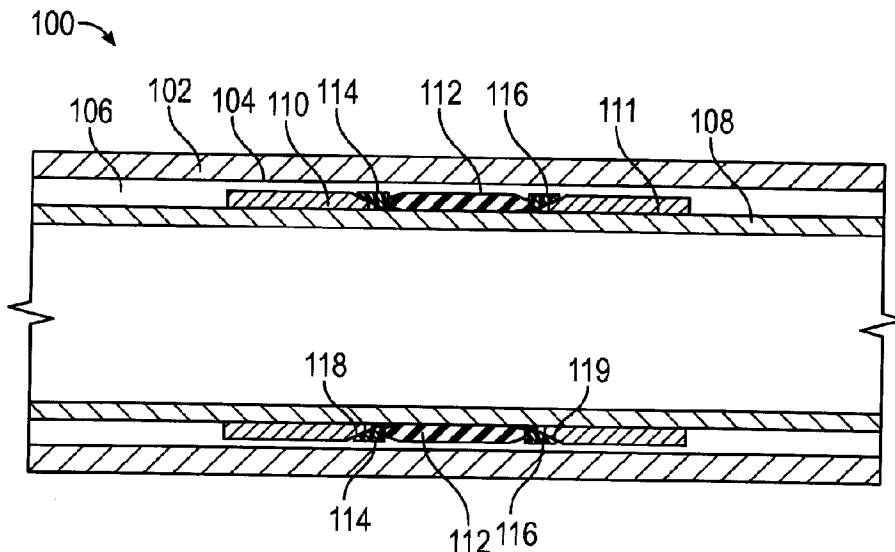




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(57) Abrégé/Abstract:

A method of retaining a packing element including utilizing a back-up ring assembly in contact with at least one packing element, the assembly comprising: at least one wedge shaped spiral ring comprising: at least one outer circumferential face configured to contact a wellbore casing or liner; at least one conical, inner circumferential face configured to contact a portion of a retainer with a conical face; and an axial end face configured to contact the at least one packing element. A back-up ring assembly including at least one wedge shaped spiral ring comprising: at least one outer circumferential face configured to contact a wellbore casing or liner; at least one conical, inner circumferential face configured to contact a portion of a retainer with a conical face; and an axial end face configured to contact a packing element.



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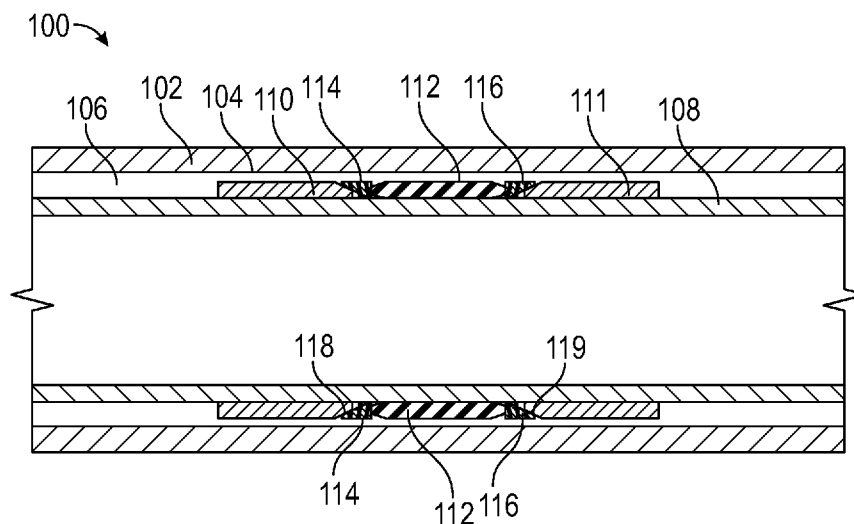


FIG. 1

(57) Abstract: A method of retaining a packing element including utilizing a back-up ring assembly in contact with at least one packing element, the assembly comprising: at least one wedge shaped spiral ring comprising: at least one outer circumferential face configured to contact a wellbore casing or liner; at least one conical, inner circumferential face configured to contact a portion of a retainer with a conical face; and an axial end face configured to contact the at least one packing element. A back-up ring assembly including at least one wedge shaped spiral ring comprising: at least one outer circumferential face configured to contact a wellbore casing or liner; at least one conical, inner circumferential face configured to contact a portion of a retainer with a conical face; and an axial end face configured to contact a packing element.

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## HIGH EXPANSION METAL BACK-UP RING FOR PACKERS AND BRIDGE PLUGS

### BACKGROUND

5 In the drilling, completion, or reworking of oil wells, a great variety of downhole tools are used including packer assemblies and bridge plugs. Packer assemblies may be used in a wellbore to separate the wellbore into one or more zones. A packer assembly may include a packer element capable of providing an annular seal between a tubing string and a casing string, a slip that can retain the packer assembly in a position by gripping the casing string, a wedge that supports the slip, and a mandrel that provides support to the assembly.

