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**Luipold**

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(54) **CLUTCH ASSEMBLY WITH A TAB RIVET CONNECTION AND METHOD THEREOF**

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**F16D 1/072** (2006.01)  
**F16D 11/14** (2006.01)  
**F16D 13/68** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **F16D 11/14** (2013.01); **F16D 1/072** (2013.01); **F16D 13/683** (2013.01); **F16D 2250/0061** (2013.01)

(58) **Field of Classification Search**  
USPC ..... 192/70.16, 112, 115; 74/446, 451  
See application file for complete search history.

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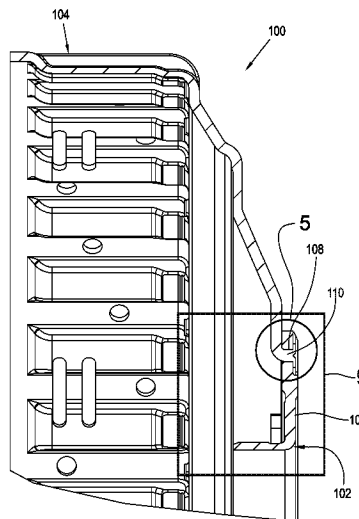
*Primary Examiner* — Rodney H Bonck

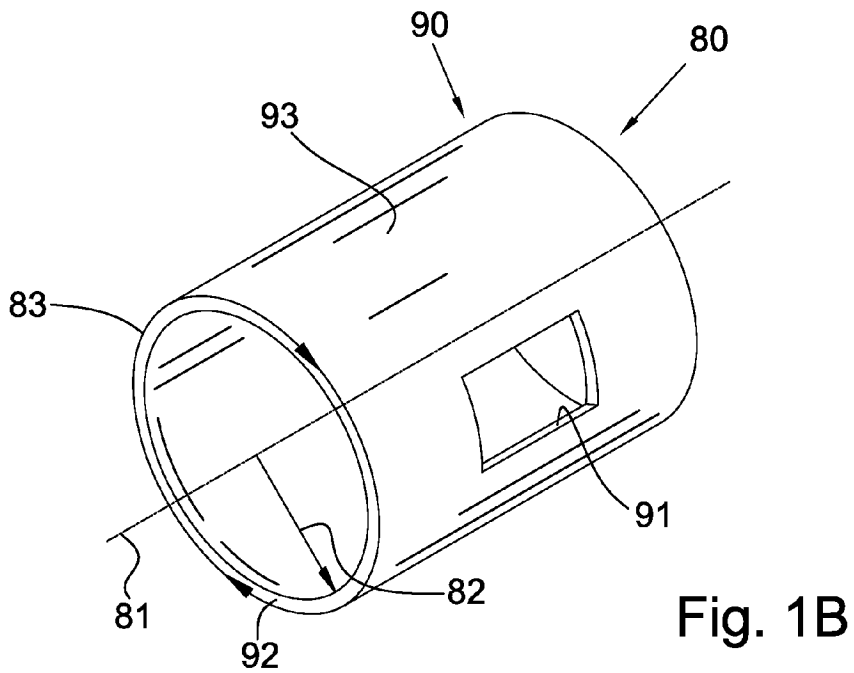
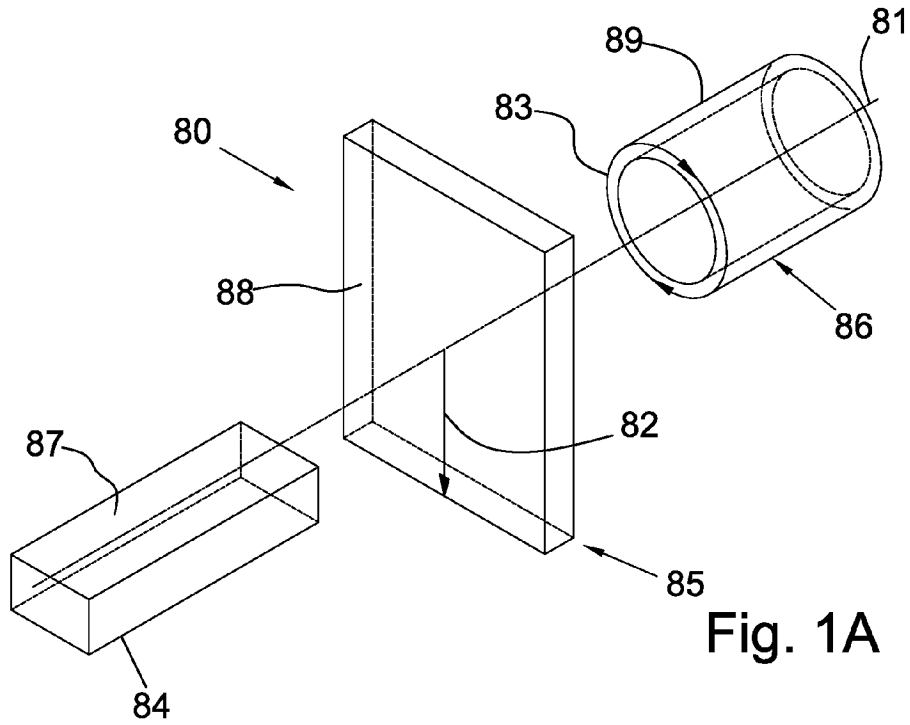
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(57) **ABSTRACT**

A clutch assembly, including: a hub including a first radially disposed portion with a plurality of circumferentially aligned slots passing through the first radially disposed portion; and a ring gear carrier including a plurality of protrusions disposed in the plurality of circumferentially aligned slots and in compressive engagement with the hub to fixedly connect the hub to the carrier. Each slot in the plurality of circumferentially aligned slots extends further in a circumferential direction than in a radial direction. Each protrusion in the plurality of protrusions extends further in the circumferential direction than in the radial direction.

