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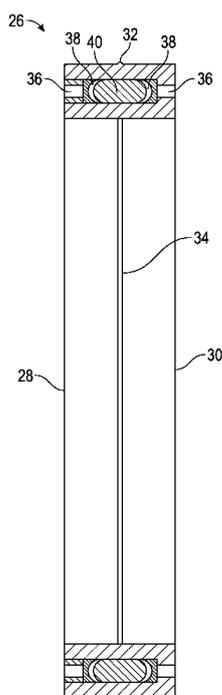


FIG. 4

(57) Abstract: A metal to metal seal and method including a first sealing member and a second sealing member, wherein the first and second sealing members are attached together to form a cylindrical sealing device; a first sealing surface and a second sealing surface on the first sealing member and the second sealing member, wherein the first and second metal sealing surfaces form a metal to metal seal with an internal cylindrical sealing surface and an external cylindrical sealing surface respectively; a transverse facing recess positioned between the first and second metal sealing surfaces; a nonmetal seal received in the transverse facing recess; and at least one pressure communication hole on each of the first and second sealing members, wherein the nonmetal seal is in fluid communication with the pressure communication holes, and a pressure differential across the sealing device energizes the nonmetal seal.



SINGLE POINT METAL TO METAL SEAL

BACKGROUND

In oil and gas wells, metal seals are sometimes used to seal between
5 structures in well tools, and in equipment used in other environments. However,
several problems are frequently encountered when metal seals are used. For
example, metal seals require very smooth and clean surfaces to seal against, and
most metals can only be elastically deformed to a limited extent (which thereby
limits the biasing force available from elastically deforming a metal seal), etc.

10 Elastomeric and other types of nonmetal seals may provide the ability to
seal against irregular and unclean surfaces, and may provide sufficient resilient
biasing force for urging the seals against the surfaces. However, nonmetal seals
tend to degrade rapidly when used in dynamic configurations, i.e., where the seal
must contact a moving surface while sealing against a pressure differential, or
15 where the seal loses contact with the surface while the pressure differential still
exists across the seal.

Metal to metal seals are preferred in some applications over elastomeric
seals. An advantage of metal to metal seals is their wear capabilities, a property
that is needed for dynamic seals and especially important when unloading
20 pressure (when a seal opens up with a pressure differential such as in valves).
Radial metal to metal seals that have two points of contact that will only seal in
one direction like, for example, metal C-ring seals. To seal in both directions one
needs at least four points of contact. The problem with having four points of
contact is that they create pressure traps between them that can significantly
25 increase stroking pressure.

Therefore, a need has arisen for an improved metal to metal seal for reliable
low and high pressure sealing.

BRIEF DESCRIPTION OF THE DRAWINGS

30 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.

FIG 1 is a schematic cross-sectional view of a wellbore system according to aspects of the disclosure.

FIG. 2 is a perspective view of a metal to metal seal according to aspects of the disclosure.

5 FIG. 3A is a cross-sectional view of a valve with a closure device in a closed position according to aspects of the disclosure.

FIG. 3B is a cross-sectional view of a valve with a closure device in an open position according to aspects of the disclosure.

10 FIG. 4 depicts a cross-sectional view of a metal to metal seal according to aspects of the disclosure.

FIG. 5 depicts a profile cross-sectional view of a metal to metal seal according to aspects of the disclosure.

FIG. 6 is an enlarged scale cross-sectional view of a metal to metal seal according to aspects of the disclosure.

15 FIG. 7A is an enlarged scale cross-sectional view of components of metal to metal seals according to aspects of the disclosure.

FIG. 7B is an enlarged scale cross-sectional view of deconstructed components of metal to metal seals according to aspects of the disclosure.

20 FIG. 8A is an enlarged scale cross-sectional view of components of metal to metal seals according to aspects of the disclosure.

FIG. 8B is an enlarged scale cross-sectional view of deconstructed components of metal to metal seals according to aspects of the disclosure.

FIG. 9A is an enlarged scale cross-sectional view of components of metal to metal seals according to aspects of the disclosure.

25 FIG. 9B is an enlarged scale cross-sectional view of deconstructed components of metal to metal seals according to aspects of the disclosure.

FIG. 10 is an exploded view of a seal according to aspects of the disclosure.

DETAILED DESCRIPTION

30 The disclosure is generally directed to two-directional metal to metal seals with only two contact points for reliable low- and high-pressure sealing. The metal to metal seal contains an elastomeric portion that is substantially static.

A wellbore tool may comprise an internal cylindrical sealing surface; an external cylindrical sealing surface; and a sealing device for sealing between the
35 internal and external cylindrical surface, the sealing device comprising: a first

sealing member and a second sealing member, wherein the first and second sealing members are attached together to form a cylindrical sealing device; a first sealing surface and a second sealing surface on at least one of the first sealing member, the second sealing member, and combinations thereof, wherein the first metal sealing surface forms a metal to metal seal with the internal cylindrical sealing surface, and the second metal sealing surface forming a metal to metal seal with the external cylindrical sealing surface; a transverse facing recess positioned between the first and second metal sealing surfaces; a nonmetal seal received in the transverse facing recess; and at least one pressure communication hole on each of the first and second sealing members, wherein the nonmetal seal is in fluid communication with the pressure communication holes, and a pressure differential across the sealing device energizes the nonmetal seal.

The energization of the nonmetal seal may bias the first sealing surface against the internal cylindrical sealing surface and biases the second sealing surface against the external cylindrical sealing surface. The bias may be adjusted by altering the flexibility of at least one of the walls of at least one of the first sealing member, second sealing member, and combinations thereof. The flexibility of the at least one wall may be altered by adjusting the length, thickness, and combinations thereof, of the at least one wall. The tool may further comprise at least one backup in the recess. The backup material may be at least one selected from the group consisting of plastic, PTFE, metal, and combinations thereof. The first and second sealing members may be attached by at least one of bolts, e-beam welding, and combinations thereof. The first metal sealing surface may only have one metal to metal contact surface with the internal cylindrical sealing surface, and the second metal sealing surface may only have one metal to metal contact surface with the external cylindrical sealing surface. Each of the metal to metal contact surfaces may be an equatorial ridge on each of the first and second metal sealing surfaces.

A sealing device may comprise: a first sealing member and a second sealing member, wherein the first and second sealing members are attached together to form a cylindrical sealing device; a first sealing surface and a second sealing surface on at least one of the first sealing member, the second sealing member, and combinations thereof, wherein the first metal sealing surface forms a metal to metal seal with an internal cylindrical sealing surface, and the second metal sealing surface forming a metal to metal seal with an external cylindrical sealing

surface; a transverse facing recess positioned between the first and second metal sealing surfaces; a nonmetal seal received in the transverse facing recess; and at least one pressure communication hole on each of the first and second sealing members, wherein the nonmetal seal is in fluid communication with the pressure communication holes, and a pressure differential across the sealing device energizes the nonmetal seal.

