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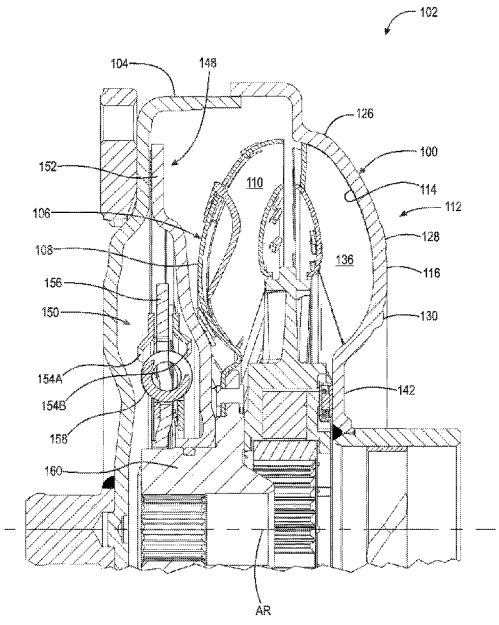


Fig. 2

(57) **Abstract**: A torque converter, including: an impeller including an impeller shell with an inner surface, an outer surface facing opposite the inner surface, a first radial portion substantially orthogonal to an axis of rotation for the torque converter, and an axial portion substantially parallel to the axis, extending from the radial portion, forming a radially outmost portion of the impeller shell and having a first thickness. The shell includes a curved portion including: a first protrusion; second and third protrusions radially inward of the first protrusion; a first portion between the radial portion and the first protrusion; and a junction portion connecting the radial portion and the first portion and having a second thickness at least 50 percent greater than the first thickness.

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IMPELLER SHELL WITH THICKENED JUNCTION AND METHOD THEREOF

TECHNICAL FIELD

[0001] The present disclosure relates generally to an impeller shell having a thickened junction between a curved portion to which impeller blades are attached and a portion extending radially outward from the curved portion. The present disclosure also relates to a method of fabricating the impeller described above.

BACKGROUND

[0002] Figure 9 is a cross-sectional view of a portion of a prior art impeller shell. Impeller shell **300** includes curved portion **302** and radial portion **304** substantially orthogonal to axis of rotation AR for the shell. Protrusion **306** is formed as a result of stamping portion **302** to form slots **308** for receiving a tab (not shown) for an impeller blade to be fixed to shell **300**. For a shell **300** fabricated from a sheet of metal, for example by stamping and coining operations, shell **300** has nominal thickness **T1** except at protrusions such as **306**. Junction **308** is subject to extreme stress during operation of a torque converter including shell **300**. However, thickness **T2** of shell **300** at junction **308** is only nominally more than **T1**, which leads an undesirable decrease in the robustness and service life of shell **300** and a torque converter including shell **300**.

[0003] Figures 10A and 10B are cross-sectional views of a prior art process for fabricating impeller shell **300** from a sheet of metal. The sheet is placed in space **310** between dies **312**, **314**, **316**, and **318** and compressed between the dies to attain the shape shown in Figure 9. Die **312** includes indentation **320** arranged to receive protrusions **306** without flattening the protrusions during formation of shell **300**. Die **312** includes indentations **322** arranged to receive protrusions on shell **300** without flattening the protrusions during formation of shell **300**. Die **318** includes indentation **324** arrange to receive protrusion on shell **300** without flattening the protrusion during formation of shell **300**.

[0004] Figure 11 is a cross-sectional view along line 11-11 in Figure 10B. Each of indentations **320** (shown in Figure 10), **322** and **324** is in the form of a respective continuous groove to enable dies **312** and **318** to be engage with and disengage from protrusions **306** and protrusions on shell **300** aligned with **308** and **310**. That is, the curved shape of dies **312** and **318** must be able to displace in directions **D1** and **D2**, without snagging on the protrusions.

[0005] Compressive force applied by dies **312** and **316** to a portion of the sheet of metal in space **310A** causes material in that portion to flow toward space **3102B**, in which junction **308** would be located. However, the compressive force between dies **312** and **314** is

not sufficient to prevent most of the flowing material to continue past space **310B** and into space **310C**. Thus, junction **308** is only nominally thickened. Specifically, the dashed lines in Figure 11 represent the sheet of metal with protrusions **306**. Spaces **326** are left between respective protrusions **306**. Die **318** does not flatten protrusions **306** (distance **328** is substantially the same before and after compression by dies **312** and **314**); therefore, there is little or no compressive force being applied to the sheet at areas corresponding to the spaces in the grooves, enabling the flow of material past junction **308** and into portion **302**.

SUMMARY

[0006] The present disclosure broadly comprises a torque converter, including: a cover arranged to receive torque; a turbine including a turbine shell and a turbine blade fixedly connected to the turbine shell; and an impeller including an impeller shell non-rotatably connected to the cover and including: an inner surface facing the turbine; an outer surface facing opposite the inner surface; a first radial portion substantially orthogonal to an axis of rotation for the torque converter; and an axial portion substantially parallel to the axis of rotation, extending from the radial portion, forming a radially outmost portion of the impeller shell and having a first thickness. The shell includes a curved portion including: a first protrusion; second and third protrusions radially inward of the first protrusion; a first portion between the first and second protrusions; and a junction portion connecting the radial portion and the curved portion and having a second thickness at least 50 percent greater than the first thickness. The torque converter includes an impeller blade fixed to the impeller shell proximate the first, second and third protrusions.

[0007] The present disclosure broadly comprises a method of fabricating an impeller for a torque converter, including: forming, using a first plurality of protrusions on a first die and a plurality of indentations in a second die, first, second and third protrusions extending from a first side of a sheet of metal, the sheet of metal having a first thickness; forming, using the first pluralities of protrusions and the plurality of indentations, first, second, and third slots in the first, second and third protrusions, respectively; clamping a first portion of the sheet metal, including the first protrusion and the first slot, between a first smooth and continuous curved shape formed by a first portion of a third die facing the first side and a second smooth and continuous curved shape formed by a first portion of a fourth die; compressing a first end portion of the sheet of metal, continuous with the first portion of the sheet metal, between a first surface formed by a second portion of the third die and a second surface formed by a fifth die; flowing material forming the first end portion into a junction

between the first portion and the first end portion; blocking the flow of material from the junction to the first portion; and increasing the thickness of the sheet of metal at the junction to a second thickness greater than the first thickness by at least 50 percent.

[0008] The present disclosure broadly comprises a method of fabricating an impeller for a torque converter, including: forming, using a first plurality of protrusions on a first die and a plurality of indentations in a second die, first, second and third protrusions extending from a first side of a sheet of metal, the sheet of metal having a first thickness; forming, using the first pluralities of protrusions and the plurality of indentations, first die, first, second, and third slots in the first, second and third protrusions, respectively; clamping a first portion of the sheet metal, including the first protrusion and the first slot, between a first smooth and continuous curved shape formed by a first portion of a third die facing the first side and a second smooth and continuous curved shape formed by a first portion of a fourth die; at least partially flattening the first protrusion with the first portion of the third die; compressing a first end portion of the sheet of metal, continuous with the first portion of the sheet metal, between a first surface formed by a second portion of the third die and a second surface formed by a fifth die; flowing material forming the first end portion into a junction between the first portion and the first end portion; blocking the flow of material from the junction to the first portion; and increasing the thickness of the sheet of metal at the junction to a second thickness greater than the first thickness by at least 50 percent.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The nature and mode of operation of the present disclosure will now be more fully described in the following detailed description of the present disclosure taken with the accompanying figures, in which:

Figure 1 is a perspective view of a cylindrical coordinate system demonstrating spatial terminology used in the present application;

Figure 2 is a cross-section view of a torque converter including an impeller shell with a thickened junction;

Figure 3 is a detail of the impeller shell in Figure 2;

Figures 4 through 7B illustrate an example method of fabricating an impeller shell with a thickened junction;

Figures 8A and 8B illustrate flattening of a protrusion on the impeller shell of Figure 3;

Figure 9 is a cross-sectional view of a portion of a prior art impeller shell;

Figures 10A and 10B are cross-sectional views of a prior art process for fabricating an impeller shell from a sheet of metal; and,

Figure 11 is a cross-sectional view along line 11-11 in Figure 10.

DETAILED DESCRIPTION

[0010] 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.