**17 Claims, 10 Drawing Sheets**





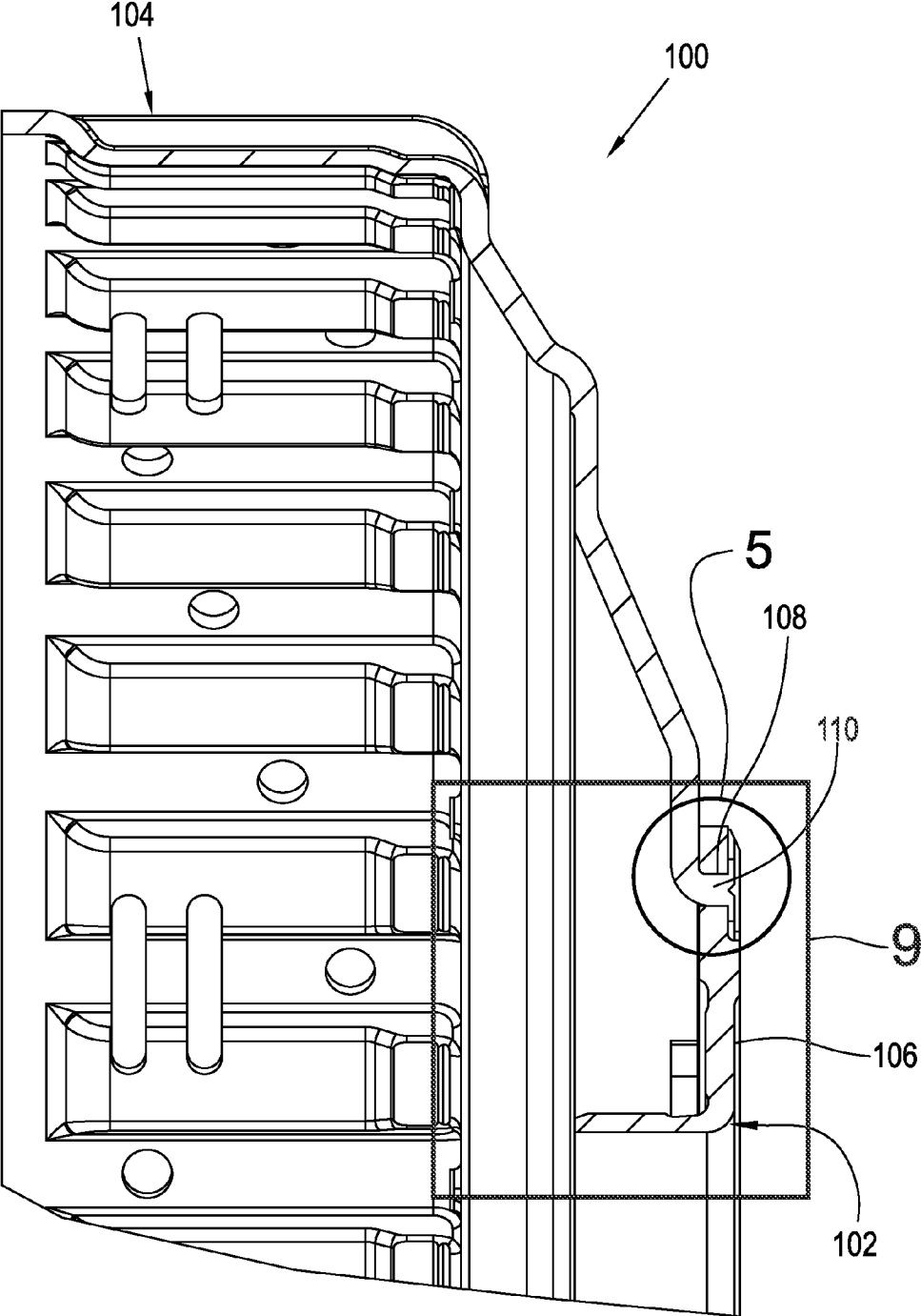


Fig. 2

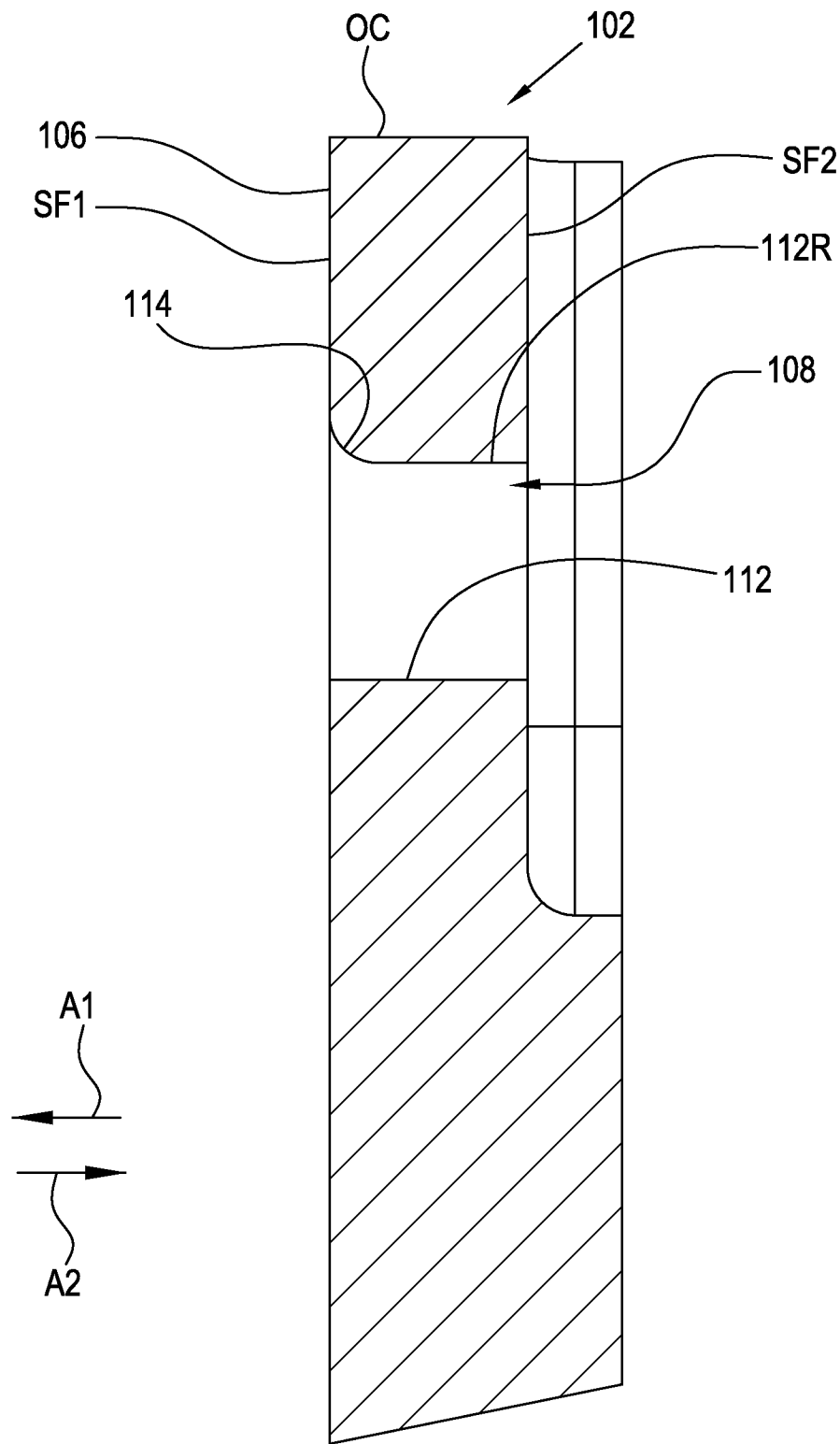


Fig. 3

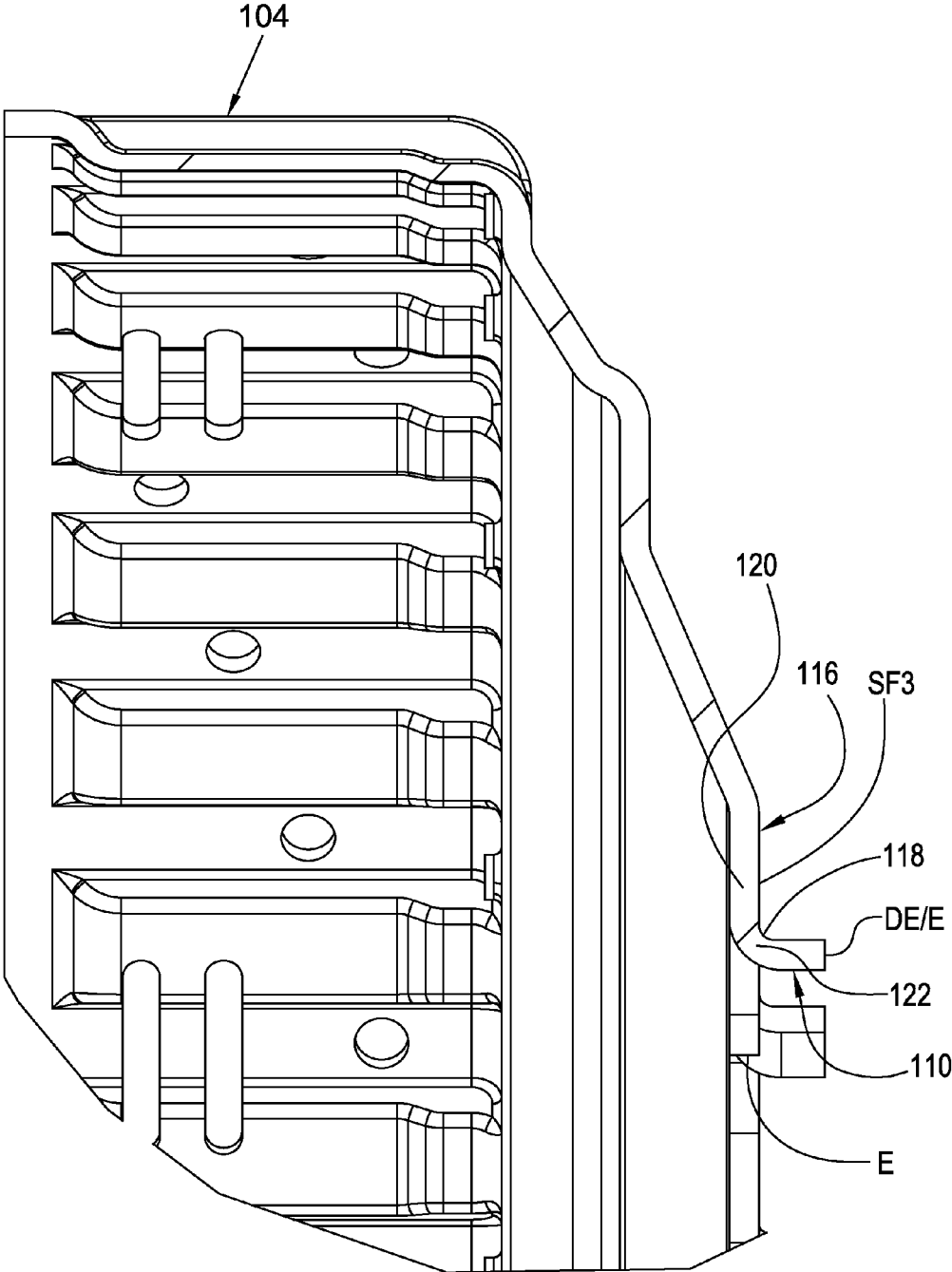


Fig. 4

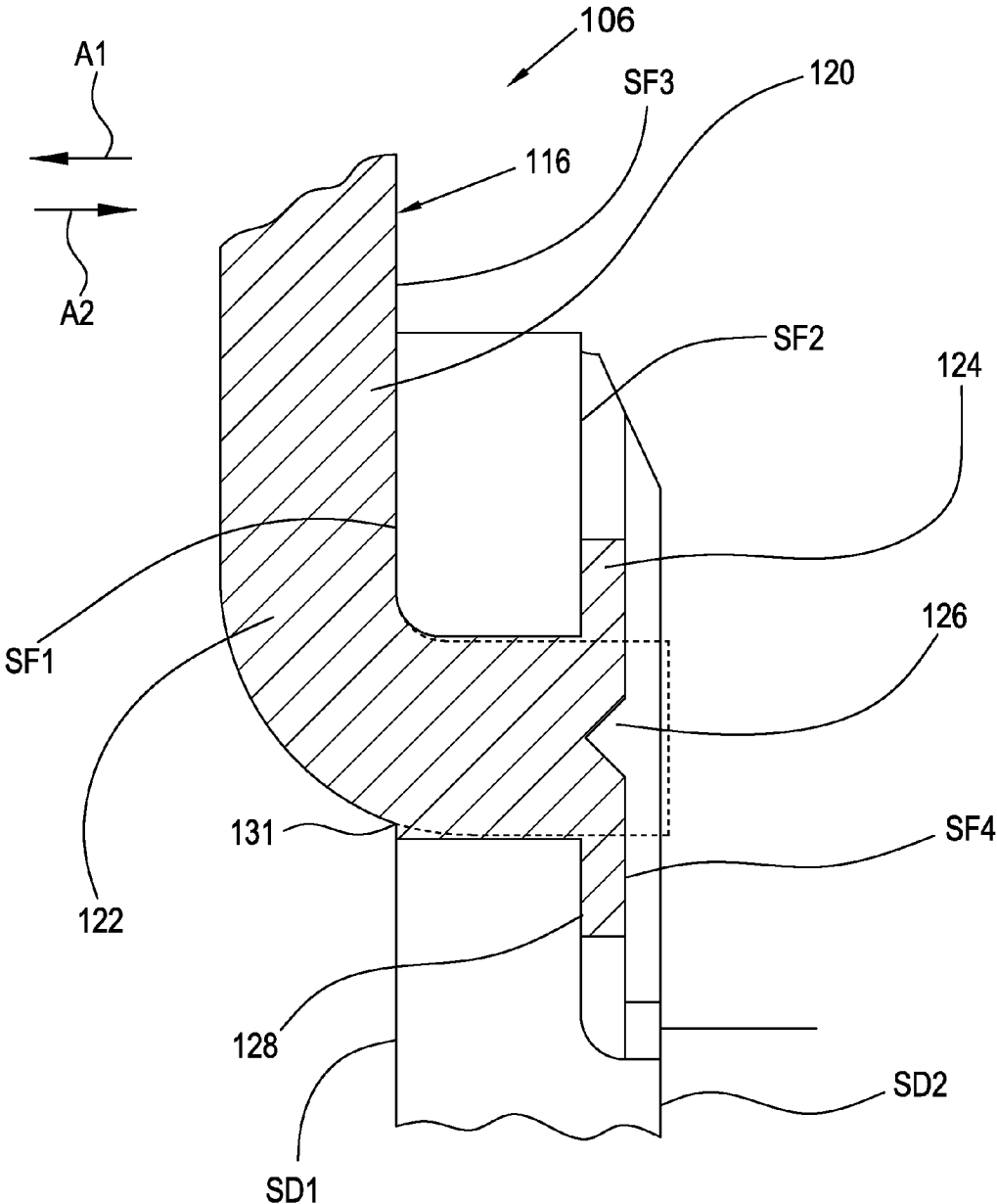