The energization of the nonmetal seal may bias the first sealing surface against an internal cylindrical sealing surface and biases the second sealing surface against an external cylindrical sealing surface. The bias may be adjusted by altering the flexibility of at least one of the walls of at least one of the first sealing member, second sealing member, and combinations thereof. The flexibility of the at least one wall may be altered by adjusting the length, thickness, and combinations thereof, of the at least one wall. The seal may further comprise at least one backup in the recess. The backup material may be at least one selected from the group consisting of plastic, PTFE, metal, and combinations thereof. The first and second sealing members may be attached by at least one of bolts, e-beam welding, and combinations thereof. The first metal sealing surface may only have one metal to metal contact surface with an internal cylindrical sealing surface, and the second metal sealing surface may only have one metal to metal contact surface with an external cylindrical sealing surface. Each of the metal to metal contact surfaces may be equatorial ridges on each of the first and second metal sealing surfaces.

A method of sealing may comprise: providing a sealing device, comprising: a first sealing member and a second sealing member, wherein the first and second sealing members are attached together to form a cylindrical sealing device; a first sealing surface and a second sealing surface on at least one of the first sealing member, the second sealing member, and combinations thereof, wherein the first metal sealing surface forms a metal to metal seal with an internal cylindrical sealing surface, and the second metal sealing surface forming a metal to metal seal with an external cylindrical sealing surface; a transverse facing recess positioned between the first and second metal sealing surfaces; a nonmetal seal received in the transverse facing recess; and at least one pressure communication hole on each of the first and second sealing members, wherein the nonmetal seal is in fluid communication with the pressure communication holes, and a pressure differential across the sealing device energizes the nonmetal seal; and applying a

differential pressure across the sealing device while the sealing device seals between an external cylindrical sealing surface and an internal cylindrical sealing surface.

The energization of the nonmetal seal may bias the first sealing surface against an internal cylindrical sealing surface and biases the second sealing surface against an external cylindrical sealing surface. The bias may be adjusted by altering the flexibility of at least one of the walls of at least one of the first sealing member, second sealing member, and combinations thereof. The flexibility of the at least one wall may be altered by adjusting the length, thickness, and combinations thereof, of the at least one wall. The method may further comprise a seal with at least one backup in the recess. The backup material may be at least one selected from the group consisting of plastic, PTFE, metal, and combinations thereof. The first and second sealing members may be attached by at least one of bolts, e-beam welding, and combinations thereof. The first metal sealing surface may only have one metal to metal contact surface with an internal cylindrical sealing surface, and the second metal sealing surface may only have one metal to metal contact surface with an external cylindrical sealing surface. Each of the metal to metal contact surfaces may be an equatorial ridge on each of the first and second metal sealing surfaces.

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.

Metal to Metal Seal

The seal may comprise two pieces of metal that are either bolted or e-beam welded together. On the inside there is a static elastomeric seal with optional backups. Both metal pieces have holes for pressure communication between the inside and the outside of the seal. FIG. 1 is a wellbore system **10** in which aspects of the present disclosure may be implemented. In the wellbore system **10**, a tubular string **12** (such as a production tubing string) is positioned in a wellbore **14** lined with casing **16**. The tubular string **12** includes wellbore

tools **18, 20**, which, in this example, are more particularly a packer **18** and a flow control device **20**.

The flow control device **20** may be a valve or choke for example. The packer **18** provides an annular seal between the tubular string **12** and the casing **16**. The flow control device **20** regulates fluid communication between the interior of the tubular string and an annulus **22** formed between the tubular string and the casing **16**. The flow control device **20** includes a closure mechanism **24** which is operated to regulate flow.

As a reminder, the aspects of this disclosure are not limited to any of the details of the wellbore system **10** described herein. For example, it is not necessary for the sealing device of this disclosure to be used in a wellbore, in a wellbore tool, in a cased wellbore, in a flow control device, in a tubular string, etc. The closure mechanism **24** could, as another example, be used in a hydraulic setting device of the packer **18**, or could be used in another type of wellbore tool. Thus, it should be clearly understood that the wellbore system **10** is only a single example of a wide variety of uses for the principles of the disclosure.

FIG. 2 is a perspective view of a sealing device **26** which may be used for sealing in the closure mechanism **24** is representatively illustrated. However, it should be understood that the sealing device **26** may be used in many other sealing applications and is not necessarily used in the wellbore system **10**.

The sealing device **26** depicted in FIG. 2 is a metal to metal seal with a first sealing member **28** and a second sealing member **30**. The metal to metal seal **28** includes a first sealing surface **32**, a second sealing surface **34**, and pressure communication holes **36**. In FIG. 2, the metal to metal sealing surfaces **32, 34**, each only have one metal to metal contact surface shown as equatorial ridges on the first and second metal sealing surfaces **32, 34**.

FIG. 3A is a cross-sectional view of a valve according to aspects of the disclosure. The metal sealing surface **34** of seal **26** may be used to seal against an interior cylindrical sealing surface in closure mechanism **24**. If the interior cylindrical sealing surface is made of a metal, then a metal to metal seal may be formed between the sealing surface **34** and the internal cylindrical sealing surface. In FIG. 3A, the closure mechanism **24** is in a closed position. FIG. 3B is a cross-sectional view of a valve where the closure mechanism **24** has been moved away from seal **26**, thereby showing the closure mechanism **24** in a partially open position.

Similarly, the metal sealing surface **32** of seal **26** may be used to seal against an exterior cylindrical sealing surface in closure mechanism **24**. If the exterior cylindrical sealing surface is made of a metal, then a metal to metal seal will be formed between the sealing surface **32** and the exterior cylindrical sealing surface.

A cross-sectional view of the metal seal **26** is representatively illustrated in FIG. 4. A transverse facing recess **38** is positioned between the first and second metal sealing surfaces **32, 34**. A nonmetal seal **40** is received in the transverse facing recess **38**. Pressure communication holes **36**, may be located on both sides of the metal seal **26**.

FIG. 5 is a profile cross-sectional view of a metal to metal seal according to aspects of the disclosure. The nonmetal seal **40** is in fluid communication with the pressure communication holes **36**, and a pressure differential across the sealing device **26** energizes the nonmetal seal **40**. The elastomeric seal **40** provides the pressure "energization" of the metal to metal sealing surfaces **32, 34**. When pressure is applied from either direction, the pressure on the elastomeric seal **40** is transferred to the metal ridges **32, 34** increasing their contact pressure and boosting the sealing capability. This may allow low contact pressure (and low stroking forces) when no differential pressure is present and also allowing high contact pressure while sealing against high pressures.