[0011] 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.

[0012] 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.

[0013] 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 present disclosure belongs. It should be appreciated that the term “substantially” is synonymous with terms such as "nearly", "very nearly”, “about", "approximately", "around", "bordering on", "close to", "essentially", "in the neighborhood of", “in the vicinity of”, etc., and such terms may be used interchangeably as appearing in the specification and claims. It should be appreciated that the term "proximate" is synonymous with terms such as "nearby", "close", "adjacent", "neighboring", "immediate", "adjoining", etc., and such terms may be used interchangeably as appearing in the specification and claims.

[0014] Figure **1** is a perspective view of cylindrical coordinate system **10** demonstrating spatial terminology used in the present application. The present application is at least partially described within the context of a cylindrical coordinate system. System **10** includes longitudinal axis **11**, used as the reference for the directional and spatial terms that follow. Axial direction **AD** is parallel to axis **11**. Radial direction **RD** is orthogonal to axis **11**. Circumferential direction **CD** is defined by an endpoint of radius **R** (orthogonal to axis **11**) rotated about axis **11**.

[0015] To clarify the spatial terminology, objects **12**, **13**, and **14** are used. An axial surface, such as surface **15** of object **12**, is formed by a plane co-planar with axis **11**. Axis **11**

passes through surface **15**; however any surface co-planar with axis **11** is an axial surface. A radial surface, such as surface **16** of object **13**, is formed by a plane orthogonal to axis **11** and co-planar with a radius, for example, radius **17**. Radius **17** passes through surface **16**; however any surface co-planar with radius **17** is a radial surface. Surface **18** of object **14** forms a circumferential, or cylindrical, surface. For example, circumference **19** is passes through surface **18**. As a further example, axial movement is parallel to axis **11**, radial movement is orthogonal to axis **11**, and circumferential movement is parallel to circumference **19**. Rotational movement is with respect to axis **11**. The adverbs "axially," "radially," and "circumferentially" refer to orientations parallel to axis **11**, radius **17**, and circumference **19**, respectively. For example, an axially disposed surface or edge extends in direction **AD**, a radially disposed surface or edge extends in direction **R**, and a circumferentially disposed surface or edge extends in direction **CD**.

[0016] Figure 2 is a cross-section view of a torque converter including impeller shell **100** with a thickened junction.

[0017] Figure 3 is a detail of impeller shell **100** in Figure 2. The following should be viewed in light of Figures 2 and 3. In an example embodiment, impeller shell **100** is part of torque converter **102**. Torque converter **102** includes: cover **104** arranged to receive torque; turbine **106** including turbine shell **108** at least one turbine blade **110** fixedly connected to the turbine shell; and impeller **112** including impeller shell **100**. Shell **100** is non-rotatably connected to cover **104** and includes inner surface **114** facing the turbine, outer surface **116** facing opposite the inner surface, radial portion **118** substantially orthogonal to axis of rotation **AR** for the torque converter, axial portion **120**, and curved portion **122**. Portion **120** is substantially parallel to axis of rotation **AR**, extends from radial portion **118**, forms the radially outmost portion of impeller shell **100**, and has thickness **124**. In an example embodiment, thickness **124** is the original thickness of a sheet of metal from which shell **100** is fabricated.

[0018] Curved portion **122** includes at least one protrusion **126**, least one each protrusions **128** and **130** radially inward of least one protrusion **124** (herein after, to simplify presentation least one protrusion **126**, least one protrusions **128** and at least one protrusion **130** are referred to as protrusion **126**, protrusions **128** and protrusion **130**, respectively). Shell **100** includes junction portion **132** connecting radial portion **118** and portion **122** and having thickness **134** at least 50% greater than thickness **124**. Impeller **112** includes at least one blade **136** fixed to impeller shell proximate protrusions **126**, **128** and **130**. For example, tabs

(not shown) are inserted in slots (further described below), associated with respective protrusions **126**, **128** and **130**. Thicknesses **124** and **134** are measured orthogonal to surface **114** or surface **116**. In an example embodiment, radial portion **118** has thickness **136** less than thickness **124**. As described below, material in portion **118** has been transferred (flowed) from portion **118** to junction portion **132**.

[0019] Impeller shell **100** includes radial portion **142** radially inward of protrusions **126**, **128** and **130**, in particular, radially inward of protrusion **130**. Portion **142** is substantially orthogonal to axis of rotation **AR**, forms a radially inmost portion of impeller shell **100** and has thickness **124**.

[0020] Protrusion **126** extends past portion **122A** by distance **144**. Portion **122A** is between protrusions **126** and **128** and has thickness **124**. Portion **122** includes portion **122B** between protrusions **128** and **130** and having thickness **124**. Protrusion **130** extends past portion **122B** by distance **146** greater than distance **144**. In an example embodiment, distance **146** is at least twice distance **144**. In an example embodiment, protrusion **128** extends past portion **122B** by distance **144**.

[0021] Torque converter **102** includes lock up clutch **148** and damper **150**. Lock up clutch **148** includes piston **152** axially displaceable to non-rotatably engage the cover to close clutch **148**. Damper **150** includes input cover plates **154A** and **154B** non-rotatably connected to each other and piston **152**, output flange **156** non-rotatably connected to output hub **160**, and spring **158** engaged with plates **154A/154** and flange **156**. Hub **160** is arranged to non-rotatably engage an input shaft for a transmission. Lockup clutch **148** is arranged: to be open to enable torque flow from the cover to the output hub via the impeller, the turbine and the damper; and to be closed to enable torque flow from the cover to the output hub via the lockup clutch and the damper.

[0022] Advantageously, junction portion **132** has a markedly increased thickness and strength in comparison to known impeller shells, thus providing a desirable increase in the robustness and service life of impeller shell **100** and torque converter **102**.

[0023] Figures 4 through 7B illustrate an example method of fabricating an impeller shell with a thickened junction. Although the method is presented as a sequence of steps for clarity, no order should be inferred from the sequence unless explicitly stated. The following should be viewed in light of Figures 2 through 7B. A first step forms, using a plurality of protrusions **200** on die **202** and indentations **206** on die **210**, protrusions **212**, **214** and **130** on side **116** of sheet **216** of metal having thickness **124**. A second step forms slots **162**, **164** and

166, in protrusions **212**, **214** and **130**, respectively. Sheet **216** is placed in space **220** between dies **222**, **224**, **226**, **228**, and **230** as described below.

[0024] A third step clamps a first portion of sheet **216**, corresponding to portion **122** and including slots **162** and protrusions **212**, in portion **220A** of space **220** between: smooth and continuous curved shape **232** formed by portion **222A** of die **222**; and smooth and continuous curved shape **234** formed portion **224A** of die **224** facing side **116**. A fourth step compressing a first end portion of sheet **216** in portion **220B** of space **220**, between surface **236** formed by portion **222B** of die **222** and surface **238** formed by die **226**.

[0025] A fifth step flows material of sheet **216** in the first portion of sheet **216** toward portion **220C** of space **220** corresponding to junction **132**. A sixth step blocks the flow of material in portion **220C** to the first portion of sheet **216** (space **220A**). A seventh step increases the thickness of sheet **216** in portion **220C** to thickness **134** greater than thickness **124**. An eighth step produces thickness **136**.

[0026] Clamping the first portion of sheet **216** includes at least partially flattening protrusions **212** to form protrusions **126**. In an example embodiment, the first portion of sheet **216** includes protrusions **214** and clamping the first portion of sheet **216** includes at least partially flattening protrusions **214** to form protrusions **128**. In an example embodiment, a ninth step clamps a third portion of sheet **214** between: smooth and continuous curved shape **240** formed by portion **224B** of die **224**; and smooth curved shape **242** formed by portion **228A** of die **228** and interrupted by at least one indentation **244** aligned with protrusion **130**. Clamping the third portion of sheet **216** includes receiving protrusions **130** in indentation **244** without substantially flattening protrusions **130**.

[0027] In an example embodiment, a tenth step compresses a fourth portion of sheet **214**, corresponding to portion **142**, in portion **220D** of space **220** between surfaces **246** and **248** formed by portion **228B** and die **230**, respectively. In an example embodiment, surface **248** is part of die **224**.