Fig. 5

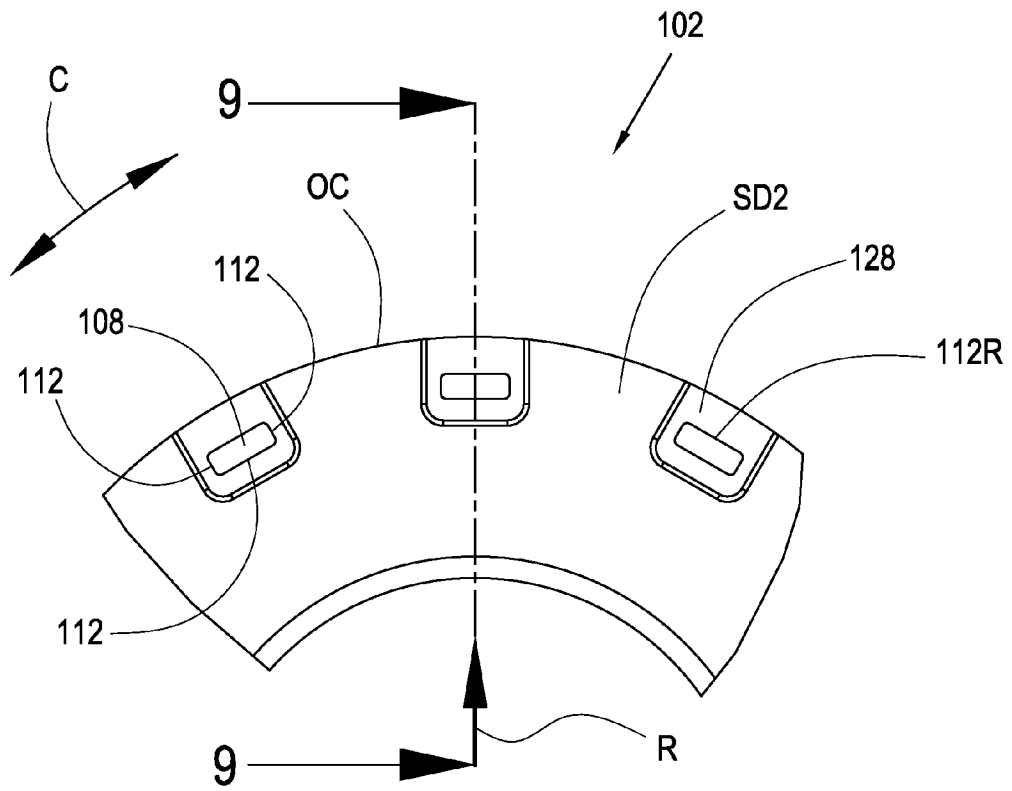


Fig. 6

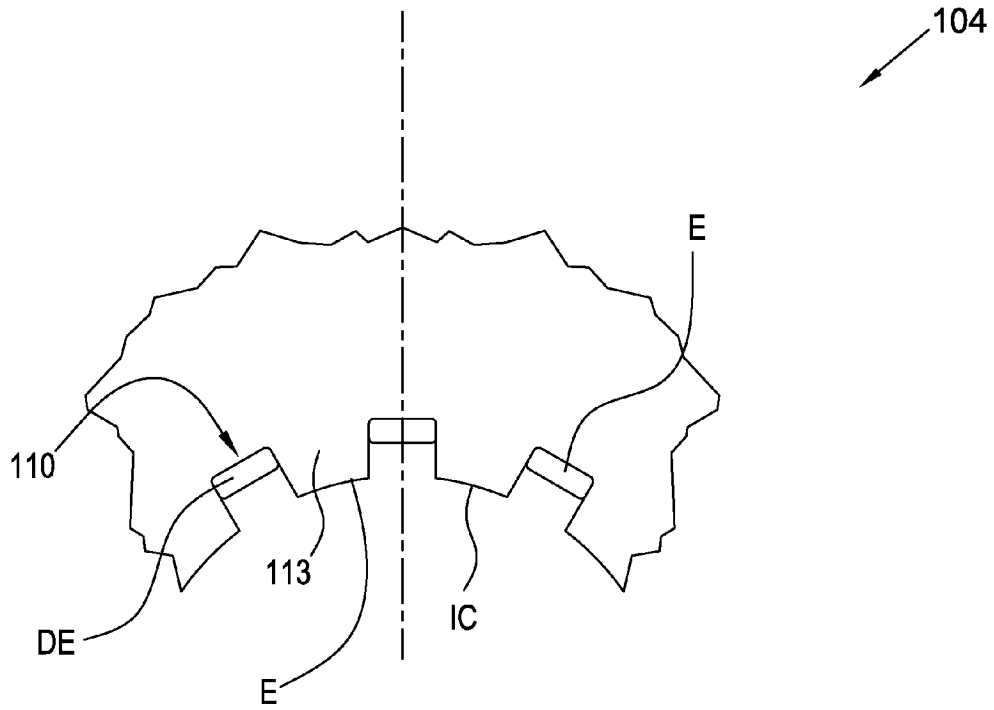


Fig. 7



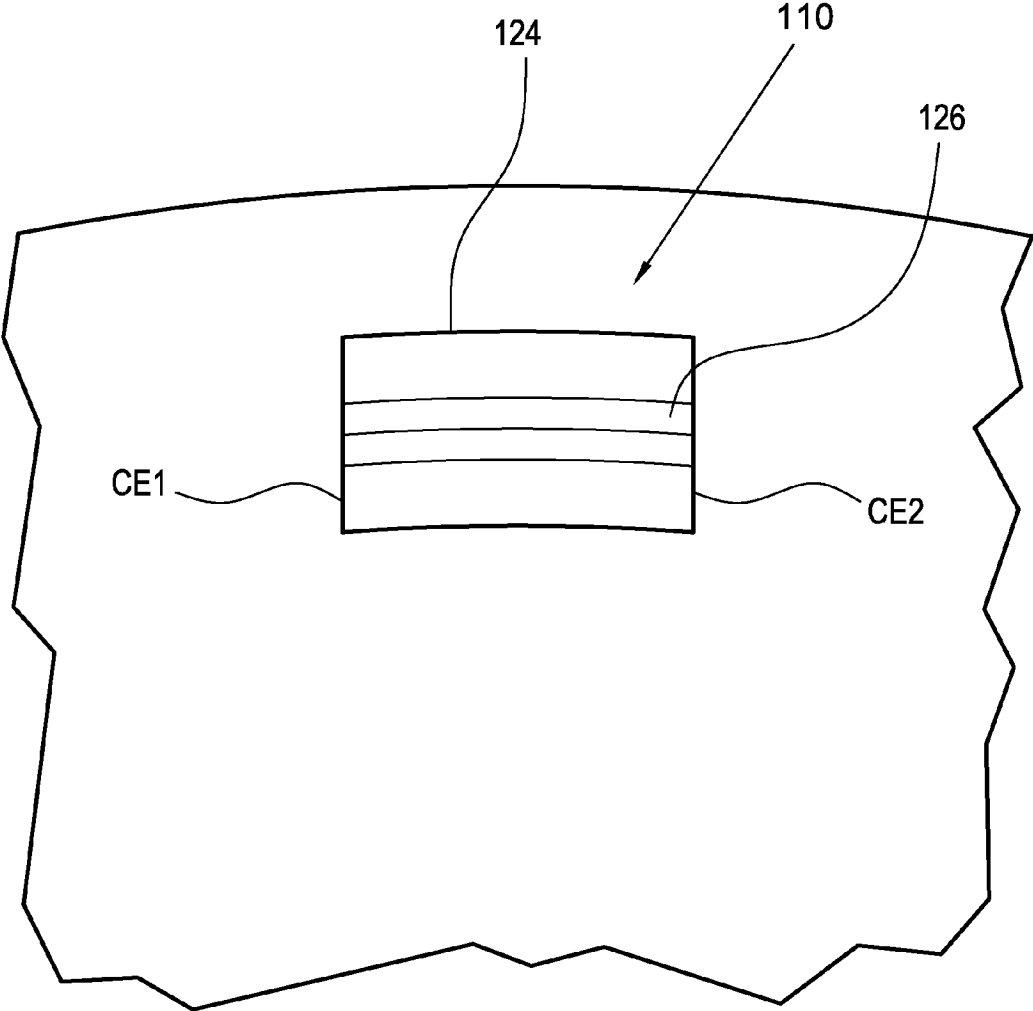


Fig. 8

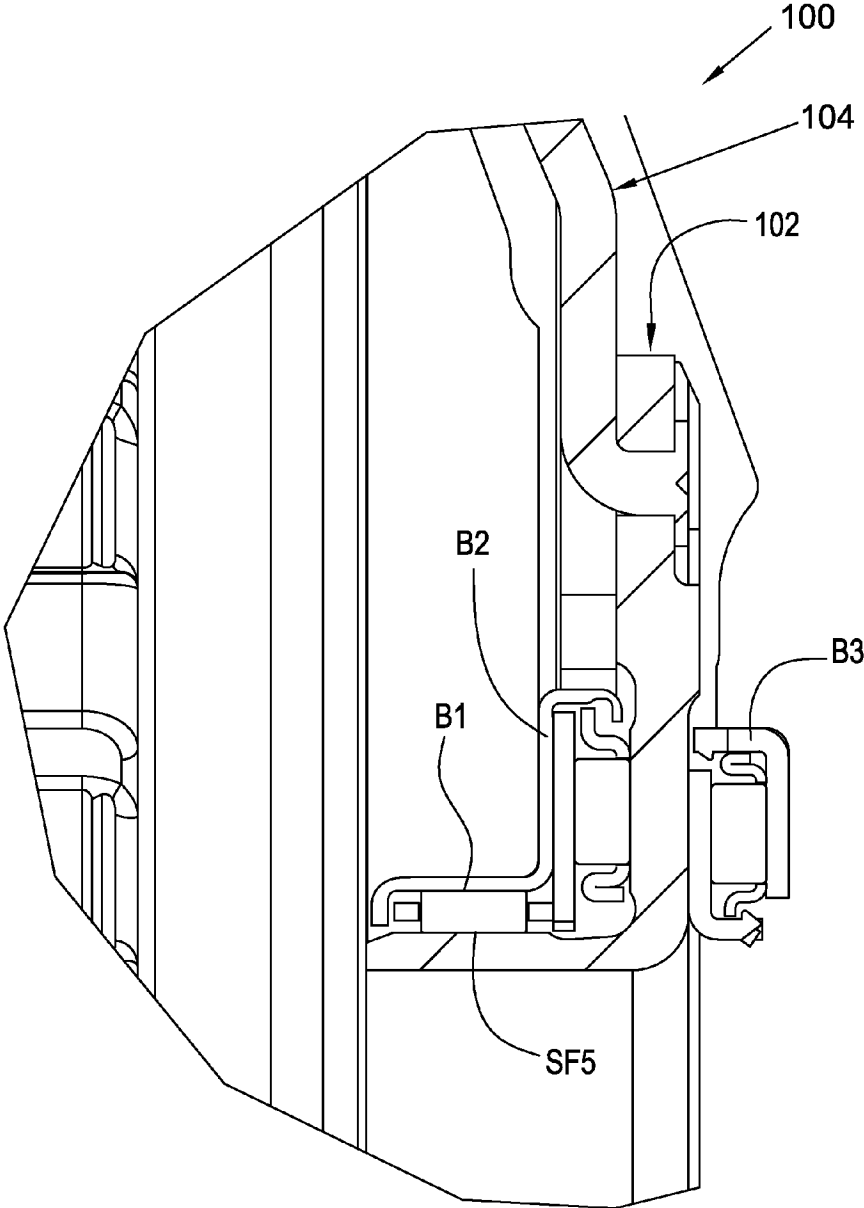


