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- (54) Title: **BACKUP BULLET SEAL WITH ACTUATION DELAY FEATURE**

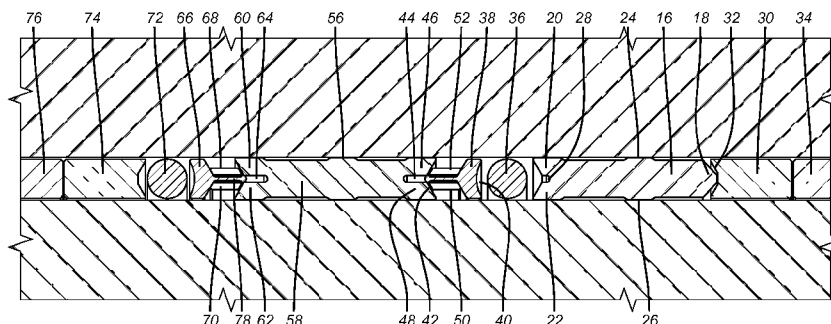


FIG. 2

(57) Abstract: A sealing system features a primary and secondary bullet seals where the secondary seal is preferably bidirectional and is activated to spread fins with a t-shaped ring that is driven with differential pressure to advance after temperature exposure softens a stop material on the extending portion of the t-shaped ring. Opposed t-shaped rings are disposed at ends of the backup ring that have fins at both ends. Advancement of the t-shaped ring spreads the fins and retains them in the spread condition for enhanced sealing. Optionally the primary seal can also be actuated with a similar t-shaped ring with a temperature sensitive delay feature.

BACKUP BULLET SEAL WITH ACTUATION DELAY FEATURE

Inventor: Siby Varghese

FIELD OF THE INVENTION

[0001] The field of the invention is high pressure and high temperature seals and more particularly sealing arrangements with backup feature and more particularly a backup that has a delay feature to energize.

BACKGROUND OF THE INVENTION

[0002] Bullet seals are described in detail in USP 5,611,547 where seals 80 and 82 are disposed in mirror image with an o-ring 78 between them to handle pressure differential in opposed directions. These seals have a generally pointed end and an opposite finned end adjacent the o-ring. These seals were designed to replace the stacks of chevron shaped seals shown in FIG. 1 of that patent. There were no backup seals used for pressure differentials in a given direction and no efforts to actuate the finned end beyond the axial pressure from fluids in the string. Other related seal designs are shown in USP: 5,879,010; 7,341,258; 5,524,905; 7,363,981; 6,318,729; 7,819,184 and 7,401,788.

[0003] Of the bullet seals that have been deployed in the past there have been issues with reliable performance particularly where significant temperature fluctuations of over 200 degrees F could occur. These seal assemblies had no backup as illustrated in FIG. 1 with opposed bullet seals **10** and **12** separated by an o-ring **14** and disposed in a mirror image layout for opposing pressure differentials from either an uphole or a downhole direction. The past design focused on ease of assembly and a need to optimize a sealing system in a small confined space. The bullets were installed in an activated configuration. In some applications backup bullet seal pairs were used where the primary and the backup seals were identically configured and installed in a configuration that application of a net differential pressure in one direction activated both the primary and secondary seals due to axial compression through the o-ring in between opposed seal pairs and more rigid end rings adjacent the tapered ends of the seals.

[0004] What is needed and provided by the present invention is an assembly of bullet seals with a backup that is delayed in being deployed using

primarily a temperature effect on a material that prevents advancement of a ring between end fins. The backup seal is not actuated until pressure is communicated to it such as by a failure of a primary seal and then there is the effect of temperature of well fluids to allow the t-shaped ring to advance as the material on the leading branch of the t-shaped ring softens to allow pressure differential to advance the ring and spread the end fins of the bullet seal to enhance its performance. These and other features of the present invention will be more readily understood by those skilled in the art from a review of the detailed description of the invention and the associated drawings while recognizing that the full scope of the invention will be determined by the appended claims.