[0028] Advantageously, the method above results in an increase in the thickness and strength of junction **132**. In particular, the sixth step noted above blocks the flow of material from junction **132** to portion **122** and the seventh step noted above increases the thickness of shell **100** at junction **132** to thickness **134**.

[0029] Figure 8A is a representation of a cross-section along line 8-8 in Figure 7 showing protrusions **212** before compression between dies **222** and **224**.

[0030] Figure 8B is a representation of a cross-section along line 8-8 in Figure 7 showing protrusions **126** formed by compressing protrusions **212**. The following should be viewed in light of Figures 2 through 8B. The dashed lines in Figures 8A and 8B represent sheet **216**. The blocking function of the sixth step is enabled by smooth continuous shape **232** formed portion **222A** of die **222**. As noted above, die **222** must be configured to enable displacement of die **222** in direction **D1** and **D2** without snagging protrusions **212**. Unlike in the prior art, shape **232** is not configured to receive protrusion **212** while applying only nominal pressure. Instead, the shallow profile of shape **232** causes considerable pressure to be imposed on protrusions **212**.

[0031] For example, in Figure 8A, contact has been made between sheet **216** and die **222**, but compressive force has not been applied to protrusions **212**. Adjacent protrusions **212** are separated by distance **250** in space **252**. In an example embodiment, **212** extends by distance **144** from portion **122**. As shown in Figure 8B, distance **250** and space **252** are dramatically reduced after compression between dies **222** and **224**. The reduction of space **252** reduces the area through which material can flow from portion **132** to **122A**, which results in the thickening of portion **132** noted above. That is, sheet **216** is compressed in areas under protrusion **126**, resulting in the halting or impeding of material flow from junction **132** to portion **122**.

[0032] It should be understood that the dies shown in Figures 7A and 7B can be differently configured while still providing the surfaces and shapes described above. For example: dies **222** and **228** could be combined into a single die; and dies **224** and **226** could be combined into a single die.

[0033] 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.

What is claimed is:

1. A torque converter, comprising:

a cover arranged to receive torque;

a turbine including:

a turbine shell; and,

a turbine blade fixedly connected to the turbine shell;

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

an inner surface facing the turbine;

an outer surface facing opposite the inner surface;

a first radial portion substantially orthogonal to an axis of rotation for the torque converter;

an axial portion:

substantially parallel to the axis of rotation;

extending from the radial portion;

forming a radially outmost portion of the impeller shell; and,

having a first thickness;

a curved portion radially inward of the first radial portion and including:

a first protrusion;

second and third protrusions radially inward of the first protrusion; and,

a first portion between the first and second protrusions;

a junction portion connecting the radial portion and the curved portion and having a second thickness at least 50 percent greater than the first thickness; and,

an impeller blade fixed to the impeller shell proximate the first, second and third protrusions.

2. The torque converter of claim 1, wherein the first radial portion has a third thickness less than the first thickness.

3. The torque converter of claim 2, wherein the first, second and third thicknesses are measured orthogonal to the inner or outer surface.

4. The torque converter of claim 1, wherein the impeller shell includes:

a second radial portion:

radially inward of the first, second, and third protrusions;

substantially orthogonal to the axis of rotation;

forming a radially inmost portion of the impeller shell; and,

having the first thickness;

the third protrusion is radially inward of the second protrusion; and,

the curved portion includes a second portion:

between the second and third protrusions; and,

having the first thickness.

5. The torque converter of claim 1, wherein the first portion has the first thickness.

6. The torque converter of claim 1, wherein:

the first protrusion extends past the first portion, in a direction orthogonal to the outer surface, by a first amount;

the third protrusion is radially inward of the second protrusion;

the curved portion includes a second portion between the second and third protrusions; and,

the third protrusion extends past the second portion, in the direction, by a second amount more than twice the first amount.

7. The torque converter of claim 1, further comprising:

a lock up clutch; and,

a damper including an input part, an output part and a spring engaged with the input and output parts, wherein:

the lockup clutch is arranged to be open to enable torque flow from the cover to the output hub via the impeller, the turbine and the damper; and,

the lockup clutch is arranged to be closed to enable torque flow from the cover to the output hub via the lockup clutch and the damper.

8. A method of fabricating an impeller for a torque converter, comprising:

forming, using a first plurality of protrusions on a first die and a plurality of indentations in a second die, first, second and third protrusions extending from a first side of a sheet of metal, the sheet of metal having a first thickness;

forming, using the first pluralities of protrusions and the plurality of indentations, first, second, and third slots in the first, second and third protrusions, respectively;

clamping a first portion of the sheet metal, including the first protrusion and the first slot, between:

a first smooth and continuous curved shape formed by a first portion of a third die facing the first side; and,

a second smooth and continuous curved shape formed by a first portion of a fourth die;

compressing a first end portion of the sheet of metal, continuous with the first portion of the sheet metal, between a first surface formed by a second portion of the third die and a second surface formed by a fifth die;

flowing material forming the first end portion into a junction between the first portion and the first end portion;

blocking the flow of material from the junction to the first portion; and,

increasing the thickness of the sheet of metal at the junction to a second thickness greater than the first thickness by at least 50 percent.

9. The method of claim 8, further comprising:

reducing a third thickness of at least a portion of the first end portion to be less than the first thickness.

10. The method of claim 8, wherein clamping the first portion of the sheet metal includes at least partially flattening the first protrusion.

11. The method of claim 10, wherein:

the first portion includes the second protrusion and the second slot; and,

clamping the first portion of the sheet metal includes at least partially flattening the second protrusion.

12. The method of claim 8, further comprising:

clamping a second portion of the sheet of metal between:

a third smooth and continuous curved shape formed by a second portion of the fourth die; and,

a fourth curved shape formed by a first portion of a sixth die and interrupted by a first indentation aligned with the third protrusion

13. The method of claim 12, wherein clamping the second portion of the sheet of metal includes receiving the third protrusion in the first indentation without substantially flattening the third protrusion.

14. The method of claim 12, further comprising:

compressing a second end portion of the sheet of metal, opposite the first end portion of the sheet of metal, and continuous with the second portion of the sheet metal, between third and fourth surfaces formed by a second portion of the sixth die and a seventh die, respectively.

15. A method of fabricating an impeller for a torque converter, comprising:

forming, using a first plurality of protrusions on a first die and a plurality of indentations in a second die, first, second and third protrusions extending from a first side of a sheet of metal, the sheet of metal having a first thickness;

forming, using the first pluralities of protrusions and the plurality of indentations, first die, first, second, and third slots in the first, second and third protrusions, respectively;

clamping a first portion of the sheet metal, including the first protrusion and the first slot, between:

a first smooth and continuous curved shape formed by a first portion of a third die facing the first side; and,

a second smooth and continuous curved shape formed by a first portion of a fourth die;

at least partially flattening the first protrusion with the first portion of the third die;

compressing a first end portion of the sheet of metal, continuous with the first portion of the sheet metal, between a first surface formed by a second portion of the third die and a second surface formed by a fifth die;

flowing material forming the first end portion into a junction between the first portion and the first end portion;

blocking the flow of material from the junction to the first portion; and,

increasing the thickness of the sheet of metal at the junction to a second thickness greater than the first thickness by at least 50 percent.

16. The method of claim 15, further comprising:

reducing a third thickness of at least a portion of the first end portion to be less than the first thickness.

17. The method of claim 15, wherein:

the first portion includes the second protrusion and the second slot; and,

clamping the first portion of the sheet metal includes at least partially flattening the second protrusion.

18. The method of claim 15, further comprising:

clamping a second portion of the sheet of metal between:

a third smooth and continuous curved shape formed by a second portion of the fourth die; and,

a smooth curved shape formed by a first portion of a sixth die and interrupted by a first indentation aligned with the third protrusion.

19. The method of claim 18, wherein clamping the second portion of the sheet of metal includes receiving the third protrusion in the first indentation without substantially flattening the third protrusion.

20. The method of claim 15, further comprising:

compressing a second end portion of the sheet of metal, opposite the first end portion of the sheet of metal, and continuous with the second portion of the sheet metal, between third and fourth surfaces formed by second portion of the sixth die and a seventh die, respectively.