Fig. 9

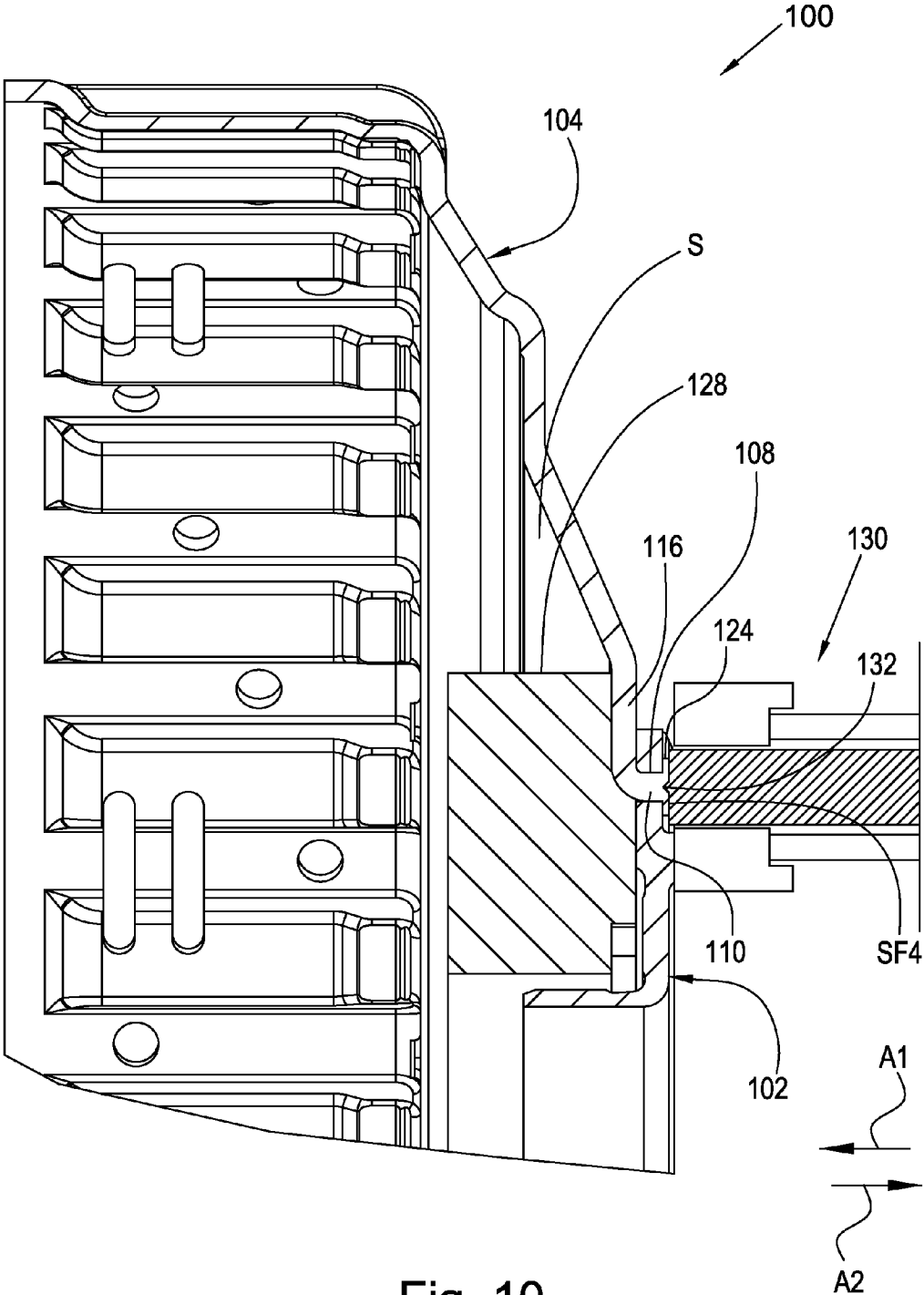


Fig. 10

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**CLUTCH ASSEMBLY WITH A TAB RIVET CONNECTION AND METHOD THEREOF****CROSS-REFERENCE TO RELATED APPLICATIONS**

This application claims the benefit under 35 U.S.C. §119 (e) of U.S. Provisional Patent Application No. 61/616,137, filed Mar. 27, 2012, which application is incorporated herein by reference.

