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(54) Title: CLUTCH DISC WITH AXIALLY EXPANDED SPLINE TEETH

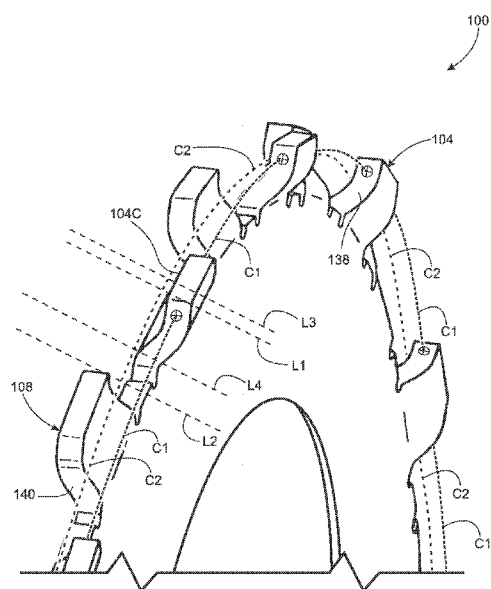


Fig. 4

(57) Abstract: A clutch disc, including: an axis of rotation; an annular core ring; a first plurality of spline teeth forming a first radially outermost portion of the clutch disc; and a second plurality of spline teeth forming a second radially outermost portion of the clutch disc, respective spline teeth in the second plurality of spline teeth alternating, in a circumferential direction, with respective teeth in the first plurality of spline teeth. A circle passing through the first plurality of spline teeth does not pass through the second plurality of spline teeth.

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CLUTCH DISC WITH AXIALLY EXPANDED SPLINE TEETH

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TECHNICAL FIELD

[0001] The present disclosure relates to a clutch disc having axially expanded spline teeth, in particular, spline teeth alternating in a circumferential direction and extending axially beyond a core ring for the clutch disc.

BACKGROUND

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[0002] At high rotational speeds, known clutch discs can flutter or wobble from side to side, for example, due to turbulent fluid forces buffeting the clutch discs. As the clutch discs flutter, the clutch discs contact clutch pack separator discs, resulting in an undesirable increase in drag torque for a clutch including the clutch discs. Grooves have been added to known clutch discs to address the flutter or wobble problem. However, the grooves have not

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[0003] Figure 9 is a partial cross-sectional view of known cast aluminum clutch disc **200**. Cast aluminum clutch disc **200** includes spline teeth **202** wider than core ring **204** for clutch disc **200**. However, cast aluminum clutch discs are more costly to fabricate than stamped steel clutch discs.

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[0004] Figures 10A and 10B are respective cross-sectional views of known clutch discs **300**. In Figures 10A and 10B, radially inner portions of core ring **302** have been folded over to form spline tooth **304**. Thus, core ring **302** and portions **304A** and **304B** of tooth **304** have a same thickness **306**. The 180 degree bend required to form portions **304A** and **304B** stresses tooth **304**, in particular at rounded ends **304C**, reducing the durability of tooth **304**.

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In Figure 10A, tooth **304** is axially asymmetrical with respect to ring **302**, for example, all of portion **304A** is radially aligned with ring **302** and portion **304B** extends past ring **302** in axial direction **AD**. In Figure 10B, portions **304A** and **304B** are axially centered (symmetrical) with respect to ring **302**; however, thickness **306** has been reduced. Reducing thickness **306** reduces the durability of disc **300**. Further, rounded ends **304C** of teeth **304**

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reduce the area of sides **308** and **310** parallel to ring **302** and in contact with a hub or other clutch component in which disc **300** is installed. Reducing the area reduces the stability of disc **300** in a clutch and increases the likelihood of disc **300** fluttering or wobbling. Increasing the area of sides **308** and **310** in contact with the hub or other clutch component,

by increasing the depth of a groove receiving tooth **304**, increases the cost of fabricating the hub or other component and may compromise the durability of the hub or other clutch component.

SUMMARY

5 **[0005]** According to aspects illustrated herein, there is provided a clutch disc, including: an axis of rotation; an annular core ring; a first plurality of spline teeth forming a first radially outermost portion of the clutch disc; and a second plurality of spline teeth forming a second radially outermost portion of the clutch disc, respective spline teeth in the second plurality of spline teeth alternating, in a circumferential direction, with respective
10 teeth in the first plurality of spline teeth. A circle passing through the first plurality of spline teeth does not pass through the second plurality of spline teeth.

[0006] According to aspects illustrated herein, there is provided a clutch disc, including: an axis of rotation; an annular core ring having first and second sides facing in first and second axial directions, respectively; a first plurality of spline teeth forming a first
15 radially outermost portion of the clutch disc and including respective first sides located further than the first and second sides in the first axial direction; and a second plurality of spline teeth forming a second radially outermost portion of the clutch disc and including respective first sides located further than the first and second sides in the second axial direction. Respective spline teeth included in the first plurality of spline teeth alternate, in a
20 circumferential direction, with respective spline teeth included in the second plurality of spline teeth.

[0007] According to aspects illustrated herein, there is provided a clutch disc, including: an axis of rotation; an annular core ring including first and second sides facing in first and second axial directions, respectively, and separated by a first distance in the first
25 axial direction; a first spline tooth including a first side located past the first and second sides of the annular core ring in the first axial direction and a second side facing in the second axial direction; and a second spline tooth including a first side located past the first and second sides of the annular core ring in the second axial direction and a second side facing in the first axial direction. The second side of the first spline tooth and the second side of the
30 second spline tooth are separated, in the first axial direction, by a second distance: equal to the first distance; or less than the first distance; or greater than the first distance.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Various embodiments are disclosed, by way of example only, with reference to the accompanying schematic drawings in which corresponding reference symbols indicate corresponding parts, 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 front perspective view of a clutch disc with axially expanded spline teeth;

Figure 3 is a back perspective view of the clutch disc of Figure 2;

Figure 4 is a detail of area 4 in Figure 2 with friction facing removed;

Figure 5 is a cross-sectional view, generally along line 5,6,7-5,6,7 in Figure 3, showing spline teeth axially separated by a distance equal to a thickness of an annular core ring for the clutch disc;

Figure 6 is a cross-sectional view, generally along line 5,6,7-5,6,7 in Figure 3, showing spline teeth axially separated by a distance less than a thickness of the annular core ring for the clutch disc;

Figure 7 is a cross-sectional view, generally along line 5,6,7-5,6,7 in Figure 3, showing spline teeth axially separated by a distance greater than a thickness of the annular core ring for the clutch disc;

Figure 8 is the view of Figure 5 with a portion of an output hub included;

Figure 9 is a partial cross-sectional view of a known art cast aluminum clutch disc; and,

Figures 10A and 10B are respective cross-sectional views of known clutch discs.

DETAILED DESCRIPTION

[0009] 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.

[0010] 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.

[0011] 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.

5 [0012] 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
10 11. Circumferential direction **CD** is defined by an endpoint of radius **R** (orthogonal to axis 11) rotated about axis 11.

[0013] 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 planar surface 15; however any planar surface co-planar with axis 11 is an
15 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 planar surface 16; however any planar 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
20 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
25 circumferentially disposed surface or edge extends in direction **CD**.

