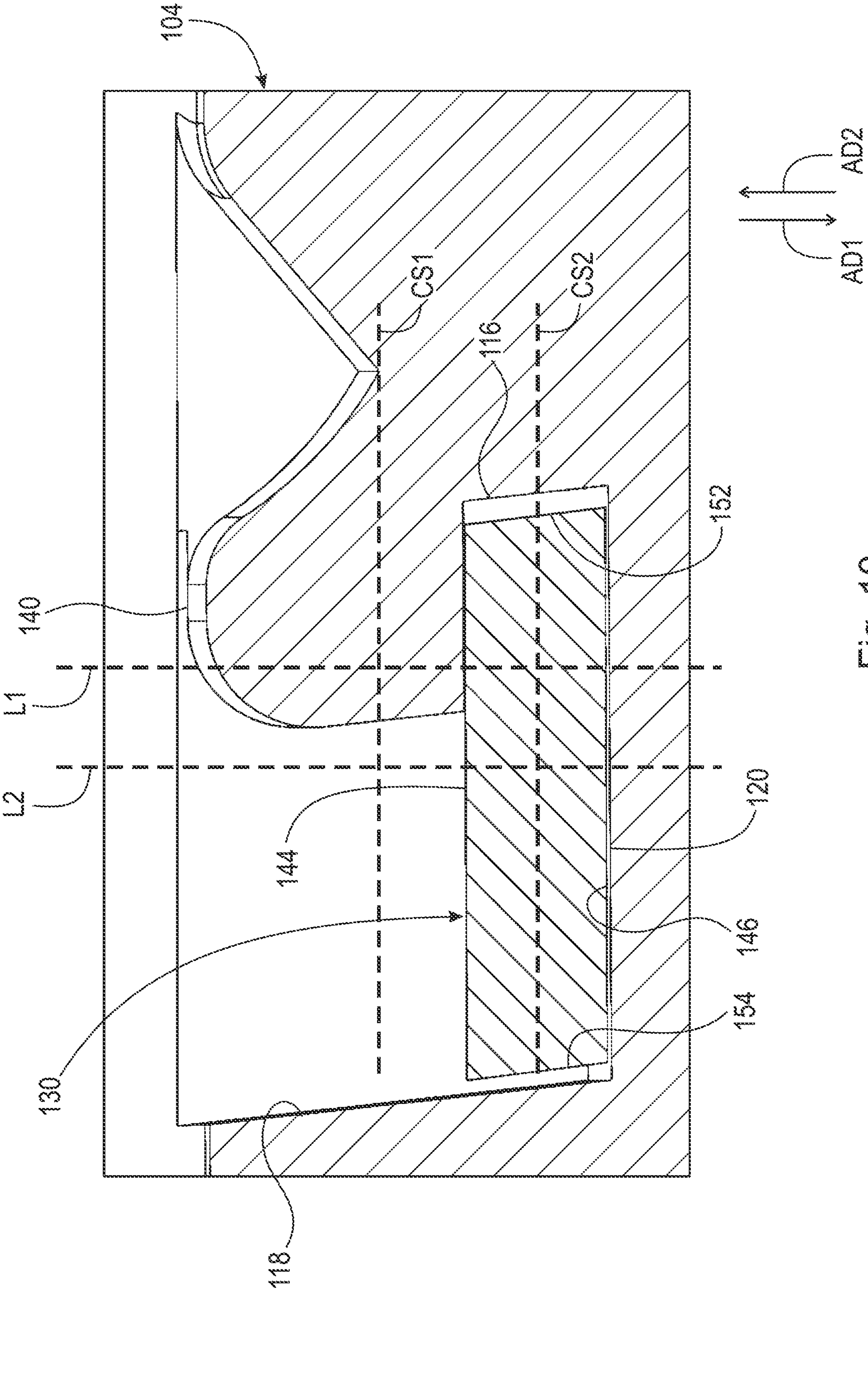


Fig. 10