10 Current packer assembly designs include a tubing string with mechanical set or hydraulic pressure set element packers thereabout which provide for well segment isolation. The packers, which are energized with mechanical force or force from a hydraulic piston, are used to isolate segments of the well, and the tubing is used to convey treatment fluids to the isolated segment. Such packers may be limited with respect to pressure capabilities as well as durability under high pressure conditions.

### BRIEF DESCRIPTION OF THE DRAWINGS

The following figures are included to illustrate certain aspects of the present invention, and should not be viewed as exclusive embodiments. The subject matter disclosed is capable of considerable modification, alteration, and equivalents in form and function, as will occur to one having ordinary skill in the art and having the benefit of this disclosure.

25 Figure 1 is a longitudinal cross-section of a packer assembly according to embodiments of the disclosure.

Figure 2A is a cross-sectional schematic view of several elements of a relaxed packer assembly according to embodiments of the disclosure.

30 Figure 2B is a cross-sectional schematic view of several elements of an expanded packer assembly according to embodiments of the disclosure.

Figures 3A-C depict a back-up ring according to embodiments of the disclosure.

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Figure 4 depicts a well system with packer assemblies according to certain embodiments of the present invention.

#### DETAILED DESCRIPTION

The disclosure is directed to a back-up ring that expands up a ramp/conical surface on a retainer to retain a packer element. The back-up ring may also retain sealing pressure inside the packer element, and may prevent extrusion of the packer element.

In an embodiment, a method of retaining a packing element comprises: utilizing a back-up ring assembly in contact with at least one packing element, the assembly comprising: at least one wedge shaped spiral ring comprising: at least one outer circumferential face configured to contact a wellbore casing or liner; at least one conical, inner circumferential face configured to contact at least one of: a portion of retainer, a portion of a retainer with a conical face, a portion of a mandrel, and combinations thereof; and an axial end face configured to contact the at least one packing element. The method may further comprise at least one retainer, wherein the at least one wedge shaped spiral ring is located between the at least one packing element and the at least one retainer. In an embodiment, the method may further comprise a mandrel, wherein the at least one wedge shaped spiral ring, the at least one packing element and the at least one retainer are located around the mandrel. In another embodiment, the method may further comprise expanding the at least one wedge shaped spiral ring between the at least one retainer and the at least one packing element thereby forming a labyrinth seal preventing packing element extrusion. The at least one wedge shaped spiral ring may act as a spring force as it expands up the conical face of the at least one retainer and contacts the casing or liner. The method may further comprise relaxing the at least one wedge shaped spiral ring, wherein the at least one ring returns to an unexpanded configuration. In another embodiment, the method may further comprise retrieving the at least one wedge shaped spiral ring from the wellbore. In an exemplary embodiment, the assembly comprises two retainers, two wedge shaped spiral rings, and one packing element, wherein each retainer is on a different side of the packing element, and each wedge shaped spiral ring is between an individual packing element and an individual retainer. The

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at least one wedge shaped spiral ring may be cut as one continuous spiral. In an embodiment, the spiral cut is about 0 to about 20 degrees from vertical. In some embodiments, the at least one ring is a 3D printed ring. In an embodiment, the angle of at least one conical, inner circumferential face may be about 5 to about 60 degrees. In an additional embodiment, the at least one retainer comprises a conical face, wherein the angle of the conical face is about 5 to about 60 degrees.

In an embodiment, a back-up ring assembly comprises: at least one wedge shaped spiral ring comprising: at least one outer circumferential face configured to contact a wellbore casing or liner; at least one conical, inner circumferential face configured to contact at least one of: a portion of a retainer, a portion of a retainer with a conical face, a portion of a mandrel, and combinations thereof; and an axial end face configured to contact a packing element. In an embodiment, the assembly further comprises at least one packing element and at least one retainer, wherein the at least one wedge shaped spiral ring is located between the at least one packing element and the at least one retainer. In one embodiment, the assembly further comprises a mandrel, wherein the at least one wedge shaped spiral ring, the at least one packing element and the at least one retainer are located around the mandrel. The at least one wedge shaped spiral ring in an expanded condition between the at least one retainer and the at least one compressed packing element may form a labyrinth seal. In an embodiment, the at least one wedge shaped spiral ring in an expanded condition contacts a casing or liner. In an exemplary embodiment, the assembly comprises two retainers, two wedge shaped spiral rings, and one packing element, wherein each retainer is on a different side of the packing element, and each wedge shaped spiral ring is between an individual packing element and an individual retainer. In another embodiment, the assembly further comprises a plug disposed within the mandrel. The at least one wedge shaped spiral ring may be cut as one continuous spiral. In an embodiment, the spiral cut is about 0 to about 20 degrees from vertical. In some embodiments, the at least one wedge shaped spiral ring is a 3D printed ring. In an embodiment, the angle of at least one conical, inner circumferential face may be about 5 to about 60 degrees. In an additional embodiment, the at least one retainer

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comprises a conical face, wherein the angle of the conical face is about 5 to about 60 degrees.