[0014] Figure 2 is a front perspective view of clutch disc 100 with axially expanded spline teeth.

[0015] Figure 3 is a back perspective view of clutch disc 100 of Figure 2. The following should be viewed in light of Figures 2 and 3. Clutch disc 100 includes axis of
30 rotation **AR**, annular core ring 102, spline teeth 104 forming radially outermost portion 106 of clutch disc 100, and spline teeth 108 forming radially outermost portion 110 of clutch disc 100. To simplify the visual representation of clutch 100, only respective parts of portions 106

and **110** are labeled in Figure 3. Respective teeth **104** alternate, in circumferential direction **CD**, with respective teeth **108**. For example, teeth **104A** and **104B** alternate with teeth **108A** and **108B** in direction **CD**.

[0016] Figure 4 is a detail of area 4 of Figure 2 with friction facing removed.

5 [0017] Figure 5 is a cross-sectional view, generally along line 5,6,7-5,6,7 in Figure 3, showing spline teeth axially separated by a distance equal to a thickness of an annular core ring for clutch disc **100**. The following should be viewed in light of Figures 2 through 5. Circle **C1**, centered on axis **AR**, passes through spline teeth **104** without passing through spline teeth **108**. Line **L1**, parallel to axis of rotation **AR**, passes through circle **C1** and a tooth, for example tooth **104C**, included in spline teeth **104** without passing through any tooth included in spline teeth **108**. Line **L2**, parallel to axis of rotation **AR** passes through circle **C1** without passing through any spline tooth included in spline teeth **104** or spline teeth **108**. Spline teeth **104** are free of contact with spline teeth **108**.

[0018] Circle **C2**, centered on axis **AR**, passes axially between spline teeth **104** and spline teeth **108**, without passing through spline teeth **104** or spline teeth **108**. Line **L3**, parallel to axis of rotation **AR**, passes through circle **C2** and a tooth, for example tooth **104C**, included in spline teeth **104** without passing through any tooth included in spline teeth **108**. Line **L4**, parallel to axis of rotation **AR** passes through circle **C2** without passing through any spline tooth included in spline teeth **104** or spline teeth **108**.

20 [0019] Annular core ring **102** has thickness **112** in axial direction **AD1**. Each spline tooth spline tooth **104** includes radially outermost end **114** with dimension **116**, in axial direction **AD1**. Each spline tooth spline tooth **108** includes radially outermost end **118** with dimension **120**, in axial direction **AD1**. In an example embodiment, dimensions **116** and **120** are each equal to thickness **112**. In an example embodiment, dimensions **116** and **120** are each no greater than thickness **112**.

[0020] Annular core ring **102** includes side **120** facing in axial direction **AD1** and side **122** facing in axial direction **AD2**, opposite direction **AD1**. Each spline tooth **104** includes side **124** located further than sides **120** and **122** in axial direction **AD1**. Each spline tooth **108** includes side **126** located further than sides **120** and **122** in axial direction **AD2**. Each spline tooth **104** includes side **128** facing axial direction **AD2**. Each spline tooth **108** includes side **130** facing axial direction **AD1**. Plane **P1**, orthogonal to axis of rotation **AR** passes through side **120**. Plane **P2**, orthogonal to axis of rotation **AR** passes through sides

128. In an example embodiment, planes **P1** and **P2** are co-linear. In the example embodiment of Figure 5, sides **128** and **130** are separated, in axial direction **AD1**, by distance **132** equal to thickness **112**.

[0021] Figure 6 is a cross-sectional view, generally along line 5,6,7-5,6,7 in Figure 3, showing spline teeth axially separated by a distance less than a thickness of the annular core ring for clutch disc **100**. The discussion for clutch disc **100** in Figures 2 through 5 is applicable to clutch disc **100** in Figure 6, except as follows. In the example of Figure 6, planes **P1** and **P2** are separated by distance **134** in axial direction **AD1**, that is, planes **P1** and **P2** are not co-planar and plane **P2** is past plane **P1** in direction **AD2**. In the example embodiment of Figure 6, sides **128** and **130** are separated, in axial direction **AD**, by distance **132** less than thickness **112**.

[0022] Figure 7 is a cross-sectional view, generally along line 5,6,7-5,6,7 in Figure 3, showing spline teeth axially separated by a distance greater than a thickness of the annular core ring for clutch disc **100**. The discussion for clutch disc **100** in Figures 2 through 5 is applicable to clutch disc **100** in Figure 7, except as follows. In the example of Figure 7, planes **P1** and **P2** are separated by distance **134** in axial direction **AD1**, that is, planes **P1** and **P2** are not co-planar and plane **P1** is past plane **P2** in direction **AD2**. In the example embodiment of Figure 7, sides **128** and **130** are separated, in axial direction **AD1**, by distance **132** greater than thickness **112**.

[0023] The following provides further detail regarding clutch disc **100**. In an example embodiment, sides **124** and **126** are orthogonal to axis of rotation **AR**, that is sides **124** and **126** are parallel to sides **120** and **122**, respectively. The orientation of sides **124** and **126**, and the circumferential interleaving of spline teeth **104** and **108** enable teeth **104** and **108** to be fabricated using standard stamping processes.

[0024] Figure 8 is Figure 5 with a portion of output hub **OH** included. The following should be viewed in light of Figures 2 through 5. However, it should be understood that the discussion for Figure 8 is applicable to Figures 6 and 7 as well. Advantageously, the parallel configuration of ring **102** and teeth **104** and **108** enables maximum mating contact between sides **124** and **126** and sides **S1** and **S2** of groove **G** in hub **OH**. Increasing the mating contact increases the stability of disc **100** in hub **OH**, reducing any tendency of disc **100** to tip, flutter or wobble.

[0025] In Figure 2, friction facing **136** is fixed to side **120**. Any friction facing known in the art can be used for facing **136**. In an example embodiment (not shown), friction facing is fixed to side **122**. As noted above, disc **100** can be fabricated using metal stamping processes. In an example embodiment, such processes result in curved segments **138** and **140** for teeth **104** and teeth **108**, respectively, connecting ring **102** with teeth **104** and **108**, respectively.

[0026] Advantageously, the axially expanded configuration of teeth **104** and **108**, that is expanding teeth **104** and **108** to extend past ring **102** in directions **AD1** and **AD2**, respectively, creates a wider and more stable base for clutch disc **100** when disc **100** is installed in hub **OH**. The wider more stable base increases the stability of disc **100** in hub **OH**, reducing any tendency of disc **100** to tip, flutter or wobble. Further, the circumferential interleaving of teeth **104** and **108** enables nesting of adjacent discs **100**, reducing the axial space required for a clutch having multiple discs **100**.

