



(51) International Patent Classification:

E21B 33/12 (2006.01)

E21B 33/129 (2006.01)

(21) International Application Number:

PCT/US2024/031240

(22) International Filing Date:

28 May 2024 (28.05.2024)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

18/326,159

31 May 2023 (31.05.2023)

US

(71) Applicant: **BAKER HUGHES OILFIELD OPERATIONS LLC** [US/US]; 17021 Aldine Westfield, Houston, Texas 77073 (US).

(72) Inventors: **ZHANG, Zhihui**; 17021 Aldine Westfield, Houston, Texas 77073 (US). **DENG, Guijun**; 17021 Aldine Westfield, Houston, Texas 77073 (US). **NUNEZ, Emerson**; 17021 Aldine Westfield, Houston, Texas 77073 (US). **HARPER, Jason**; 17021 Aldine Westfield, Houston, Texas 77073 (US).

(74) Agent: **DUPHORNE, Darin** et al.; 14990 Yorktown Plaza Drive, Houston, Texas 77040 (US).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE,

(54) Title: A SEAL ASSEMBLY, AND SYSTEM

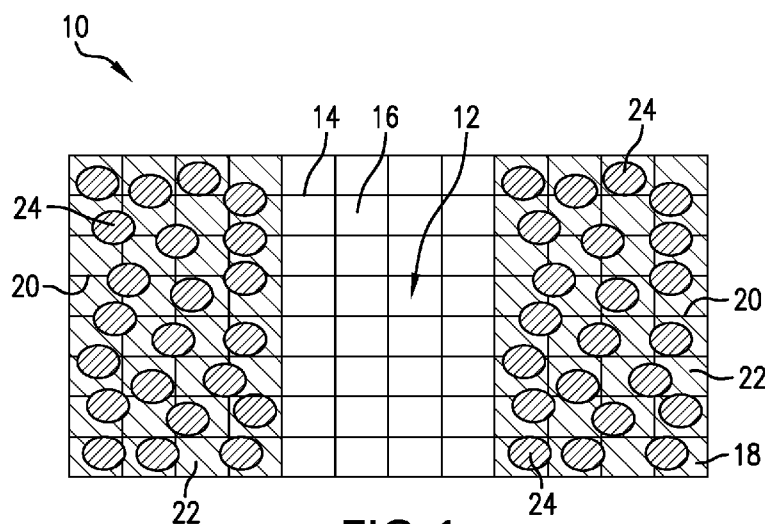


FIG. 1

(57) Abstract: A seal assembly, including a seal including a first lattice impregnated with a conformable resilient material, a backup including a second lattice impregnated with a conformable resilient material, the second lattice having a greater rigidity than the first lattice. A borehole system including a borehole in a subsurface formation, a string in the borehole, and a seal assembly disposed within or as a part of the string.

SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN,
GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:

- *with international search report (Art. 21(3))*

A SEAL ASSEMBLY, AND SYSTEM

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to U.S. Provisional Patent Application No. 18/326,159, filed on May 31, 2023, in the United States Patent and Trademark Office, and all the benefits accruing therefrom under 35 U.S.C. § 119, the content of which is incorporated herein in its entirety by reference.

BACKGROUND

[0002] In the resource recovery and fluid sequestration industries, sealing various parts relative to other parts is ubiquitous. Challenges abound due to temperature ranges and fluctuations, pressure ranges and fluctuations, and the complexities of systems to manage these. The art is always receptive to developments that improve the state of the art.

SUMMARY

[0003] An embodiment of a seal assembly, including a seal including a first lattice impregnated with a conformable resilient material, a backup including a second lattice impregnated with a conformable resilient material, the second lattice having a greater rigidity than the first lattice.

[0004] An embodiment of a borehole system including a borehole in a subsurface formation, a string in the borehole, and a seal assembly disposed within or as a part of the string.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] The following descriptions should not be considered limiting in any way. With reference to the accompanying drawings, like elements are numbered alike:

[0006] Figure 1 is a schematic cross section view of a seal assembly as disclosed herein;

[0007] Figure 2 is a schematic cross section view of another embodiment of a seal assembly as disclosed herein;

[0008] Figures 3 and 4 are schematic illustrations of the seal assembly of Figure 1 in run in and set positions;

[0009] Figures 5 and 6 are schematic illustrations of an alternate configuration of seal assembly in run in and set positions;

[0010] Figures 7 and 8 are schematic illustrations of another alternate configuration of seal assembly in run in and set positions; and

[0011] Figure 9 is a view of a borehole system including a seal assembly as disclosed herein.