In an embodiment, a downhole assembly comprises: an elongate mandrel configured to be placed in a wellbore casing or liner; a retainer configured to slideably engage along the mandrel, wherein said retainer comprises a conical face; a packing element configured to slide along the mandrel; at least one wedge shaped spiral ring disposed between the retainer and the packing element, the ring comprising: at least one outer circumferential face configured to contact the casing or string; at least one conical, inner circumferential face configured to contact at least one of: a portion of the retainer, a portion of the conical face of the retainer, a portion of the mandrel, and combinations thereof; and an axial end face configured to contact the packing element. In another embodiment, the assembly further comprises a plug disposed within the mandrel.

The following illustrative examples are given to introduce the general subject matter discussed here and are not intended to limit the scope of the disclosed concepts. The following sections describe various additional embodiments and examples with reference to the drawings in which like numerals indicate like elements, and directional descriptions are used to describe the illustrative embodiments but, like the illustrative embodiments, should not be used to limit the present disclosure.

#### Packer Assembly

A packer assembly according to an embodiment of the disclosure may include a mandrel, at least one retainer, at least one back-up ring, and a packer element. FIG. 1 is a longitudinal cross-section of a packer assembly embodiment 100 in an unset or run-in condition. Casing 102 has an inner surface 104 and an annulus 106 is defined between casing 102 and mandrel 108. Retainers 110, 111 expand packer element 112 as the retainers 110, 111 are drawn towards each other. Back-up rings 114, 116 are disposed between the retainers 110, 111 and the packer element 112. As packer element 112 is expanded outward toward the casing inner surface 104, the back-up rings 114, 116 ride up the ramps 118, 119 on the retainers 110, 111 on either side of packing element 112, thereby performing at least one of the following: retaining packing element 112,

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retaining sealing pressure inside the packer elements, preventing its extrusion by creating a labyrinth seal, and combinations thereof.

In some embodiments, the aforementioned assembly contains a plug (not shown) connected within the mandrel by matching threads, pins, welding, or any other suitable means, and said assembly is referred to as a bridge plug. The plug has a seal located between plug and the internal diameter of the mandrel to prevent fluid flow therebetween. Packer assemblies typically have at least one means for allowing fluid communication through the tool. Packers may allow for the controlling of fluid passage therethrough by way of one or more valve mechanisms which may be integral to the packer body or which may be externally attached to the packer body. Such valve mechanisms are not shown in the drawings of the present document. Packer tools may be deployed in wellbores having casings or other such annular structure or geometry in which the tool may be set.

FIG. 2A is a cross-sectional schematic view of several elements of a packer assembly 200A in a relaxed state, otherwise known as an unset or run-in condition. Retainers 210, 211 expand packer element 212 as the retainers 210, 211 are drawn towards each other. Back-up rings 214, 216 are disposed between the retainers 210, 211 and the packer element 212. As packer element 212 is expanded outward toward the casing inner surface 220, the back-up rings 214, 216 ride up the ramps 218, 219 on the retainers 210, 211 on either side of packing element 212. The expanded packer element assembly 200B is the result. The back-up rings 214, 216 retain packing element 212 and preventing its extrusion by creating a labyrinth seal.

The retainers may have a ramp shaped face 218, 219 on the end that comes into contact with the back-up ring and the packer element. The angle of the ramp may be any angle that can accept the corresponding conical shaped face of the back-up ring and allow the ring to slide up the ramp as the packer element is expanded. The angle may depend on the geometry of the gap between the retainer and the casing. In an embodiment, the angle is about 5 to about 60 degrees. In another embodiment, the angle is about 20 to about 35 degrees.

Back-up Rings

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The back-up rings of the present disclosure may retain the packer element and prevent extrusion of the packer element.

FIGs. 3A-C depict a back-up ring according to an embodiment of the disclosure. The basic construction of the back-up ring may be a wedge with a spiral cut. Back-up ring 300 includes at least one outer circumferential face 302, at least one conical, inner circumferential face 304, and an axial end face 306. The outer circumferential face 302 may be configured to contact a wellbore casing or liner. The conical, inner circumferential face 304 may contact at least one of a portion of a retainer, a portion of a retainer conical surface, a portion of a mandrel, and combinations thereof. Further, the axial end face 306 may be configured to contact a packing element.

The angle of the conical, inner circumferential face may be any angle that slides up the corresponding ramp/conical face of the retainer. In an embodiment, the angle is about 5 to about 60 degrees.

The spiral cut through the wedge shaped back-up ring is two flat surfaces. The spiral cut may be vertical cut at zero degrees from the vertical. The spiral cut may be about 0 to about 20 degrees from the vertical.

The back-up ring unwinds as it moves up the conical face of the retainer. The ends of the spiral shape turn and the outer surface 302 increases in diameter as the back-up ring slides up the angle of the conical ramp 218, 219.

There are several benefits to the back-up rings of the disclosure. The spiral ring shape acts as a spring as it expands up the ramp/cone shaped ends of the retainers. The spring force tries to pull the expanded back-up ring back down to the mandrel. The spring force may aid in retrieval because the back-up ring will return to, or nearly to, the run-in shape for retrieval.