[0027] 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
	AR	axis of rotation
	C1	circle
5	C2	circle
	CD	circumferential direction
	G	groove
	L1	axial line
	L2	axial line
10	L3	axial line
	L4	axial line
	OH	output hub
	P1	radial plane
	P2	radial plane
15	S1	side of groove G
	S2	side of groove G
	100	clutch disk
	102	core ring
	104	spline teeth
20	104A	spline tooth
	104B	spline tooth
	104C	spline tooth
	106	radially outermost portion of clutch disc 100
	108	spline teeth
25	108A	spline tooth
	108B	spline tooth
	110	radially outermost portion of clutch disc 100
	112	thickness of core ring 102
	114	radially outermost end of teeth 104
30	116	axial dimension of end 114
	118	radially outermost end of teeth 108
	120	axial dimension of end 118
	120	side of core ring 102

	122	side of core ring 102
	124	side of teeth 104
	126	side of teeth 108
	128	side of teeth 104
5	130	side of teeth 108
	132	axial distance
	134	axial distance
	136	friction facing
	138	curved segment for teeth 104
10	140	curved segment for teeth 108

CLAIMS

1. A clutch disc, comprising:
an axis of rotation;
5 an annular core ring;
a first plurality of spline teeth forming a first radially outermost portion of the clutch disc; and,
a second plurality of spline teeth forming a second radially outermost portion of the clutch disc, respective spline teeth in the second plurality of spline teeth alternating, in a circumferential direction, with respective teeth in the first plurality of spline teeth, wherein a
10 circle passing through the first plurality of spline teeth does not pass through the second plurality of spline teeth.
2. The clutch disc of claim 1, wherein a line parallel to the axis of rotation passes
15 through the circle and a tooth in the first plurality of spline teeth without passing through any tooth in the second plurality of spline teeth.
3. The clutch disc of claim 1, wherein a line parallel to the axis of rotation passes through the circle without passing through any spline tooth in the first or second plurality of
20 spline teeth.
4. The clutch disc of claim 1, wherein the first plurality of spline teeth is free of contact with the second plurality of spline teeth.
- 25 5. The clutch disc of claim 1, wherein:
the annular core ring has a thickness in an axial direction;
each spline tooth in the first plurality of spline teeth includes a radially outermost end with a dimension, in the axial direction, equal to the thickness of the annular core ring; and,
each spline tooth in the second plurality of spline teeth includes a radially outermost
30 end with a dimension, in the axial direction, equal to the thickness of the annular core ring.
6. The clutch disc of claim 1, wherein:

the annular core ring has first and second sides facing in first and second axial directions, respectively;

a spline tooth in the first plurality of spline teeth includes a first side located further than the first and second sides of the annular core ring in the first axial direction; and,

5 a spline tooth in the second plurality of spline teeth includes a first side located further than the first and second sides of the annular core ring in the second axial direction.

7. The clutch disc of claim 1, wherein the respective spline teeth in the first plurality of spline teeth are separated, in a circumferential direction, from the respective spline teeth in
10 the second plurality of spline teeth.

8. A clutch disc, comprising:

an axis of rotation;

15 an annular core ring having first and second sides facing in first and second axial directions, respectively;

a first plurality of spline teeth:

forming a first radially outermost portion of the clutch disc; and,

including respective first sides located further than the first and second sides of the annular core ring in the first axial direction; and,

20 a second plurality of spline teeth:

forming a second radially outermost portion of the clutch disc; and,

including respective first sides located further than the first and second sides of the annular core ring in the second axial direction, wherein respective spline teeth included in the first plurality of spline teeth alternate, in a circumferential direction, with respective
25 spline teeth included in the second plurality of spline teeth.

9. The clutch disc of claim 8, wherein a circle passing through the first plurality of spline teeth does not pass through the second plurality of spline teeth.

30 10. A clutch disc, comprising:

an axis of rotation;

an annular core ring including first and second sides facing in first and second axial directions, respectively, and separated by a first distance in the first axial direction; and,

a first spline tooth including:

5 a first side located past the first and second sides of the annular core ring in the first axial direction; and,

a second side facing in the second axial direction; and,

a second spline tooth including:

a first side located past the first and second sides of the annular core ring in the second axial direction; and,

10 a second side facing in the first axial direction, wherein the second side of the first spline tooth and the second side of the second spline tooth are separated, in the first axial direction, by a second distance:

equal to the first distance; or,

less than the first distance; or,

15 greater than the first distance.

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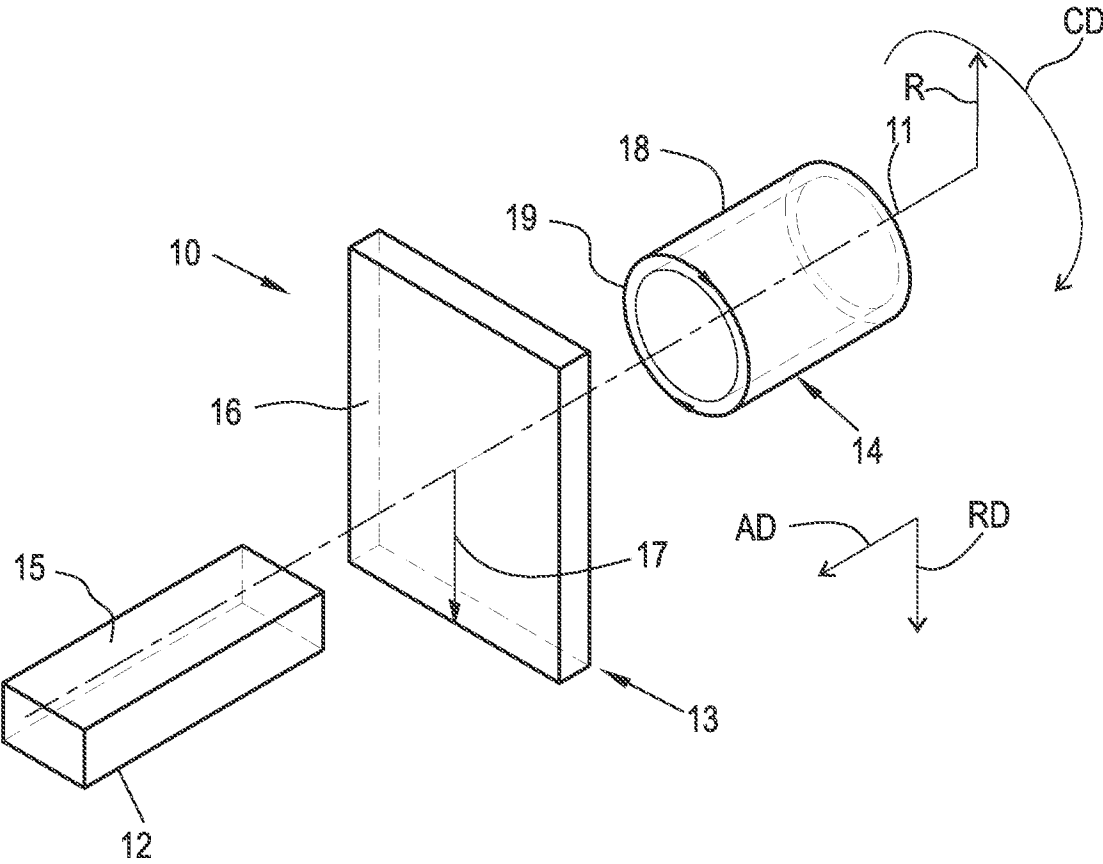