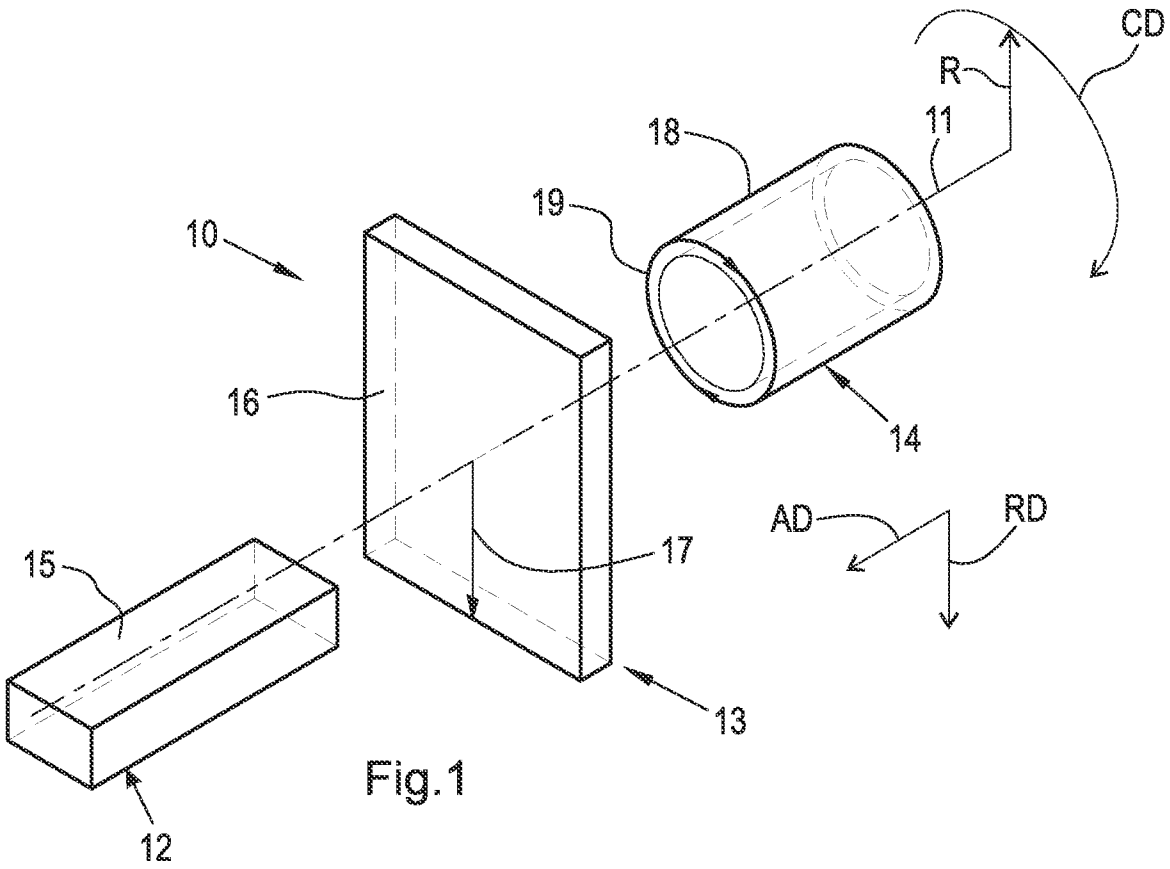


Fig.1

Fig.1

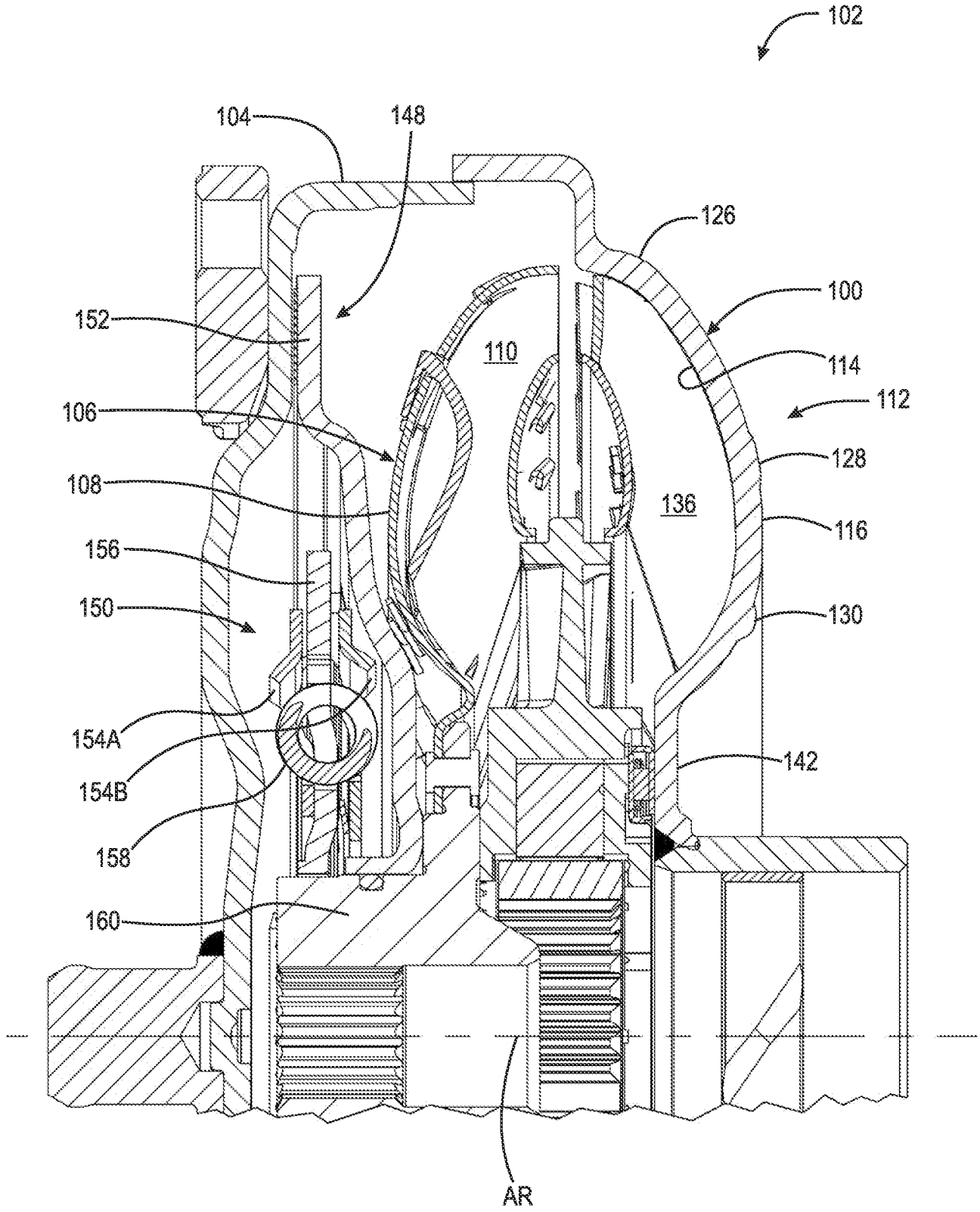

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148
126
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156
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154A
142
154B
158
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AR