SUMMARY OF THE INVENTION

[0005] A sealing system features a primary and secondary bullet seals where the secondary seal is preferably bidirectional and is activated to spread fins with a t-shaped ring that is driven with differential pressure to advance after temperature exposure softens a stop material on the extending portion of the t-shaped ring. Opposed t-shaped rings are disposed at ends of the backup ring that have fins at both ends. Advancement of the t-shaped ring spreads the fins and retains them in the spread condition for enhanced sealing. Optionally the primary seal can also be actuated with a similar t-shaped ring with a temperature sensitive delay feature.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] FIG. 1 is a prior art installation of opposed bullet seals located on opposed sides of a fixed support location;

[0007] FIG. 2 shows a primary seal used in conjunction with a bidirectional bullet seal as backup when the backup seal is not activated; and

[0008] FIG. 3 is the view of FIG. 2 with the backup bullet seal activated by enabled advancement of the t-shaped rings into the space between the fins.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0009] FIG. 2 illustrates a primary bullet seal **16** that has a tapered nose **18** and opposed fins **20** and **22** respectively on the outside diameter and the inside diameter. There are outside and inside sealing areas **24** and **26** respectively. A circular groove **28** divides the fins **20** and **22**. A leading end ring **30** has a

taper **32** to accept the tapered nose **18**. This ring is typically plastic that has the needed properties of compressive strength and tolerance to well fluids and anticipated temperature. The material can be PEEK for example. Another ring **34** that is typically metal is disposed ahead of ring **30** for backup. On the other end of the primary bullet seal **16** is an o-ring **36**.

[0010] Adjacent o-ring **36** is t-shaped ring **38** that has a concave curved end **40** that contacts o-ring **36** and a branch component **42** that is formed to fit into groove **44** that is disposed between outside and inside fins **46** and **48** respectively. However, internal and external rings **50** and **52** are disposed on opposed sides of the branch component **42** with the purpose of keeping the branch component **42** out of groove **44** until rings **50** and **52** respond to thermal or other inputs and soften or weaken or collapse or dissolve or otherwise get out of the way so that a net force applied from the downhole side represented by arrow **54** in FIG. 3 allows the branch component **42** to advance into groove **44**. That advancing spreads the fins **46** and **48** by about 10-15 thousands beyond the dimension at **56**, in a laterally unrestrained condition.

[0011] At the opposite end of bidirectional backup seal **58** there are mirror image fins **60** and **62** to fins **46** and **48**. Fins **60** and **62** are separated by groove **64** with a similar arrangement using t-shaped ring **66** with rings **68** and **70** as previously described for the other end of the backup seal **58**. Adjacent to the t-shaped ring **66** is o-ring **72** which is followed by plastic ring **74** made of PEEK or other material suitable for the load, chemical exposure and thermal conditions downhole. Finally another support ring **76** that is generally metallic follows adjacent ring **74**.

[0012] Loading comes primarily from downhole represented by arrow **54**. That pressure compresses the assembly shown in FIG. 2. Normally the sealing function is carried out by the primary seal **16** with force transferred to o-ring **36** and into t-shaped ring **38** and then through rings **50** and **52** into the backup seal **58** and through the mirror image rings **68** and **70** to t-shaped ring **66** and onto o-ring **72** and ultimately against rings **74** and **76** that are backstopped by a fixed support that is not shown. With the primary ring **16** functional against pressure from downhole the well fluids and their temperature will not reach

rings **50**, **52**, **68** and **70** and they will retain their structural rigidity. However, if there is a failure of the seal **16** the fluids from downhole will reach these rings and cause them to weaken so that they no longer impede the relative movement with respect to seal **58** and the branch components **42** and **78** can respectively then enter grooves **44** and **64** to apply a radial sealing force to the respective pair of fins that define the grooves **44** and **64** to enhance the effectiveness of the backup seal **58** to pressure differential in opposed directions. This position is shown in FIG. 3.