Fig. 1

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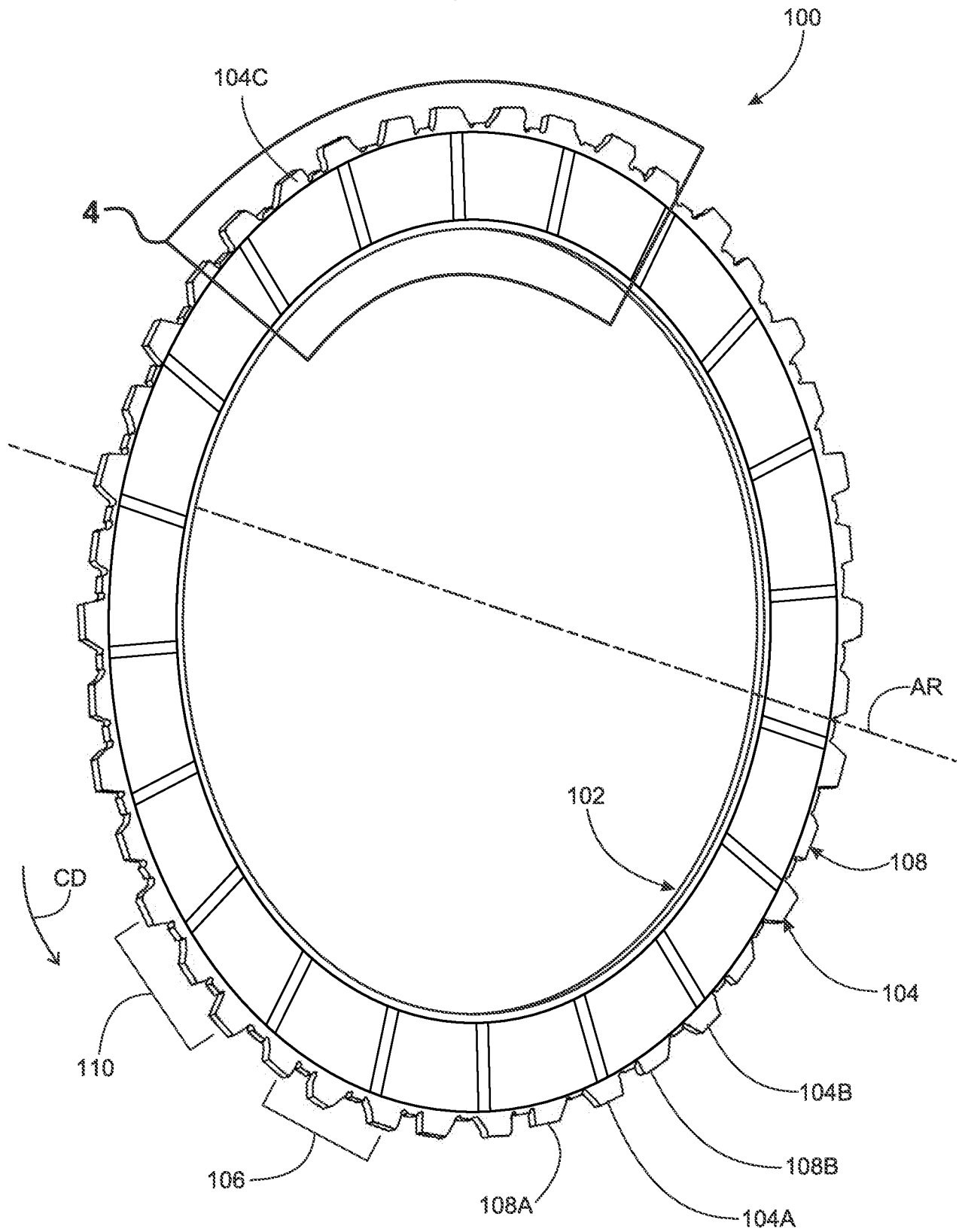