**TECHNICAL FIELD**

The present disclosure relates a clutch assembly with a ring gear carrier and a hub joined by protrusions from the carrier disposed in slots in the hub, in particular, protrusions formed by bending portions of a circumference for the carrier.

**BACKGROUND**

It is known to join a carrier and a hub for a transmission clutch assembly using welding, for example as taught by U.S. Pat. No. 5,916,056. However, welding is costly and can result in heat distortion of parts and contamination from splatter. It also is known to join a carrier and a hub for a transmission clutch using a spline and snap ring arrangement, for example as taught by U.S. Pat. No. 5,026,337. However, this arrangement increases the complexity of the assembly and requires an undesirable increase in the axial extent of the assembly.

**SUMMARY**

According to aspects illustrated herein, there is provided a clutch assembly, including: a hub including a first radially disposed portion with a plurality of circumferentially aligned slots passing through the first radially disposed portion; and a ring gear carrier including a plurality of protrusions disposed in the plurality of circumferentially aligned slots and in compressive engagement with the hub to fixedly connect the hub to the carrier. Each slot in the plurality of circumferentially aligned slots extends further in a circumferential direction than in a radial direction. Each protrusion in the plurality of protrusions extends further in the circumferential direction than in the radial direction.

According to aspects illustrated herein, there is provided a method of fabricating a clutch assembly, including: forming a plurality of circumferentially aligned slots in a first radially disposed portion of a hub, such that each slot in the plurality of circumferentially aligned slots extends further in a circumferential direction than in a radial direction; forming a plurality of protrusions extending from a second radially disposed portion of a ring gear carrier such that each protrusion in the plurality of protrusions extends further in the circumferential direction than in the radial direction; inserting the plurality of protrusions in the plurality of circumferentially aligned slots such that respective segments of the plurality of protrusions extend beyond the first radially disposed portion; and exerting force on the plurality of protrusions such that the plurality of protrusions compressively engage the first radially disposed portion to fixedly connect the hub to the ring gear carrier.

According to aspects illustrated herein, there is provided a clutch assembly, including a hub with a first radially disposed portion and a plurality of circumferentially aligned slots in the first radially disposed portion. The assembly includes a ring gear carrier with a second radially disposed portion forming a radially innermost circumference for the ring gear carrier and a plurality of protrusions extending in an axial

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direction from the second radially disposed portion, disposed in the plurality of circumferentially aligned slots, and in compressive engagement with the first radially disposed portion to fixedly connect the hub to the carrier. Respective openings formed by the plurality of circumferentially aligned slots are wholly surrounded by the first radially disposed portion. Each slot in the plurality of circumferentially aligned slots extends further in a circumferential direction than in a radial direction. Each protrusion in the plurality of protrusions extends further in the circumferential direction than in the radial direction.

**BRIEF DESCRIPTION OF THE DRAWINGS**

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:

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

FIG. 1B is a perspective view of an object in the cylindrical coordinate system of FIG. 1A demonstrating spatial terminology used in the present application; and,

FIG. 2 is a partial cross-sectional view of clutch assembly with a tab rivet connection;

FIG. 3 is a detail of the hub shown in FIG. 2;

FIG. 4 is a cross-sectional view of the ring gear carrier shown in FIG. 2;

FIG. 5 is a detail of area 5 in FIG. 2;

FIG. 6 is a back view of the hub shown in FIG. 2;

FIG. 7 is a back view of the ring gear carrier shown in FIG. 2;

FIG. 8 is a detail of a protrusion in FIG. 2 showing the circumferential groove;

FIG. 9 is a detail of area of area 9 in FIG. 2 showing bearings; and,

FIG. 10 is a partial cross-sectional view of clutch assembly with a tab rivet connection showing an anvil and punch used in fabrication.

**DETAILED DESCRIPTION**

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.

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.

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.

FIG. 1A is a perspective view of cylindrical coordinate system **80** demonstrating spatial terminology used in the present application. The present invention is at least partially described within the context of a cylindrical coordinate system. System **80** has a longitudinal axis **81**, used as the reference for the directional and spatial terms that follow. The adjectives “axial,” “radial,” and “circumferential” are with respect to an orientation parallel to axis **81**, radius **82** (which

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is orthogonal to axis **81**), and circumference **83**, respectively. The adjectives “axial,” “radial” and “circumferential” also are regarding orientation parallel to respective planes. To clarify the disposition of the various planes, objects **84**, **85**, and **86** are used. Surface **87** of object **84** forms an axial plane. That is, axis **81** forms a line along the surface. Surface **88** of object **85** forms a radial plane. That is, radius **82** forms a line along the surface. Surface **89** of object **86** forms a circumferential plane. That is, circumference **83** forms a line along the surface. As a further example, axial movement or disposition is parallel to axis **81**, radial movement or disposition is parallel to radius **82**, and circumferential movement or disposition is parallel to circumference **83**. Rotation is with respect to axis **81**.

The adverbs “axially,” “radially,” and “circumferentially” are with respect to an orientation parallel to axis **81**, radius **82**, or circumference **83**, respectively. The adverbs “axially,” “radially,” and “circumferentially” also are regarding orientation parallel to respective planes.

FIG. 1B is a perspective view of object **90** in cylindrical coordinate system **80** of FIG. 1A demonstrating spatial terminology used in the present application. Cylindrical object **90** is representative of a cylindrical object in a cylindrical coordinate system and is not intended to limit the present invention in any manner. Object **90** includes axial surface **91**, radial surface **92**, and circumferential surface **93**. Surface **91** is part of an axial plane, surface **92** is part of a radial plane, and surface **93** is a circumferential surface.

FIG. 2 is a partial cross-sectional view of clutch assembly **100** with a tab rivet connection.

FIG. 3 is a detail of the hub shown in FIG. 2.

FIG. 4 is a cross-sectional view of the ring gear carrier shown in FIG. 2.

FIG. 5 is a detail of area **5** in FIG. 2. The following should be viewed in light of FIGS. 2 through 5. Clutch assembly **100** includes hub **102** and ring gear carrier **104**. The hub includes radially disposed portion **106** with circumferentially aligned slots **108** passing through portion **106**. The ring gear carrier includes protrusions, or tab rivets, **110** disposed in slots **108** and in compressive engagement with the hub, in particular, edges **112** of the slots, to fixedly connect the hub to the carrier.

FIG. 6 is a back view of hub **102** shown in FIG. 2.

FIG. 7 is a back view of ring gear carrier **104** shown in FIG. 2. The following should be viewed in light of FIGS. 2 through 7. In an example embodiment, each slot extends further in circumferential direction **C** than in radial direction **R**. In an example embodiment, each protrusion extends further in circumferential direction **C** than in radial direction **R**.