FIG. 6 is an enlarged scale cross-sectional view of the sealing device **26** depicting how the first sealing member **28** and the second sealing member **30** may be joined together to create a transverse facing recess **38**. The first and second sealing members **28, 30** may be attached at **42** by at least one of bolts, e-beam welding, and combinations thereof. The energization of the nonmetal seal **40** deflects radially the first sealing surface **32** against an exterior cylindrical sealing surface and deflects radially the second sealing surface **34** against an interior cylindrical sealing surface. This deflection causes elastic deformation of the walls **44, 46** of the sealing members **28, 30**, resulting in a biasing force being applied by the walls **44, 46** to the sealing surfaces **32, 34**. The bias may be adjusted by altering the flexibility of at least one of the walls **44, 46** of at least one of the first sealing member **28**, second sealing member **30**, and combinations thereof. The flexibility of the metal walls **44** and **46** may be adjusted by changing their length, thickness, and combinations thereof. The biasing force may increase

the contact pressure between the sealing surfaces **32, 34** of the seal and the surfaces of a tool to be sealed, such as the closure mechanism **24** in FIG. 3.

FIGS. 7 - 9 are demonstrating several ways in which the first sealing member **28** and the second sealing member **30** may be joined together. FIG. 7A is an enlarged scale cross-sectional view of components of metal to metal seals according to aspects of the disclosure. FIG. 7B is a deconstructed view of the components in FIG. 7A illustrating how sealing members **28A** and **30B** may come together to form sealing device **26**. FIG. 8A is an enlarged scale cross-sectional view of components of metal to metal seals according to aspects of the disclosure. FIG. 8B is a deconstructed view of the components in FIG. 8A illustrating how sealing members **50A** and **52B** may be joined to form seal **48**. FIG. 9A is an enlarged scale cross-sectional view of components of metal to metal seals according to aspects of the disclosure. FIG. 9B is a deconstructed view of the components in FIG. 9A illustrating how, in a preferred arrangement, sealing members **56A** and **58B** have an "L" type of configuration and may be joined together to form seal **54**.

FIG. 10 is an exploded view of a seal **60** demonstrating how the various components of the seal **60** may be assembled together. Between first sealing member **62** and second sealing member **64** are an optional backup **68**, a nonmetal seal **66**, and an optional backup **70**.

The metal to metal seals in the disclosure may be made of any material strong enough to create a two contact point seal under downhole conditions. The metal sealing surfaces are preferably made of strong, durable and resilient metals, such as Inconel 718, 13-chrome steel, stainless steel, etc. It should be clearly understood that any metal materials may be used for the metal seals in aspects of this disclosure. The metal ring may be stainless steel. The first and second sealing members may be attached by at least one of bolts, e-beam welding, and combinations thereof.

The nonmetallic portion of the seals may be made of high temperature resistant, well fluid resistant, strong, and elastomeric materials, such as NBR, HNBR, fluoroelastomers, etc. Non elastomeric materials, such as plastic, PTFE, metal, and combinations thereof, may additionally or alternatively be used in the nonmetallic portions of the seals. When used with the elastomeric materials, the non-elastomeric materials may be referred to as backups. PEEK may be used as a backup material.

One of skill in the art will realize that there are several benefits to the sealing devices and methods of the disclosure. One benefit is the possibility of low stroking forces. Because there are only two metal to metal contact points instead of the typical four, the stroke force may be half of the value in a four point contact seal. Further, the designs in the disclosure may eliminate pressure traps, which may result in significantly increasing stroking forces.

Additionally, the seals and methods of the disclosure may utilize pressure energization. When the pressure differential is applied across the seal, the nonmetallic seal transfers pressure to the metal walls in the sealing members, thereby increasing the contact pressure of the metal ridges and boosting their sealing capability. Further, the nonmetallic portion is static and may not be subject to wear from dynamic loading and/or erosion from pressure unloading.

Use in Wellbore

The disclosed sealing devices may directly or indirectly affect the various downhole equipment and tools that may come into contact with the sealing devices during operation. Such equipment and tools may include, but are not limited to, wellbore casing, wellbore liner, completion string, insert strings, drill string, coiled tubing, slickline, wireline, drill pipe, drill collars, mud motors, downhole motors and/or pumps, surface-mounted motors and/or pumps, centralizers, turbolizers, scratchers, floats (e.g., shoes, collars, valves, etc.), logging tools and related telemetry equipment, actuators (e.g., electromechanical devices, hydromechanical devices, etc.), sliding sleeves, production sleeves, plugs, screens, filters, flow control devices (e.g., inflow control devices, autonomous inflow control devices, outflow control devices, etc.), couplings (e.g., electro-hydraulic wet connect, dry connect, inductive coupler, etc.), control lines (e.g., electrical, fiber optic, hydraulic, etc.), surveillance lines, drill bits and reamers, sensors or distributed sensors, downhole heat exchangers, valves and corresponding actuation devices, tool seals, packers, cement plugs, bridge plugs, and other wellbore isolation devices, or components, and the like. Any of these components may be included in the systems generally described above and depicted in FIG. 1.

While preferred aspects 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
5 of the claim.

Aspects disclosed herein include:

A: A wellbore tool comprising an internal cylindrical sealing surface; an external cylindrical sealing surface; and a sealing device for sealing between the internal and external cylindrical surface, the sealing device comprising: a first
10 sealing member and a second sealing member, wherein the first and second sealing members are attached together to form a cylindrical sealing device; a first sealing surface and a second sealing surface on at least one of the first sealing member, the second sealing member, and combinations thereof, wherein the first
15 metal sealing surface forms a metal to metal seal with the internal cylindrical sealing surface, and the second metal sealing surface forming a metal to metal seal with the external cylindrical sealing surface; a transverse facing recess positioned between the first and second metal sealing surfaces; a nonmetal seal received in the transverse facing recess; and at least one pressure communication
20 hole on each of the first and second sealing members, wherein the nonmetal seal is in fluid communication with the pressure communication holes, and a pressure differential across the sealing device energizes the nonmetal seal.