Additionally, the spring force may also push on the packing elements to keep the element system energized. The element is less likely to lose pressure with the additional spring force provided by the back-up rings. Further, the spiral cut in the spiral ring may close after it is pushed up the ramp/cone ends of the retainer, thereby forming a labyrinth seal preventing element extrusion.

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The back-up may be made of any material strong enough to retain the expanded packer element under downhole conditions. In an embodiment, the back-up ring starts as a metal wedge made from annealed stainless steel. The wedge is spiral cut with Electrical Discharge Machining (EDM). In some embodiments, the back-up ring is an investment casting. In another embodiment, the back-up ring is 3D printed in the finished shape.

One of skill in the art will realize that the back-up ring assemblies according to embodiments of this disclosure have many functions and advantages, including expanding out to contact the casing, possessing high expansion properties that retain the packing elements, potentially being retrievable because the back-up ring spring force may return the rings to the run-in shape, and potentially forming a labyrinth seal to prevent element extrusion.

#### Use in Wellbore

FIG. 4 depicts a well system 400 with packer assemblies according to certain embodiments of the present invention. The well system 400 includes a wellbore 410 extending through various earth strata. The wellbore 410 has a substantially vertical section 404 and a substantially horizontal section 406. The substantially vertical section 404 and the substantially horizontal section 406 may include a casing string 409 cemented 408 at an upper portion of the substantially vertical section 104. The substantially horizontal section 406 extends through a hydrocarbon bearing subterranean formation.

A tubing string 412 extends from the surface within wellbore 410, with an annulus 402. The tubing string 412 may provide a conduit for formation fluids to travel from the substantially horizontal section 106 to the surface. Packer assemblies 414, 416 may be positioned with the tubing string 412 in the horizontal section 406. Other components (not shown), such as production tubing, screens, inflow control devices, may be positioned in the wellbore 410. Packer assemblies 414, 416 may provide annular seals between the tubing string 412 and the casing string 408 to define zones 418, 420. One or both packer assemblies 414, 416 may provide desired load performance and be retrievable from the wellbore 410.

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Although FIG. 4 depicts packer assemblies 414, 416 positioned in the substantially horizontal section 106, packer assemblies 414, 416 according to various embodiments of the present invention may be located, additionally or alternatively, in the substantially vertical section 404. Furthermore, any number of packer assemblies, including one, may be used. In some embodiments, packer assemblies 414, 416 may be disposed in simpler wellbores, such as wellbores having only a substantially vertical section.

While preferred embodiments of the invention have been shown and described, modifications thereof can be made by one skilled in the art without departing from the spirit and teachings of the invention. The embodiments described herein are exemplary only, and are not intended to be limiting. Many variations and modifications of the invention disclosed herein are possible and are within the scope of the invention. Use of the term "optionally" with respect to any element of a claim is intended to mean that the subject element is required, or alternatively, is not required. Both alternatives are intended to be within the scope of the claim.

Embodiments disclosed herein include:

A: A method of retaining a packing element comprising utilizing a back-up ring assembly in contact with at least one packing element, the assembly comprising: at least one wedge shaped spiral ring comprising: at least one outer circumferential face configured to contact a wellbore casing or liner; at least one conical, inner circumferential face configured to contact at least one of: a portion of retainer, a portion of a retainer with a conical face, a portion of a mandrel, and combinations thereof; and an axial end face configured to contact the at least one packing element.

B: A back-up ring assembly comprising at least one wedge shaped spiral ring comprising: at least one outer circumferential face configured to contact a wellbore casing or liner; at least one conical, inner circumferential face configured to contact at least one of: a portion of a retainer, a portion of a retainer with a conical face, a portion of a mandrel, and combinations thereof; and an axial end face configured to contact a packing element.

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C: A downhole assembly comprising an elongate mandrel configured to be placed in a wellbore casing or liner; a retainer configured to slideably engage along the mandrel, wherein said retainer comprises a conical face; a packing element configured to slide along the mandrel; at least one wedge shaped spiral ring disposed between the retainer and the packing element, the ring comprising: at least one outer circumferential face configured to contact the casing or string; at least one conical, inner circumferential face configured to contact at least one of: a portion of the retainer, a portion of the conical face of the retainer, a portion of the mandrel, and combinations thereof; and an axial end face configured to contact the packing element.