Fig. 2

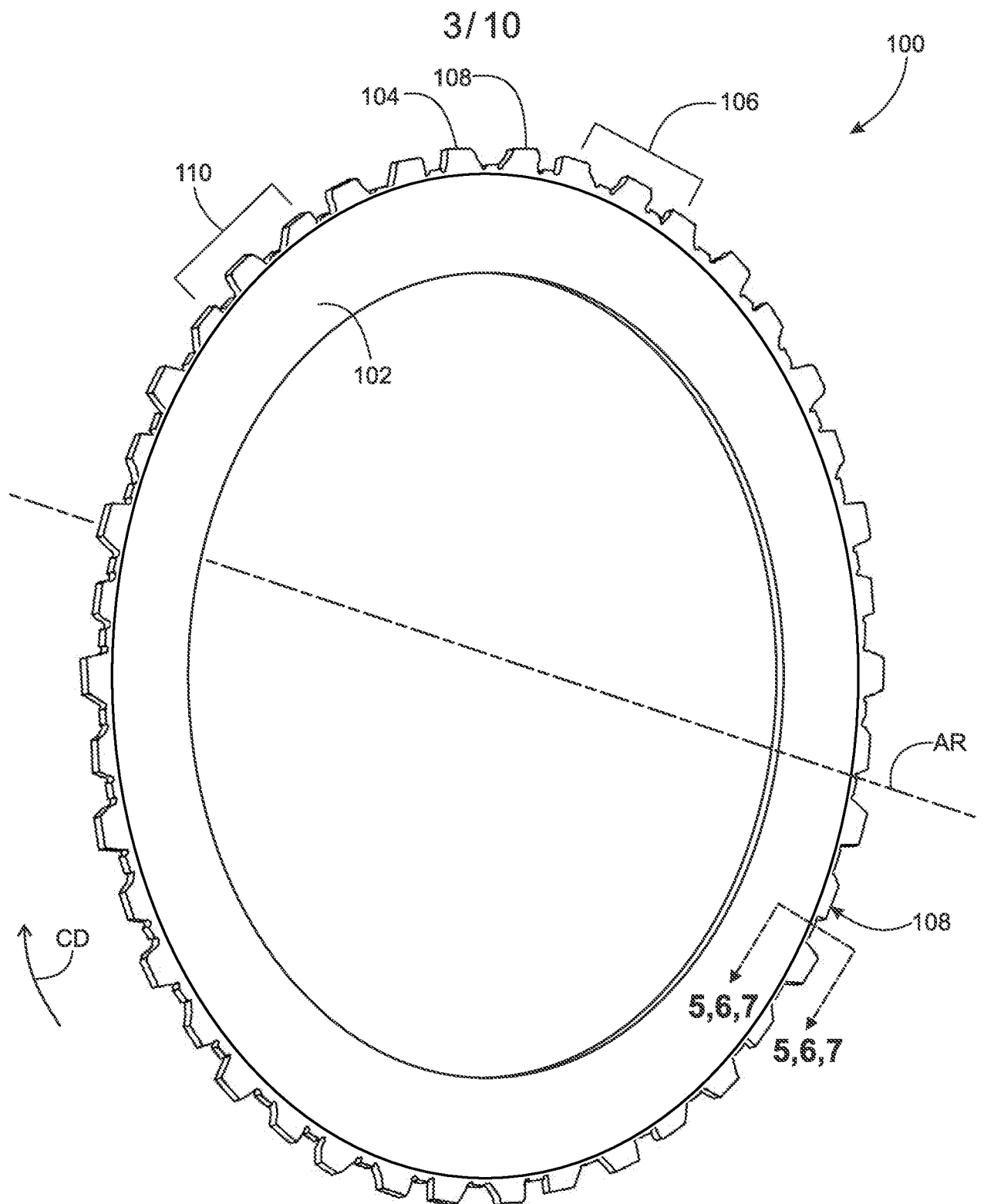


Fig. 3

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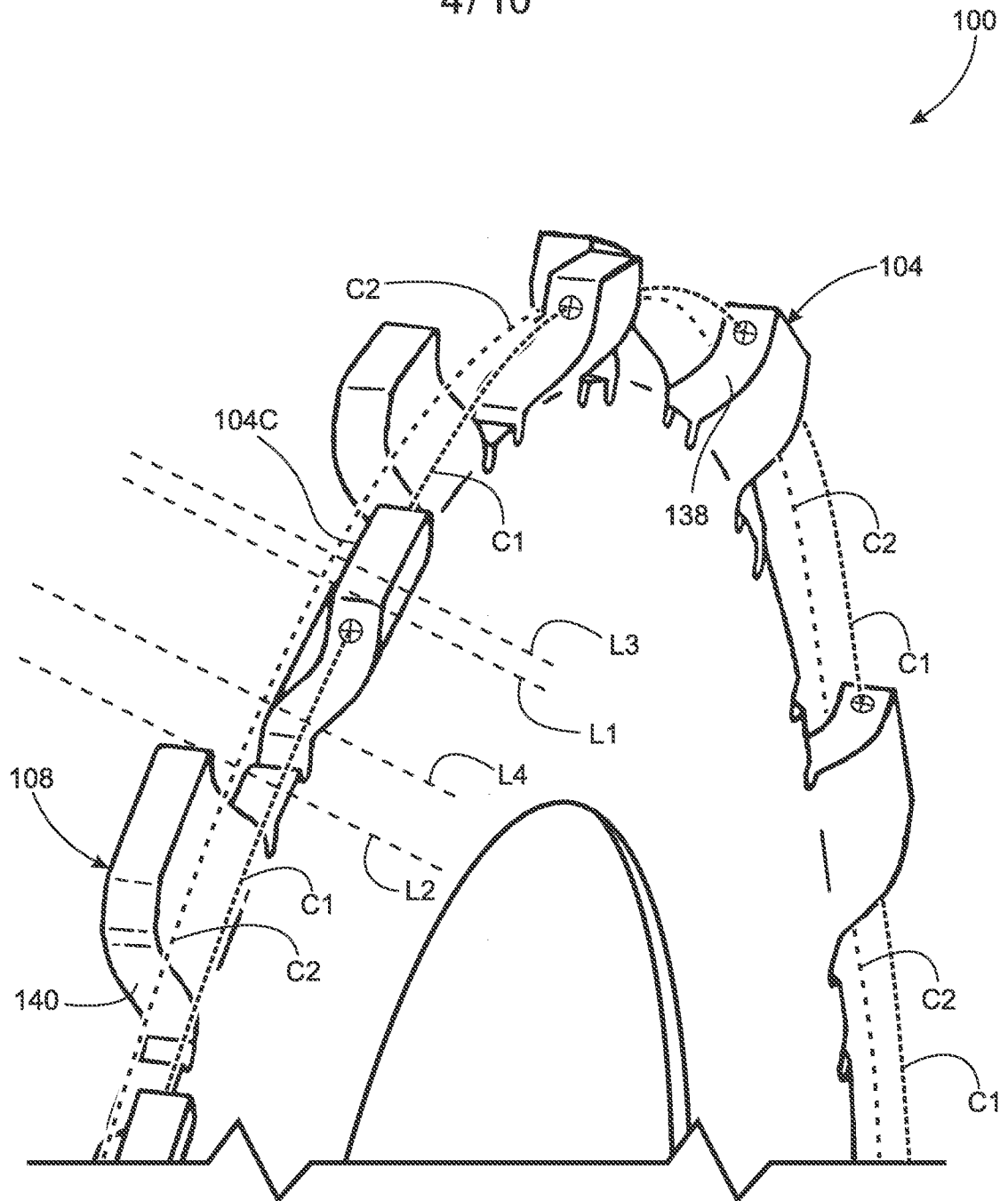