DETAILED DESCRIPTION

[0012] A detailed description of one or more embodiments of the disclosed apparatus and method are presented herein by way of exemplification and not limitation with reference to the Figures.

[0013] Referring to Figure 1, a first embodiment of a seal assembly 10 is illustrated. Seal assembly 10 comprises a seal 12 including a first lattice 14 impregnated with a conformable resilient material 16. The lattice 14 is a geometric structure that exhibits a rigidity that is higher than that of the conformable resilient material 16. Lattice 16 may be of a metal such as stainless steel or a plastic such as polyether ether ketone (PEEK) and may have geometric shapes such as cubic, honeycomb, or other geometries. The conformable resilient material is a softer material that is suitable for creating a seal when urged into contact with another structure such as a casing. In embodiments, the material 16 may be a rubbery material such as Polytetrafluoroethylene (PTFE), Ethylene Propylene Diene Monomer (EPDM), Perfluoroalkoxy alkane (PFA), and other similar materials. In each case the material 16 is injected into the lattice 14 or is overmolded on the lattice 16.

[0014] Still referring to Figure 1, a backup 18 includes a second lattice 20 impregnated with a conformable resilient material 22 (which may be the same as material 16 or may be other similar materials). The second lattice 20 may be of the same rigidity as the first lattice 14 or may be of a higher rigidity than the first lattice 14. If the lattice 20 is the same rigidity as the lattice 14, as is illustrated in Figure 1, then a particulate additive 24 is added to increase overall rigidity (lattice 20, material 22, and particulate 24) of the backup 18 relative to the overall rigidity (lattice 14, and material 16) of the seal 12. Alternatively, the second lattice 20 may have a greater rigidity than the first lattice 14 and be used without any particulate additive 24 as is illustrated in Figure 2, where the size of the internal repeating shapes defined by the lattice 14 is different from the size of the shapes defined by the lattice 20. In embodiments, the greater rigidity may be due to an increase in the thickness of material used for the lattice 20 or may be due to the dimensions of the repeating units of the lattice in the lattice 20 vs lattice 14. In either case, the overall rigidity of the seal 12 and the backup 18 will be different in that the backup 18 will be of a higher rigidity than the seal 12. In embodiments where a particulate additive

24 is employed, the additive 24 may be spherical objects of stainless steel or other metals or materials not likely to plastically deform under loads associated with setting of the seal assembly 10. “Roundy” geometries improve flow characteristics of the additive 24 in the material 22. By “roundy” it is meant, spherical, oblate spheroids, prolate spheroids, tori, and other geometric shapes that have been rounded where corners, vertexes, or edges are normally presented. The additive 24 significantly increases rigidity of the backup 18. In an embodiment, a ratio of rigidity of backup to seal is about 1.1:1 to about 2:1, achievable with lattice 14 to lattice 20 difference alone, lattice 14 to lattice 20 difference plus additive 24, or lattice 14 and lattice 20 being the same but with an additive 24. In another embodiment, a volume percentage of lattice 20 and/or additive 24 to the total volume of the backup 18 is about 50% to about 85%. The volume percentage of lattice 14 in the seal 12 will be less than the percentage in the backup 18.

[0015] It is to be understood that in at least some of the embodiments, the seal 12 and backup 18 may be a single unit or may be different components like rings that are stacked next to one another. Further, the lattice 14 and 20 may be contiguous, with and different conformable resilient materials 16 and 22 impregnated in the locations illustrated for the seal 12 and backup 18.

[0016] Referring to Figures 3 and 4, the embodiment of Figure 1 is illustrated in situ upon a mandrel 30 and inside of a casing 32 (any tubular structure). Gauge rings 34 and 36 are also illustrated and are clearly not compressing the seal assembly 10 in Figure 3. In Figure 4, however, the gauge rings 34 and 36 have been moved closer together to squeeze the seal assembly 10. The less rigid seal 12 expands radially outwardly more quickly than the more rigid backups 18 forming a seal against the casing 32. The backups 18 also expand radially outwardly into contact with the casing 32 and due to their rigidity prevent extrusion of the seal 12 during use.

[0017] Referring to Figures 5 and 6, an alternate embodiment is illustrated that uses different shapes for the seal 12 and backups 18 to promote certain shapes of radial expansion upon setting, as illustrated. It will be noted that the shape of the gauge rings is also different in that they are angled toward each other as then increase in distance from the mandrel 30. The embodiment increases extraction resistance by preferentially causing the backups 18 to angle toward one another.