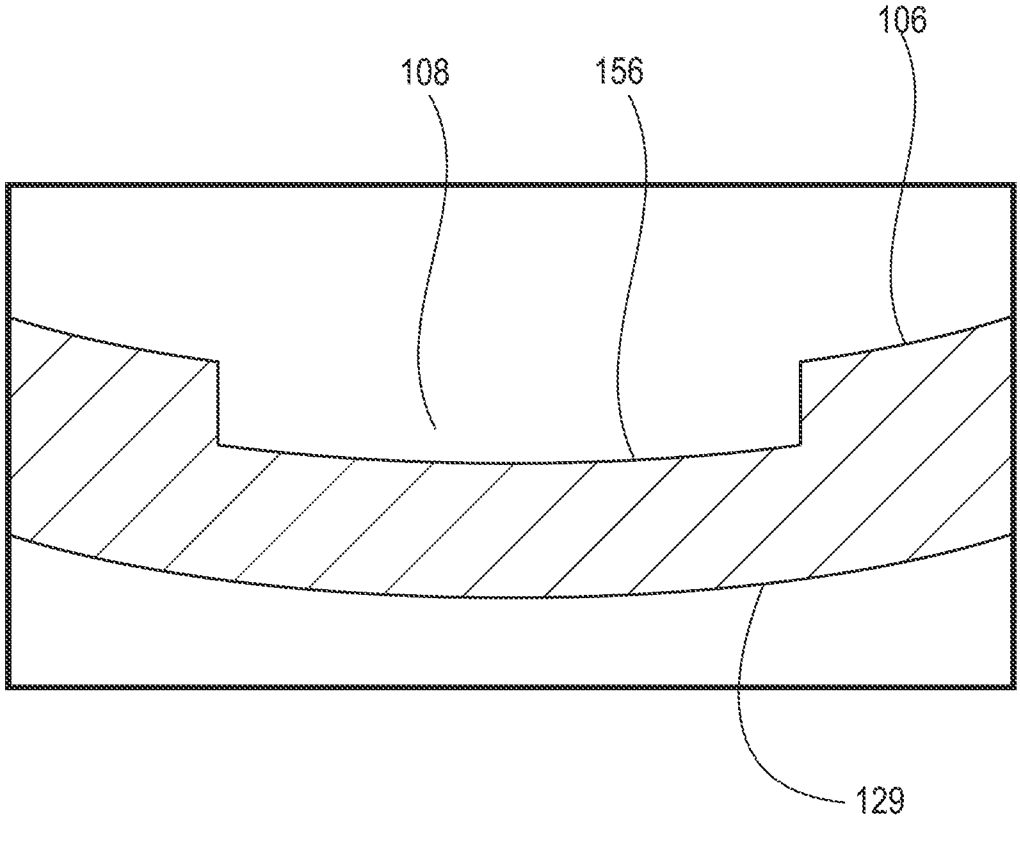
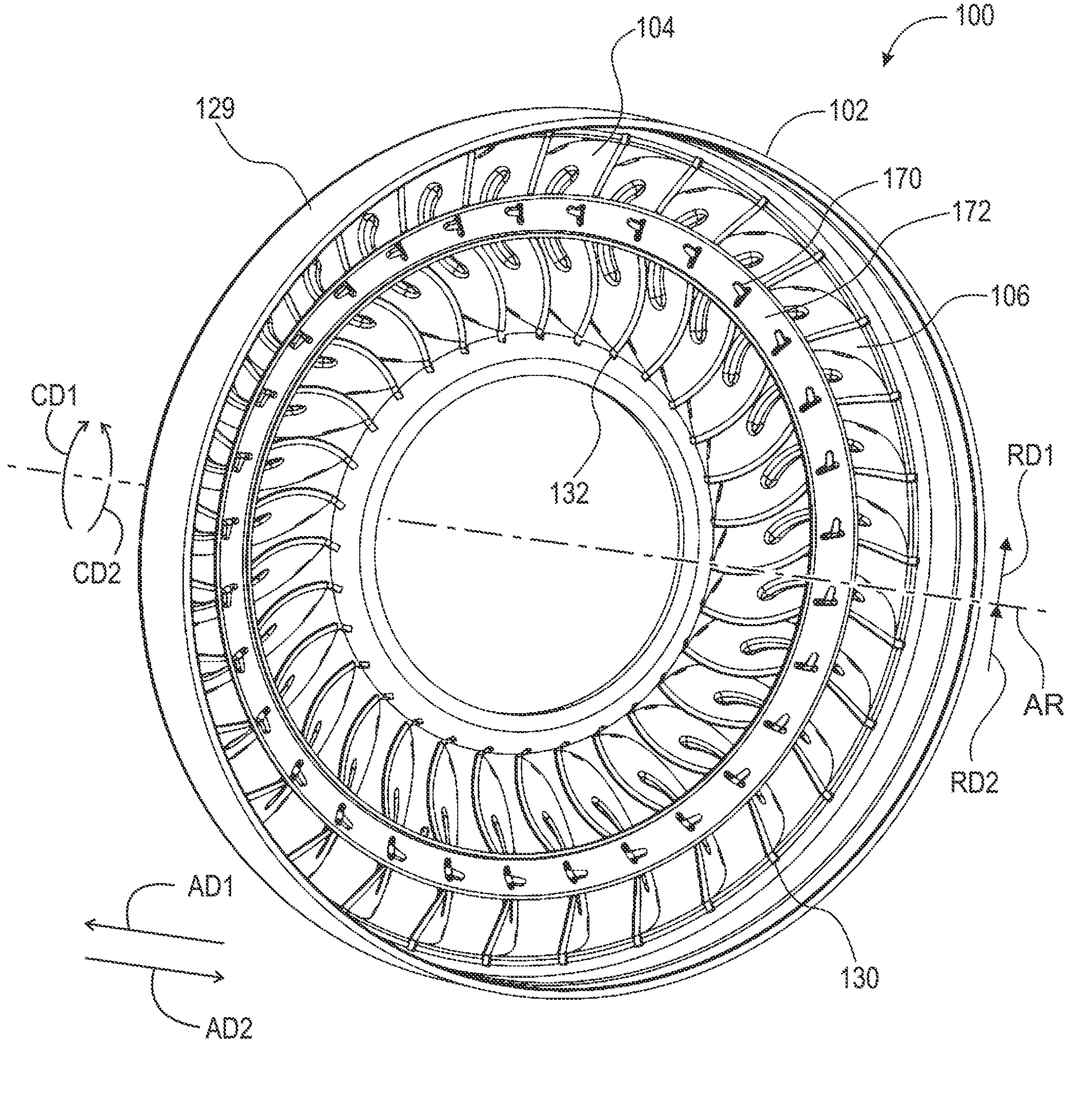