B: A sealing device comprising a first sealing member and a second sealing member, wherein the first and second sealing members are attached together to form a cylindrical sealing device; a first sealing surface and a second sealing
25 surface on at least one of the first sealing member, the second sealing member, and combinations thereof, wherein the first metal sealing surface forms a metal to metal seal with an internal cylindrical sealing surface, and the second metal sealing surface forming a metal to metal seal with an external cylindrical sealing surface; a transverse facing recess positioned between the first and second metal
30 sealing surfaces; a nonmetal seal received in the transverse facing recess; and at least one pressure communication hole on each of the first and second sealing members, wherein the nonmetal seal is in fluid communication with the pressure communication holes, and a pressure differential across the sealing device energizes the nonmetal seal.

C: A method of sealing comprising providing a sealing device, comprising: a first sealing member and a second sealing member, wherein the first and second sealing members are attached together to form a cylindrical sealing device; a first sealing surface and a second sealing surface on at least one of the first sealing member, the second sealing member, and combinations thereof, wherein the first metal sealing surface forms a metal to metal seal with an internal cylindrical sealing surface, and the second metal sealing surface forming a metal to metal seal with an external cylindrical sealing surface; a transverse facing recess positioned between the first and second metal sealing surfaces; a nonmetal seal received in the transverse facing recess; and at least one pressure communication hole on each of the first and second sealing members, wherein the nonmetal seal is in fluid communication with the pressure communication holes, and a pressure differential across the sealing device energizes the nonmetal seal; and applying a differential pressure across the sealing device while the sealing device seals between an external cylindrical sealing surface and an internal cylindrical sealing surface.

Each of aspects A, B, and C may have one or more of the following additional elements in any combination: Element 1: wherein the energization of the nonmetal seal biases the first sealing surface against the internal cylindrical sealing surface and biases the second sealing surface against the external cylindrical sealing surface. Element 2: wherein the bias is adjusted by altering the flexibility of at least one of the walls of at least one of the first sealing member, second sealing member, and combinations thereof. Element 3: wherein the flexibility of the at least one wall is altered by adjusting the length, thickness, and combinations thereof of the at least one wall. Element 4: further comprising at least one backup in the recess. Element 5: wherein the backup material is at least one selected from the group consisting of plastic, PTFE, metal, and combinations thereof. Element 6: wherein the first and second sealing members are attached by at least one of bolts, e-beam welding, and combinations thereof. Element 7: wherein the first metal sealing surface only has one metal to metal contact surface with the internal cylindrical sealing surface, and the second metal sealing surface only has one metal to metal contact surface with the external cylindrical sealing surface. Element 8: wherein each of the metal to metal contact surfaces is an equatorial ridge on each of the first and second metal sealing surfaces. Element 9: wherein the energization of the nonmetal seal biases the first sealing surface

against an internal cylindrical sealing surface and biases the second sealing surface against an external cylindrical sealing surface.

Numerous other modifications, equivalents, and alternatives, will become apparent to those skilled in the art once the above disclosure is fully appreciated.

- 5 It is intended that the following claims be interpreted to embrace all such modifications, equivalents, and alternatives where applicable.

CLAIMS

1. A wellbore tool, comprising:

an internal cylindrical sealing surface;

an external cylindrical sealing surface; and

5 a sealing device for sealing between the internal and external cylindrical surface, the sealing device comprising:

a first sealing member and a second sealing member, wherein the first and second sealing members are attached together to form a cylindrical sealing device;

10 a first sealing surface and a second sealing surface on at least one of the first seal member, the second seal member, and combinations thereof, wherein the first metal sealing surface forms a metal to metal seal with the internal cylindrical sealing surface, and the second metal sealing surface forming a metal to metal seal with
15 the external cylindrical sealing surface;

a transverse facing recess positioned between the first and second metal sealing surfaces;

a nonmetal seal received in the transverse facing recess; and

20 at least one pressure communication hole on each of the first and second sealing members, wherein the nonmetal seal is in fluid communication with the pressure communication holes, and a pressure differential across the sealing device energizes the nonmetal seal.

2. The tool of claim 1, wherein the energization of the nonmetal seal
25 biases the first sealing surface against the internal cylindrical sealing surface and biases the second sealing surface against the external cylindrical sealing surface.

3. The tool of claim 2, wherein the bias is adjusted by altering the flexibility of at least one of the walls of at least one of the first sealing member, second sealing member, and combinations thereof.

4. The tool of claim 3, wherein the flexibility of the at least one wall is altered by adjusting the length, thickness, and combinations thereof of the at least one wall.

5. The tool of claim 1, further comprising at least one backup in the recess.

6. The tool of claim 5, wherein the backup material is at least one selected from the group consisting of plastic, PTFE, metal, and combinations thereof.

7. The tool of claim 1, wherein the first and second sealing members are attached by at least one of bolts, e-beam welding, and combinations thereof.

8. The tool of claim 1, wherein the first metal sealing surface only has one metal to metal contact surface with the internal cylindrical sealing surface, and the second metal sealing surface only has one metal to metal contact surface with the external cylindrical sealing surface.

9. The tool of claim 8, wherein each of the metal to metal contact surfaces is an equatorial ridge on each of the first and second metal sealing surfaces.

10. A sealing device, comprising:

a first sealing member and a second sealing member, wherein the first and second sealing members are attached together to form a cylindrical sealing device;

a first sealing surface and a second sealing surface on at least one of the first sealing member, the second sealing member, and combinations thereof, wherein the first metal sealing surface forms a metal to metal seal

with an internal cylindrical sealing surface, and the second metal sealing surface forming a metal to metal seal with an external cylindrical sealing surface;

5 a transverse facing recess positioned between the first and second metal sealing surfaces;

a nonmetal seal received in the transverse facing recess; and

10 at least one pressure communication hole on each of the first and second sealing members, wherein the nonmetal seal is in fluid communication with the pressure communication holes, and a pressure differential across the sealing device energizes the nonmetal seal.

11. The device of claim 10, wherein the energization of the nonmetal seal biases the first sealing surface against an internal cylindrical sealing surface and biases the second sealing surface against an external cylindrical sealing surface.

15 12. The device of claim 11, wherein the bias is adjusted by altering the length, thickness, and combinations thereof, of the walls of at least one of the first sealing member, second sealing member, and combinations thereof.

20 13. The device of claim 10, further comprising at least one backup in the recess.

14. The device of claim 13, wherein the backup material is at least one selected from the group consisting of plastic, PTFE, metal, and combinations thereof.

25 15. The device of claim 10, wherein the first and second sealing members are attached by at least one of bolts, e-beam welding, and combinations thereof.

16. The device of claim 10, wherein the wherein the first metal sealing surface only has one metal to metal contact surface with an internal

cylindrical sealing surface, and the second metal sealing surface only has one metal to metal contact surface with an external cylindrical sealing surface.

