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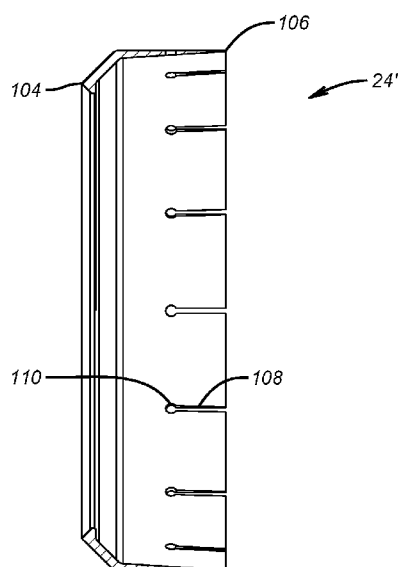


FIG. 10

(57) Abstract: A unique backup ring against ends of a sealing element features axial slots extending part way along a cylindrical segment of the backup ring. The slots end in rounded openings to relieve stress and a part of the cylindrical shape of the backup ring is solid. The slotted end of the cylindrical portion is tapered in section toward the end overlapping the sealing element. The face of the backup ring away from the sealing element is tapered and rides on an adjacent tapered surface away from the mandrel during the setting. The tapered seal end of the backup ring bends to reach the surrounding tubular before the balance of the cylindrical portion reaches the surrounding tubular. Extrusion along the mandrel is stopped by a mandrel seal on an adjacent wedge ring. The mandrel end of the backup ring has a peripheral stiffener to lend rigidity.

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SLOTTED BACKUP RING ASSEMBLY

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application is a Continuation-in-Part and claims priority to U.S. Application Serial No. 14/989,199 filed on January 6, 2016.

FIELD OF THE INVENTION

[0002] The field of the invention is sealing systems for subterranean tools against tubular or open hole or cased hole and more particularly backup rings that are disposed at opposed ends of a sealing element assembly to contain the sealing element against axial extrusion.

BACKGROUND OF THE INVENTION

[0003] In the unconventional drilling and completion industry, oil and gas deposits are often produced from tight reservoir formations through the use of fracturing and frack packing methods. To frack a well involves the high pressure and high velocity introduction of water and particulate media, typically a sand or proppant, into the near wellbore to create flow paths or conduits for the trapped deposits to flow to surface, the sand or proppant holding the earthen conduits open. Often, wells have multiples of these production zones. Within each production zone it is often desirable to have multiple frack zones. For these operations, it is necessary to provide a seal known as a frack packer, between the outer surface of a tubular string and the surrounding casing or borehole wall, below the zone being fractured, to prevent the pumped fluid and proppant from travelling further down the borehole into other production zones. Therefore, there is a need for multiple packers to provide isolation both above and below the multiple frack zones.

[0004] A packer typically consists of a cylindrical elastomeric element that is compressed axially, or set, from one end or both by gages within a backup system that cause the elastomer to expand radially and form a seal in the annular space. Gages are compressed axially with various setting mechanisms, including mechanical tools from surface, hydraulic pistons, atmospheric chambers, etc. Setting typically requires a fixed end for the gages to push against. These fixed ends are often permanent features of a mandrel

but can include a dynamic backup system. When compressed, the elastomeric seal has a tendency to extrude past the gages. Therefore, anti-extrusion backups have become common in the art. However, typical elastomeric seals maintain the tendency to extrude through even the smallest gaps in an anti-extrusion backup system.

[0005] In cased-hole applications, anchoring of compression set packers is a common feature in the completion architecture. Anchoring is provided by wedge-shaped slips with teeth that ride up ramps or cones and bite into the casing before a packer is set. These systems are not part of the backup system nor are they designed to provide anti-extrusion. Often they are used in the setting of the packer to center the assembly which lowers the amount of axial force needed to fully set the elastomer seal. Once set, anchoring systems are also useful for the life of the packer to provide a uniform extrusion gap, maintain location and help support the weight of a bottom-hole assembly in the case of coiled tubing frack jobs. Anchors also prevent tube movement in jointed strings resulting from the cooling of the string by the frack fluid. Movement of the packers can cause them to leak and lose seal.

[0006] In open-hole frack pack applications it is rarer for the packer to have anchoring mechanisms, as the anchor teeth create point load locations that can overstress the formation, causing localized flow paths around the packer through the near well-bore. However, without anchors, movement from the base pipe tubing can further energize the elastomeric seal. Energizing the seal from tube movement tends to overstress the near wellbore as well, leading to additional overstressing of the wellbore, allowing communication around the packer, loss of production, and potential loss of well control to surface. However, the art of anchoring has been reintroduced in new reservoirs in deep-water open-hole fracking operations. The current state of the art in open-hole frack pack operations requires a choice between losing sealing due to anchor contact induced fractures, packer movement, or over-energizing of the elastomeric element.

[0007] Extrusion barriers involving tapers to urge their movement to block an extrusion path for a sealing element have been in use for a long time as evidenced by US 4204690. Some designs have employed tapered surfaces to urge the anti-extrusion ring into position by wedging them outwardly as in US

6598672 or in some cases inwardly as in US 8701787. Other designs simply wrap thin metal rings at the extremities of the sealing element that are designed to contact the surrounding tubular to create the anti-extrusion barrier. Some examples of these designs are US 8479809; US 7708080; US 2012/0018143 and US 2013/0147120. Of more general interest in the area of extrusion barriers are US 9140094 and WO 2013/128222.

[0008] These solid rings used in the past against the ends of the sealing element assembly still had issues with preventing axial extrusion and provided a great deal of resistance in the setting process. Accordingly, a backup ring with axial slots having rounded ends was developed where the slots go part way down the cylindrical portion of the backup ring assembly and the cross-sectional shape of the cylindrical portion is tapered down in a direction toward the free end of the cylindrical portion. The face opposite the contact face with the sealing element is abutted to a sloping surface to allow the backup ring to ride up radially away from the mandrel during the setting. The tapered segment flexes toward the surrounding tubular during setting movement and the remainder of the cylindrical portion then arrives to contact the surrounding tubular. The non-slotted portion of the cylindrical shape acts as a barrier against the surrounding tubular. A seal on an adjacent wedge ring that is against the mandrel ultimately stops axial extrusion along the mandrel.

[0009] In some applications the gap across which the seal is expected to function is quite large placing such applications beyond the limits of the design in US 6598672. There is a need for an extended reach design that can withstand the pressure differentials. This need is addressed with a wedge shaped extrusion ring assembly that, depending on the gap to be spanned is pushed on opposing ramps along a pedestal ring for extended reach when contacted by an outer support ring. To fixate the extrusion ring in the extended position an outer support ring also moves into contact with the extrusion ring in its extended position on the pedestal ring. In the extended reach configuration of the extrusion ring, the backup ring moves part way toward the surrounding tubular or borehole. In shorter reach applications the extrusion ring can move out to the surrounding tubular or borehole wall on one side of the pedestal ring and the outer support ring is eliminated. The backup ring is wedged against the surrounding borehole wall to allow it to act as an anchor

for the plug that has the sealing system. In the extended reach configuration the reaction forces from the extrusion ring are directed into the abutting backup ring and into the setting system so that the backup ring is prevented from being squeezed out of its wedged position against the pedestal ring. The present invention is focused on the extrusion ring abutting the ends of the sealing element and the various features and movement of that ring to provide reliable barrier against extrusion along the borehole wall. These and other aspects of the present invention will be more readily apparent to those skilled in the art from a review of the description of the preferred embodiment and the associated drawings while understanding that the full scope of the invention is to be found in the appended claims.