Fig. 11



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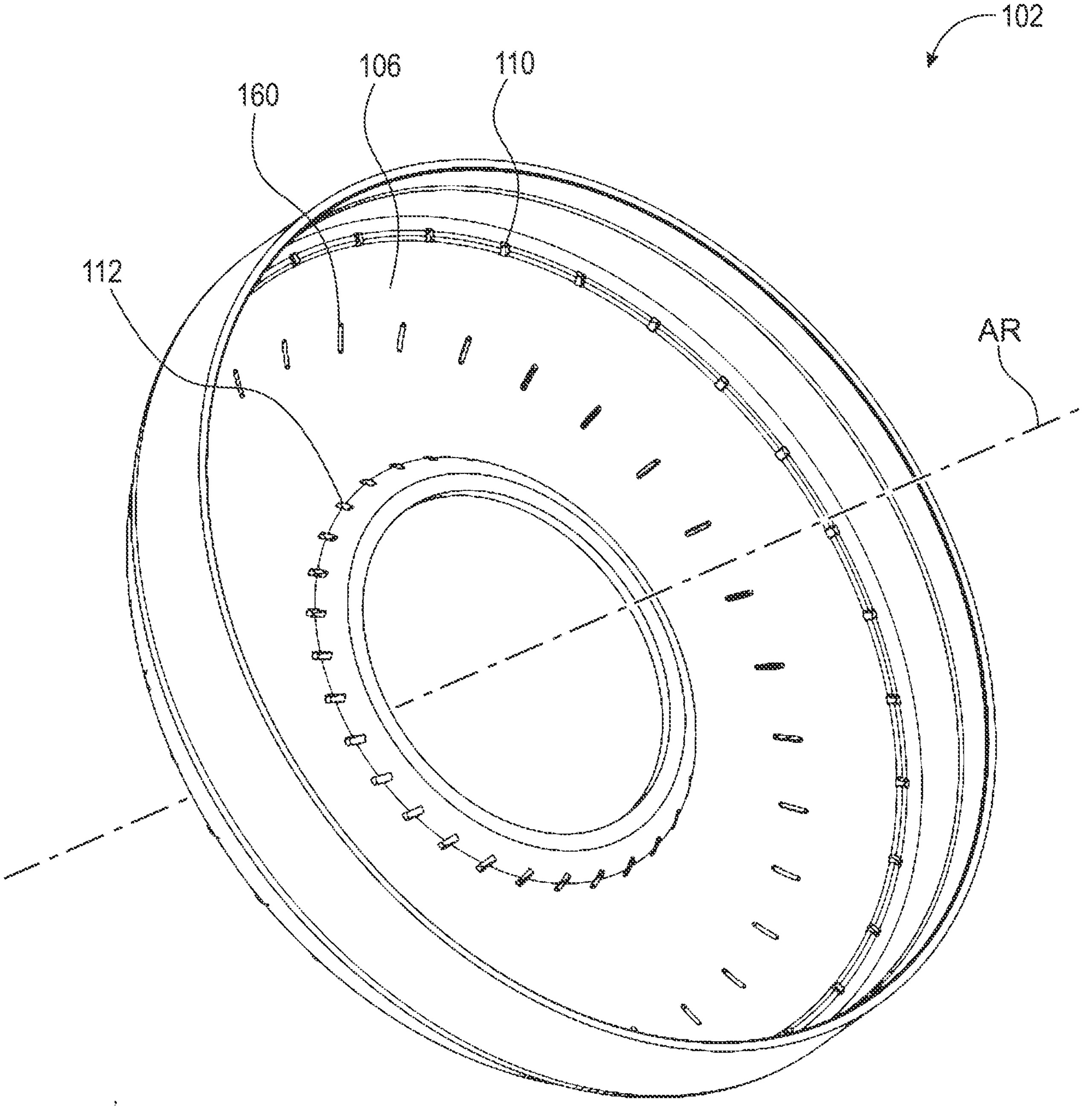
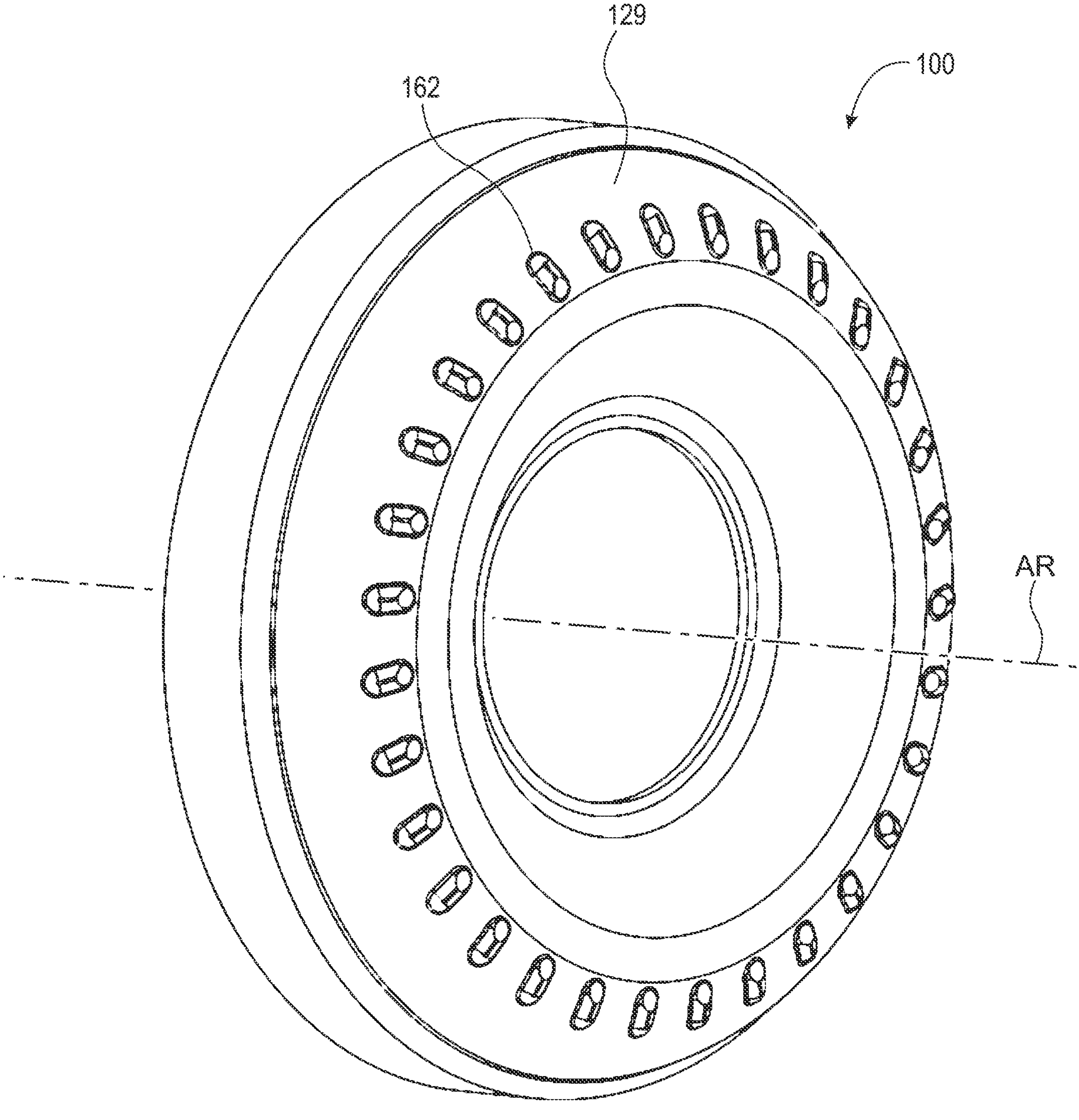