17. The device of claim 16, wherein each of the metal to metal contact surfaces is an equatorial ridge on each of the first and second metal sealing surfaces.

18. A method of sealing, comprising:

providing a sealing device, comprising:

10 a first sealing member and a second sealing member, wherein the first and second sealing members are attached together to form a cylindrical sealing device;

15 a first sealing surface and a second sealing surface on at least one of the first sealing member, the second sealing member, and combinations thereof, wherein the first metal sealing surface forms a metal to metal seal with an internal cylindrical sealing surface, and the second metal sealing surface forming a metal to metal seal with an external cylindrical sealing surface;

a transverse facing recess positioned between the first and second metal sealing surfaces;

20 a nonmetal seal received in the transverse facing recess;

25 at least one pressure communication hole on each of the first and second sealing members, wherein the nonmetal seal is in fluid communication with the pressure communication holes, and a pressure differential across the sealing device energizes the nonmetal seal; and

applying a differential pressure across the sealing device while the sealing device seals between an external cylindrical sealing surface and an internal cylindrical sealing surface.

19. The method of claim 18, wherein the energization of the nonmetal seal biases the first sealing surface against an internal cylindrical sealing surface and biases the second sealing surface against an external cylindrical sealing surface.

5 20. The method of claim 19, wherein the bias is adjusted by altering the length, thickness, and combinations thereof, of at least one of the walls of at least one of the first sealing member, second sealing member, and combinations thereof.

10 21. The method of claim 18, further comprising at least one backup in the recess.

22. The method of claim 21, wherein the backup material is at least one selected from the group consisting of plastic, PTFE, metal, and combinations thereof.

15 23. The method of claim 18, wherein the first and second sealing members are attached by at least one of bolts, e-beam welding, and combinations thereof.

20 24. The method of claim 18, wherein the wherein the first metal sealing surface only has one metal to metal contact surface with an internal cylindrical sealing surface, and the second metal sealing surface only has one metal to metal contact surface with an external cylindrical sealing surface.

25 25. The method of claim 24, wherein each of the metal to metal contact surfaces is an equatorial ridge on each of the first and second metal sealing surfaces.

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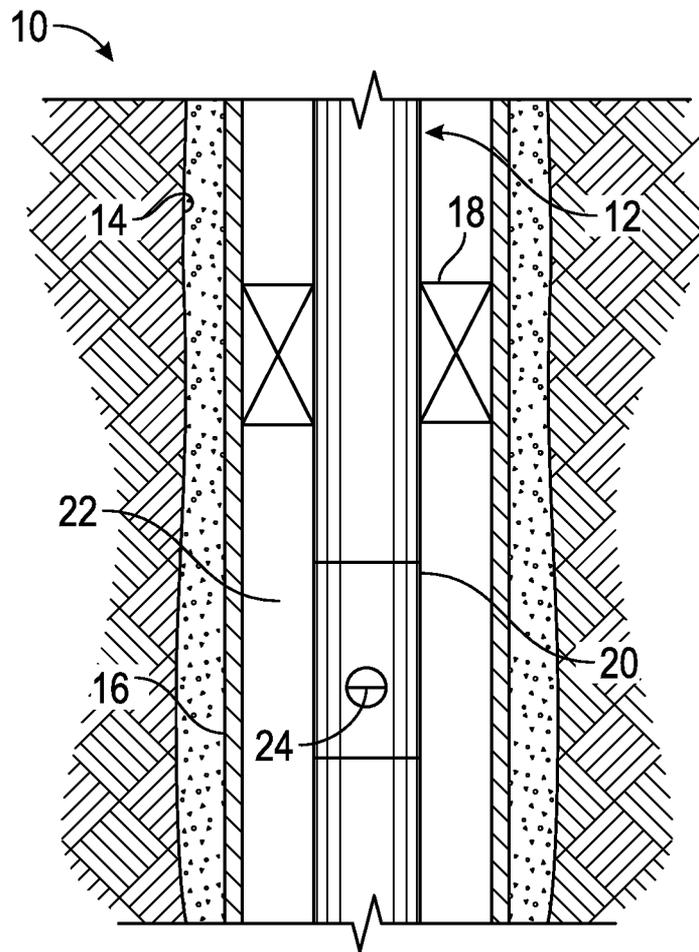


FIG. 1

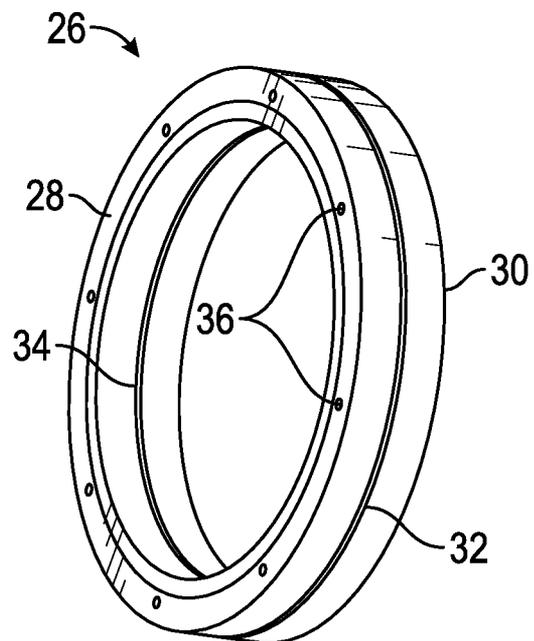


FIG. 2

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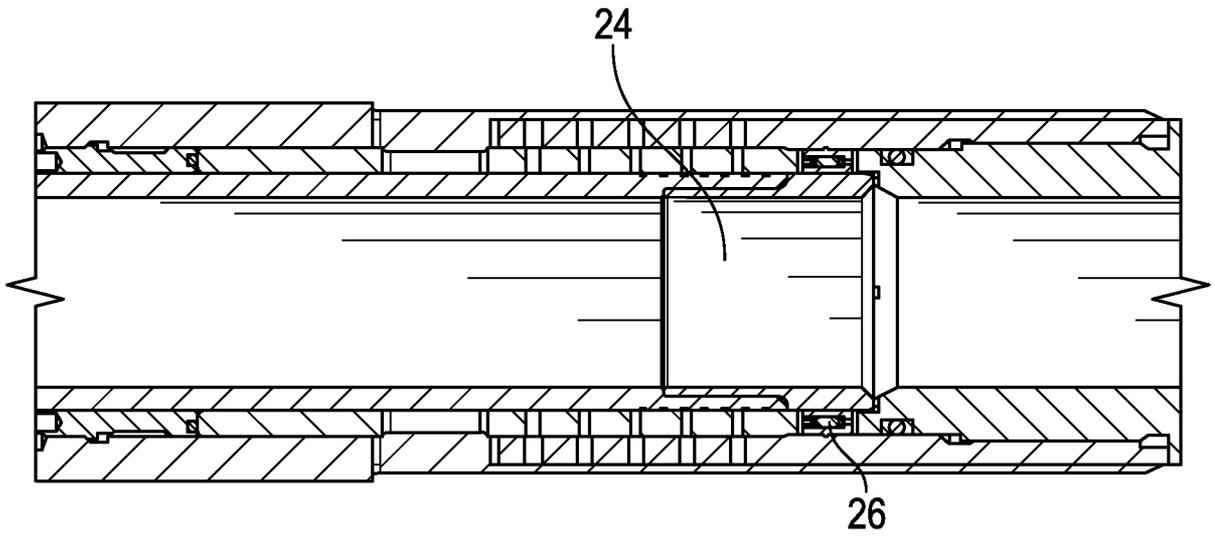