Fig. 4

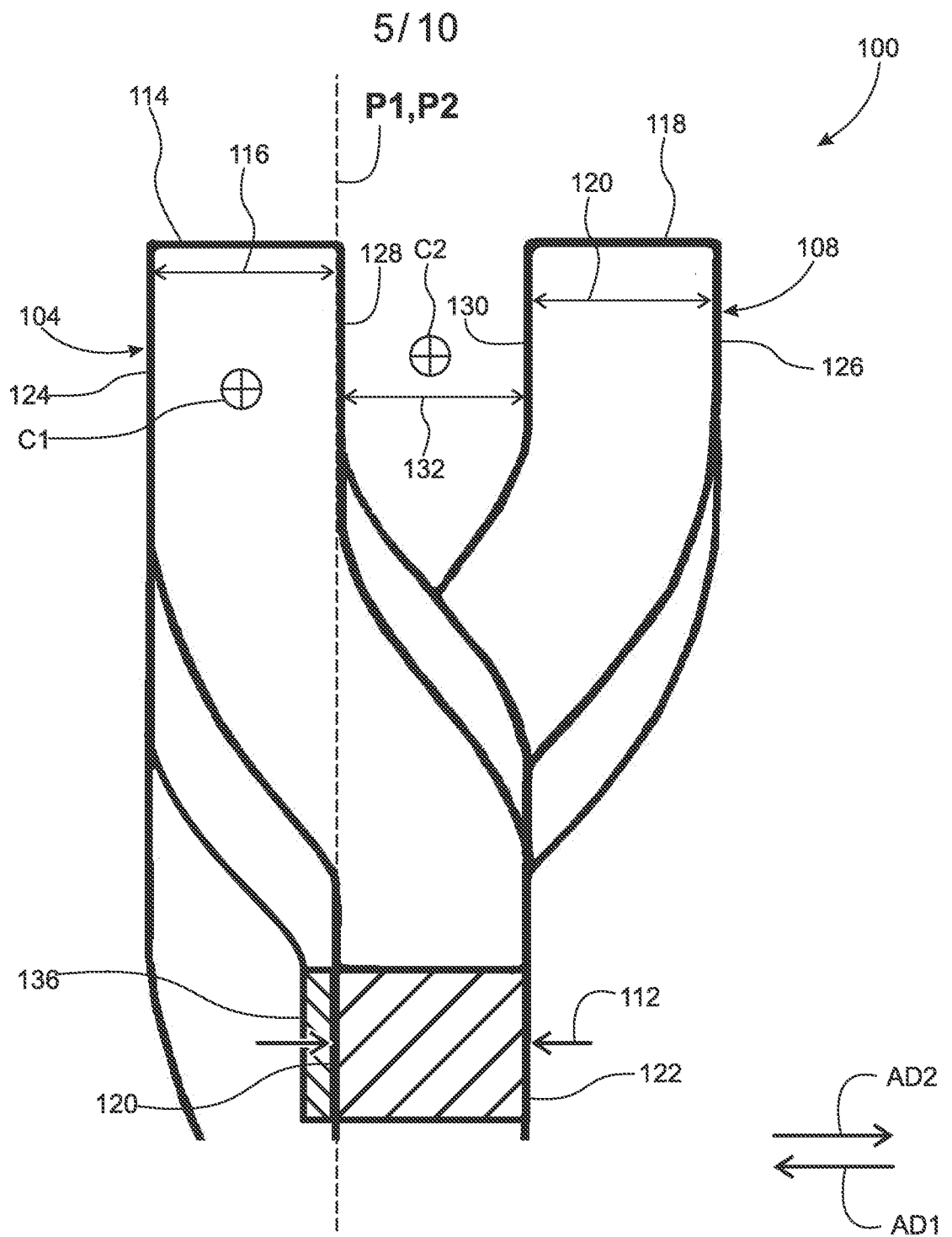


Fig. 5

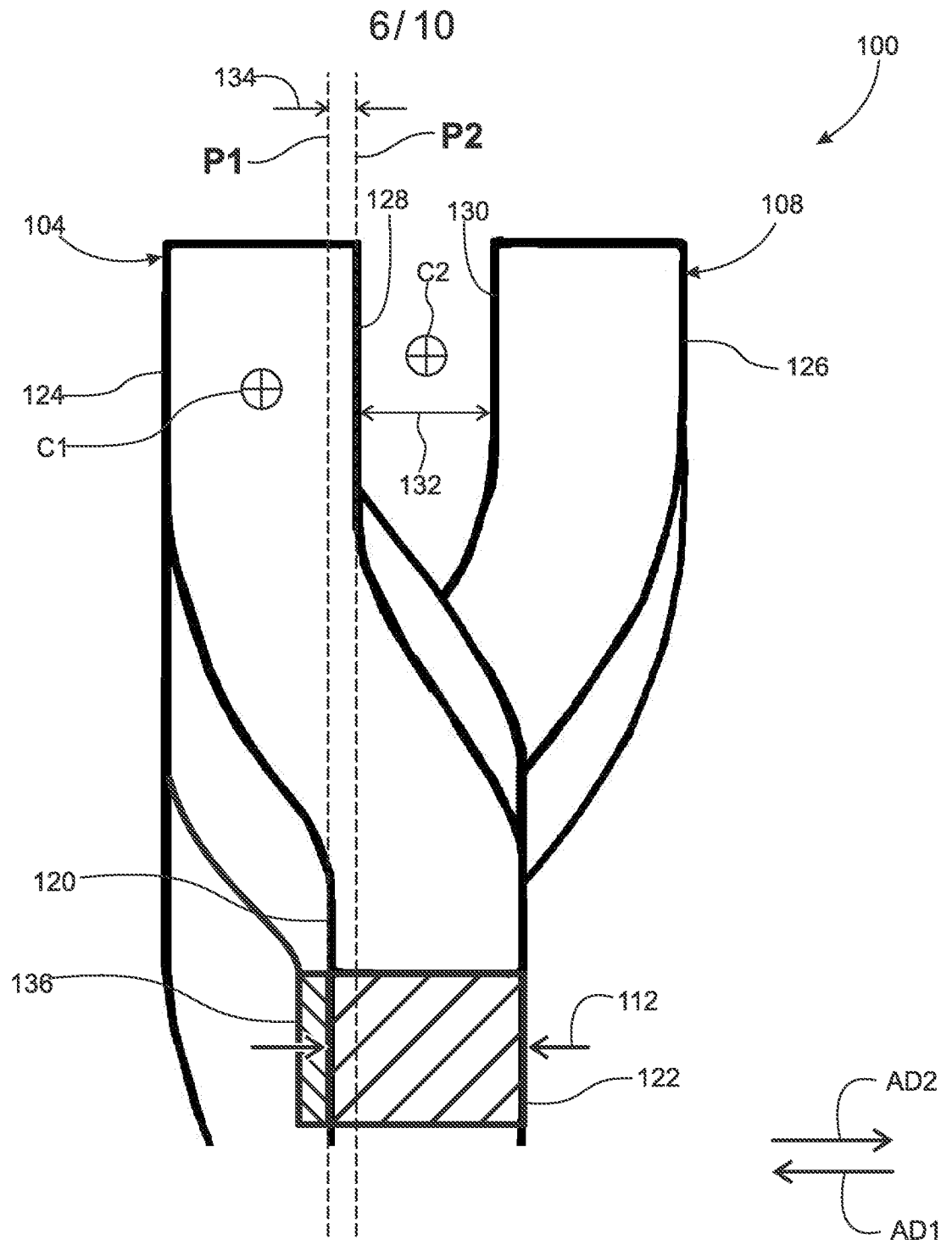


Fig. 6

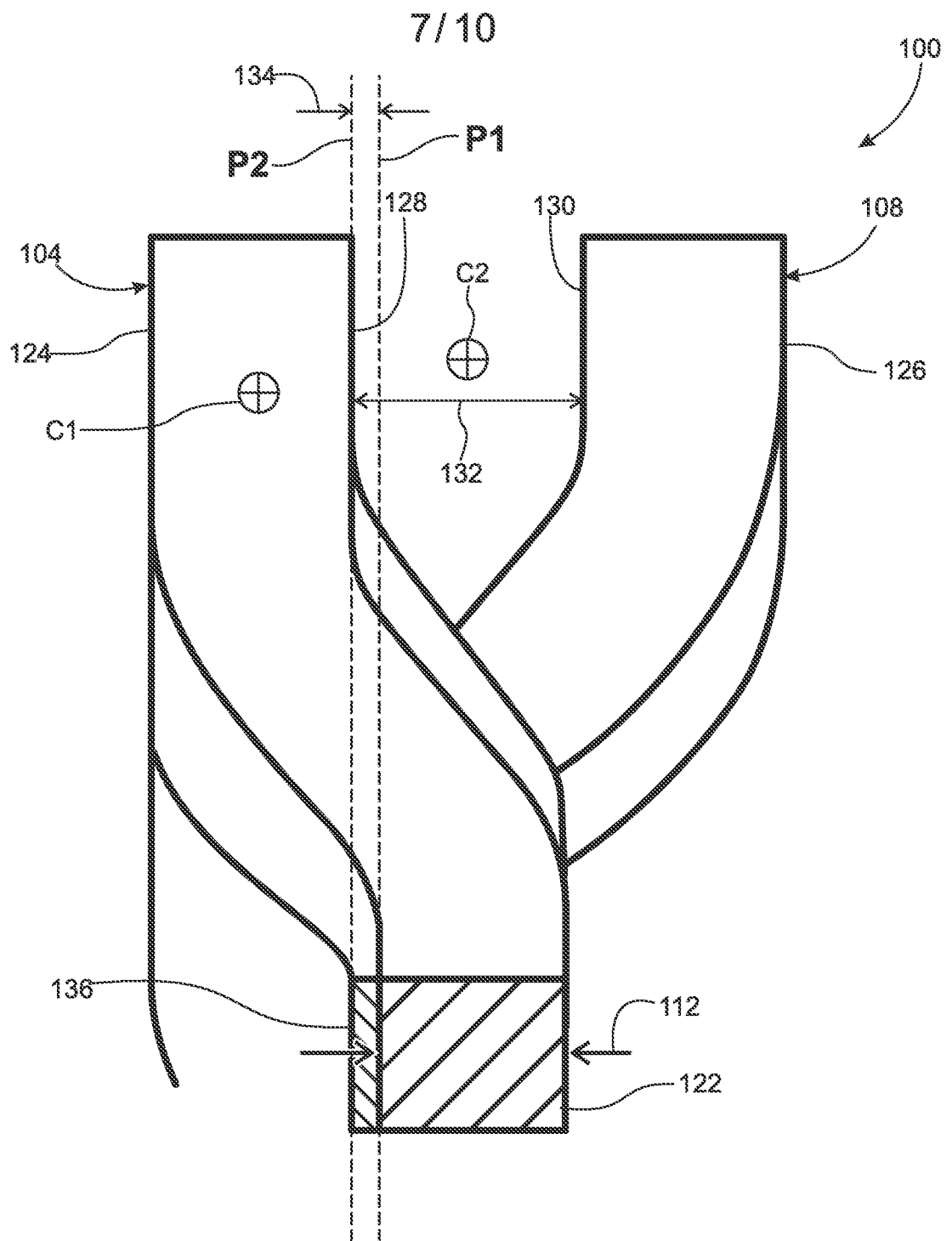