Fig. 2

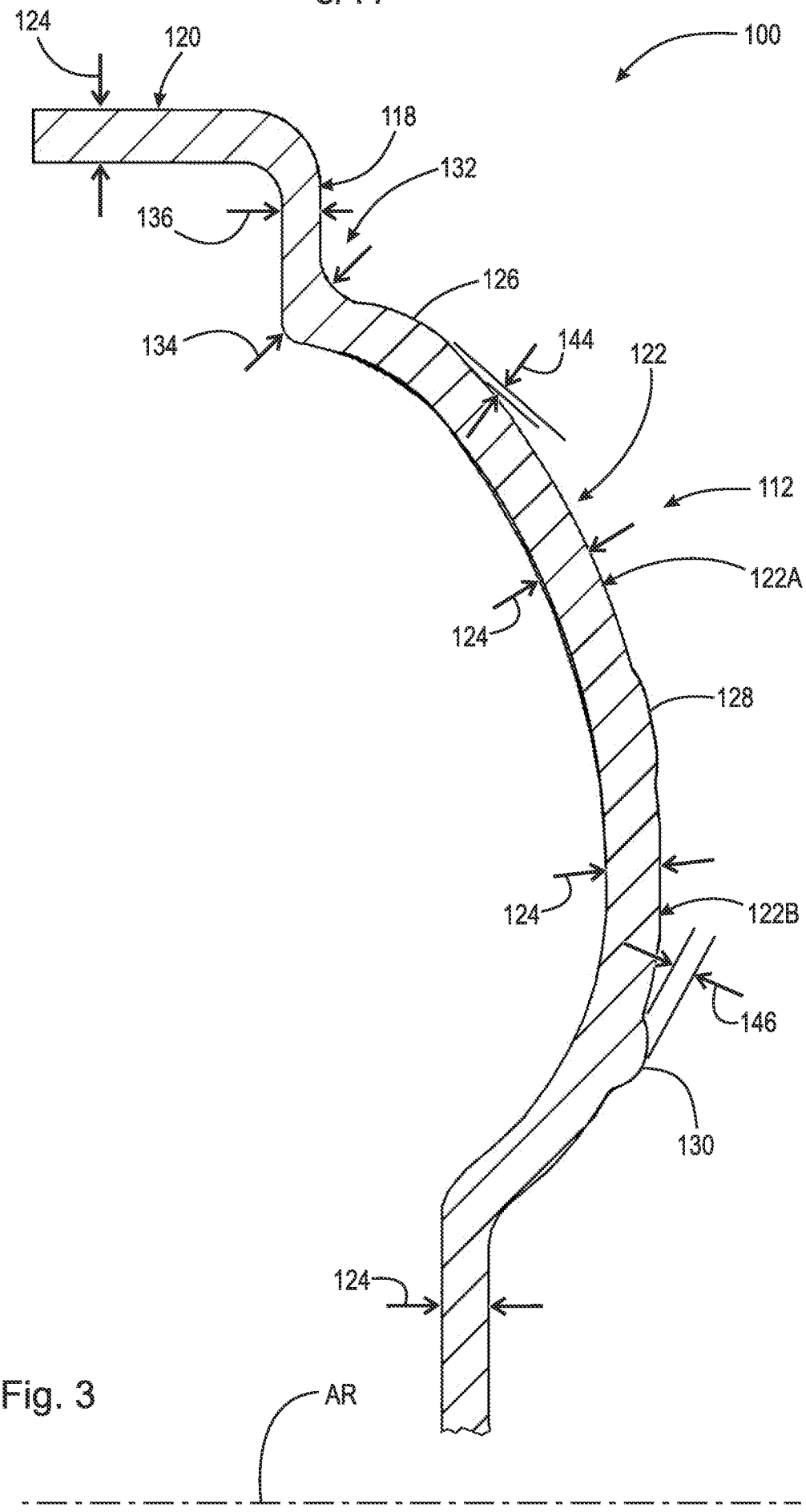

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144
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122A
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122B
146
130
124
AR