FIG. 3A

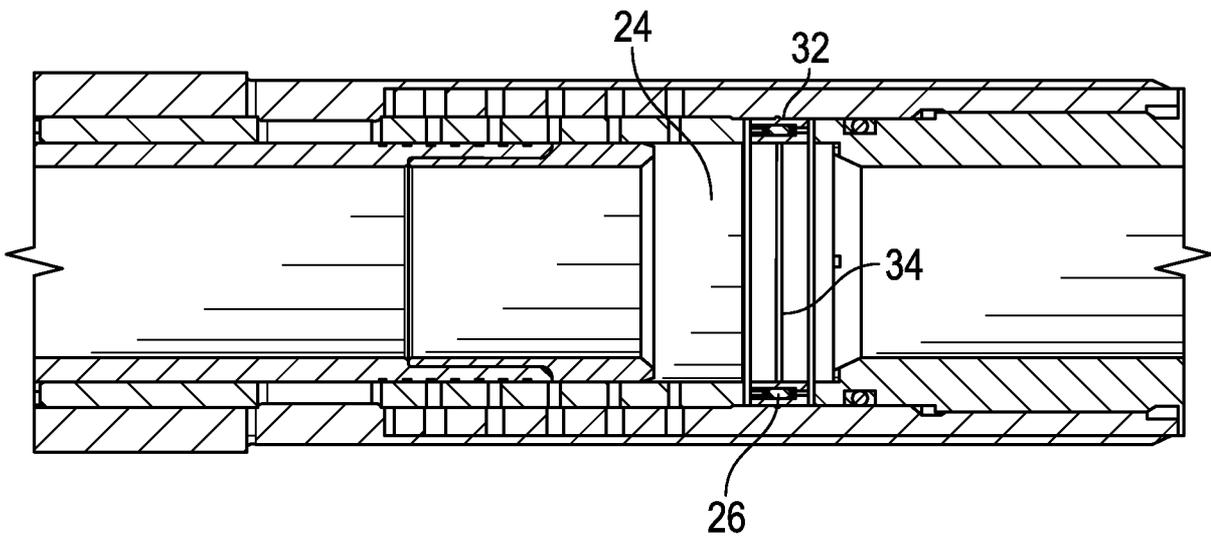


FIG. 3B

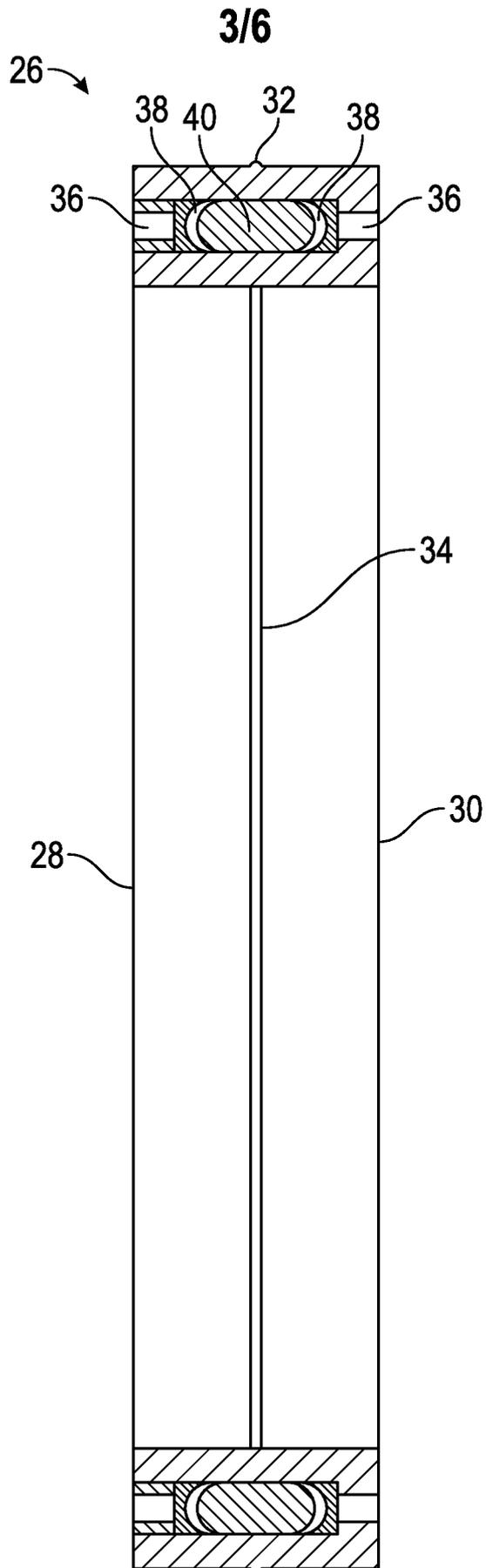


FIG. 4

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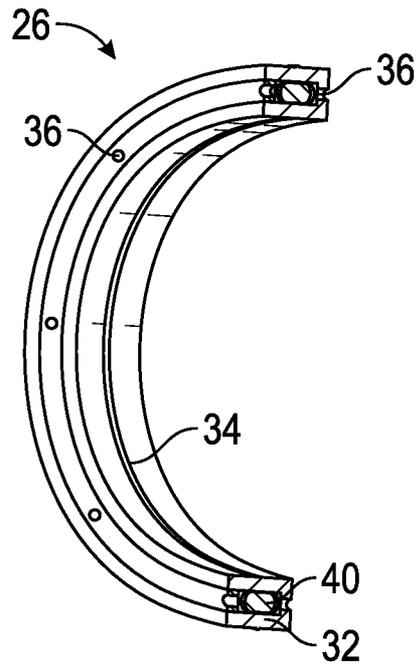