Fig. 13



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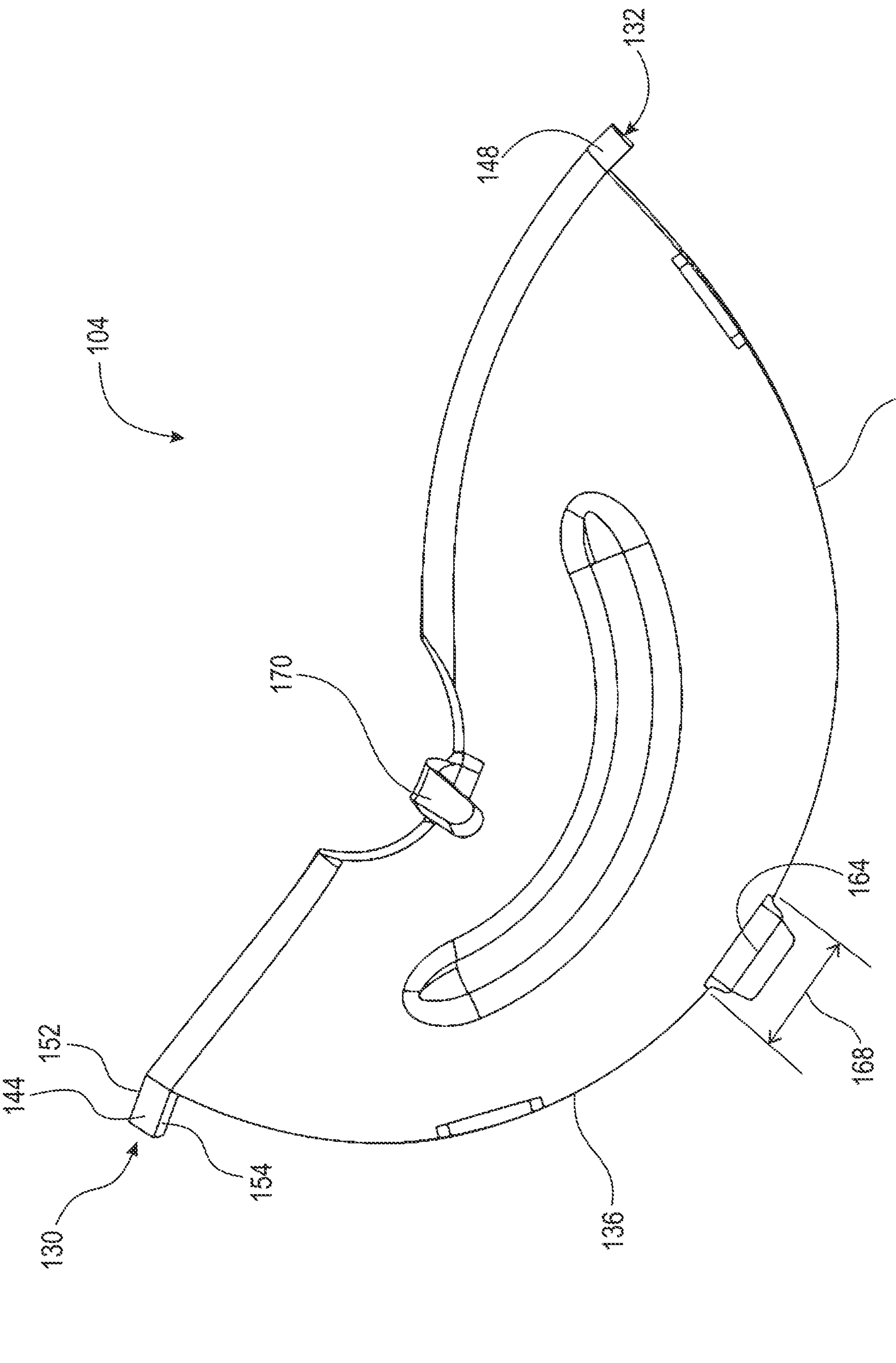