SUMMARY OF THE INVENTION

[0010] A sealing element is flanked by wedge-shaped extrusion ring assemblies. The extrusion rings are continuous for 360 degrees and are slotted from the outside dimension and alternatively from the inside dimension to allow the diameter to increase to the surround tubular or open hole. The extrusion rings climb a ramp on an adjacent pedestal ring on the way out to the borehole wall. Depending on the dimension of the gap to be spanned the extrusion ring slides a variable distance up the pedestal ring ramp. An optional anchor ring is initially forced up an opposite ramp of the pedestal ring. If the sealing gap is short the anchor ring can be eliminated. For larger gaps the anchor ring moves out far enough toward the borehole wall to contact the extrusion ring located on an opposing ramp of the pedestal ring so that reaction forces are directed to keep the anchor ring wedged in position for support of the extrusion ring assembly.

[0011] A unique backup ring against ends of a sealing element features axial slots extending part way along a cylindrical segment of the backup ring. The slots end in rounded openings to relieve stress and a part of the cylindrical shape of the backup ring is solid. The slotted end of the cylindrical portion is tapered in section toward the end overlapping the sealing element. The face of the backup ring away from the sealing element is tapered and rides on an adjacent tapered surface away from the mandrel during the setting. The tapered seal end of the backup ring bends to reach the surrounding tubular before the balance of the cylindrical portion reaches the surrounding tubular.

Extrusion along the mandrel is stopped by a mandrel seal on an adjacent wedge ring. The mandrel end of the backup ring has a peripheral stiffener to lend rigidity.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIG. 1a is a prior art perspective view of split extrusion rings keyed together with splits opposed at 180 degrees shown in the run in condition;

[0013] FIG. 1b is the view of FIG. 1a in the expanded condition showing the size increase for the split in the adjacent rings;

[0014] FIG. 2 is a section view in the run in position for a long reach embodiment;

[0015] FIG. 3 is the view of FIG. 2 in the set position;

[0016] FIG. 4a is a perspective view of the extrusion ring in the run in position;

[0017] FIG. 4b is the view of FIG. 4a in the set position;

[0018] FIG. 5 is a side view of a backup ring that is located next to a sealing element;

[0019] FIG. 6 is a perspective view of an optional anchoring ring shown in the run in condition;

[0020] FIG. 7 is a section view of a short reach embodiment in the run in position;

[0021] FIG. 8 is the view of FIG. 7 in the set position;

[0022] FIG. 9 is a perspective view of FIG. 3;

[0023] FIG. 10 is a section view of the backup showing its axial slots;

[0024] FIG. 11 is a perspective view of the ring of FIG. 10;

[0025] FIG. 12 is a section view of a sealing assembly with the backup ring of FIG. 10 in the run in position;

[0026] FIG. 13 is the view of FIG. 12 during the setting;

[0027] FIG. 14 is the view of FIG. 13 after the setting is complete;

[0028] FIG. 15 is a detailed view of circle D in FIG. 14;

[0029] FIG. 16 is an outside view of the assembly shown in FIG. 12.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0030] To appreciate the benefits of the present invention it is necessary to review the state of the art in compression set element extrusion barriers. The sealing element design is typically one or more rubber sleeves that are axially

compressed against a surrounding tubular. Extrusion barriers can be one or more layers of flexible thin sheet located at an end of a sealing assembly. As the sealing element deforms due to axial compression the extrusion barrier rings such as item 64 in US 5311938 bends with the end of sealing element and makes contact with the opposing wall to bridge the sealing gap with the idea that the rubber is prevented from extruding axially. While serviceable this design has issues in releasing which sometimes led to the packer getting stuck even when the sealing element extended and relaxed but the extrusion ring did not relax.

[0031] FIG. 1a shows another extrusion barrier ring assembly using a pair of split rings **10** and **12** that have splits **14** and **16** respectively. The rings **10** and **12** are keyed to prevent relative rotation to keep the splits **14** and **16** spaced 180 degrees apart. When the sealing element is axially compressed these rings are moved out radially on a ring with a taper to contact the surrounding tubular as the gaps **14** and **16** get substantially larger. The enlarged gaps still created issues for rubber extrusion for the sealing element particularly in high pressure high temperature applications. With pressure differentials of over 10,000 PSI extrusion past assemblies shown in FIGS. 1a and 1b was still a significant concern.

[0032] The present invention addresses this concern in high temperature and high pressure applications by the creation and application of a 360 expandable ring design featuring alternating inner and outer radially oriented slits. For low and medium reach the expandable ring rides up a wedge ring until the surrounding tubular or the open hole borehole is contacted. In high reach application an outer expandable ring of a similar design rides on an opposite side of a wedge ring until forced into supporting contact of the principal expandable ring pushing the principal expandable ring against the surrounding borehole or tubular. The expandable rings can be made of Teflon or another flexible material that is sufficiently resilient while resistant to high temperatures and well fluids.

[0033] FIG. 2 shows the basic layout for a long reach application. Sealing element **20** can optionally have a filler ring **22** in the center. The assemblies on opposed ends of the element **20** are preferably mirror image and so they will be described only for one side with the understanding that the opposed side is

an identical mirror image. An extrusion barrier in the form of an expanding ring **24** is attached to the element **20** and is sufficiently flexible to move with it. FIG. 5 shows a section view of the bonded expanding ring **24**. Ring **24** prevents the sealing element from escaping the cut slots of ring **34** and better conformability to the casing inside diameter or the borehole wall **54**. It could be made of non-metallic material or very ductile metallic material.

[0034] It has sides **26**, **28** and **30** against seal **20** and a ramp surface **32**. Inner expandable ring **34** rides on ramp **32** on one side and ramp **36** of ramp ring **38**. Ring **38** has another ramp **40** opposite ramp **36** on which rides outer expandable ring **42**. Ramp **44** on outer expandable ring **42** rides on ramp **40** of ring **38**. On the other side ramp **46** rides on ramp **48** of setting ring **50**. The setting sequence results from relative movement between rings **50** and **52**. Usually one is moving while the other is stationary. FIG. 3 shows the result of the relative movement. The element **20** is up against the borehole wall or surrounding tubular **54** as is the adjacent ring **24**. Ring **38** has shifted toward element **20** by going under ring **24** that is continuously supported for 360 degrees by expandable ring **34**. Inner expandable ring **34** has moved against the borehole wall or tubular **54** by sliding along opposed ramp surfaces **32** and **36**. The outer expandable ring **42** has moved out on ramps **40** and **48** until its surface **56** engages surface **58** of inner expandable ring **34** to wedge it against the borehole wall or tubular **54**. The new relative position of rings **50** and **52** can be releasably locked to hold the FIG. 3 set position until it is time to retrieve the packer. The abutting of rings **42** and **34** allows ring **34** to travel further out radially than in the FIG. 8 embodiment which is otherwise the same except outer expandable ring **42** is not shown because the required radial movement in FIG. 8 is much less than in FIG. 3. As a result in FIG. 8 the inner expandable ring **34** simply rides out on ramps **36** and **32** until contact is made with the borehole wall or tubular **54**. Ring **38** abuts ring **50** and does not go under ring **24** as in FIG. 3. The reach in FIG. 8 is much shorter than in FIG. 3.

[0035] FIGS. 4a and 4b show ring **34** in the run in and the set positions respectively. An outer face **60** continues along a tapered surface **62** to internal surface **64** seen as the inner parallel surface of a trapezoidal section in FIG. 3 and a continuous line in perspective in the views of FIG. 4. Slots **66** circumferentially alternate with slots **68** and are radially oriented to preferably

align with the center of ring **34**. Slots **66** start at the outer face **60** and slots **68** start at the surface **64**. Slots **68** end in a transverse segment **70** and slots **66** end in a transverse segment **72**. The transverse segments are there to limit stress as the slots **66** and **68** open up as the sealing element **20** is set against the borehole wall or tubular **54**. Outer expandable ring **42** is shown in perspective in FIG. 6 and essentially has a similar slot configuration as described in FIGS. 4a and 4b with the section profile being different as shown in FIGS. 2 and 3. However it is the same continuous 360 degree design for the ring **42** as the ring **34** with alternating slots with transverse end portions that start from opposing ends of the ring structure. Specifically, slots **80** and **82** start respectively at outer face **84** and inner dimension **86** seen as a ring in FIG. 6 and as a flat in section in FIG. 2. The slots extend radially and preferably in alignment with the center of ring **42**. Alternatively the slots can extend axially but radially is preferred. At the respective ends of slots **80** and **82** are transverse ends **88** and **90**. As ring **42** expands from the FIG. 2 to the FIG. 3 position, the slots **80** and **82** open up to allow the diameter to increase until surface **56** hits surface **58** of inner expandable ring **34** as shown in FIG. 3.