[0013] Those skilled in the art will appreciate that there are variations contemplated on the illustrated assembly in FIGS. 2 and 3. For example a mirror image of the entire assembly can be located further uphole above ring **76** and can function in a similar way to retain differential pressures from uphole in the direction of arrow **80**. Alternatively, the entire assembly can be as depicted in FIGS. 2 and 3. The primary seal **16** can be outfitted with its own t-shaped ring similarly shaped as ring **38** with thermally responsive rings **50** and **52** but with a branch component such as **42** oriented toward groove **28** for selective entry therein when the right conditions of compressive force and predetermined temperature are reached. Such a ring would be located between o-ring **36** and fins **20** and **22**.

[0014] The dimensions of the seals **16** and **58** at outer locations **24** and **56** are preferably the same. Rings such as **50** or **52** can be a rubber or elastomer or a polymer such as shape memory polymer.

[0015] Those skilled in the art will appreciate that the delay feature provided by rings such as **50** and **52** will facilitate assembly since there will be negligible resistance to installation during the assembly process with a reduced chance for distortion or twisting in the bullet seals that make up the sealing assembly. Premature activation can impede the installation effort and can cause damage such as tears or cracks that can compromise the seal in high temperature applications with conditions reaching to 350 degrees F or more and pressures in thousands of pounds. The driving into a groove of a branch component such as **42** is a more assured way for enhancing sealing force than pushing an o-ring against fins because the nature of the displacement that is obtained is more certain whereas the o-ring can distort in a variety of ways

that will not necessarily deliver the desired fin movement or will not retain the initial displacement in a manner that filling the groove with the branch component that in essence widens the groove as the component is advanced and stays put thereafter to enhance the sealing in the region of the fins. The backup seal **58** winds up only fully actuated at a later time than the initial assembly and likely well after deployment upon exposure to predetermined compressive force and temperature of well fluids.

[0016] One condition that can make a primary seal **16** fail can be dramatic temperature changes with associated dimensional changes that can be experienced as different procedures are undertaken such as cycles of steam injection and downtime. In such circumstances with differentials in temperature of over 200 degrees F that may make a primary seal fail to hold pressure, the actuation of the secondary bidirectional seal **58** can prevent a leakage situation. Seal **58** can also be optionally unidirectional and optionally more than a single seal **58** can be used in a configuration to prevent leakage in a given direction apart from the option of a full mirror image layout for the assembly shown in FIGS. 1 and 2.

[0017] 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:

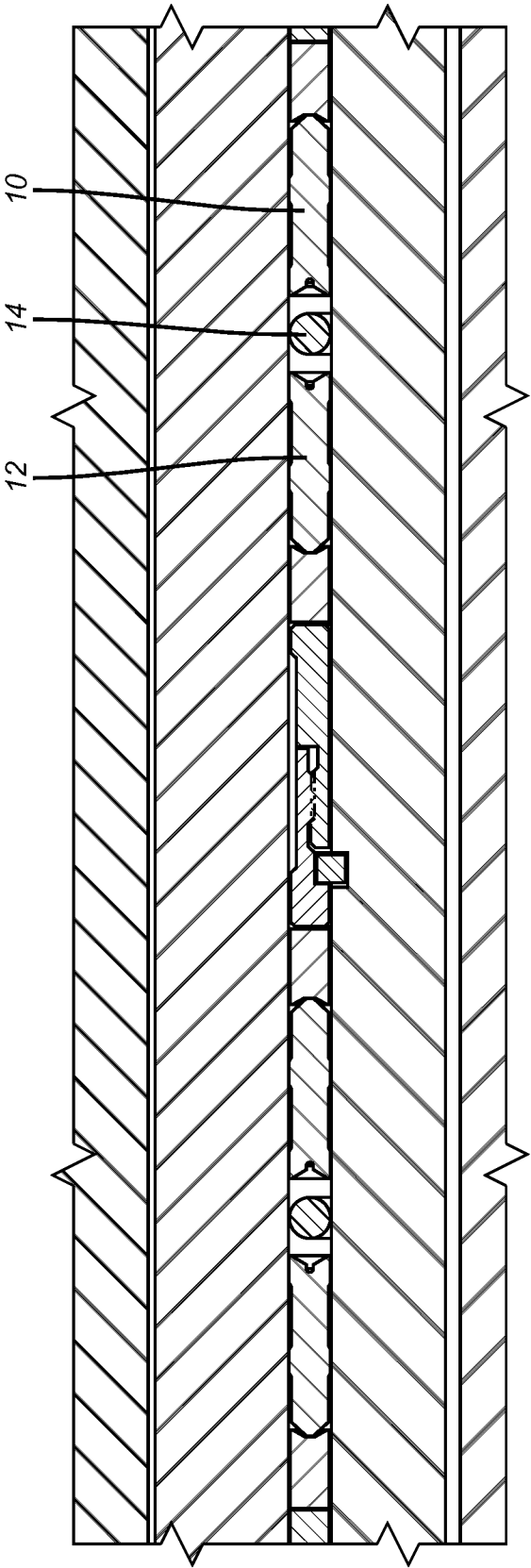
I claim:

1. A seal assembly a bullet shaped cross-section for an annular space having an uphole and a downhole end for subterranean use, comprising:
 - opposed fins on at least one end of at least one seal body that are spaced apart to define a groove therebetween;
 - at least one ring having an extending branch positioned in alignment with and initially substantially out of said groove; and
 - at least one selective travel stop to prevent movement of said extending branch into said groove upon installation of the seal assembly, said travel stop being defeated at the subterranean location for movement into said groove to deliver a sealing force to said fins.
2. The assembly of claim 1, wherein:
 - said travel stop comprises a material whose compressive strength decreases on exposure to thermal stress.
3. The assembly of claim 1, wherein:
 - said travel stop comprises rings disposed on opposed sides of said extending branch.
4. The assembly of claim 3, wherein:
 - said rings are made of an elastomer or a polymer.
5. The assembly of claim 1, wherein:
 - said travel stop collapses at the subterranean location under a predetermined compressive force and under the influence of thermal loads at the subterranean location.
6. The assembly of claim 1, wherein:
 - said at least one seal body comprises opposed fins at both ends thereof;
 - said at least one ring comprises a plurality of rings;
 - said at least one travel stop comprising a plurality of travel stops
 - said rings disposed in mirror image with extending branches and associated travel stops positioned in alignment with and initially substantially out of respective grooves on opposed ends of said seal body.
7. The assembly of claim 6, further comprising:
 - at least one o-ring adjacent a conforming end shape of an associated said ring.

8. The assembly of claim 7, wherein:
said extending branch is wider than said groove before entry in the range of at least 10 thousandths of an inch.
9. The assembly of claim 8, wherein:
said travel stop comprises a material whose compressive strength decreases on exposure to thermal stress.
10. The assembly of claim 9, wherein:
said travel stop comprises rings disposed on opposed sides of said extending branch.
11. The assembly of claim 10, wherein:
said rings are made of an elastomer or a polymer.
12. The assembly of claim 11, wherein:
said travel stop collapses at the subterranean location under a predetermined compressive force and under the influence of thermal loads at the subterranean location.
13. The assembly of claim 12, wherein:
said at least one seal body comprises multiple seal bodies further comprising a primary seal body having opposed fins on one end thereof and a tapered opposed end and a secondary seal body having opposed fins on opposed ends thereof;
said at least one o-ring comprising a plurality of o-rings disposed on opposed sides of said secondary seal body and in contact with an associated said ring.
14. The assembly of claim 14, wherein:
said extending branch of each said ring enters a respective groove in said secondary seal subsequent to initial assembly upon thermal loading of said travel stops resulting from failure of said primary seal.
15. The assembly of claim 14, wherein:
said primary seal further comprises an associated said ring and said travel stop with an extending branch substantially aligned and initially positioned substantially outside said associated groove.