Each of embodiments A, B, and C may have one or more of the following additional elements in any combination: Element 1: further comprising at least one retainer, wherein the at least one wedge shaped spiral ring is located between the at least one packing element and the at least one retainer. Element 2: further comprising a mandrel, wherein the at least one wedge shaped spiral ring, the at least one packing element and the at least one retainer are located around the mandrel. Element 3: further comprising expanding the at least one wedge shaped spiral ring between the at least one retainer and the at least one packing element thereby forming a labyrinth seal preventing packing element extrusion. Element 4: wherein the at least one wedge shaped spiral ring acts as a spring force as it expands up the conical face of the at least one retainer and contacts the casing or liner. Element 5: further comprising relaxing the at least one wedge shaped spiral ring, wherein the at least one ring returns to an unexpanded configuration. Element 6: further comprising retrieving the at least one wedge shaped spiral ring from the wellbore. Element 7: wherein the assembly comprises two retainers, two wedge shaped spiral rings, and one packing element, wherein each retainer is on a different side of the packing element, and each wedge shaped spiral ring is between an individual packing element and an individual retainer. Element 8: wherein the at least one wedge shaped spiral ring is cut as one continuous spiral. Element 9: wherein the at least one wedge shaped spiral ring is a 3D printed ring. Element 10: further comprising at least one packing element and at least one retainer, wherein the at least one

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wedge shaped spiral ring is located between the at least one packing element and the at least one retainer. Element 11: wherein the at least one wedge shaped spiral ring in an expanded condition between the at least one retainer and the at least one compressed packing element forms a labyrinth seal. Element 12: wherein the at least one wedge shaped spiral ring in an expanded condition contacts a casing or liner. Element 13: further comprising a plug disposed within the mandrel. Element 14: wherein the spiral cut is about 0 to about 20 degrees from vertical. Element 15: wherein the angle of at least one conical, inner circumferential face is about 5 to about 60 degrees. Element 16: wherein the at least one retainer comprises a conical face, wherein the angle of the conical face is about 5 to about 60 degrees. Element 17: wherein the at least one retainer comprises a conical face, wherein the angle of the conical face is about 20 to about 35 degrees. Element 18: wherein the angle of at least one conical, inner circumferential face is about 20 to about 35 degrees.

Numerous other modifications, equivalents, and alternatives, will become apparent to those skilled in the art once the above disclosure is fully appreciated. It is intended that the following claims be interpreted to embrace all such modifications, equivalents, and alternatives where applicable.

## CLAIMS

1. A method of retaining a packing element comprising:  
utilizing a back-up ring assembly in contact with at least one  
packing element, the assembly comprising:  
5 at least one wedge shaped spiral ring comprising:  
at least one outer circumferential face configured to contact a  
wellbore casing or liner;  
at least one conical, inner circumferential face configured to  
directly contact a portion of a retainer, wherein the at least one  
10 conical, inner circumferential face is angled relative to the at least  
one outer circumferential face;  
an axial end face configured to directly contact the at least  
one packing element, wherein the axial end face is perpendicular to  
the at least one outer circumferential face; and  
15 a spiral cut extending entirely through the at least one wedge  
shaped spiral ring between the at least one outer circumferential  
face and the at least one conical, inner circumferential face, the  
spiral cut making at least two full revolutions around the at least  
one wedge shaped spiral ring.
- 20 2. The method of claim 1, further comprising at least one retainer,  
wherein the at least one wedge shaped spiral ring is located between the  
at least one packing element and the at least one retainer.
3. The method of claim 2, further comprising a mandrel, wherein the  
at least one wedge shaped spiral ring, the at least one packing element  
25 and the at least one retainer are located around the mandrel.
4. The method of claim 3, further comprising expanding the at least  
one wedge shaped spiral ring between the at least one retainer and the at  
least one packing element thereby forming a labyrinth seal preventing  
packing element extrusion.
- 30 5. The method of claim 4, wherein the at least one retainer comprises  
a conical face and wherein the at least one wedge shaped spiral ring acts

as a spring force as it expands up the conical face of the at least one retainer and contacts the casing or liner.

5        6.        The method of claim 4, further comprising relaxing the at least one wedge shaped spiral ring, wherein the at least one wedge shaped spiral ring returns to an unexpanded configuration.

7.        The method of claim 6, further comprising retrieving the at least one wedge shaped spiral ring from the wellbore.

10       8.        The method of claim 1, wherein the assembly comprises two retainers, two wedge shaped spiral rings, and one packing element, wherein each retainer is on a different side of the packing element, and each wedge shaped spiral ring is between an individual packing element and an individual retainer.

9.        The method of claim 1, wherein the spiral cut is a single continuous spiral cut.

15       10.       The method of claim 9, wherein the spiral cut is about 0 to about 20 degrees from vertical.

11.       The method of claim 1, wherein the at least one wedge shaped spiral ring is a 3D printed ring.

20       12.       The method of claim 2, wherein the at least one retainer comprises a conical face, and wherein an angle of the conical face is about 5 to about 60 degrees.

13.       The method of claim 1, wherein an angle of the at least one conical, inner circumferential face relative to the at least one outer circumferential face is about 5 to about 60 degrees.