[0036] Rings **34** and **40** can be Teflon, metallic, composite to name a few examples. The shape can be created with lasers or wire EDM fabrication methods. Although in FIGS. 2 and 3 a single inner ring **34** and outer ring **40** are illustrated multiple pairs of such rings that function in the same way can be used. In the case of FIGS. 7 and 8 multiple pairs of expandable ring **36** and ramp ring **38** can be used and they can operate in the same manner as illustrated for a single such pair of rings as shown in FIGS. 7 and 8. The 360 degree design for rings **34** and **42** combined with solid expandable ring **24**, which prevents the rubber element **20** from escaping through cut slots in ring **34** and improves conformance to tubular or borehole inside diameter dramatically reduces extrusion of seal **20** even though the slots expand for the larger set position. The 360 degree feature of the rings **34**, **42** and **24**, if used, limit the extrusion gaps and allow a given sealing system **20** to be serviceable in higher pressure differential applications without extrusion risk. The design is modular so that it is simple to switch between the FIG. 2 and FIG. 7 configurations for different applications. The ring **42** backing up the ring **34** wedges ring **34** in the FIG. 3 set position wedges in ring **34** to hold it in

position against high differential pressures that can exceed 10,000 PSI. The slot ends can be a transverse slot or an enlarged rounded end or other shape that limit stress concentration at the ends of the radial slots.

[0037] A preferred design for backup ring 24' is shown in FIGS. 10 and 11. It features a cylindrically shaped component 100 that transitions to a tapered segment 102 that ends at an enlarged end 104 that turns inwardly toward mandrel 105 shown in FIG. 8. The cylindrically shaped component is tapered to its minimum thickness at end 106. An array of slots 108 start at end 106 and extend generally axially to rounded ends 110 that are there to reduce stress concentration at the ends of slots 108. The slots 108 are preferably equally spaced and of uniform width and length. The preferred length is less than half of the axial length of the cylindrically shaped component 100. The tapered section allows greater flexibility near end 106 during the setting as shown in FIG. 13 such that end 106 and some of the adjacent cylindrically shaped segment 100 that has slots 108 makes initial contact with the surrounding borehole wall 112. As the setting movement continues the cylindrically shaped component 100 continues to make contact with the borehole wall 112 past the rounded ends 110 of slots 108 so that a slot free segment of the cylindrically shaped component then makes contact with the borehole wall 112. The slots 108 make the end 106 more flexible to allow early initial movement toward the borehole wall 112 with reduced radial pushing force so that the end 106 is preferably already in contact with the borehole wall 112 before the internal pressure of the sealing assembly 20 get very high as it is axially compressed to be radially extended against the surrounding borehole wall 112. On further axial compression of the sealing assembly 20 the non-slotted portion of the cylindrically shaped segment 100 makes contact with borehole wall 112 to close off axial slots 108 as potential extrusion paths. As that happens the tapered segment 102 is backed up by ring 34 that has a tapered surface 62 that conforms to the angle of the tapered segment 102. Enlarged end 104 serves as a stiffening rib near the mandrel 105 but is driven away from mandrel 105 in the set position of FIGS. 14 and 15. There is a path for the material of seal assembly 20 to pass under wedge ring 38 until that path is closed with a seal 114 against mandrel 105 in groove 116.

During the setting the enlarged end 104 contacts wedge ring 38 and rides up inclined surface 36 of wedge ring 38.

[0038] Backup ring 24' performs markedly better than backup ring 24 in high pressure and high temperature applications. One of the reasons is that there are slots 108 and a tapered section near end 106. This allows early movement of end 106 against the borehole wall 112 with the onset of application of the compressive setting force. The slotted portion of the cylindrically shaped segment 100 can establish itself against the borehole wall 112 before the internal pressure on the sealing element assembly 20 increases significantly so that extrusion into the slots 108 can start. While the seal material fills the slots 108 those slots get closed off quickly before the internal pressure in the seal material 20 increases appreciably as the set position is achieved. The contact of the non-slotted portion of the cylindrically shaped component 100 with the borehole wall provided strength due to absence of slots 108 and closure at the rounded slot ends 110 against axial extrusion along the borehole wall 105. At the same time the seal 114 in groove 116 in wedge ring 38 prevents extrusion along mandrel 105 even though some small part of the seal assembly 20 does move axially under the wedge ring 38 as shown in FIGS. 14 and 15. FIG. 16 shows the arrangement can be symmetrical about opposed ends of the sealing element assembly 20.

[0039] The teachings of the present disclosure may be used in a variety of well operations. These operations may involve using one or more treatment agents to treat a formation, the fluids resident in a formation, a wellbore, and / or equipment in the wellbore, such as production tubing. The treatment agents may be in the form of liquids, gases, solids, semi-solids, and mixtures thereof. Illustrative treatment agents include, but are not limited to, fracturing fluids, acids, steam, water, brine, anti-corrosion agents, cement, permeability modifiers, drilling muds, emulsifiers, demulsifiers, tracers, flow improvers etc. Illustrative well operations include, but are not limited to, hydraulic fracturing, stimulation, tracer injection, cleaning, acidizing, steam injection, water flooding, cementing, etc.

[0040] The above description is illustrative of the preferred embodiment and many modifications may be made by those skilled in the art without

departing from the invention whose scope is to be determined from the literal and equivalent scope of the claims below:

We claim:

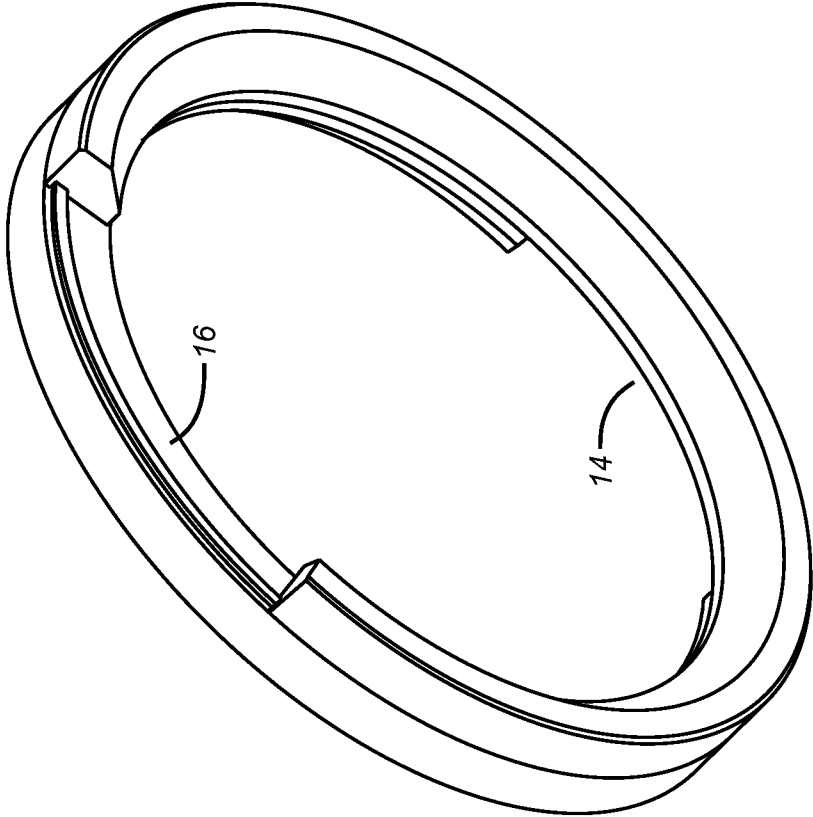
1. An extrusion barrier assembly for a mandrel (105) mounted sealing element assembly (20) of a borehole isolation device, comprising:
at least one extrusion barrier ring (24') surrounding the mandrel (105) and initially abutting and radially overlapping at least one end of the sealing element assembly (20), said extrusion barrier ring (24') **characterized by** a cylindrically shaped segment (100) which initially overlaps the sealing element assembly (20) and features at least one axially oriented slot (108).
2. The assembly of claim 1, wherein:
said at least one slot (108) is shorter than an axial length of said cylindrically shaped segment (100).
3. The assembly of claim 2, wherein:
said at least one slot (108) extends for less than half the axial length of said cylindrically shaped segment (100).
4. The assembly of claim 2, wherein:
said at least one slot (108) extends to an end (106) of said cylindrically shaped segment (100).
5. The assembly of claim 4, wherein:
said cylindrically shaped segment (100) narrows in section toward said end (106).
6. The assembly of claim 2, wherein:
said cylindrically shaped segment (100) tapers in section for an axial length coincident with said at least one slot (108).
7. The assembly of claim 2, wherein:
said at least one slot (108) comprises a plurality of axially extending slots (108) from an end of said cylindrically shaped segment (100).
8. The assembly of claim 7, wherein:
said slots (108) are evenly spaced and end in said cylindrically shaped segment (100) with a rounded end (110).
9. The assembly of claim 5, wherein:
said end makes initial contact with the borehole before the balance of said cylindrically shaped segment (100).