16. The assembly of claim 1, wherein:
said travel stop fails in compression at a predetermined force.
17. The assembly of claim 1, wherein:
said travel stop axially collapses under compressive loading upon
exposure to well fluid or thermal stress from well fluid.
18. The assembly of claim 1, wherein:
said travel stop dissolves upon selective exposure to well fluids.

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(PRIOR ART)
FIG. 1

2/3

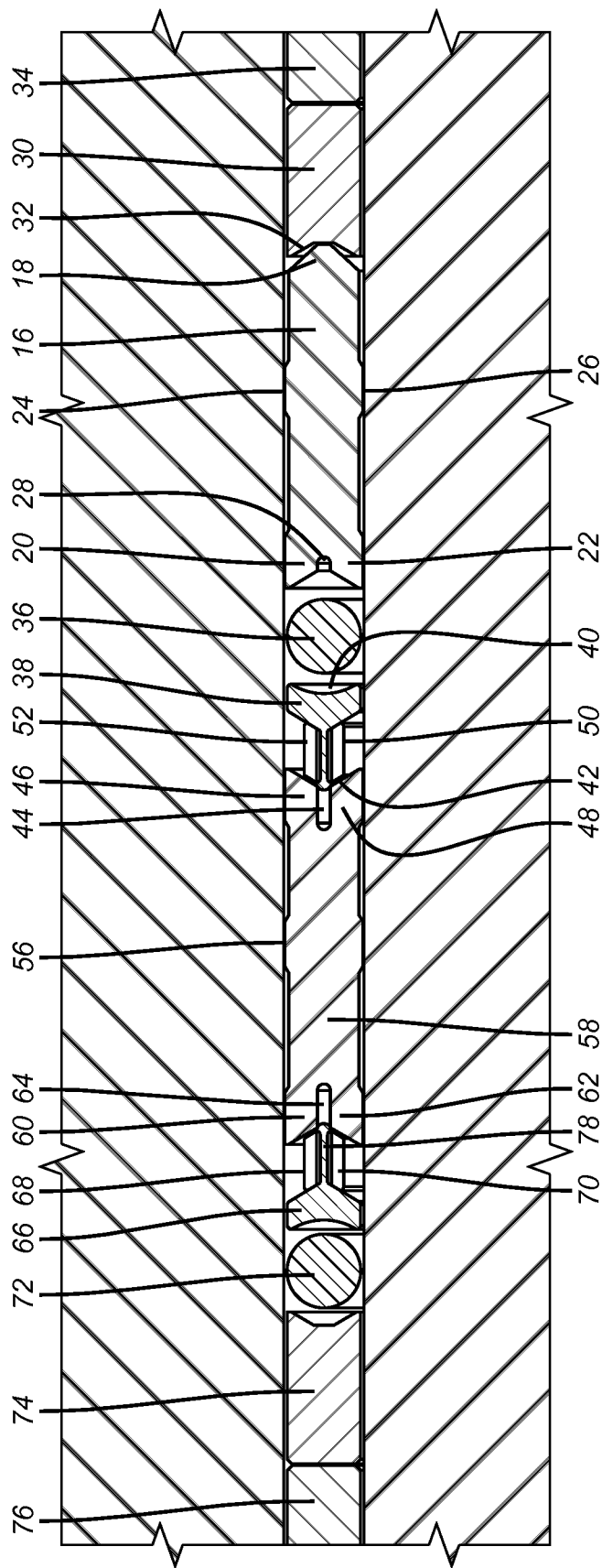


FIG. 2

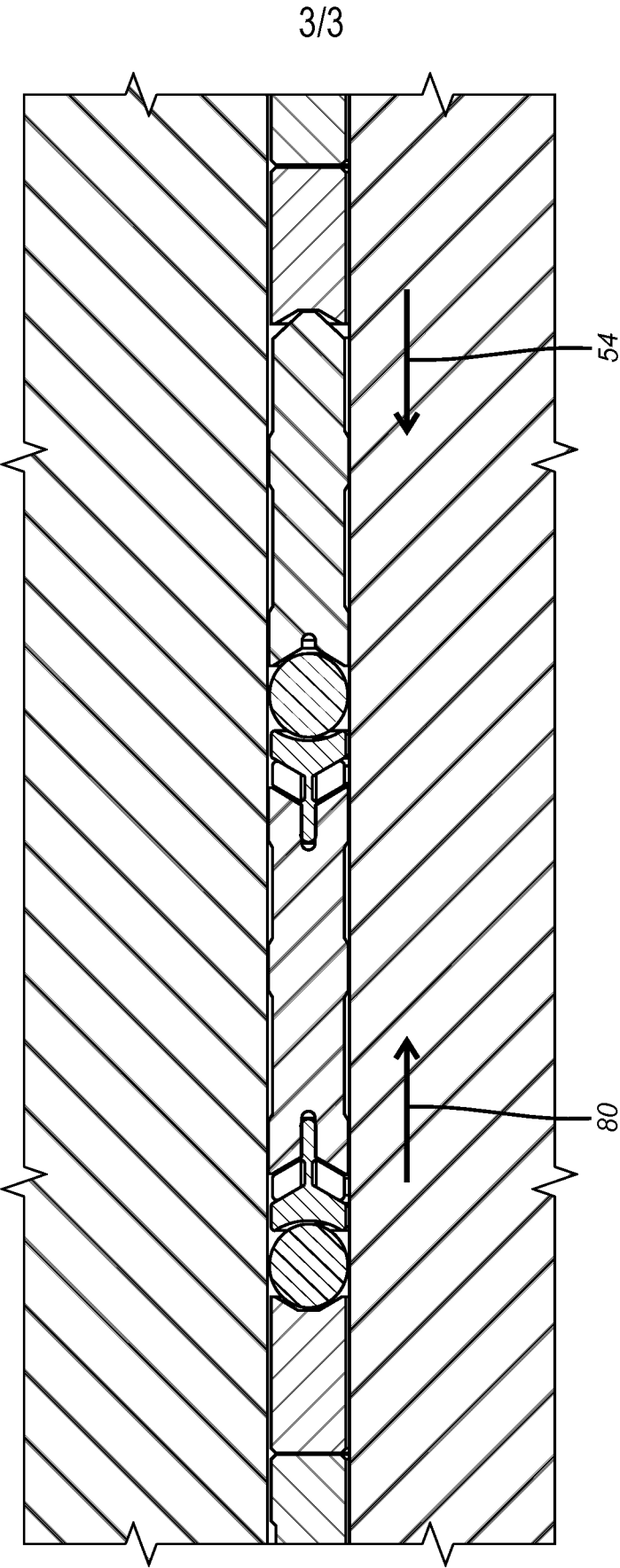


FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/012241**A. CLASSIFICATION OF SUBJECT MATTER****F16J 15/28(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 15/28; E21B 33/128; E21B 33/12; F16J 15/20; E21B 34/14

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: seal, ring, groove, branch, fin, travel stop, backup, temperature and pressure

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2008-0029264 A1 (WILLIAMS et al.) 07 February 2008 See abstract; paragraphs 16,18; claims 2-3 and figures 3-4.	1-5, 16-18
Y		6-15
Y	US 5611547 A (BAUGH et al.) 18 March 1997 See abstract; column 4, lines 43-58; column 6, lines 17-51; claim 11 and figures 2-3.	6-15
A	US 6318729 B1 (PITTS, JR. et al.) 20 November 2001 See abstract; column 6, lines 16-52; claim 1 and figure 4.	1-18
A	US 6203020 B1 (MIRELES, JR. et al.) 20 March 2001 See abstract; column 2, lines 4-20; claim 1 and figure 1.	1-18
A	US 4811959 A (BULLARD et al.) 14 March 1989 See abstract; column 3, lines 56-66; claim 1 and figures 2-3.	1-18



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"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

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2014/012241

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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US 6318729 B1	20/11/2001	GB 0101441 D0 GB 2358419 A GB 2358419 B	07/03/2001 25/07/2001 21/01/2004
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US 4811959 A	14/03/1989	None	