Fig. 3

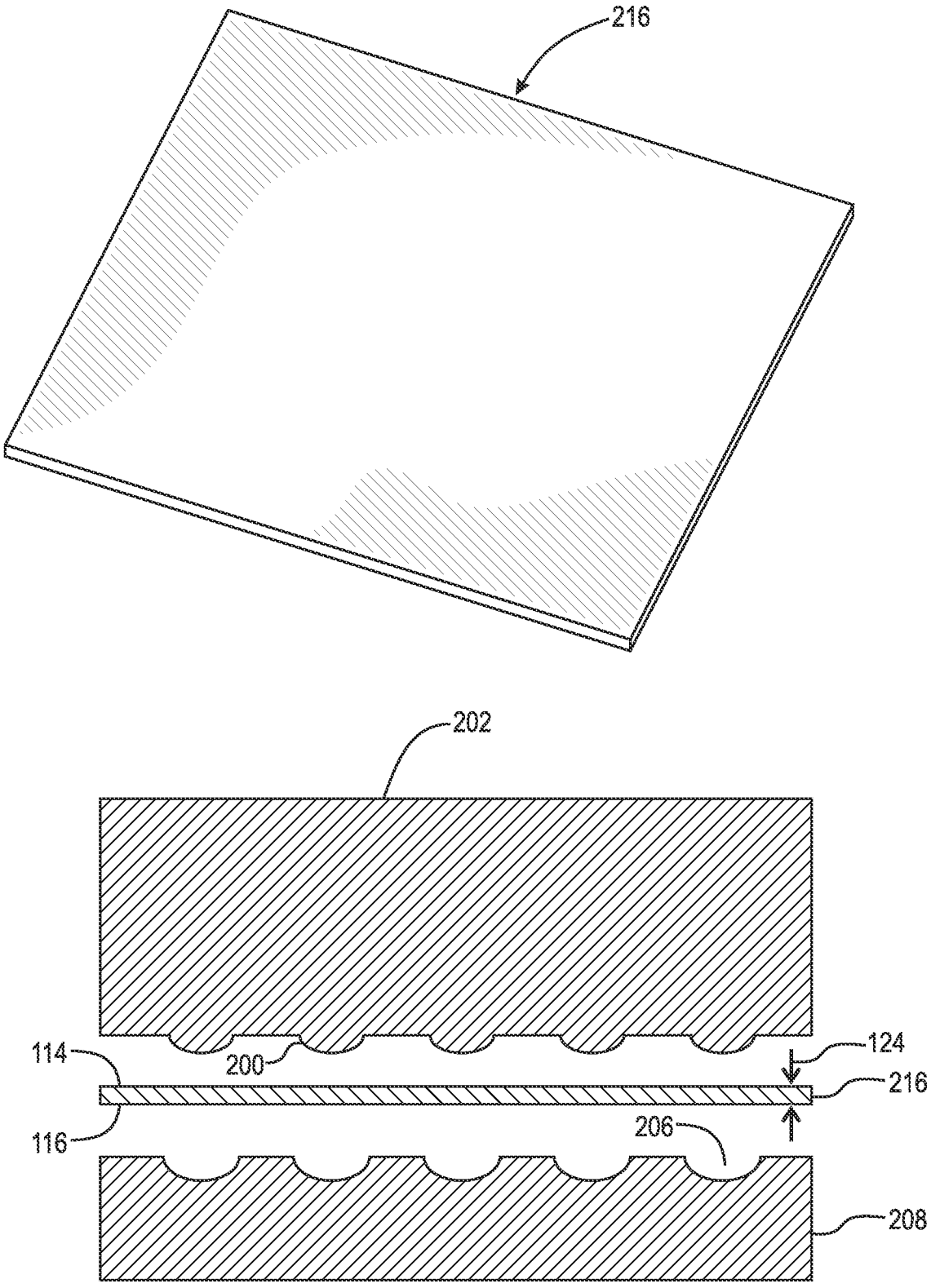


Fig. 4

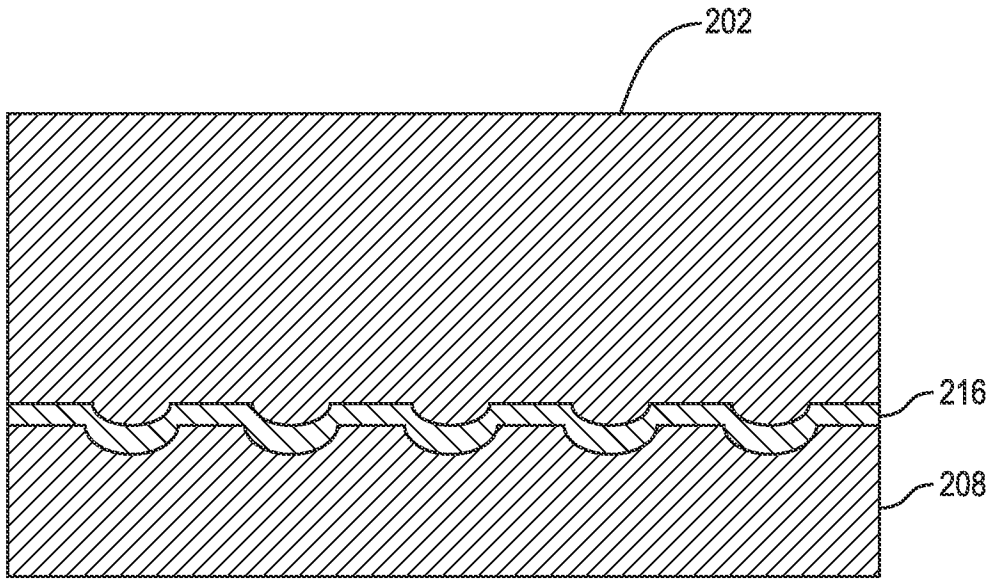


Fig. 5

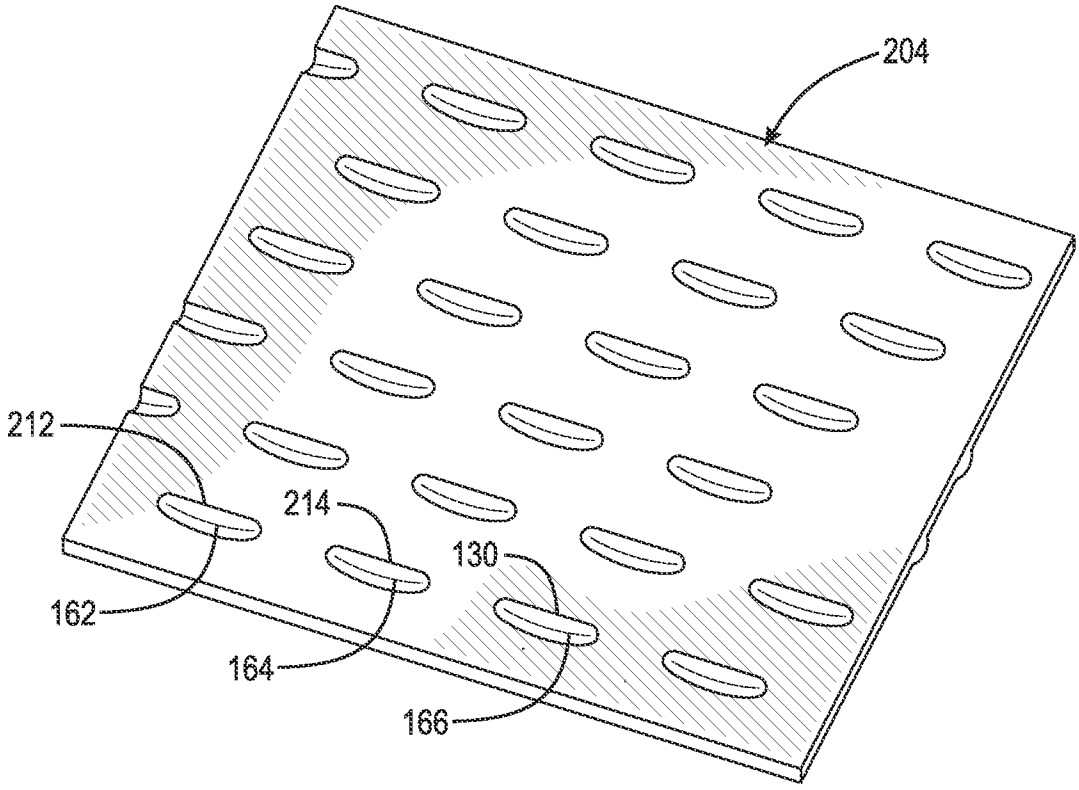


Fig. 6

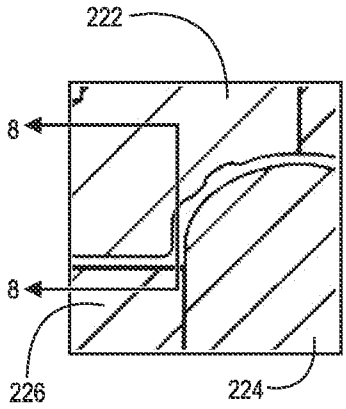

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Fig. 7B

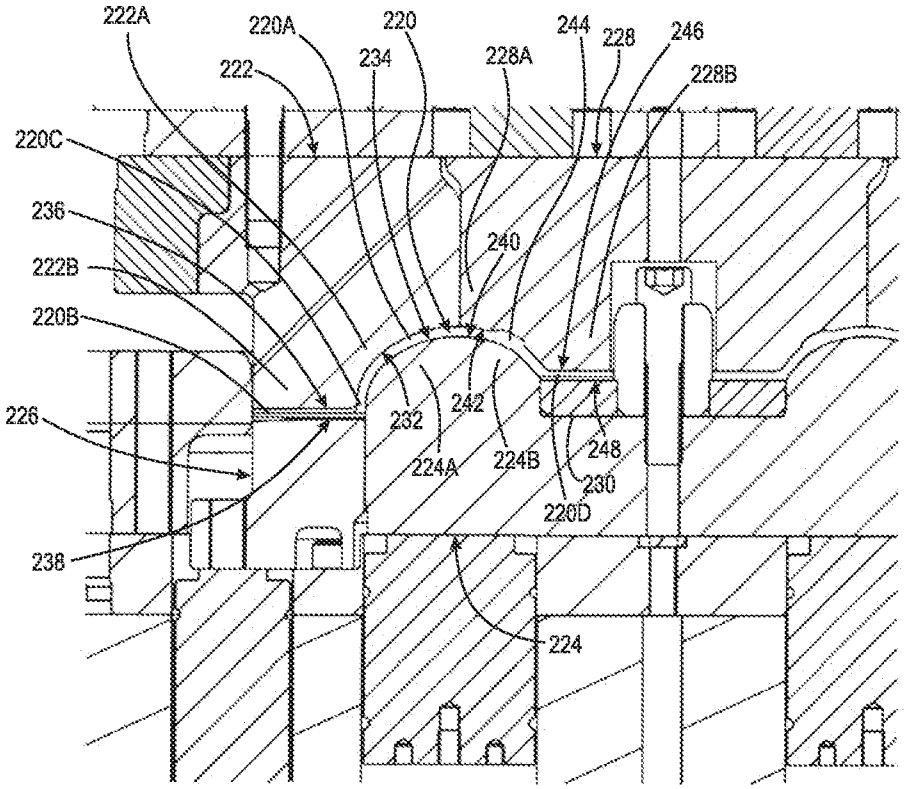

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220A
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228A
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228
246
228B
220C
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222B
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224A
224B
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230
220D
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Fig. 7A