10. The assembly of claim 1, wherein:
said ring comprising a tapered segment (102) extending from said cylindrically shaped segment (100) and toward said mandrel (105) where said tapered segment (102) ends in a thicker portion for stiffness.
11. The assembly of claim 10, wherein:
said tapered segment (102) selectively movable axially to contact a wedge ring as an intermediate ring between said tapered segment (102) and said wedge ring is forced out radially away from the mandrel (105).
12. The assembly of claim 11, wherein:
said wedge ring having opposed tapered sides to a peak spaced apart from the mandrel (105), said thicker portion of said tapered segment (102) moving away from the mandrel (105) along one of said opposed tapered sides as said cylindrically shaped segment (100) makes contact with the borehole.
13. An extrusion barrier assembly for a mandrel (105) mounted sealing element assembly (20) of a borehole isolation device, comprising:
at least one extrusion barrier ring (24') surrounding the mandrel (105) and initially abutting and radially overlapping at least one end of the sealing element assembly (20), said extrusion barrier ring (24') **characterized by** a cylindrically shaped segment (100) which initially overlaps the sealing element assembly (20) and features a tapered cross-section that narrows in a direction toward said end.
14. A treatment method using borehole isolation device comprising an extrusion barrier assembly for a mandrel (105) mounted sealing element assembly (20), comprising:
providing at least one extrusion barrier ring (24') surrounding the mandrel (105) and initially abutting and radially overlapping at least one end of the sealing element assembly (20), said extrusion barrier ring (24') **characterized by** a cylindrically shaped segment (100) which initially overlaps the sealing element assembly (20) and features at least one axially oriented slot (108);
performing a treatment against said sealing element assembly (20) into at least one formation adjacent the borehole.

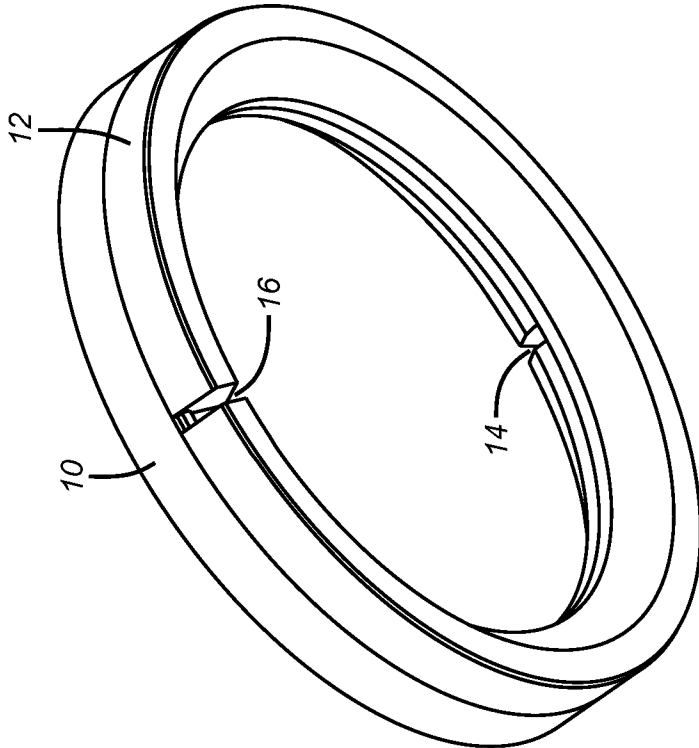
15. A treatment method using borehole isolation device comprising an extrusion barrier assembly for a mandrel (105) mounted sealing element assembly (20), comprising:

providing at least one extrusion barrier ring (24') surrounding the mandrel (105) and initially abutting and radially overlapping at least one end of the sealing element assembly (20), said extrusion barrier ring (24') **characterized by** a cylindrically shaped segment (100) which initially overlaps the sealing element assembly (20) and features a tapered cross-section that narrows in a direction toward said end;