[0018] Referring to Figures 7 and 8, yet another embodiment is illustrated having anchor flanges 38. This embodiment exhibits a complex shape for the seal 12 and the backups

18. The anchor flanges 38 tend to anchor the backups under the seal 12 during pressure reversals.

[0019] Referring to Figure 9, a borehole system 40 is illustrated. The system 40 comprises a borehole 42 in a subsurface formation 44. A string 46 is disposed within the borehole 42. A seal assembly 10 as disclosed herein is disposed within or as a part of the string 46.

[0020] Set forth below are some embodiments of the foregoing disclosure:

[0021] Embodiment 1: A seal assembly, including a seal including a first lattice impregnated with a conformable resilient material, a backup including a second lattice impregnated with a conformable resilient material, the second lattice having a greater rigidity than the first lattice.

[0022] Embodiment 2: The seal assembly as in any prior embodiment, wherein the backup has a rigidity in a ratio of about 1.1:1 to about 2:1 with the seal.

[0023] Embodiment 3: The seal assembly as in any prior embodiment, further including a particulate additive dispersed in the conformable resilient material in the second lattice.

[0024] Embodiment 4: The seal assembly as in any prior embodiment, wherein the particulate additive is a spherical additive.

[0025] Embodiment 5: The seal assembly as in any prior embodiment, wherein the additive is stainless steel.

[0026] Embodiment 6: The seal assembly as in any prior embodiment, wherein the additive is of curvilinear geometry.

[0027] Embodiment 7: The seal assembly as in any prior embodiment, wherein the seal and the backup form a single piece structure.

[0028] Embodiment 8: The seal assembly as in any prior embodiment, wherein the first lattice and/or the second lattice defines shapes that are cubic in geometry.

[0029] Embodiment 9: The seal assembly as in any prior embodiment, wherein first lattice defines internal repeating shapes; the second lattice defines internal repeating shapes, and the shapes of the first lattice are smaller in dimension than the shapes of the second lattice.

[0030] Embodiment 10: The seal assembly as in any prior embodiment, wherein at least one of the first and second lattices comprise a metal material.

[0031] Embodiment 11: The seal assembly as in any prior embodiment, wherein the at least one of the first and second lattices comprise a plastic material.

[0032] Embodiment 12: The seal assembly as in any prior embodiment, wherein the metal material is stainless steel.

[0033] Embodiment 13: The seal assembly as in any prior embodiment, wherein the conformable resilient material of the seal material and the conformable resilient material of the backup material are the different materials.

[0034] Embodiment 14: The seal assembly as in any prior embodiment, wherein the conformable resilient material of the seal material and the conformable resilient material of the backup material are the same material.

[0035] Embodiment 15: The seal assembly as in any prior embodiment, wherein the conformable resilient material of the seal material and/or the conformable resilient material of the backup material comprises a polymeric material.

[0036] Embodiment 16: The seal assembly as in any prior embodiment, wherein the polymeric material includes poly tetra fluoroethelene, ethylene propylene diene monomer, perfluoroalkoxy alkane, and combinations including at least one of the foregoing.

[0037] Embodiment 17: The seal assembly as in any prior embodiment, wherein the seal exhibits a cross section, taken in parallel to a longitudinal axis of the seal assembly, that is a parallelogram.

[0038] Embodiment 18: The seal assembly as in any prior embodiment, wherein the seal exhibits a cross section, taken in parallel to a longitudinal axis of the seal assembly, having a larger dimension radially inwardly and a smaller cross section radially outwardly,

[0039] Embodiment 19: The seal assembly as in any prior embodiment, wherein the backup exhibits a cross section, taken in parallel to a longitudinal axis of the seal assembly, that is a parallelogram.

[0040] Embodiment 20: A borehole system including a borehole in a subsurface formation, a string in the borehole, and a seal assembly as in any prior embodiment disposed within or as a part of the string.

[0041] The use of the terms “a” and “an” and “the” and similar referents in the context of describing the invention (especially in the context of the following claims) are to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. Further, it should be noted that the terms “first,” “second,” and the like herein do not denote any order, quantity, or importance, but rather are used to distinguish one element from another. The terms “about”, “substantially” and “generally” are intended to include the degree of error associated with measurement of the particular quantity based upon the equipment available at the time of filing the application. For example, “about” and/or “substantially” and/or “generally” can include a range of $\pm 8\%$ a given value.

[0042] 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 borehole, and / or equipment in the borehole, 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.