Fig. 15

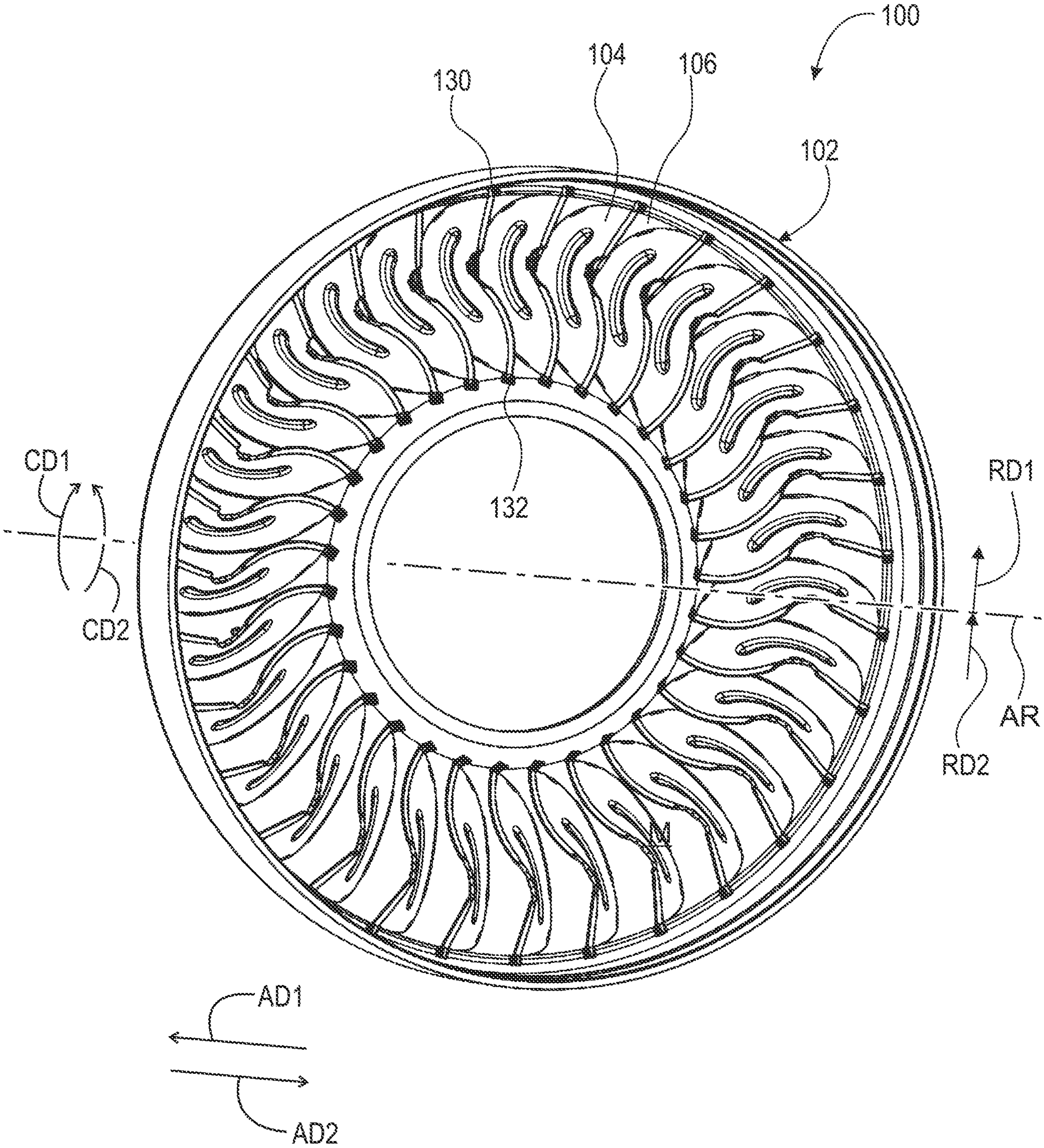

Fig. 16

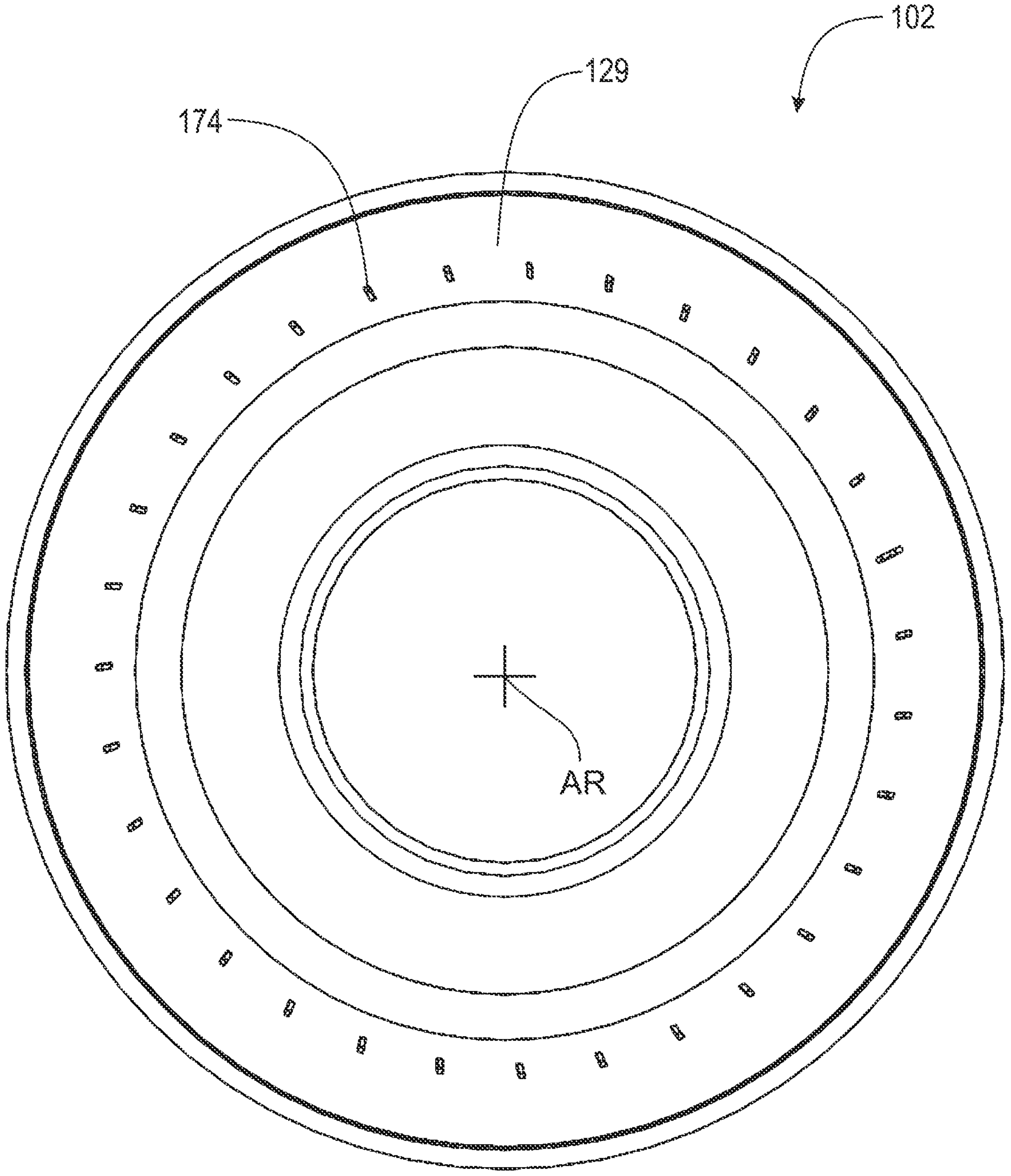

Fig. 17

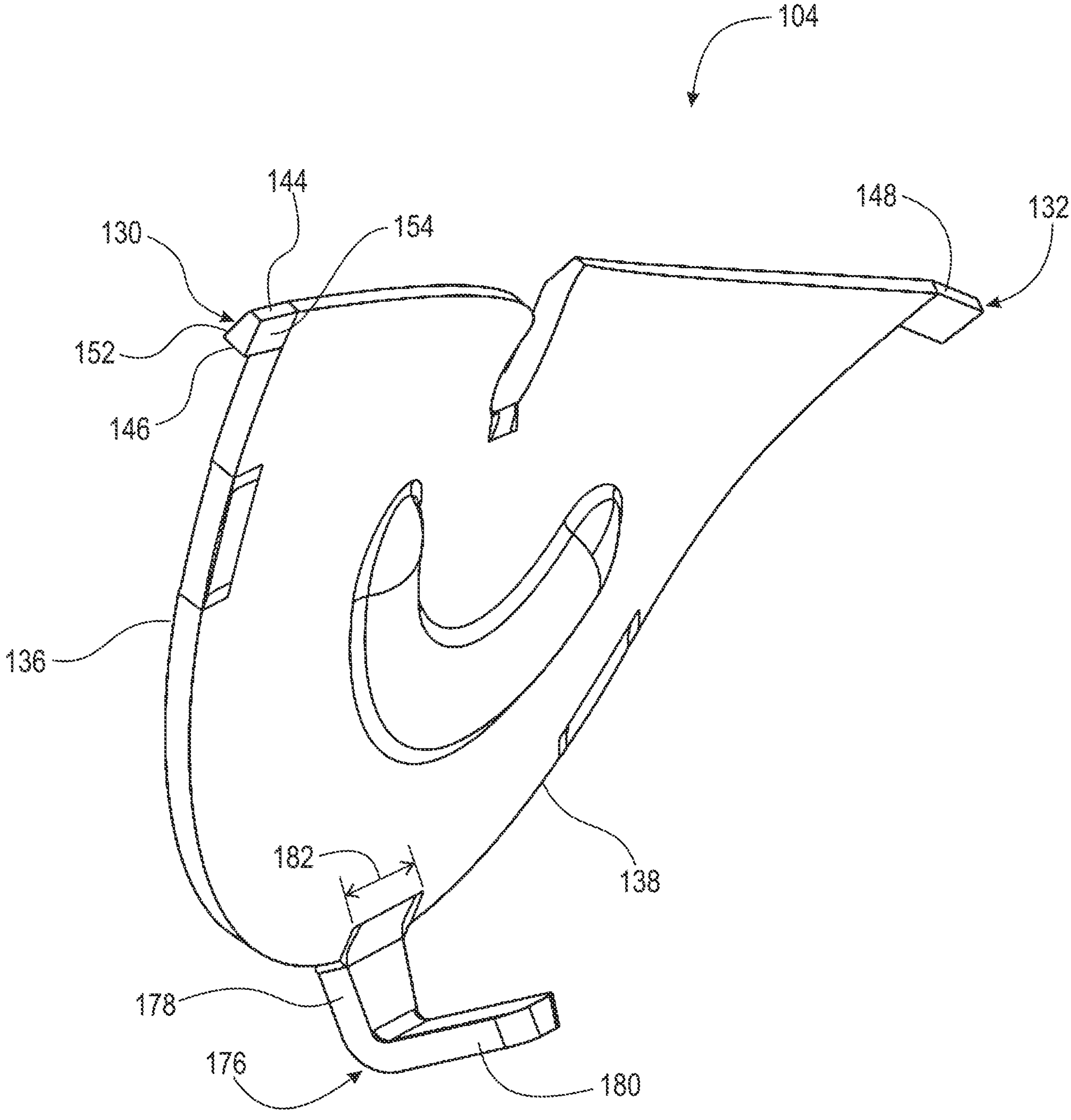