25

14. A back-up ring assembly comprising:  
at least one wedge shaped spiral ring comprising:  
at least one outer circumferential face configured to contact a wellbore casing or liner;  
5 at least one conical, inner circumferential face configured to directly contact a portion of a retainer, wherein the at least one conical, inner circumferential face is angled relative to the at least one outer circumferential face;  
an axial end face configured to directly contact a packing  
10 element, wherein the axial end face is perpendicular to the at least one outer circumferential face; and  
a spiral cut extending entirely through the at least one wedge shaped spiral ring between the at least one outer circumferential face and the at least one conical, inner circumferential face, the  
15 spiral cut making at least two full revolutions around the at least one wedge shaped spiral ring.
15. The assembly of claim 14, further comprising at least one packing element and at least one retainer, wherein the at least one wedge shaped spiral ring is located between the at least one packing element and the at  
20 least one retainer.
16. The assembly of claim 15, further comprising a mandrel, wherein the at least one wedge shaped spiral ring, the at least one packing element and the at least one retainer are located around the mandrel.
17. The assembly of claim 16, wherein the at least one wedge shaped spiral ring in an expanded condition between the at least one retainer and  
25 the at least one compressed packing element forms a labyrinth seal.
18. The assembly of claim 16, wherein the at least one wedge shaped spiral ring in an expanded condition contacts a casing or liner.
19. The assembly of claim 14, wherein the assembly comprises two  
30 retainers, two wedge shaped spiral rings, and one packing element, wherein each retainer is on a different side of the packing element, and

each wedge shaped spiral ring is between an individual packing element and an individual retainer.

20. The assembly of claim 16, further comprising a plug disposed within the mandrel.

5 21. The assembly of claim 14, wherein the spiral cut is a single continuous spiral cut.

22. The assembly of claim 21, wherein the spiral cut is about 0 to about 20 degrees from vertical.

10 23. The assembly of claim 14, wherein the at least one wedge shaped spiral ring is metal.

24. The assembly of claim 14, wherein the at least one wedge shaped spiral ring is a 3D printed ring.

15 25. The assembly of claim 15, wherein the at least one retainer comprises a conical face, and wherein an angle of the conical face is about 5 to about 60 degrees.

26. The assembly of claim 14, wherein the angle of the at least one conical, inner circumferential face relative to the at least one outer circumferential face is about 5 to about 60 degrees.

20 27. A downhole assembly comprising:  
an elongate mandrel configured to be placed in a wellbore casing or liner;  
a retainer configured to slideably engage along the mandrel,  
wherein said retainer comprises a conical face;  
25 a packing element configured to slide along the mandrel;  
at least one wedge shaped spiral ring disposed between the retainer and the packing element, the at least one wedge shaped spiral ring comprising:  
at least one outer circumferential face configured to contact  
30 the casing or string;

at least one conical, inner circumferential face configured to directly contact a portion of the retainer, wherein the at least one conical, inner circumferential face is angled relative to the at least one outer circumferential face;

5 an axial end face configured to directly contact the packing element, wherein the axial end face is perpendicular to the at least one outer circumferential face; and

10 a spiral cut extending entirely through the at least one wedge shaped spiral ring between the at least one outer circumferential face and the at least one conical, inner circumferential face, the spiral cut making at least two full revolutions around the at least one wedge shaped spiral ring.

28. The assembly of claim 27, further comprising a plug disposed within the mandrel.

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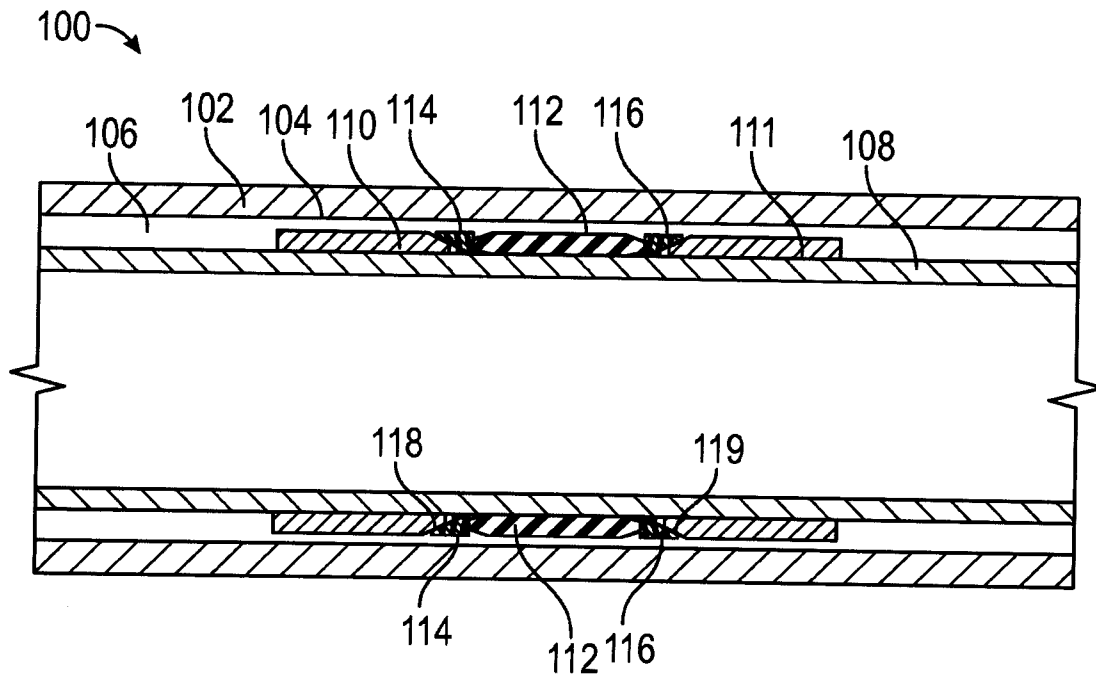