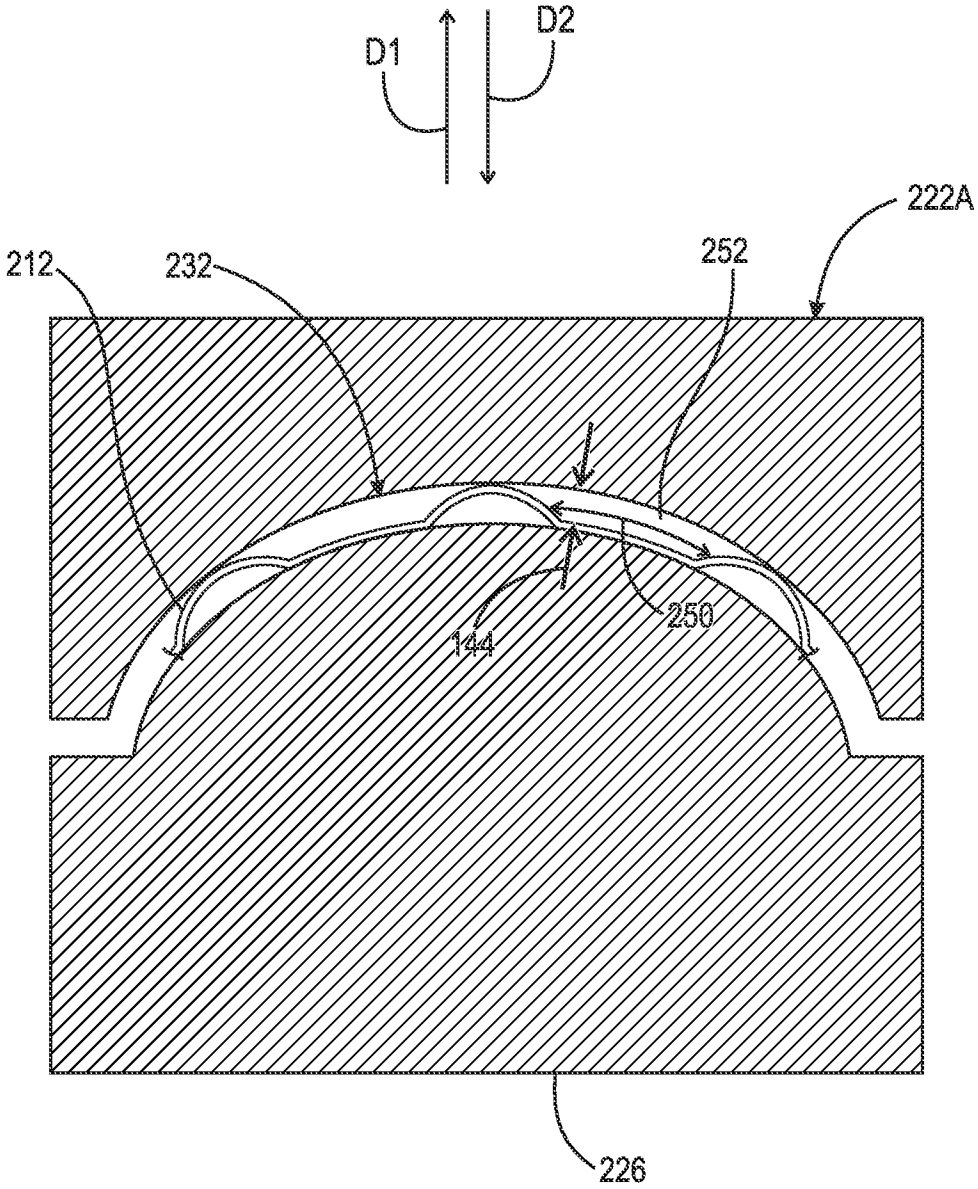


Fig. 8A

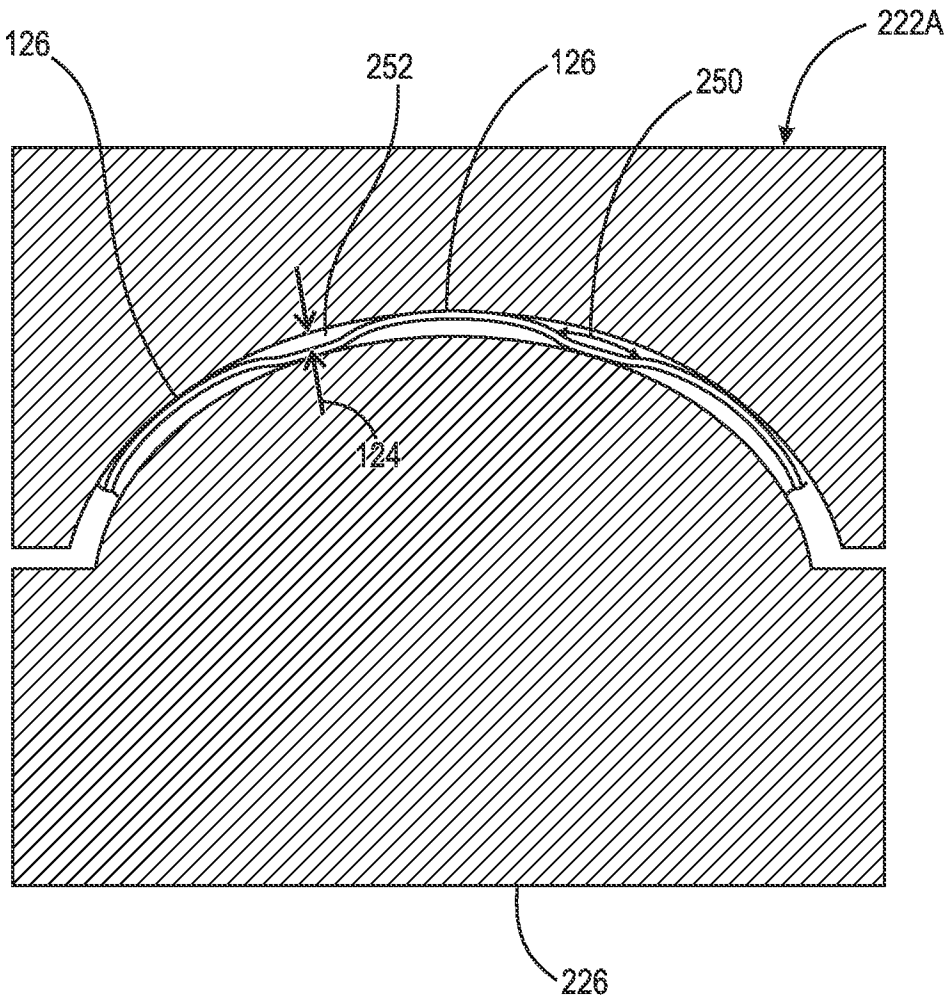
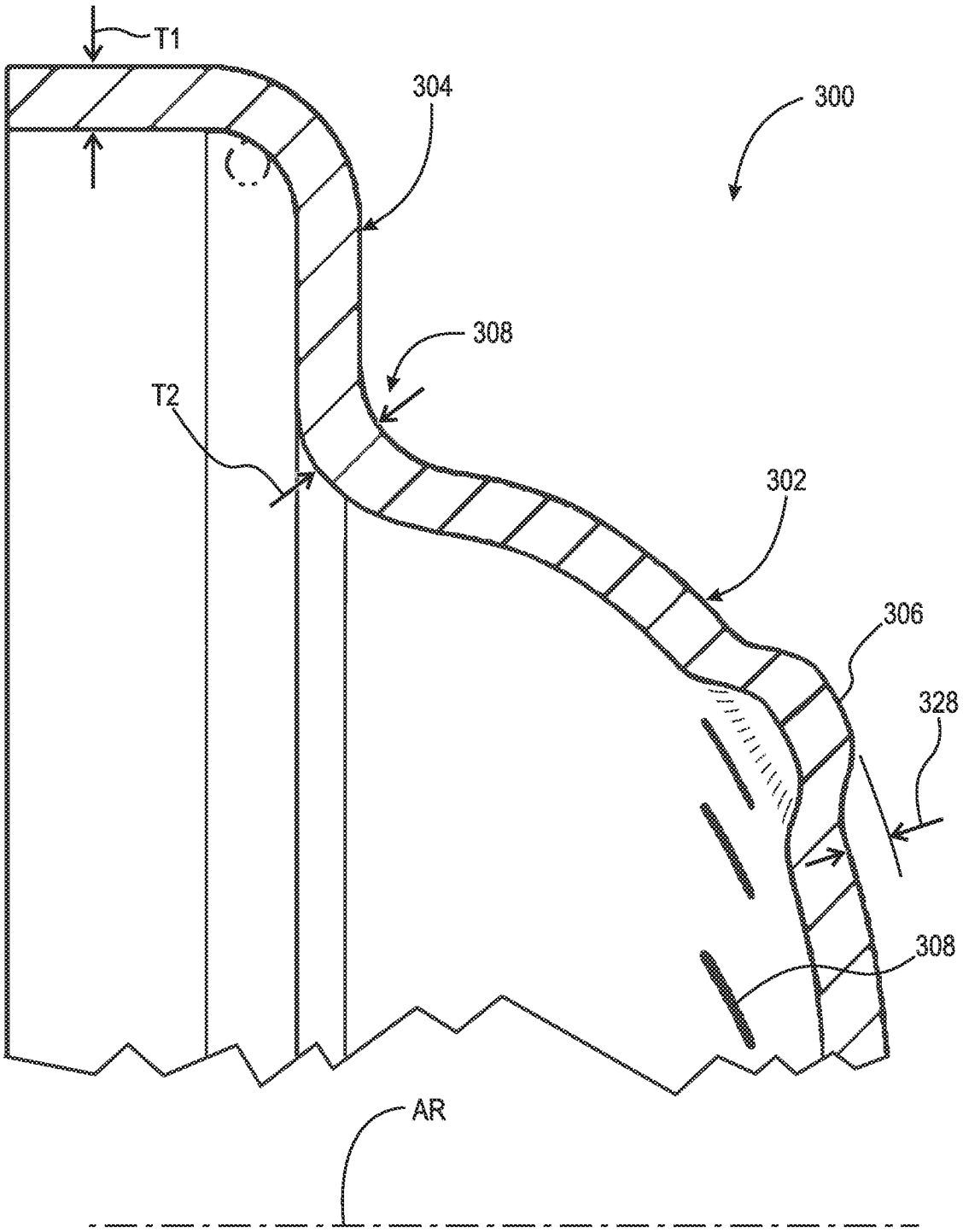
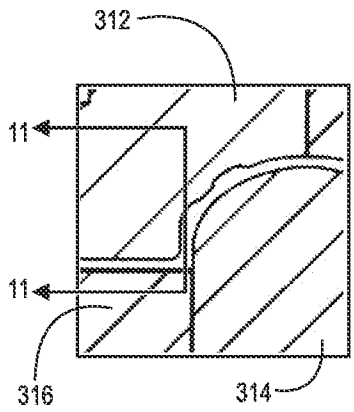