In an example embodiment, openings formed by the slots are wholly surrounded by portion **106**, for example, the slots do not open to outer circumference **OC** of portion **106**. In an example embodiment, each protrusion includes a respective distal end **DE** and each **DE** forms a respective portion of an edge for the ring gear carrier, for example edge **E**, part of which forms inner circumference **IC** for carrier **104**. For example, as described below, **IC** is punched to form segments **113** and every other segment **113** is axially bent to form a protrusion **110**.

In an example embodiment, each slot includes a respective radially outermost edge **112R**, and respective corners **114** formed by portion **106** and **112R** are rounded. In an example embodiment, the ring gear carrier includes radially disposed portion **116**, the protrusions extend axially from portion **116**; and, respective corners **118** formed by portion **116** and the protrusions are rounded. In an example embodiment, corners **114** and **118** are complementarily shaped and are matingly

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engaged. By ‘matingly engaged’ we mean that the respective radially and axially aligned portions of corners **114** and **118** are in contact.

In an example embodiment, respective segments **120** of portion **116**, radially outward from corners **114** are under a first amount of compressive stress, and respective segments **122** of portion **116** axially aligned with corners **118** are under a second amount of compressive stress, greater than the first amount of compressive stress. In general, tensile forces associated with torque loads on assembly **100**, in particular on segments **122**, work to separate the hub from the ring gear carrier. Advantageously, the creation of additional compressive stress in segments **122** counters the tensile forces, increasing the torque capacity of assembly **100**.

FIG. 8 is a detail of a protrusion in FIG. 2 showing a circumferential groove. The following should be viewed in light of FIGS. 2 through 8. Portion **106** includes surfaces **SF1** and **SF2** facing in opposite axial directions, for example, in axial directions **A1** and **A2**, respectively. Portion **116**, in particular, surface **SF3**, is in contact with **SF1**. Each protrusion includes a respective segment **124** in contact with **SF2**. In an example embodiment, each segment **124** includes surface **SF4** facing in the same axial direction as **SF2**, for example, **A2**, and including a circumferentially disposed groove **126**. Grooves **126**, resulting from the axial compression of the protrusions, as described infra, result in an advantageous displacement, radially inward and outward of the slots, of the material forming the portion of the protrusions extending beyond portion **106** in direction **A2**. In an example embodiment, grooves **126** extend the full circumferential extent of segments **124**, for example, from circumferential end **CE1** to circumferential end **CE2**.

In an example embodiment, portion **106** includes sides **SD1** and **SD2** facing in opposite axial directions, for example, in axial directions **A1** and **A2**, respectively. **SD2** includes indented segments **128**. Slots **108** are located in the plurality of indented segments.

FIG. 9 is a detail of area of area **9** in FIG. 2 showing bearings. The following should be viewed in light of FIGS. 2 through 9. In an example embodiment, assembly **100** is used in a transmission. In an example embodiment, bearings **B1** are used to axially guide the assembly and thrust bearings **B2** and **B3** are used to radially guide the assembly. As further described below, the fabrication of assembly **100** advantageously facilitates the hardening of surface **SF5** of the hub upon which bearings **B1** ride.

FIG. 10 is a partial cross-sectional view of clutch assembly with a tab rivet connection showing an anvil and punch used in fabrication. The following should be viewed in light of FIGS. 2 through 10. The following described a method of fabricating a clutch assembly. Assembly **100** is used in the example description that follows; however, it should be understood that the method is not limited to the configuration shown and described for assembly **100**. One step forms slots **108** in portion **106** of hub **102**, such that each slot extends further in circumferential direction **C** than in radial direction **R**. Another step forms protrusions **110** extending from portion **116** of ring gear carrier **104** such that each protrusion extends further in direction **C** than in the direction **R**. Another step inserts the protrusions in the slots such that respective segments of the protrusions extend beyond portion **106**, for example, in direction **A2**. A further step exerts force on the protrusions such that the protrusions compressively engage portion **106** to fixedly connect the hub to the ring gear carrier.

In an example embodiment, forming slots includes wholly surrounding respective openings formed by the plurality of circumferentially aligned slots with portion **106**. For

example, the slots do not open to outer circumference OC of portion 106. In an example embodiment, forming the protrusions includes axially bending a plurality of radially aligned segments forming a portion of an inner circumference for the second radially disposed portion, for example segments 113 forming portions of inner circumference IC for portion 116.

In an example embodiment, forming slots includes rounding respective corners 114 formed by portion 106 and respective radially outermost edges 112R of the slots. In an example embodiment, forming the protrusions includes rounding respective corners 118 formed by portion 116 and the protrusions. In an example embodiment, a further step matingly engages the first and second respective corners.

In an example embodiment, exerting force on the plurality of protrusions includes: placing segments 120 of portion 106, radially outward from corners 114, under a first amount of compressive stress, and placing respective segments 122 of portion 106, axially aligned with corners 114, under a second amount of compressive stress, greater than the first amount of compressive stress.

In an example embodiment, inserting the protrusions in the slots includes extending respective segments 124 of the protrusions axially beyond portion 106, and exerting force on the protrusions includes displacing respective portions of segments 124 to contact surface SF2 of portion 106 facing away from the ring gear carrier. In an example embodiment, displacing respective portions of segments 124 includes indenting surface SF4 of portions 124, facing away from the ring gear carrier, to displace the respective portions in radially inward and outward directions, and to form respective circumferentially disposed grooves 126.

In FIG. 10, anvil 128 has been inserted behind portion 116 to axially support portion 116 and the protrusions. Punch 130 applies force in axial direction A1 to the protrusion, in particular, to surface SF4 of segments 124, to compressively engage the protrusions with the hub. As shown by the dashed lines in FIG. 5, prior to upsetting, a radius of corner 118 of protrusion 110 is larger than a radius of corner 114 of slot 108. Furthermore, to accommodate assembly of the carrier to the hub, protrusion 110 is smaller than slot 108. The anvil limits axial motion of the carrier so that the protrusion is radially and circumferentially expanded into the slot, and corner 118 is pressed into contact with corner 114 during the application of force by punch 130, resulting in the increase of compressive stress noted supra on segments 122. As a result of the position of the anvil, step 131 is formed in protrusion 110 by the expansion of the protrusion in response to punch 130. Punch 130 includes protrusion 132, which engages surface SF4 to cause a more uniform and extensive displacement of the material forming the protrusions along and in contact with the slot. The contact of protrusion 132 with surface SF4 results in grooves 126.

The following provides further detail and information regarding assembly 100 and the fabrication of assembly 100. In an example embodiment, indented segments 128 are formed by coining to reduce the thickness of the material forming portion 106 and which is pierced to form slots 108. As well, the coining process eliminates the need for machining of the hub in the areas of the protrusions to reduce the thickness. Machining would result in an interrupted cut that would require deburring at a substantial cost. By 'coining' we mean a process that produces the indented segments by compressing the material in the area of the segments.

In an example embodiment, corners 114 and 118 also are formed by coining process, that is, by applying compressive force to form the corners. The coined corners help to improve fill, that is, the expansion of the protrusions to fill the slot and

compressively engaged the hub, and to better seat the hub and the ring gear carrier. In an example embodiment, once the protrusions are inserted into the slots, spring loaded punch 130 provides the axial force noted above, which seats the hub and the ring gear carrier together. During the application of the axial force an additional amount of residual compressive stress is put into corner 114 and segment 122. This residual compressive stress results in a durability improvement, that is, the compressive stress counteracts the tensile stresses associated with operation of assembly 100. Protrusion 132 helps to distribute material to both radial sides of the slots.