[0043] While the invention has been described with reference to an exemplary embodiment or embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the claims. Also, in the drawings and the description, there have been disclosed exemplary embodiments of the invention and, although specific terms may have been employed, they are unless otherwise stated used in a generic and descriptive sense only and not for purposes of limitation, the scope of the invention therefore not being so limited.

CLAIMS

What is claimed is:

1. A seal assembly (10), characterized by:
a seal (12) including a first lattice (14) impregnated with a conformable resilient material (16);
a backup (18) including a second lattice (20) impregnated with a conformable resilient material (22), the second lattice (20) having a greater rigidity than the first lattice (14).
2. The seal assembly (10) as claimed in claim 1, wherein the backup (18) has a rigidity in a ratio of about 1.1:1 to about 2:1 with the seal (12).
3. The seal assembly (10) as claimed in claim 1, further including a particulate additive (24) dispersed in the conformable resilient material (22) in the second lattice (20).
4. The seal assembly (10) as claimed in claim 2, wherein the particulate additive (24) is a spherical additive.
5. The seal assembly (10) as claimed in claim 1, wherein the seal (12) and the backup (18) form a single piece structure.
6. The seal assembly (10) as claimed in claim 1, wherein first lattice (14) defines internal repeating shapes; the second lattice (20) defines internal repeating shapes, and the shapes of the first lattice (14) are smaller in dimension than the shapes of the second lattice (20).
7. The seal assembly (10) as claimed in claim 1, wherein at least one of the first (14) and second (20) lattices comprise a metal material.
8. The seal assembly (10) as claimed in claim 1, wherein the at least one of the first (14) and second (20) lattices comprise a plastic material.
9. The seal assembly (10) as claimed in claim 1, wherein the conformable resilient material (16) of the seal material and the conformable resilient material (22) of the backup material are the different materials.
10. The seal assembly (10) as claimed in claim 1, wherein the conformable resilient material (16) of the seal material and the conformable resilient material (22) of the backup material are the same material.
11. The seal assembly (10) as claimed in claim 1, wherein the conformable resilient material (16) of the seal material and/or the conformable resilient material (22) of the backup material comprises a polymeric material.

12. The seal assembly (10) as claimed in claim 10, wherein the polymeric material includes poly tetra fluoroethelene, ethylene propylene diene monomer, perfluoroalkoxy alkane, and combinations including at least one of the foregoing.

13. The seal assembly (10) as claimed in claim 1, wherein the seal (12) exhibits a cross section, taken in parallel to a longitudinal axis of the seal assembly (10), that is a parallelogram.