Fig. 18

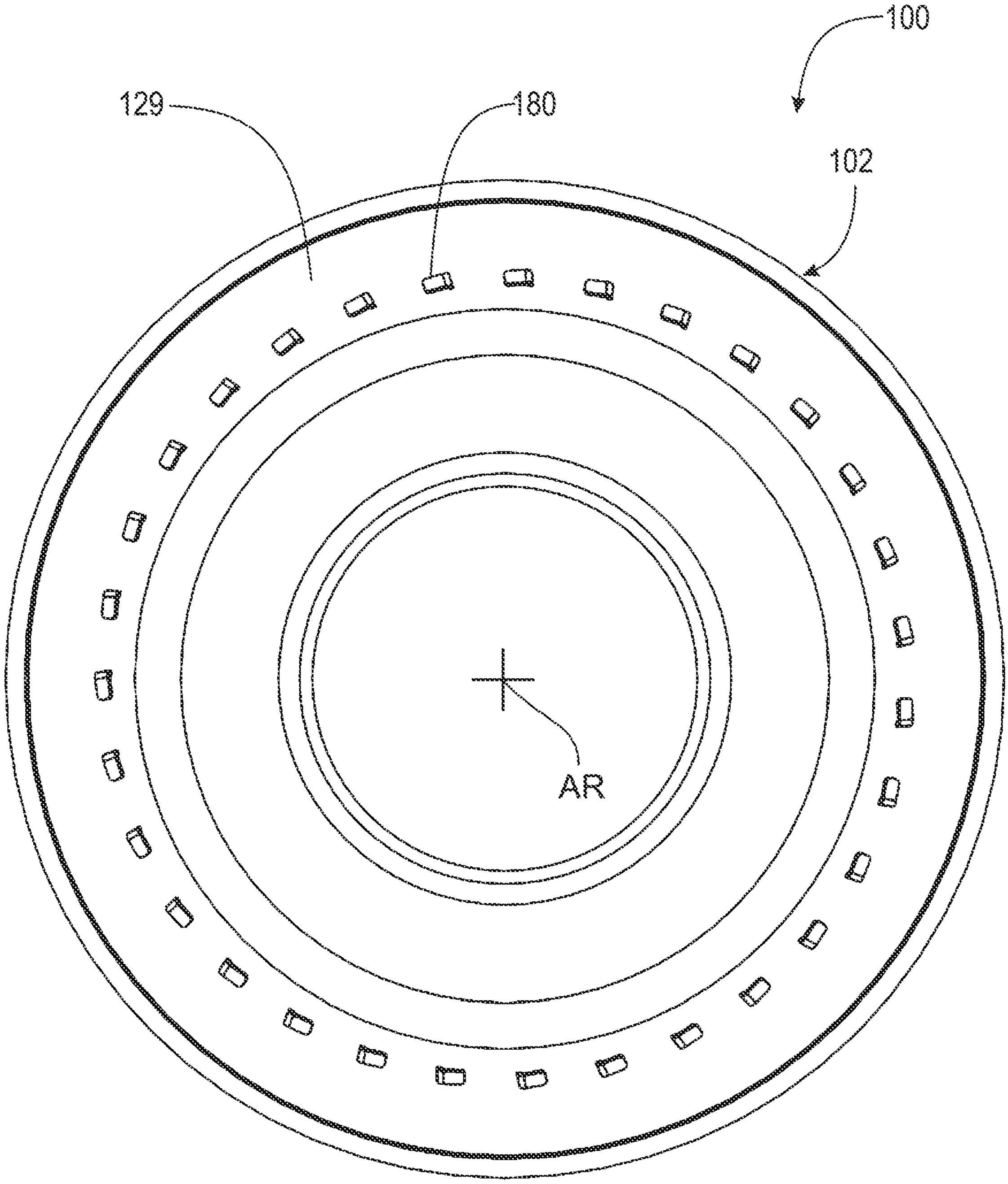

Fig. 19

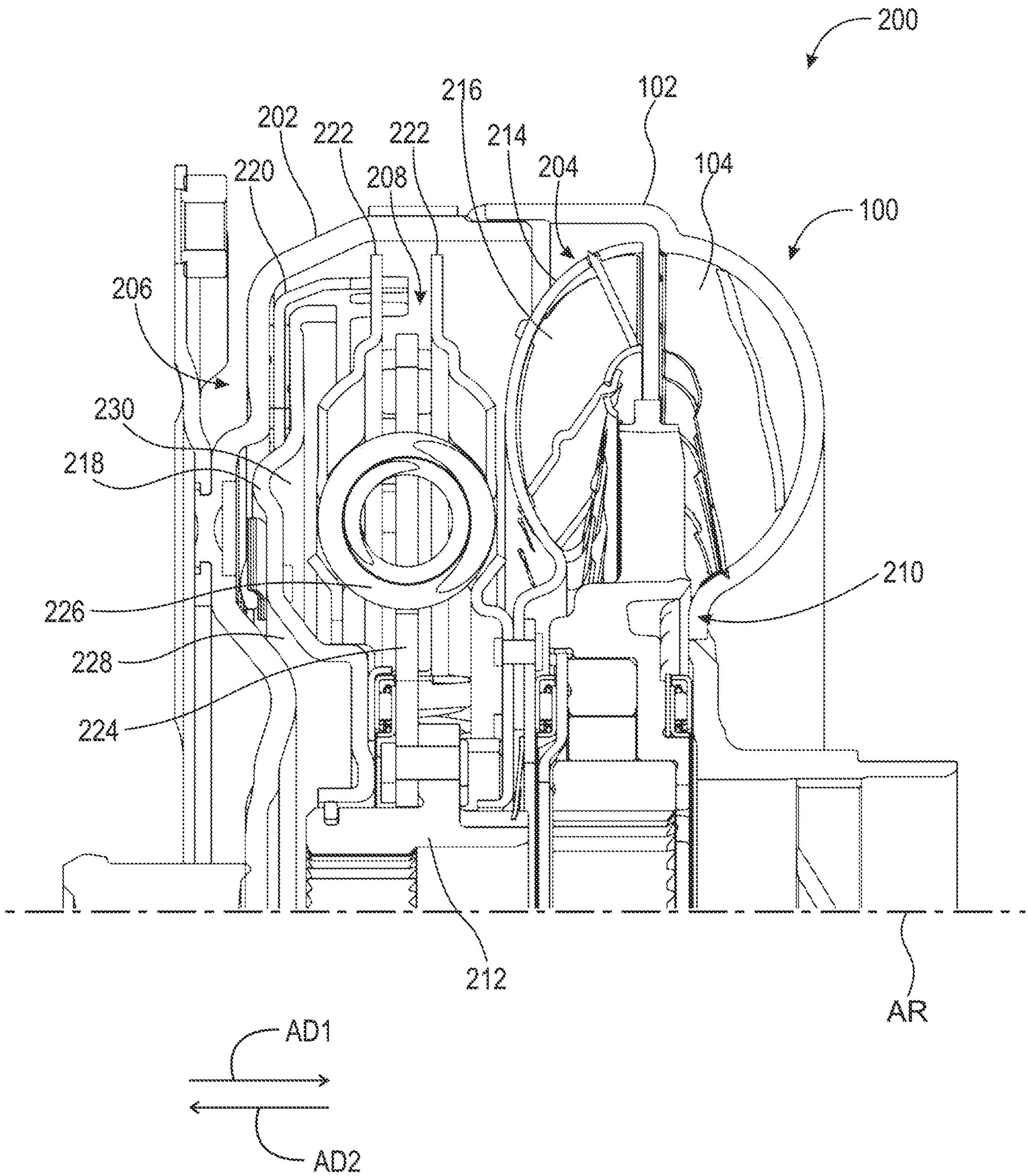