Fig. 8B



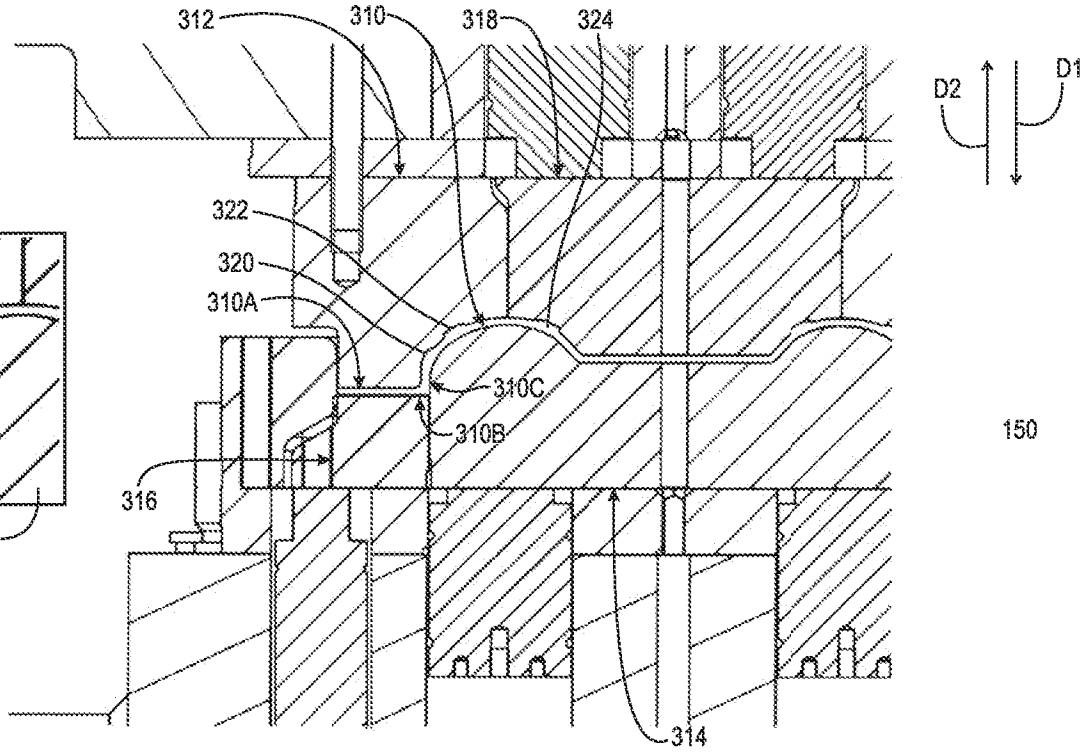
PRIOR ART

Fig. 9



PRIOR ART

Fig. 10B



PRIOR ART

Fig. 10A

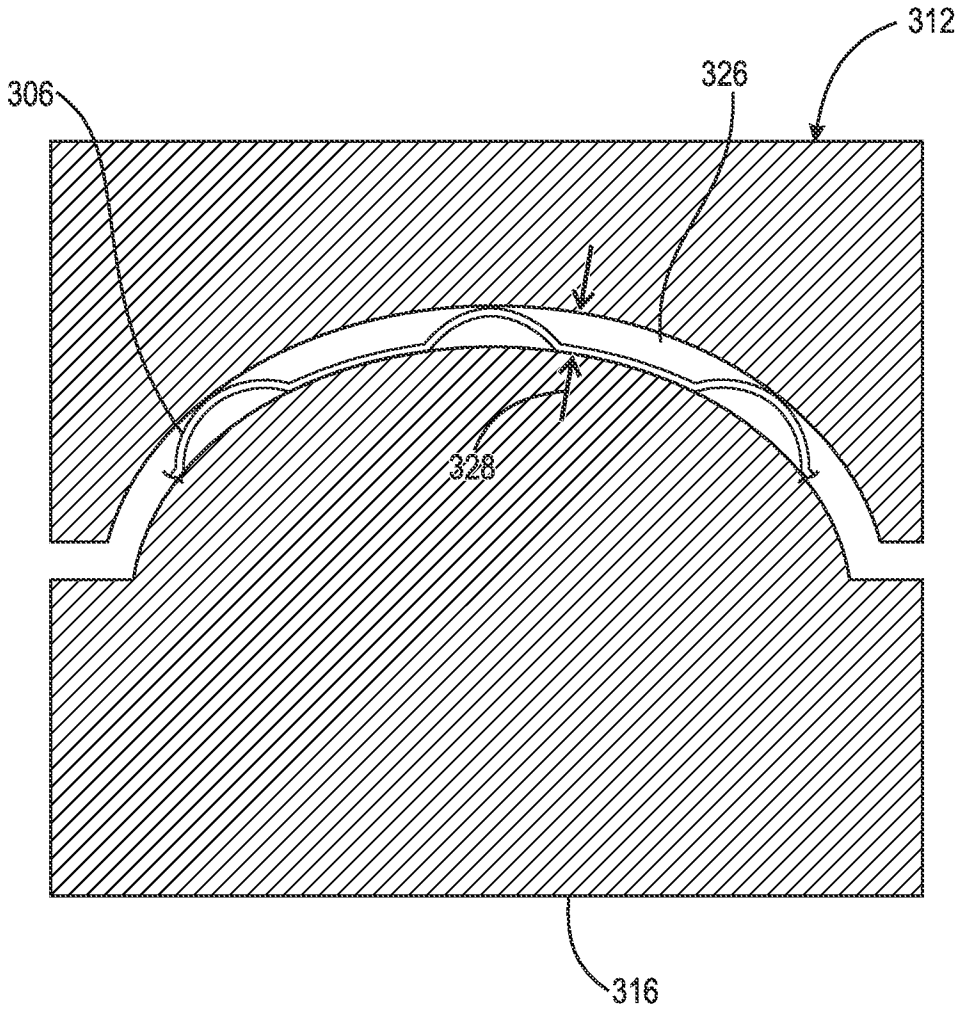


Fig. 11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/012678

A. CLASSIFICATION OF SUBJECT MATTER

F16H 41/02(2006.01)i, F16H 41/28(2006.01)i, F16H 45/02(2006.01)i, F01D 5/22(2006.01)i, F16D 33/00(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 41/02; F16H 45/02; F16H 41/26; B21D 22/30; F16H 41/28; B21D 22/26; B21D 22/16; F01D 5/22; F16D 33/00

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: torque converter, clamping, compressing, junction, thickness, and slot

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5996391 A (MIZOBUCHI, NAOKI) 07 December 1999 See column 3, lines 28-67, column 4, lines 15-49, column 5, lines 12-20 and figures 1-4.	1-7
Y		8-20
Y	US 2004-0250594 A1 (SCHWENK, WILFRIED) 16 December 2004 See paragraphs [0026]-[0028] and figures 1, 2.	8-20
A	JP 2002-039322 A (NISSAN MOTOR CO., LTD.) 06 February 2002 See paragraphs [0036], [0037], [0040] and figures 1, 3.	1-20
A	JP 11-002304 A (EXEDY CORP.) 06 January 1999 See paragraphs [0017]-[0020] and figures 1, 4.	1-20
A	US 2003-0217902 A1 (KUWAHARA, KUNIAKI) 27 November 2003 See paragraphs [0012]-[0014] and figures 1, 2.	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
"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
10 September 2015 (10.09.2015)	**11 September 2015 (11.09.2015)**

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2015/012678

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JP 11-002304 A	06/01/1999	None	
US 2003-0217902 A1	27/11/2003	DE 10313354 A1	20/11/2003
		DE 10313354 B4	26/10/2006
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