Fig. 7

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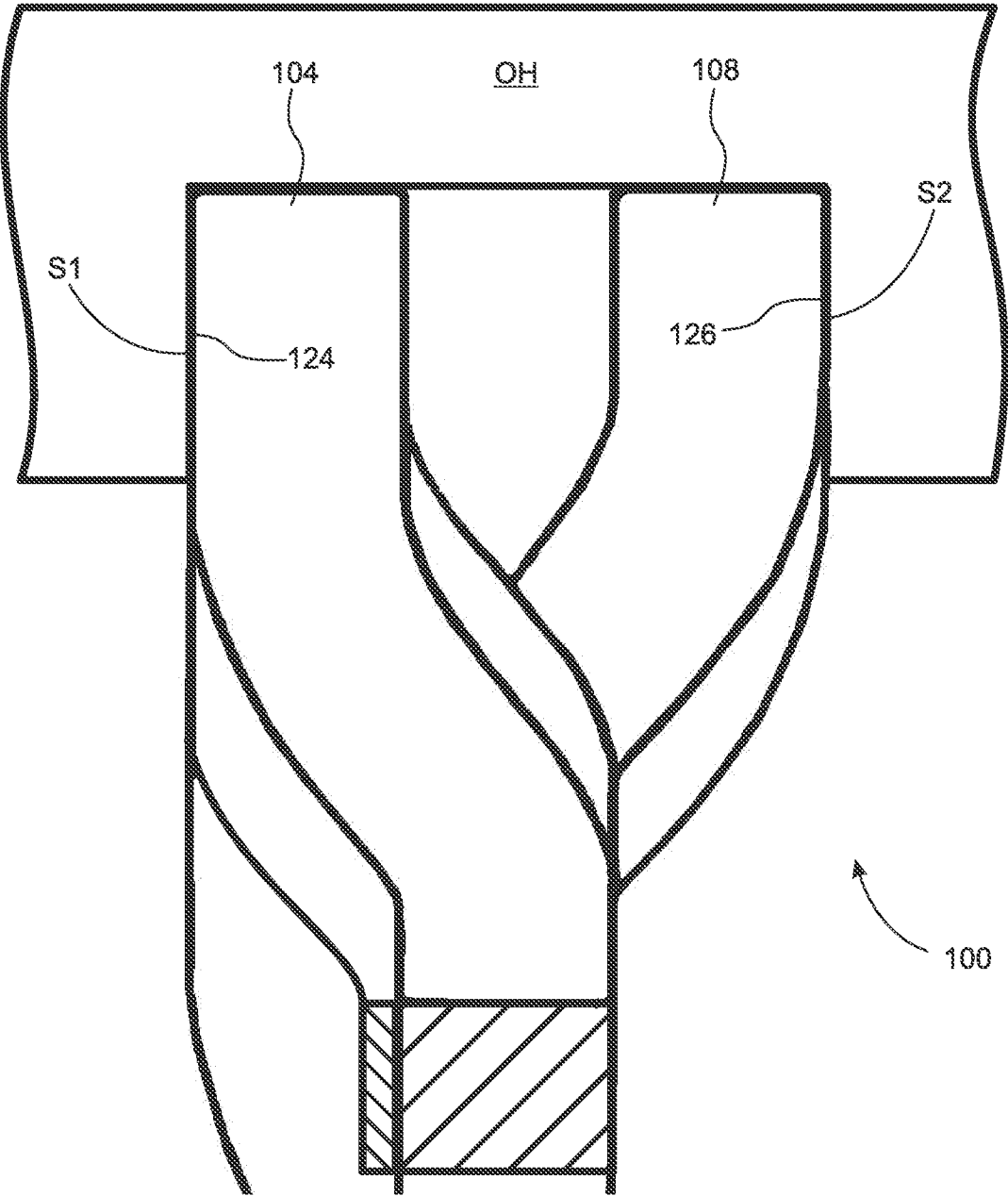
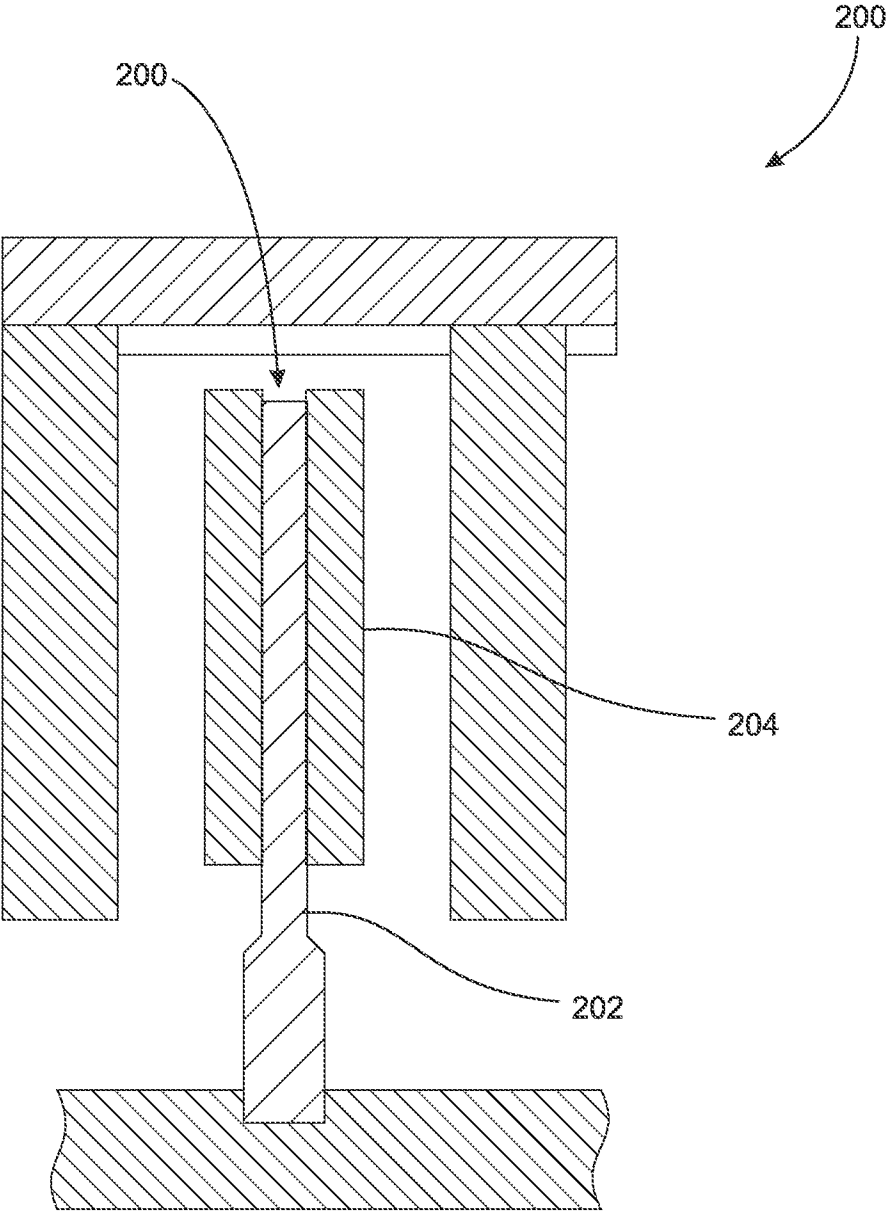