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Fig. 20

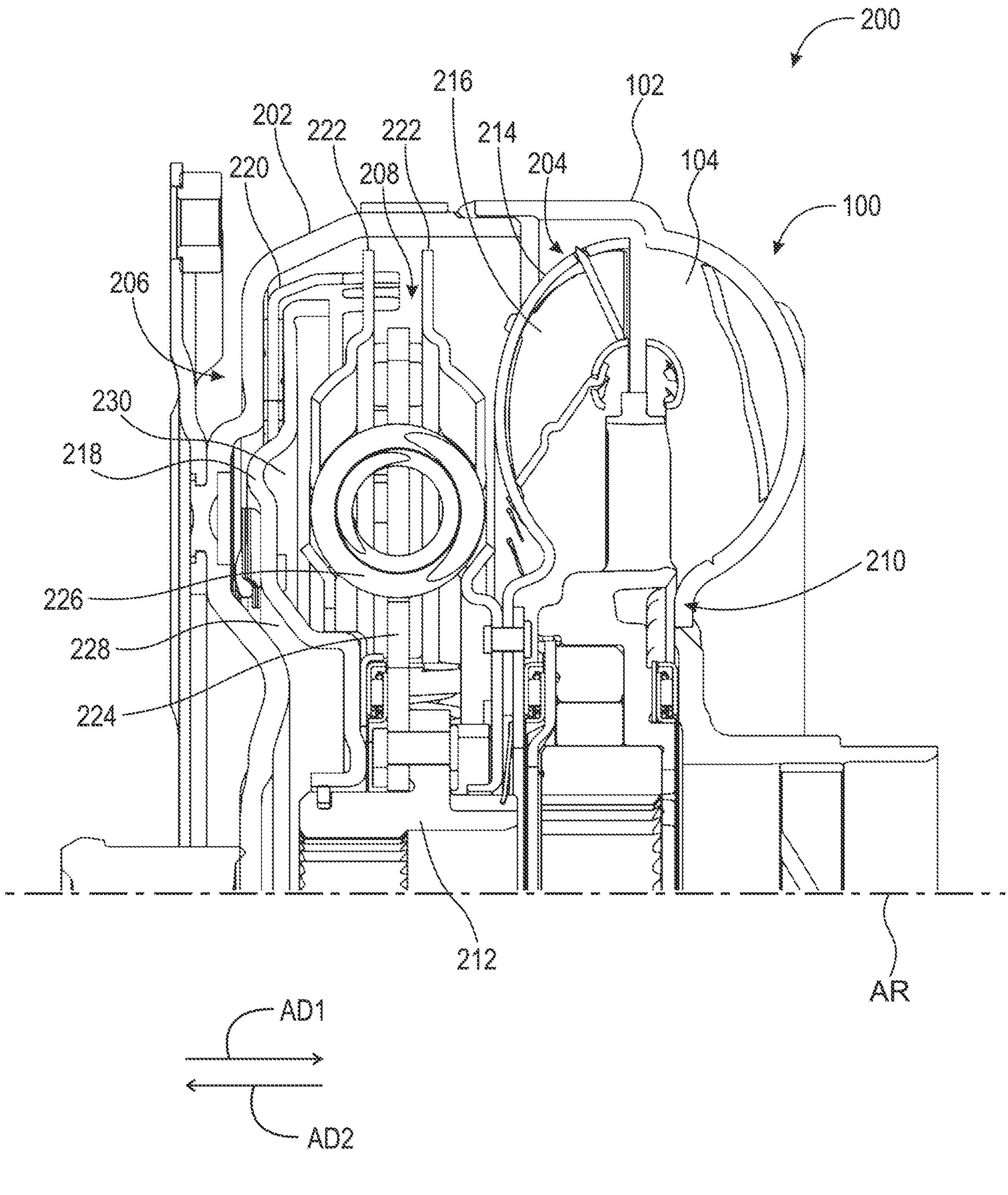
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Fig. 21