FIG. 5

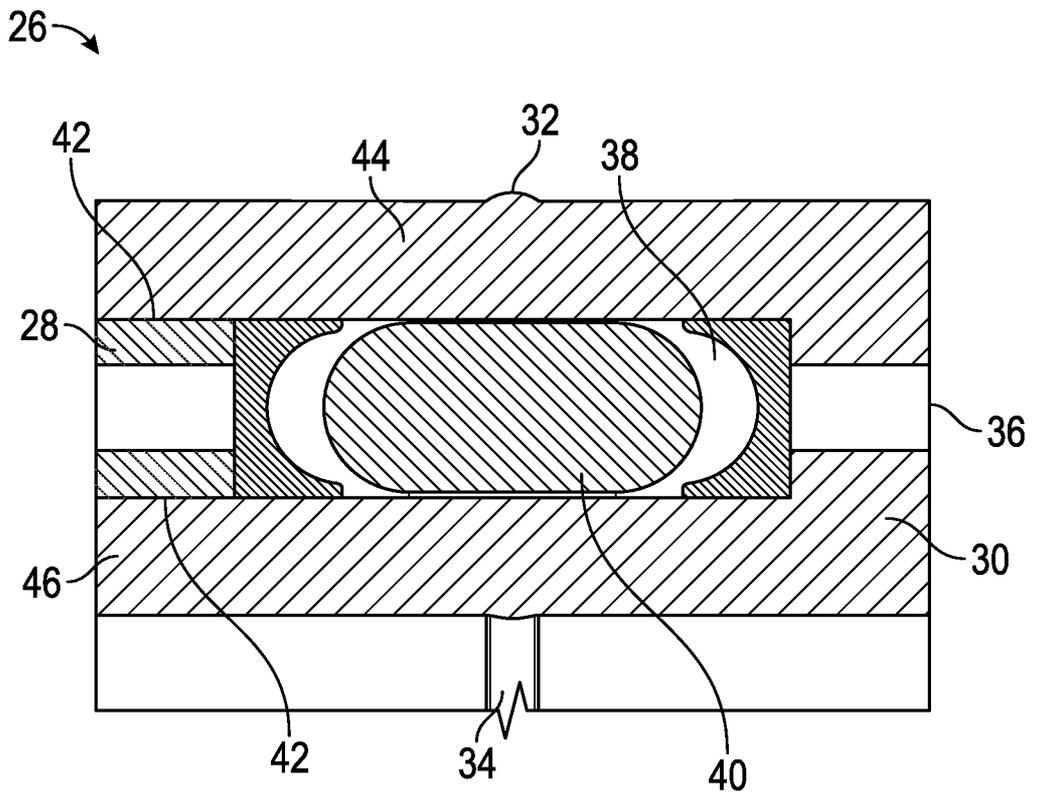


FIG. 6

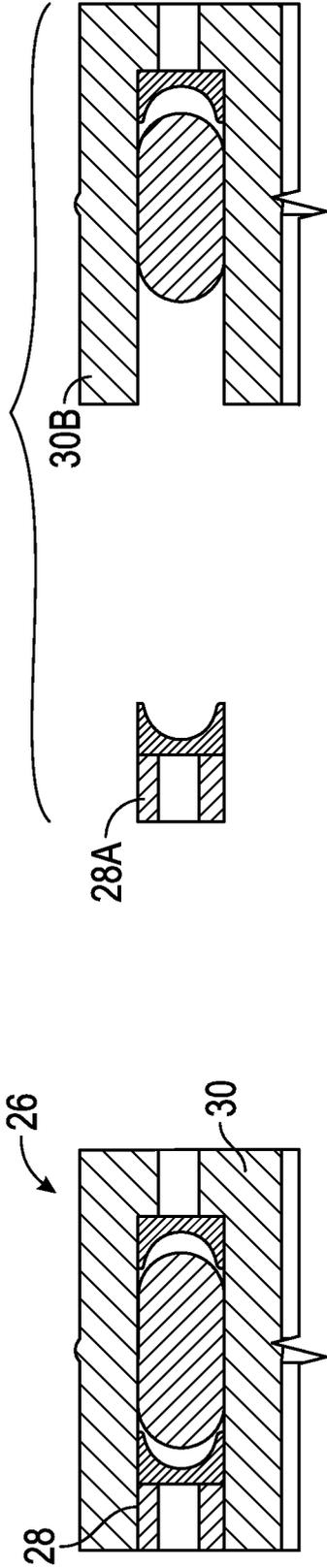


FIG. 7A

FIG. 7B

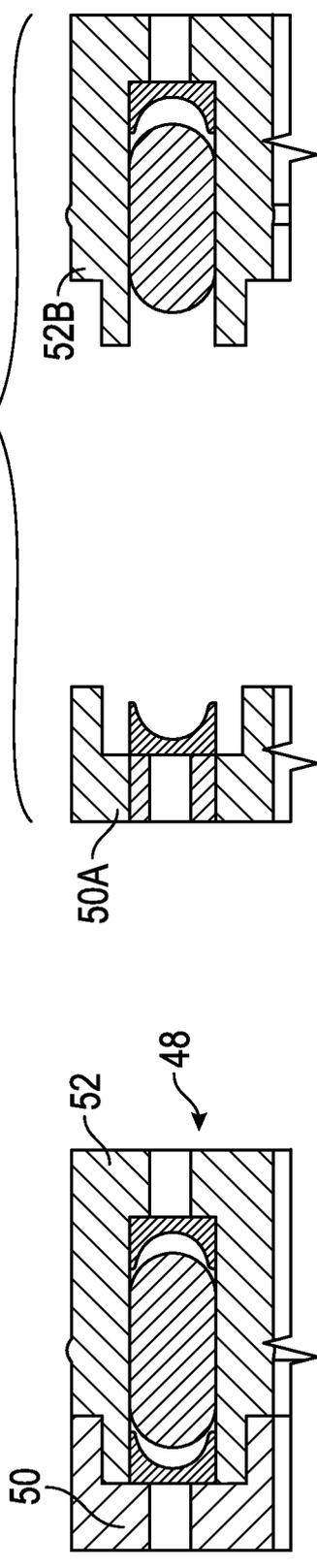


FIG. 8A

FIG. 8B

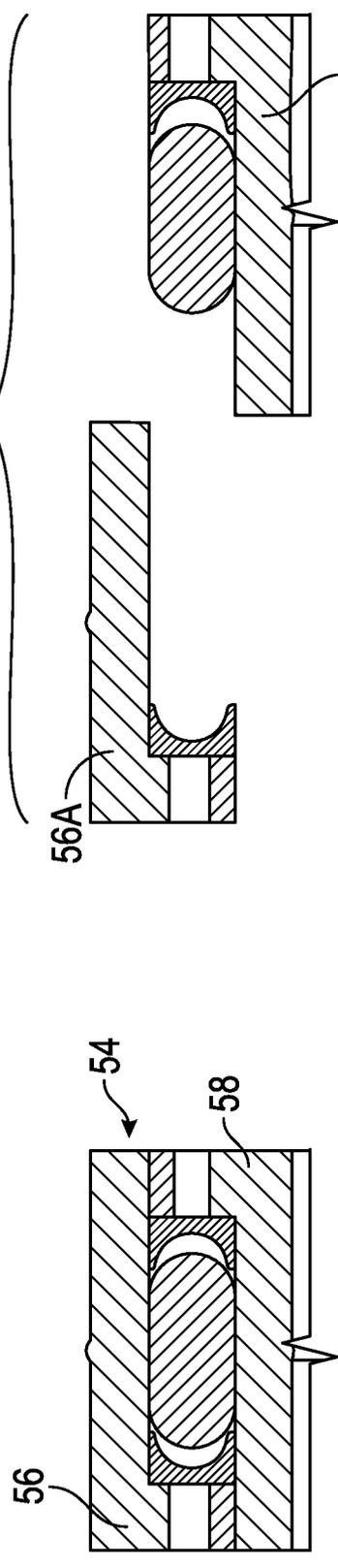


FIG. 9A

FIG. 9B

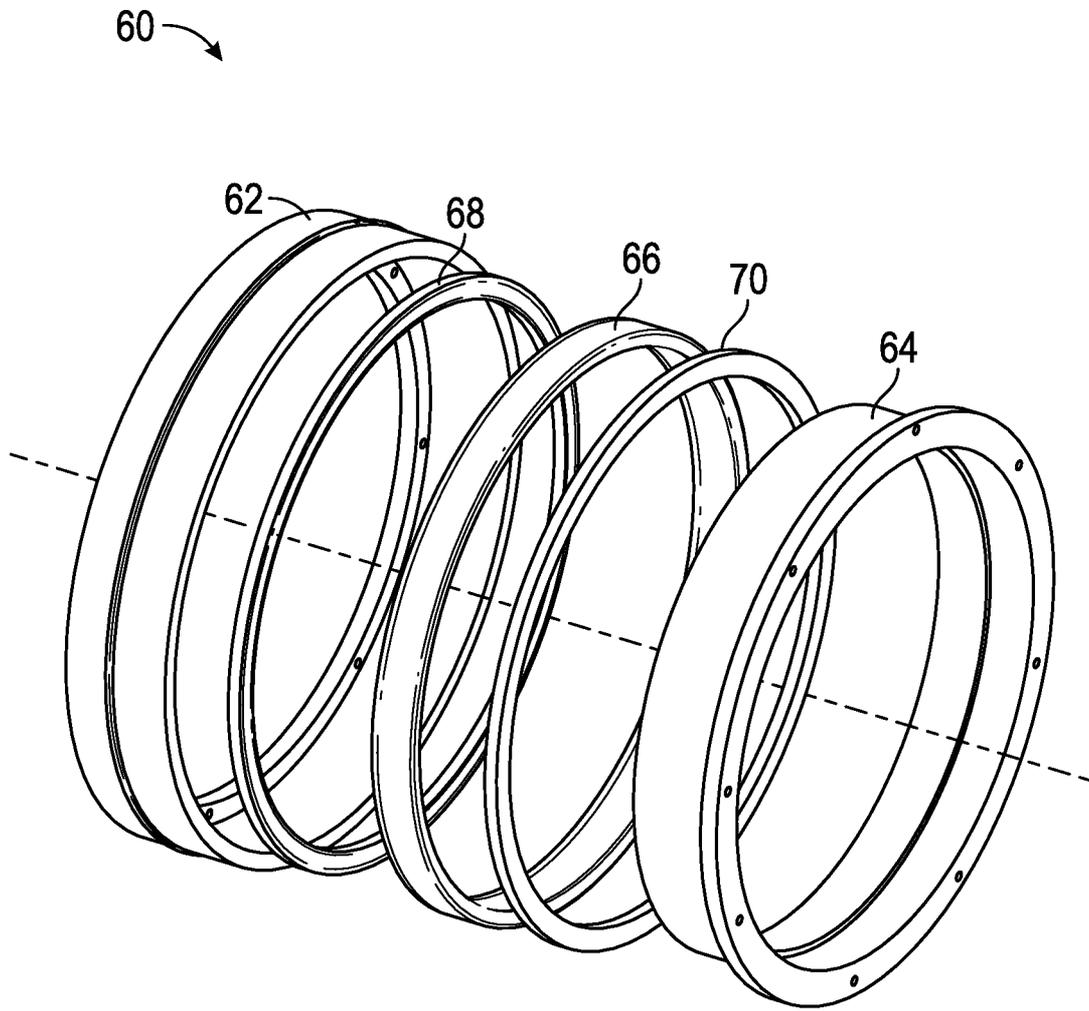


FIG. 10

A. CLASSIFICATION OF SUBJECT MATTER**F16J 15/02(2006.01)i, F16J 15/08(2006.01)i, F16L 5/10(2006.01)i**

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F16J 15/02; E21B 33/10; E21B 34/00; F16J 15/40; F16J 15/00; F16J 15/12; F16J 15/38; F16J 15/20; F16L 17/00; F16J 15/08; F16L 5/10

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & keywords: sealing surface, metal to metal contact, single point, nonmetal seal, transverse facing recess, and pressure communication hole

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2009-0194945 A1 (BHAT et al.) 06 August 2009 See paragraphs [0034]-[0044], claims 1, 5, 9, 15 and figures 2-5.	1-25
Y	US 6086069 A (BEDFORD, BILLY R.) 11 July 2000 See column 2, lines 24-44 and figure 2.	1-25
A	US 2009-0277642 A1 (CURINGTON, ALFRED R.) 12 November 2009 See paragraphs [0020]-[0040] and figures 2-5.	1-25
A	US 2013-0020799 A1 (SILVEIRA et al.) 24 January 2013 See paragraphs [0018]-[0028] and figure 1.	1-25
A	US 8794638 B2 (TUCKNESS et al.) 05 August 2014 See column 7, line 13 - column 8, line 54 and figures 3-4.	1-25

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

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

13 January 2017 (13.01.2017)

Date of mailing of the international search report

16 January 2017 (16.01.2017)

Name and mailing address of the ISA/KR

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2016/031042

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