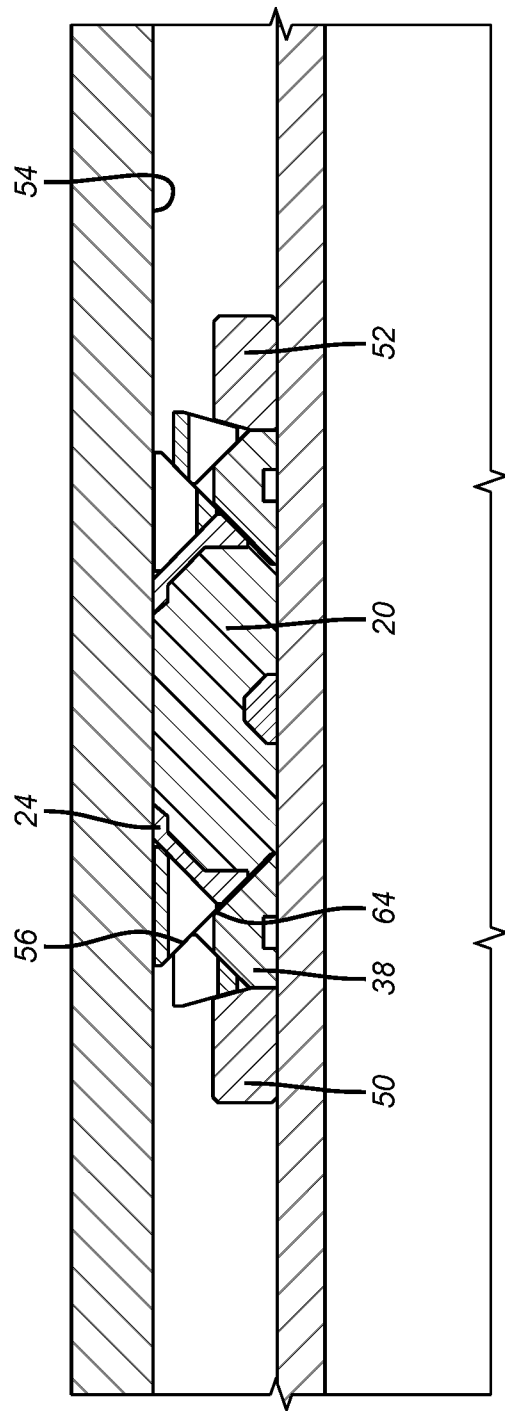
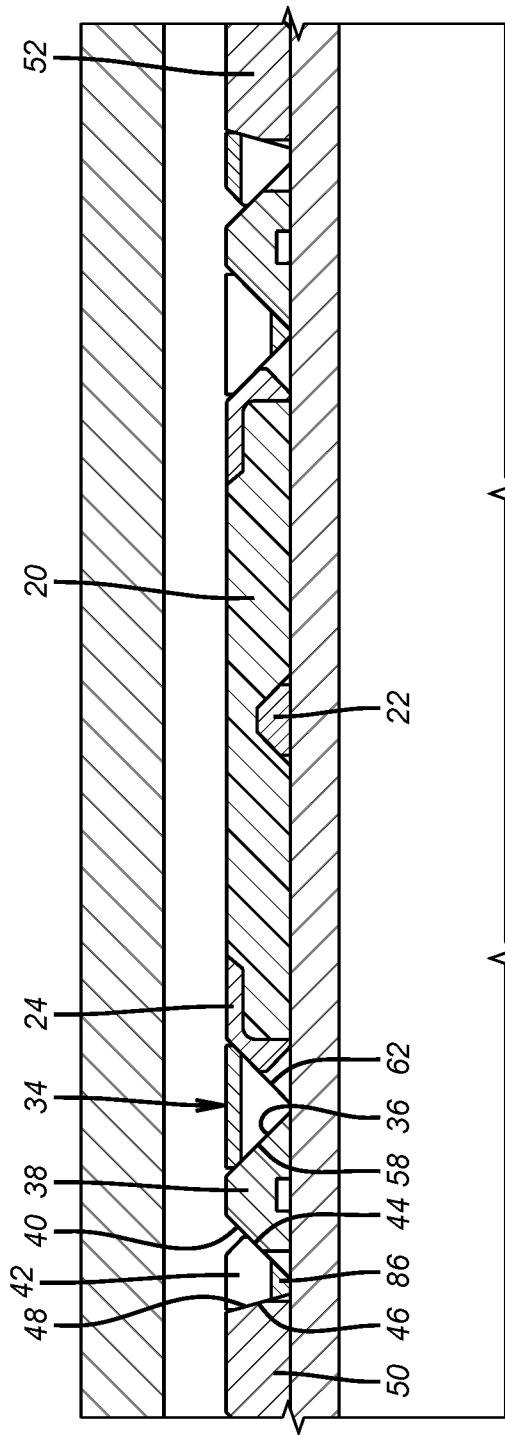
performing a treatment against said sealing element assembly (20) into at least one formation adjacent the borehole.