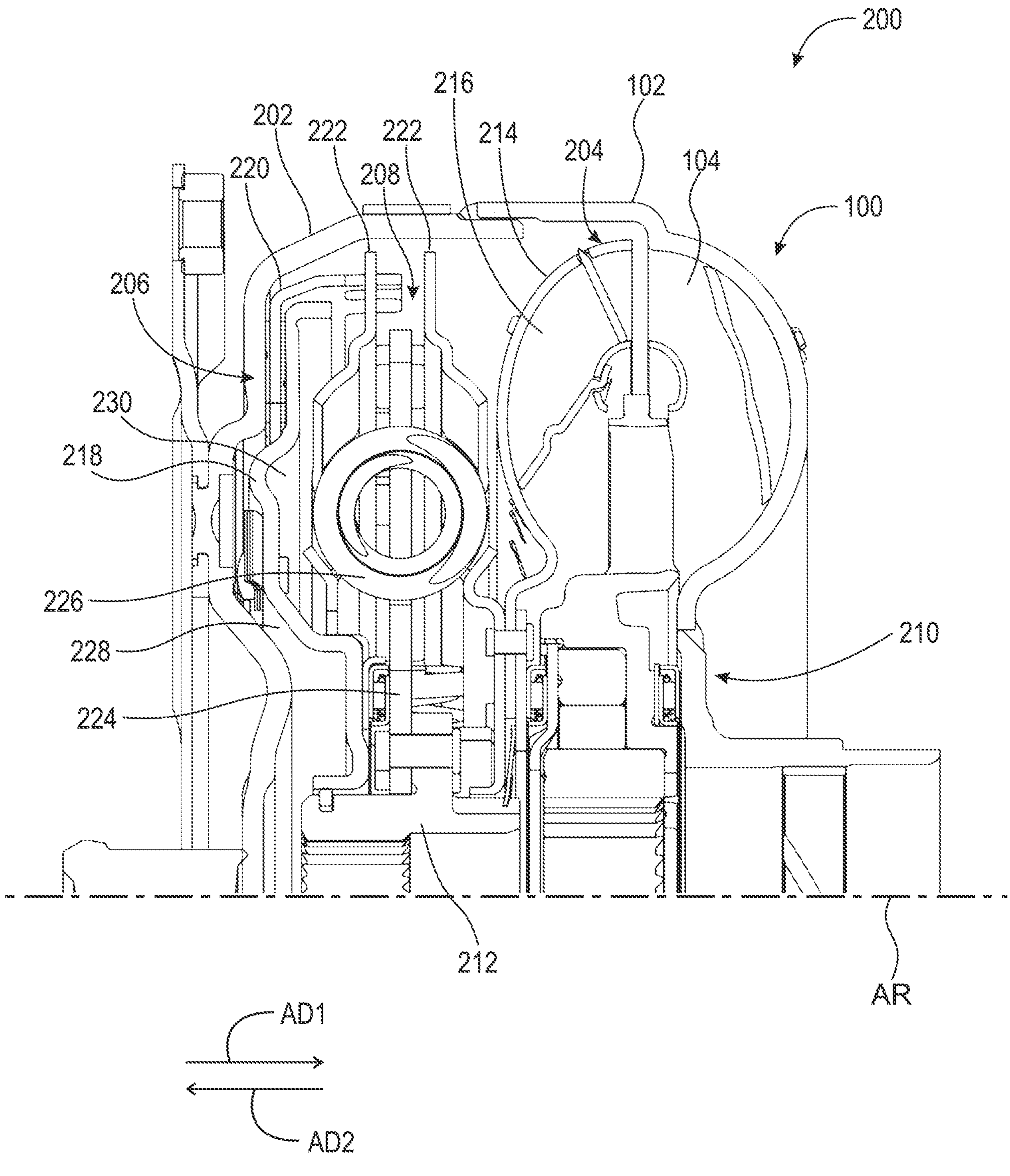
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Fig. 22

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2022/027759

A. CLASSIFICATION OF SUBJECT MATTER

F16H 41/24(2006.01)i; **F16D 33/18**(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F16H 41/24(2006.01); B23P 15/00(2006.01); B29C 70/34(2006.01); F01D 11/08(2006.01); F04D 29/38(2006.01); F16D 33/00(2006.01); F16H 41/28(2006.01)

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

Korean utility models and applications for utility models
Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & Keywords: impeller, blade, vane, turbine, torque converter, shell, tab, indentation, fix, overlap

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2009-0241533 A1 (MARATHE, BHASKAR) 01 October 2009 (2009-10-01) paragraphs [0002], [0020], [0047]-[0048], claims 1, 22 and figures 1, 4-5, 7A-7B, 8, 10	1-20
A	US 2013-0022470 A1 (RESH et al.) 24 January 2013 (2013-01-24) paragraphs [0023]-[0030] and figures 2-5B	1-20
A	JP 2009-535582 A (LUK LAMELLEN & KUPPLUNGSBAU) 01 October 2009 (2009-10-01) paragraphs [0082]-[0085] and figures 5-8	1-20
A	US 5109604 A (KOEBELE, RALPH R.) 05 May 1992 (1992-05-05) column 2, line 57 - column 5, line 11 and figures 1-7	1-20
A	EP 1800840 A1 (SAAB AB.) 27 June 2007 (2007-06-27) paragraph [0039] and figure 1a	1-20

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 August 2022	**18 August 2022**

Name and mailing address of the ISA/KR	Authorized officer
Korean Intellectual Property Office **189 Cheongsa-ro, Seo-gu, Daejeon** **35208, Republic of Korea**	**PARK, Tae Wook**
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/US2022/027759

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