Fig. 8

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PRIOR ART

Fig. 9

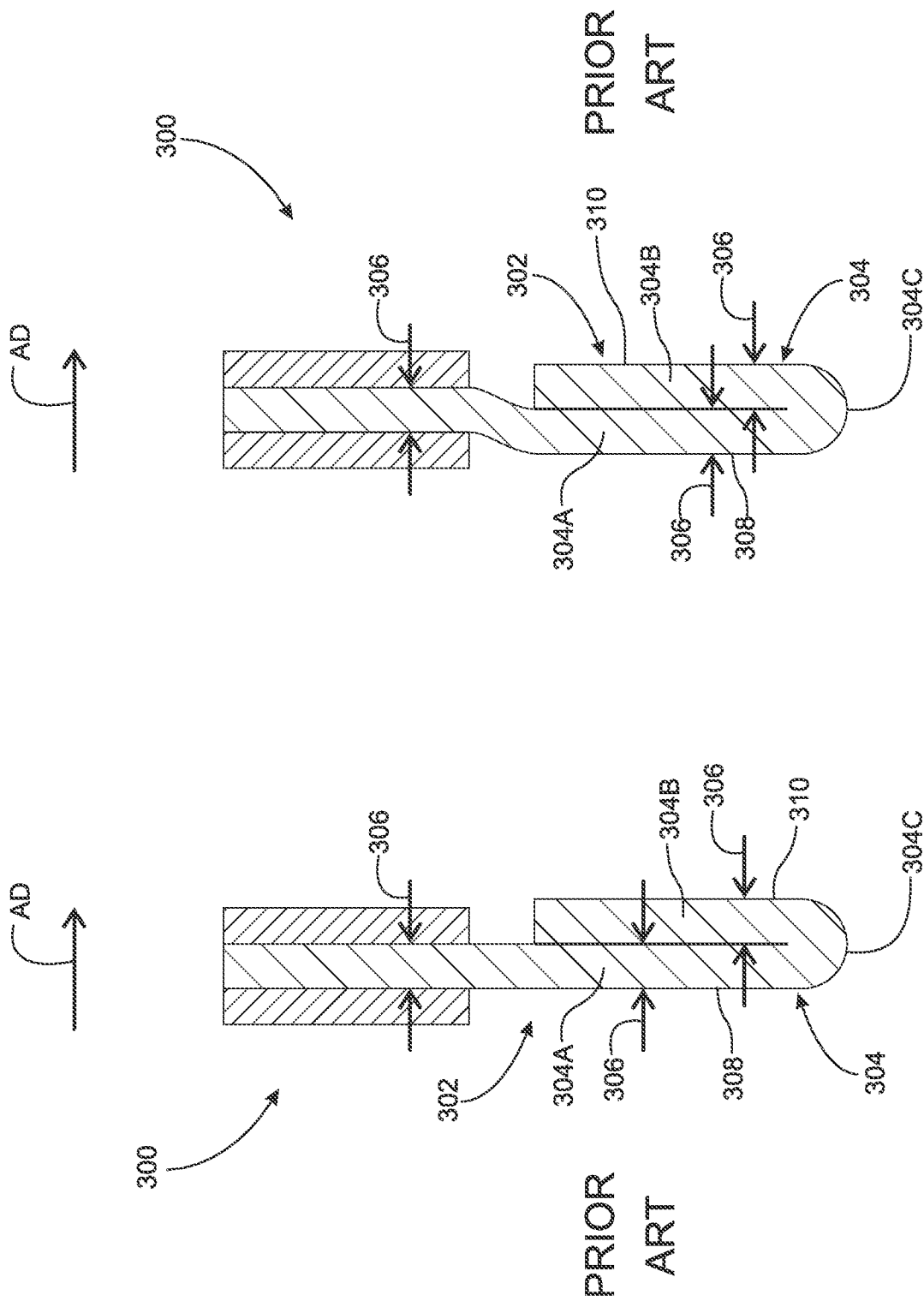


Fig. 10B

Fig. 10A

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2017/050283**A. CLASSIFICATION OF SUBJECT MATTER****F16D 13/64(2006.01)i**

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

B. FIELDS SEARCHEDMinimum documentation searched (classification system followed by classification symbols)
F16D 13/64; F16D 13/68; F16D 3/44; F16D 3/18; F16D 13/52; F16D 55/02; F16D 13/60Documentation 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 modelsElectronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: clutch disc, spline teeth, alternating, separate, core ring, circle, outermost**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2011-0067971 A1 (RATNER, MICHAEL) 24 March 2011 See paragraphs [0001], [0031]-[0035]; claim 7; and figures 1-2, 9A-9B.	1-10
A	US 2013-0270054 A1 (GM GLOBAL TECHNOLOGY OPERATIONS L.L.C.) 17 October 2013 See paragraphs [0022]-[0033]; and figure 4.	1-10
A	US 2002-0017435 A1 (FELDMANN et al.) 14 February 2002 See paragraphs [0081]-[0092]; and figures 6-7.	1-10
A	US 2001-0001768 A1 (KUNDERMANN, WOLFGANG) 24 May 2001 See paragraphs [0144]-[0152]; and figures 29-34.	1-10

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

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Date of the actual completion of the international search

28 December 2017 (28.12.2017)

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