(PRIOR ART)
FIG. 1b



(PRIOR ART)
FIG. 1a



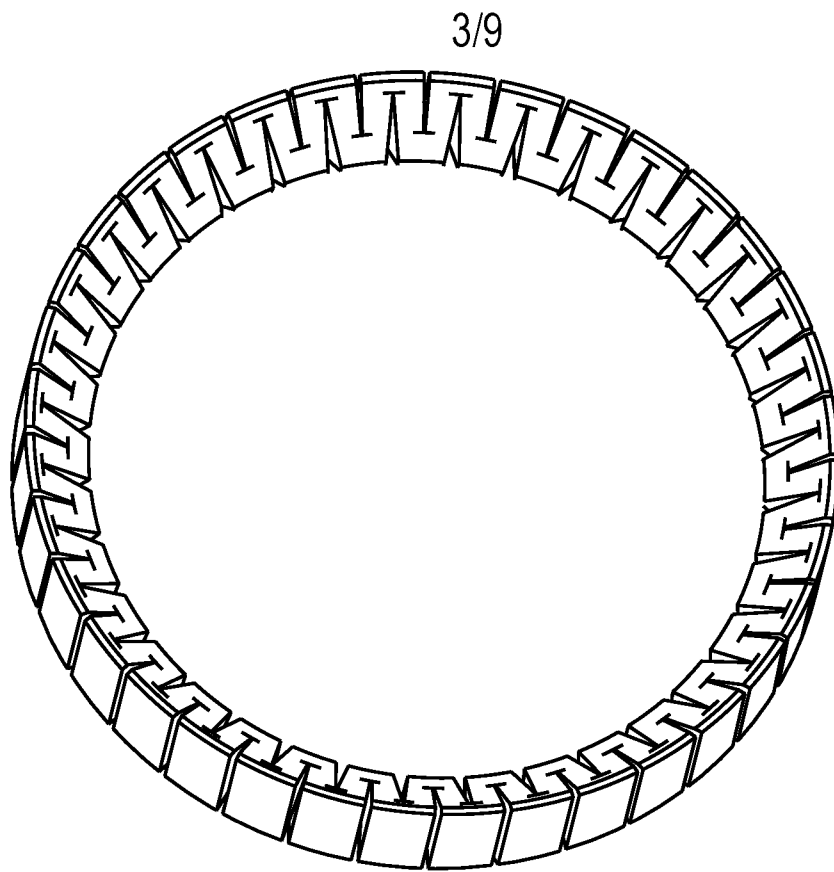


FIG. 4b

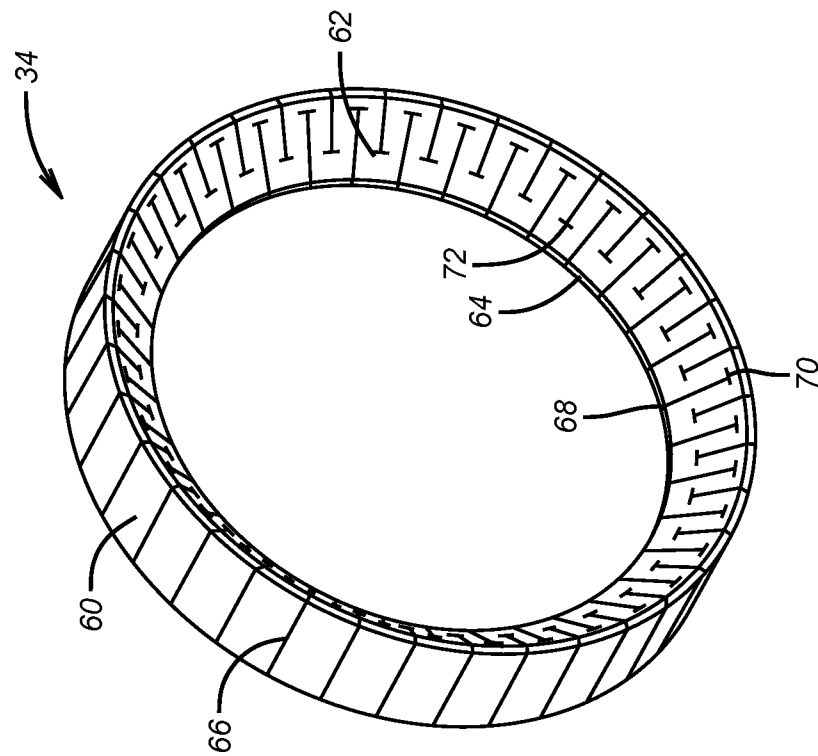


FIG. 4a

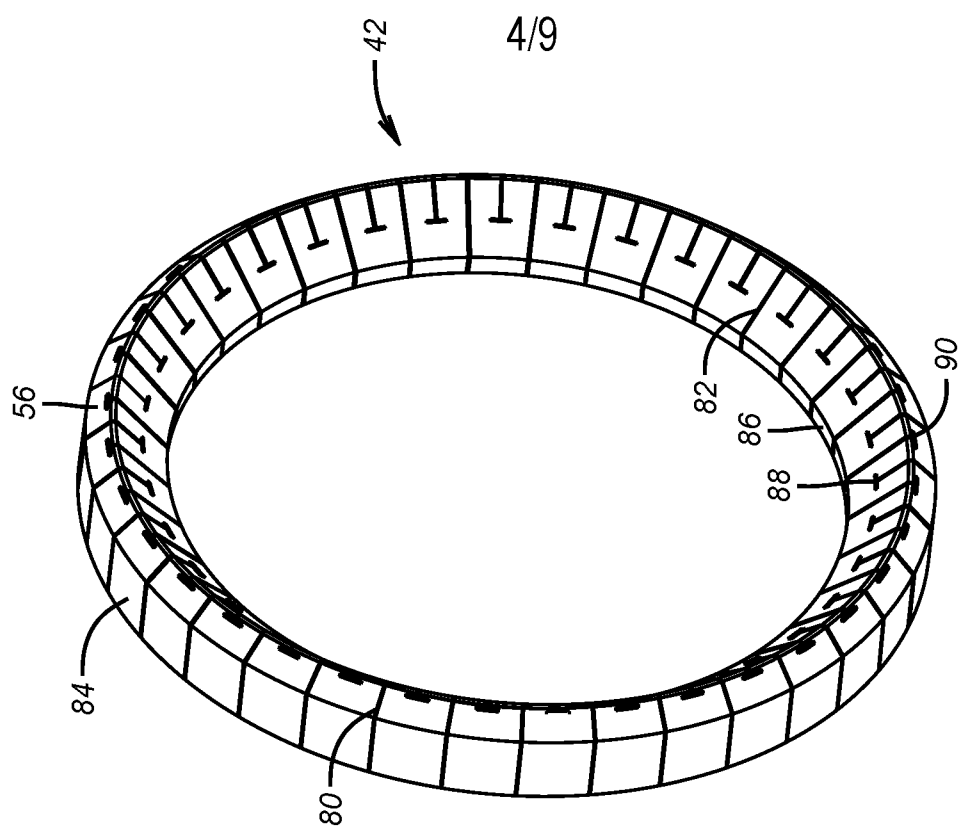


FIG. 6

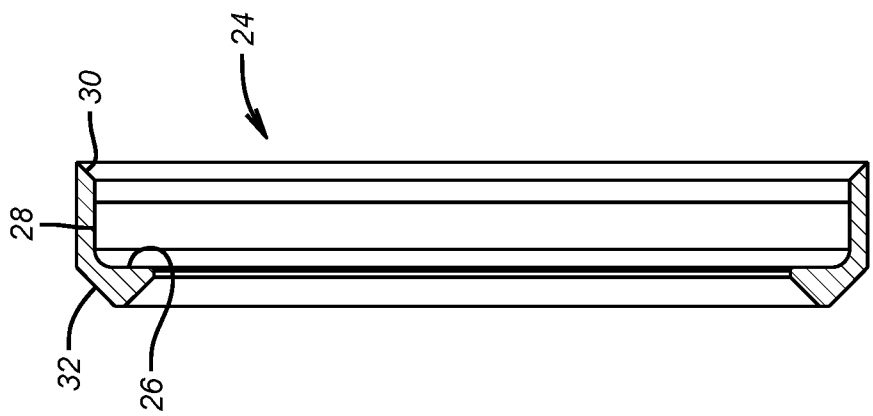


FIG. 5

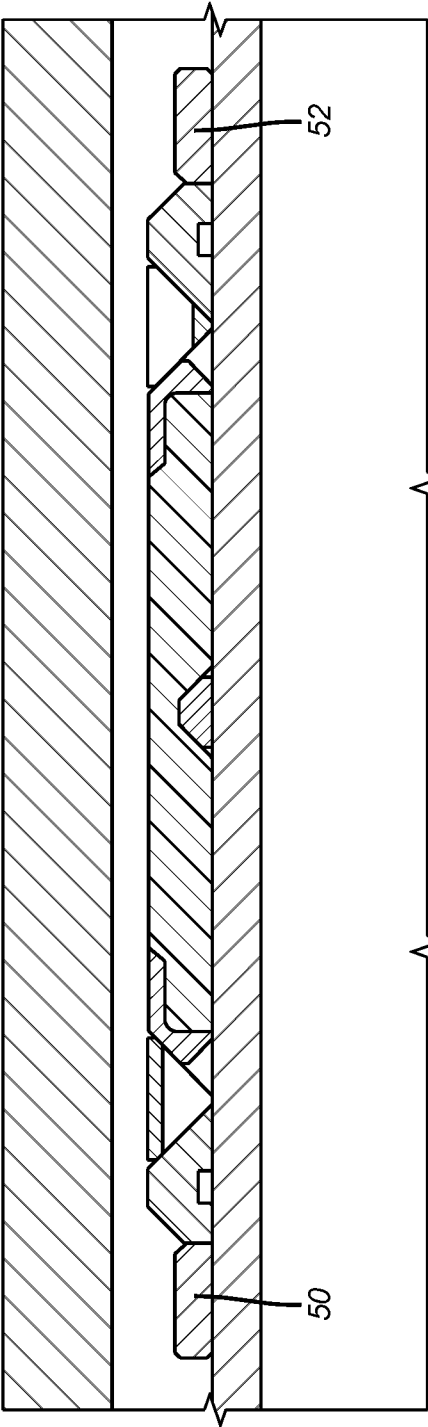


FIG. 7