In an example embodiment, while punch 130 is applying force, the protrusions are fully supported through corner 118 with anvil 128 to prevent the protrusions from being pushed back out of the slot.

Advantageously, the configuration of assembly 100 minimizes the axial extent of the ring gear carrier, in particular, the axial extent of space S needed to accommodate the anvil. Assembly 100 also replaces welding of the hub to the ring gear carrier. Welding would undesirably increase cost and complexity for fabricating assembly 100 and could result in undesirably heating and possible warping of parts forming the assembly.

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 I claim is:

1. A clutch assembly, comprising:

- a hub including a first radially disposed portion with a plurality of circumferentially aligned slots passing through the first radially disposed portion; and,
- a ring gear carrier including a plurality of protrusions disposed in the plurality of circumferentially aligned slots and in compressive engagement with the hub to fixedly connect the hub to the carrier, wherein:
  - each slot in the plurality of circumferentially aligned slots extends further in a circumferential direction than in a radial direction;
  - each protrusion in the plurality of protrusions extends further in the circumferential direction than in the radial direction;
  - the first radially disposed portion includes first and second surfaces facing in opposite axial directions;
  - the ring gear carrier includes a second radially disposed portion in contact with the first surface; and,
  - each protrusion in the plurality of protrusions includes a respective segment in contact with the second surface.

2. The clutch assembly of claim 1, wherein respective openings formed by the plurality of circumferentially aligned slots are wholly surrounded by the first radially disposed portion.

3. The clutch assembly of claim 1, wherein each protrusion from the plurality of protrusions includes a respective distal end forming a respective portion of an edge for the ring gear carrier.

4. The clutch assembly of claim 1, wherein:

- each slot in the plurality of circumferentially aligned slots includes a respective radially outermost edge;
- first respective corners formed by the first radially disposed portion and the respective radially outermost edge are rounded;

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the ring gear carrier includes a second radially disposed portion; and,  
second respective corners formed by the second radially disposed portion and the plurality of protrusions are rounded and matingly engaged with the first respective corners.

5. The clutch assembly of claim 4, wherein:  
first respective segments of the second radially disposed portion radially outward from the second respective corners are under a first amount of compressive stress; and,  
second respective segments of the second radially disposed portion axially aligned with the second respective corners are under a second amount of compressive stress, greater than the first amount of compressive stress.

6. The clutch assembly of claim 1, wherein said respective segment includes a third surface facing in a same axial direction as the second surface and including a circumferentially disposed groove.

7. The clutch assembly of claim 1, wherein:  
the first radially disposed portion includes first and second sides facing in opposite axial directions;  
the ring gear carrier includes a second radially disposed portion in contact with the first side;  
the first side includes a plurality of indented segments; and,  
the plurality of circumferentially aligned slots are located in the plurality of indented segments.

8. A method of fabricating a clutch assembly, comprising:  
forming a plurality of circumferentially aligned slots in a first radially disposed portion of a hub, such that each slot in the plurality of circumferentially aligned slots extends further in a circumferential direction than in a radial direction;

forming a plurality of protrusions extending from a second radially disposed portion of a ring gear carrier such that each protrusion in the plurality of protrusions extends further in the circumferential direction than in the radial direction;

inserting the plurality of protrusions in the plurality of circumferentially aligned slots such that respective segments of the plurality of protrusions extend beyond the first radially disposed portion; and,

exerting force on the plurality of protrusions such that the plurality of protrusions compressively engage the first radially disposed portion to fixedly connect the hub to the ring gear carrier, wherein forming a plurality of protrusions includes axially bending a plurality of radially aligned segments forming a portion of an inner circumference for the second radially disposed portion.

9. The method of claim 8, wherein forming a plurality of circumferentially aligned slots includes wholly surrounding respective openings formed by the plurality of circumferentially aligned slots with the first radially disposed portion.

10. The method of claim 8, wherein:  
forming a plurality of circumferentially aligned slots includes rounding first respective corners formed by the first radially disposed portion and respective radially outermost edges of the plurality of circumferentially aligned slots; and,

forming a plurality of protrusions includes rounding second respective corners formed by the second radially disposed portion and the plurality of protrusions, the method further comprising matingly engaging the first and second respective corners.

11. The method of claim 10, wherein exerting force on the plurality of protrusions includes:

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placing first respective segments of the first radially disposed portion, radially outward from the first respective corners, under a first amount of compressive stress; and,  
placing second respective segments of the first radially disposed portion, axially aligned with the second respective corners, under a second amount of compressive stress, greater than the first amount of compressive stress.

12. The method of claim 8, wherein:  
inserting the plurality of protrusions in the plurality of circumferentially aligned slots includes extending respective segments of the plurality of protrusions axially beyond the first radially disposed portion; and,  
exerting force on the plurality of protrusions includes displacing respective portions of the respective segments to contact a surface of the first radially disposed portion facing away from the ring gear carrier.

13. The method of claim 12, wherein displacing respective portions of the respective segments includes indenting a surface of the respective portions, facing away from the ring gear carrier, to displace the respective portions in radially inward and outward directions, and to form respective circumferentially disposed grooves.

14. A clutch assembly, comprising:

a hub including:  
a first radially disposed portion including a first surface facing in a first axial direction; and,  
a plurality of circumferentially aligned slots in the first radially disposed portion; and,

a ring gear carrier including:  
a second radially disposed portion:  
including a second surface in contact with the first surface and facing in a second axial direction opposite the first axial direction; and,  
a plurality of protrusions:

forming a radially innermost circumference for the ring gear carrier;  
extending in the second axial direction from the second radially disposed portion;  
disposed in the plurality of circumferentially aligned slots;  
forming respective portions of the ring gear carrier extending furthest in the second axial direction; and,  
in compressive engagement with the first radially disposed portion to fixedly connect the hub to the carrier, wherein:

respective openings formed by the plurality of circumferentially aligned slots are wholly surrounded by the first radially disposed portion;

each slot in the plurality of circumferentially aligned slots extends further in a circumferential direction than in a radial direction; and,

each protrusion in the plurality of protrusions extends further in the circumferential direction than in the radial direction.

15. The clutch assembly of claim 14, wherein:  
the hub includes respective first rounded corners formed by the first radially disposed portion and respective radially outermost edges of the plurality of circumferentially aligned slots;

the ring gear carrier includes respective second rounded corners formed by the second radially disposed portion and respective radially outwardly facing surfaces of the plurality of protrusions;

the first and second respective corners are matingly engaged;

first respective segments of the first radially disposed portion radially outward from the first respective corners are under a first amount of compressive stress; and, second respective segments of the first radially disposed portion axially aligned with the first respective corners are under a second amount of compressive stress, greater than the first amount of compressive stress.

**16.** The clutch assembly of claim **15**, wherein:

the first radially disposed portion includes a third surface facing in the second axial direction; each protrusion in the plurality of protrusions includes a respective segment in contact with the third surface; and said respective segment includes a fourth surface facing in the first axial direction and including a circumferentially disposed groove.

**17.** The clutch assembly of claim **14**, wherein each protrusion from the plurality of protrusions includes a respective distal end forming a respective portion of an edge of the ring gear carrier.

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