FIG. 1

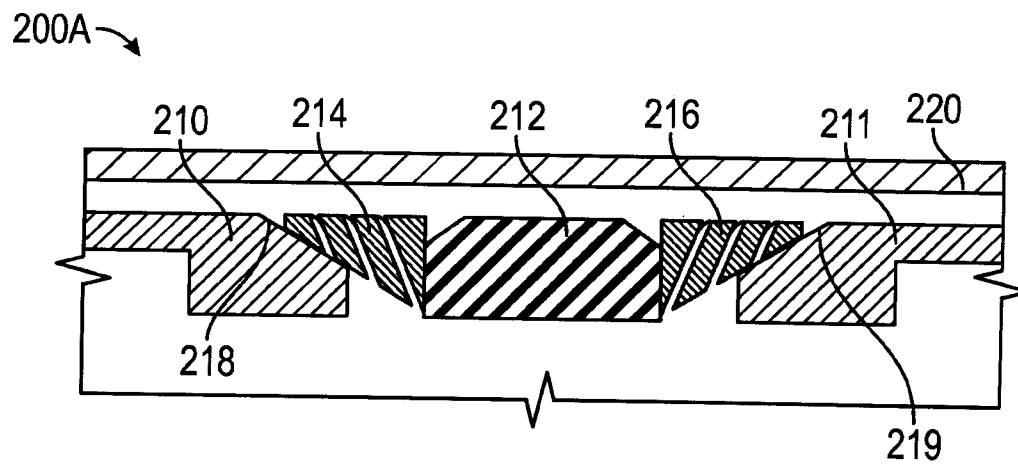


FIG. 2A

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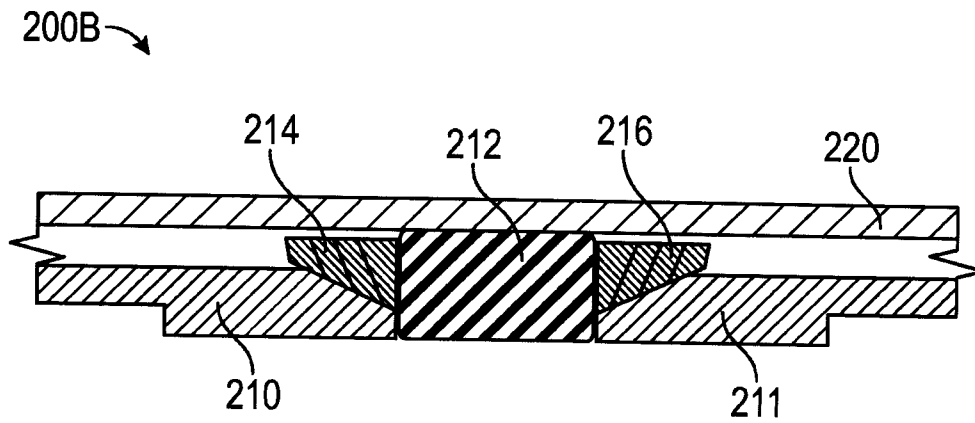


FIG. 2B

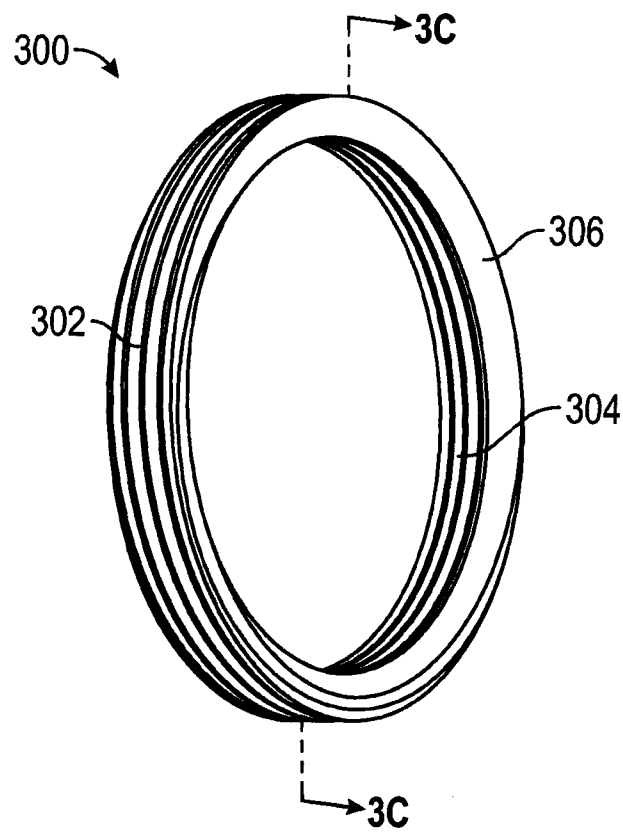


FIG. 3A

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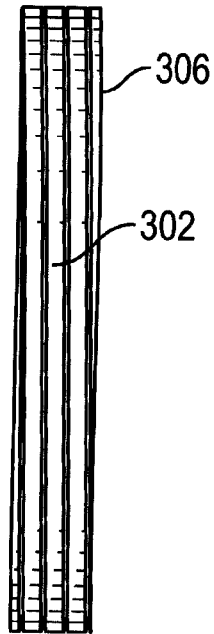