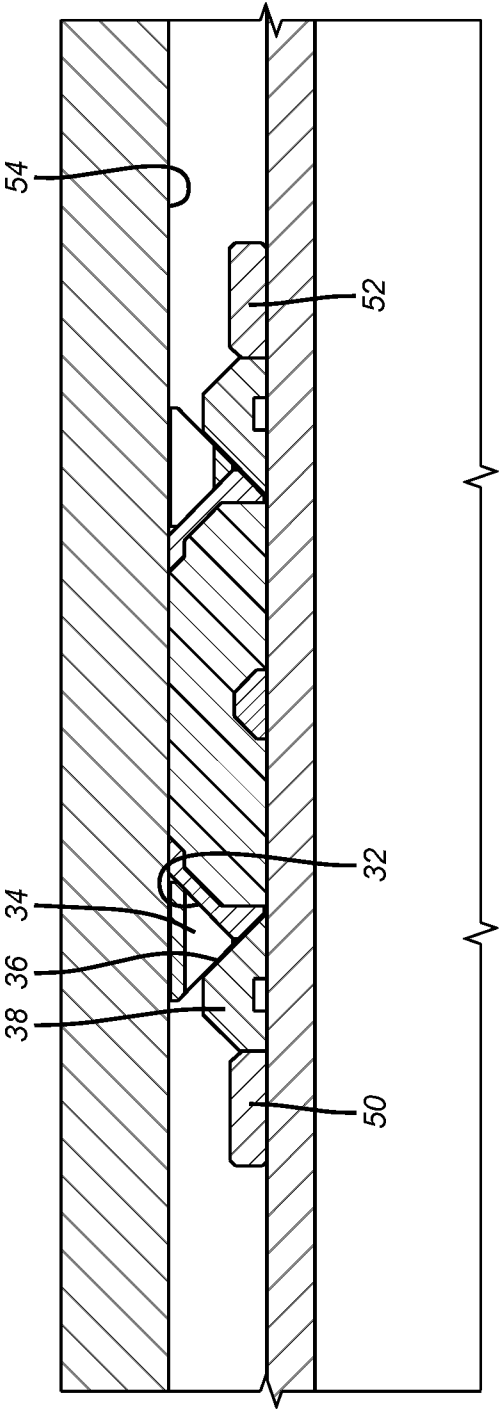


FIG. 8

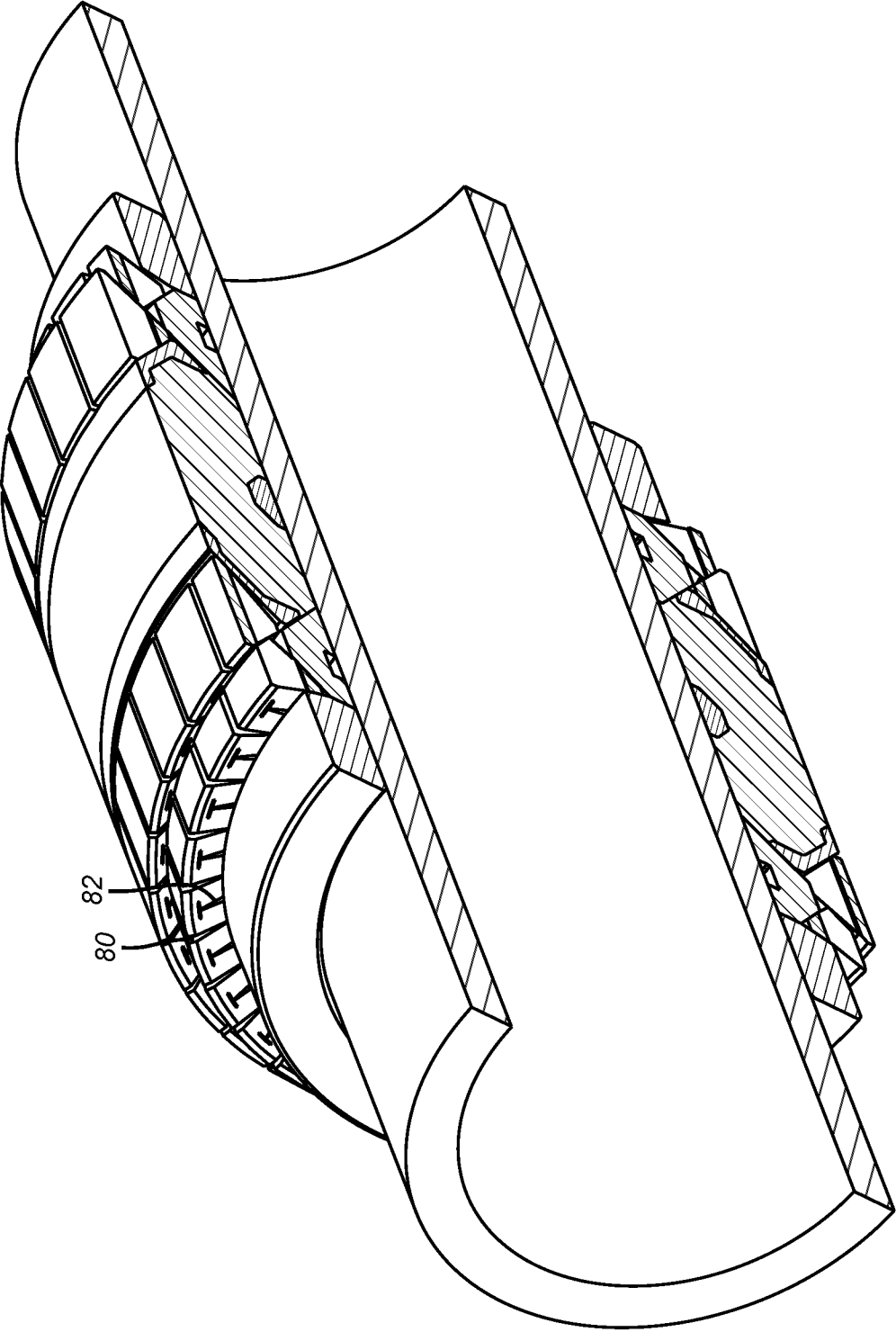


FIG. 9

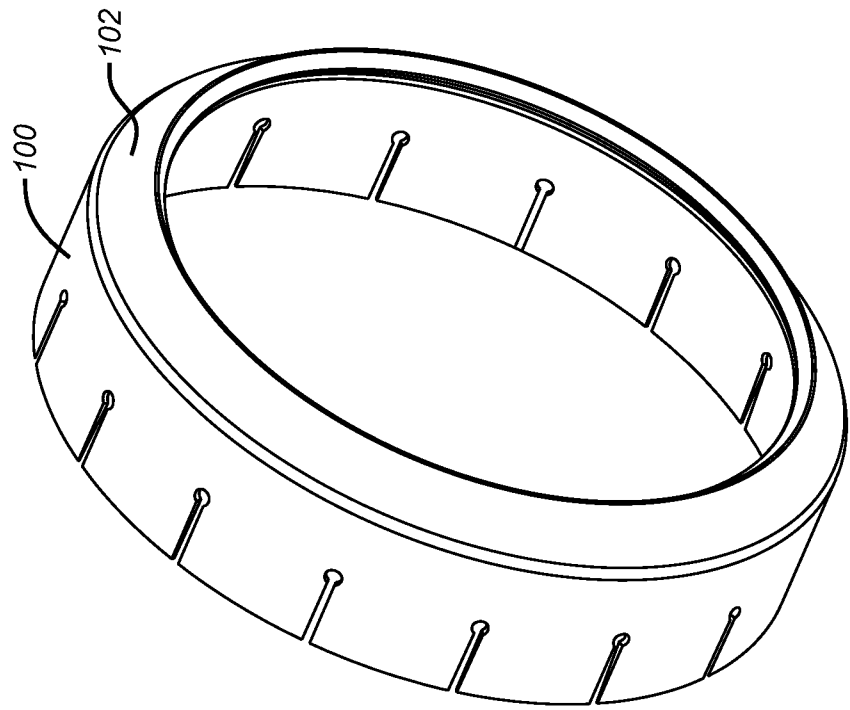


FIG. 11

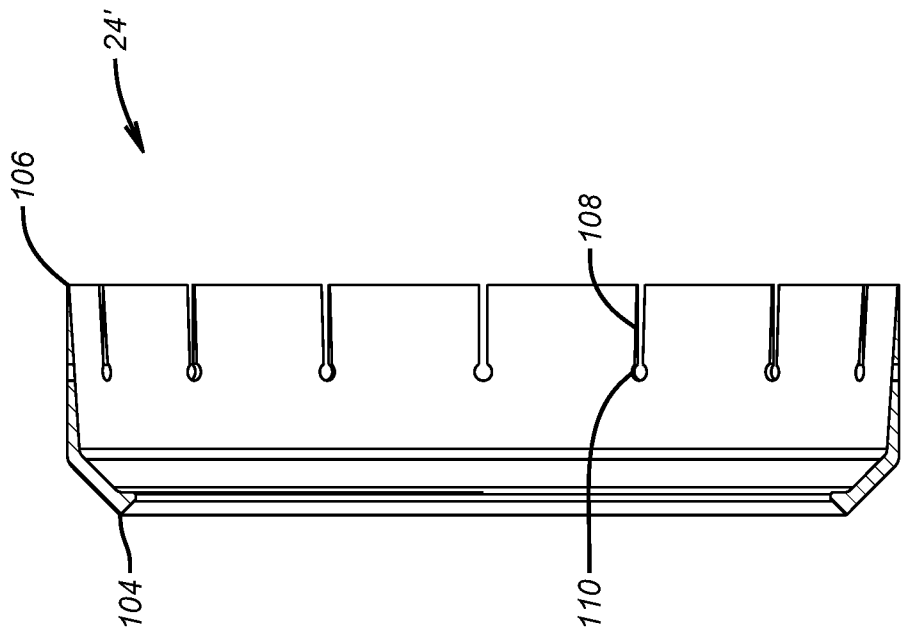


FIG. 10

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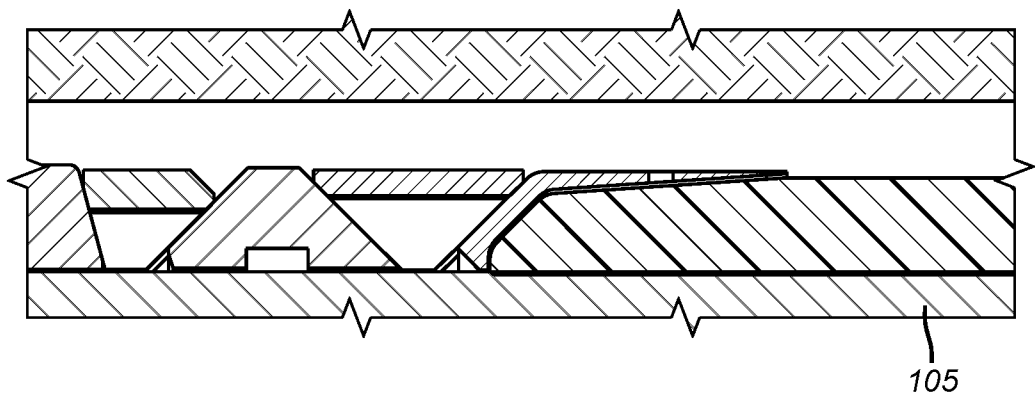