FIG. 3B

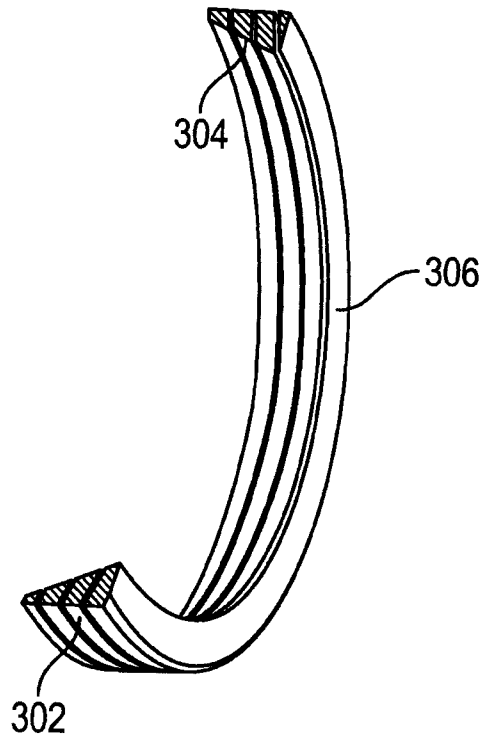


FIG. 3C

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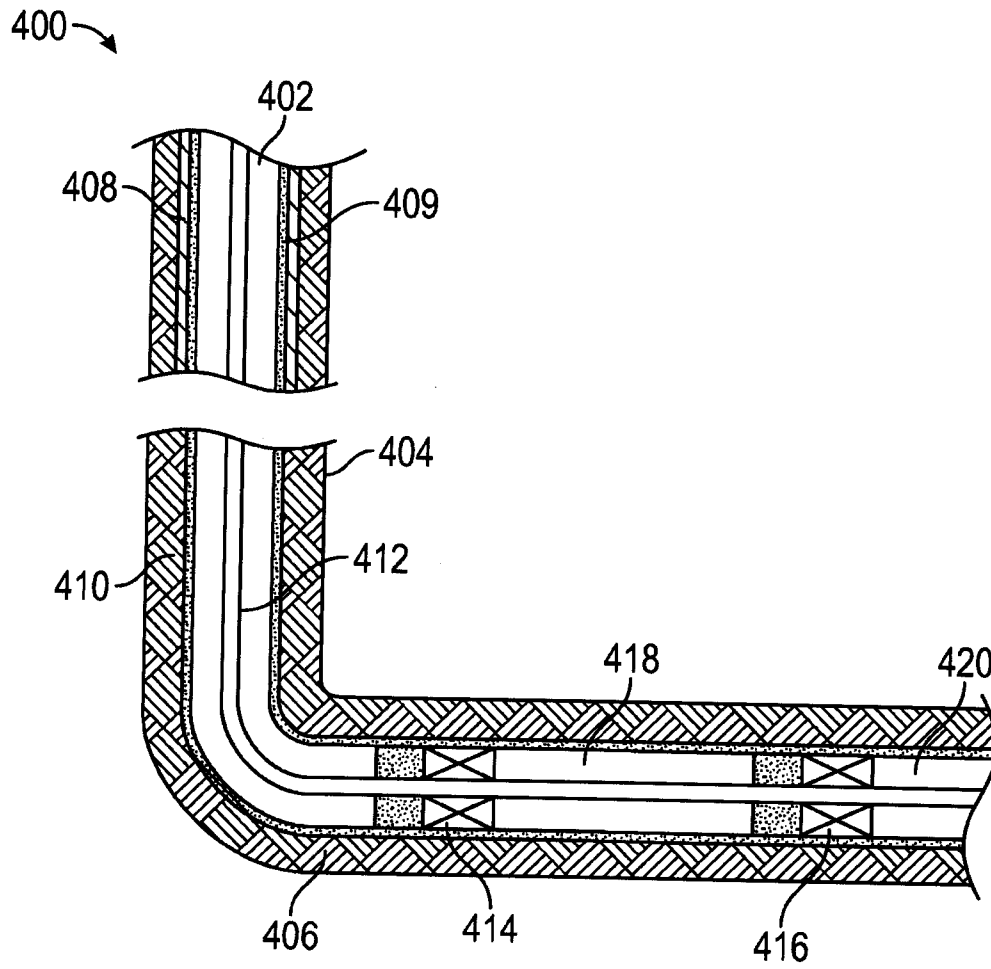


FIG. 4