FIG. 12

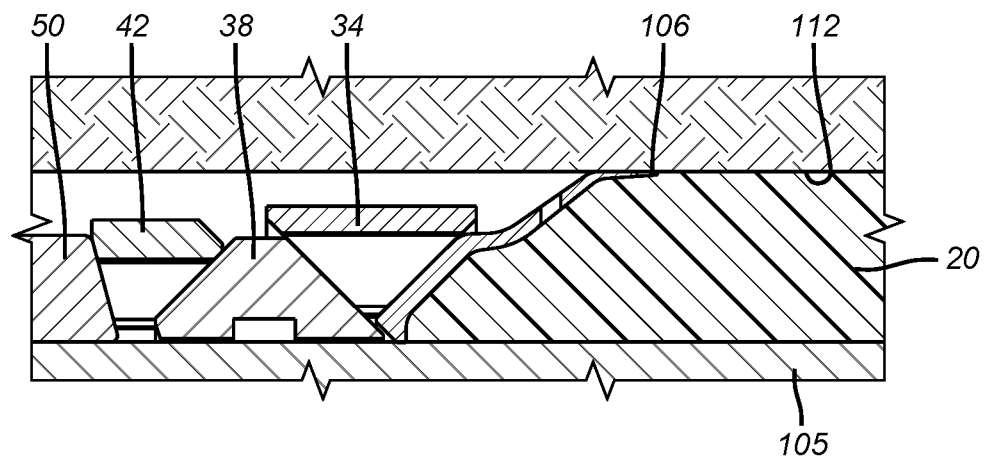


FIG. 13

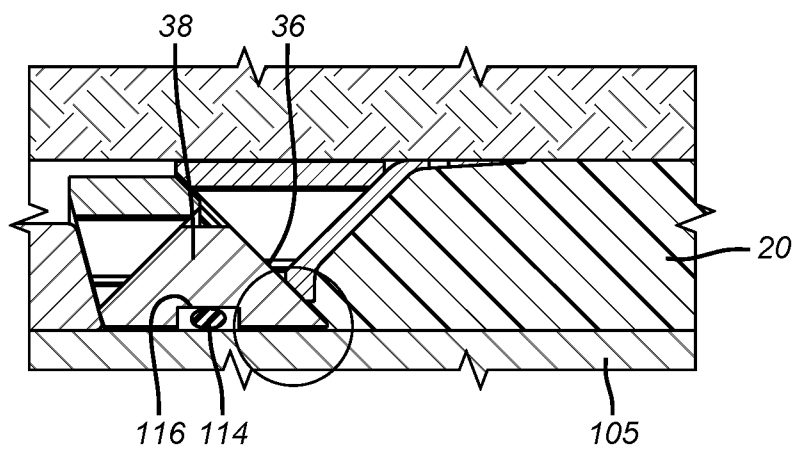


FIG. 14

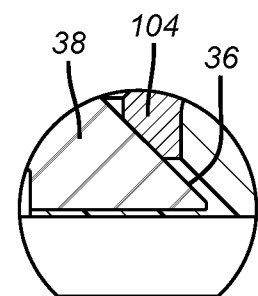


FIG. 15

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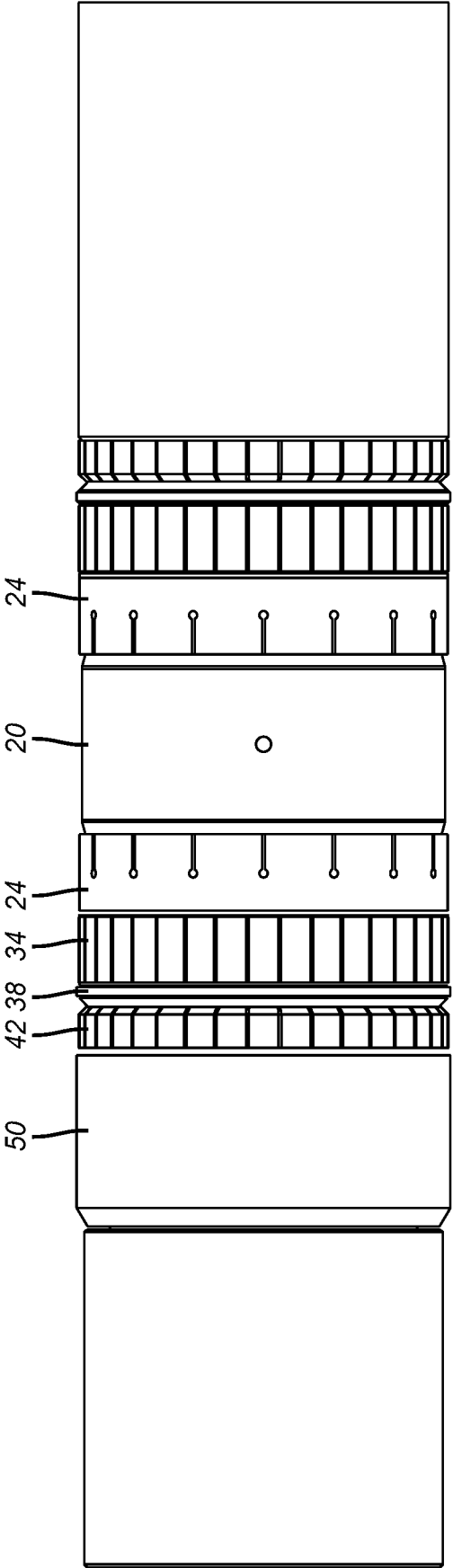


FIG. 16

A. CLASSIFICATION OF SUBJECT MATTER**E21B 33/12(2006.01)i, E21B 33/128(2006.01)i, E21B 43/14(2006.01)i, E21B 43/26(2006.01)i, F16J 15/02(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)

E21B 33/12; E21B 23/06; E21B 33/127; E21B 33/128; E21B 33/16; E21B 43/14; E21B 43/26; F16J 15/02

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: extrusion barrier ring, sealing element assembly, slot, taper, narrow, wedge ring

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2015-0308214 A1 (SCHLUMBERGER TECHNOLOGY CORPORATION) 29 October 2015 See paragraphs [0002], [0019]–[0020], [0023]–[0024] and figures 2–3, 5.	1–4, 7–8, 13–15
Y		5–6, 9–12
Y	US 2012-0217025 A1 (SHKURTI et al.) 30 August 2012 See paragraph [0061] and figures 13–14.	5–6, 9
Y	US 2017-0191340 A1 (BAKER HUGHES INCORPORATED) 06 July 2017 See paragraphs [0023]–[0024] and figures 2–3, 5.	10–12
A	US 2012-0018143 A1 (LEMBCKE JEFFREY J.) 26 January 2012 See paragraph [0019] and figure 3.	1–15
A	US 2014-0290946 A1 (WEATHERFORD/LAMB, INC.) 02 October 2014 See paragraph [0033] and figures 2, 7A.	1–15



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

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Date of the actual completion of the international search

21 November 2018 (21.11.2018)

Date of mailing of the international search report

21 November 2018 (21.11.2018)

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2018/041880

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