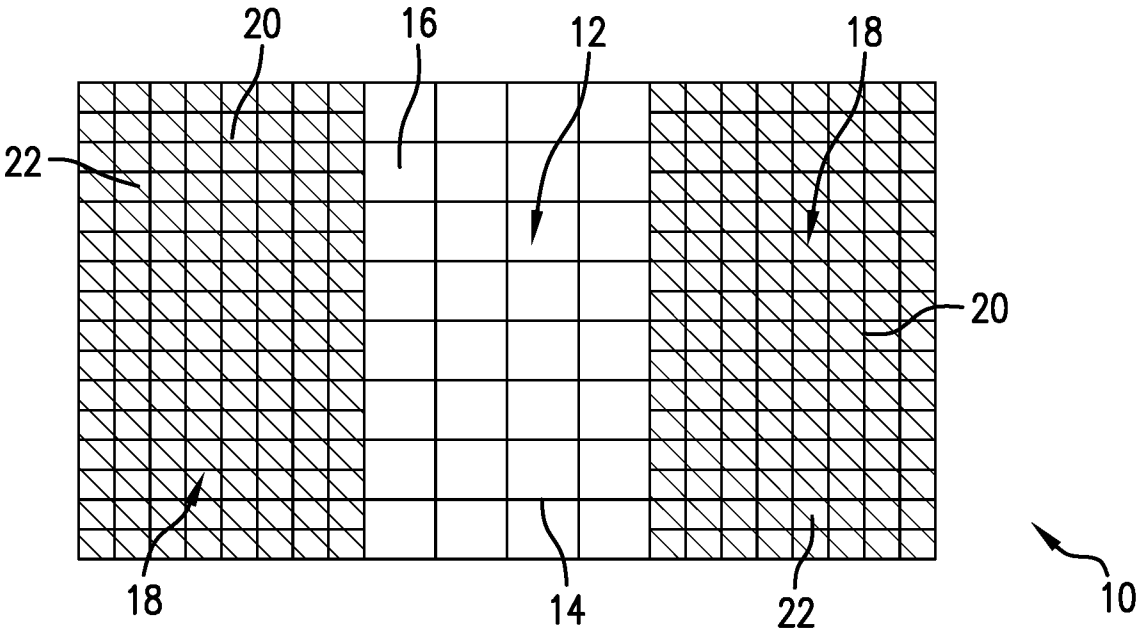
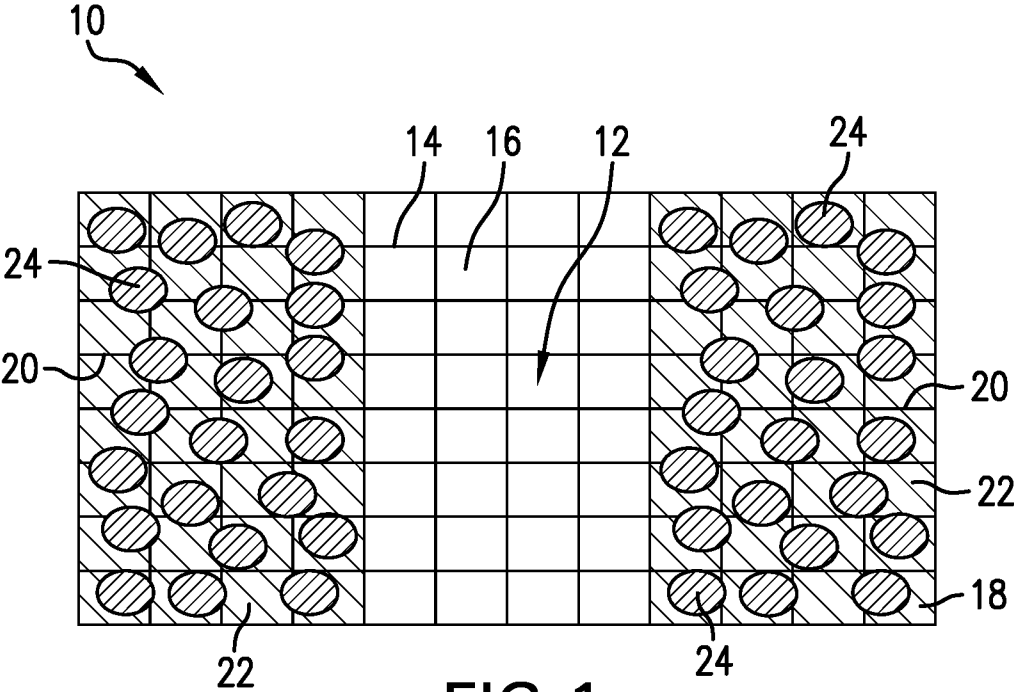
14. The seal assembly (10) as claimed in claim 1, wherein the seal (12) exhibits a cross section, taken in parallel to a longitudinal axis of the seal assembly (10), having a larger dimension radially inwardly and a smaller cross section radially outwardly,

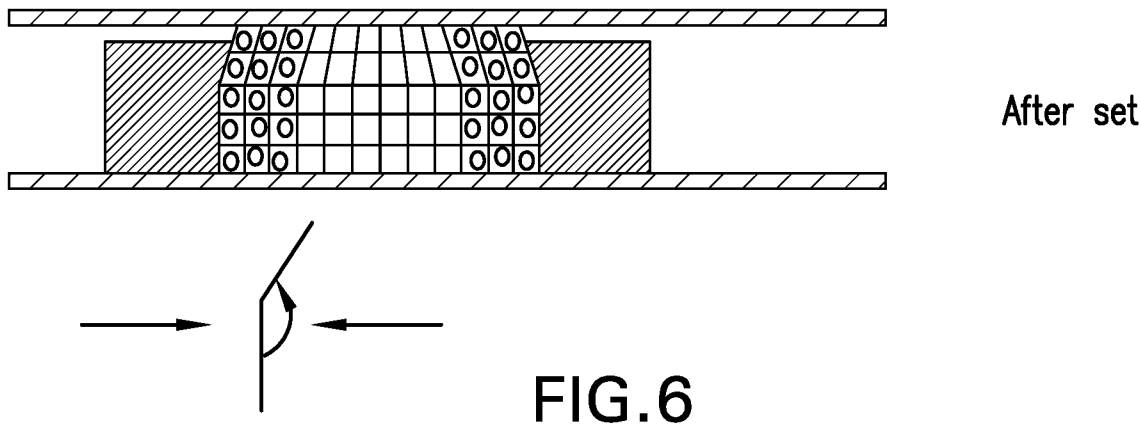
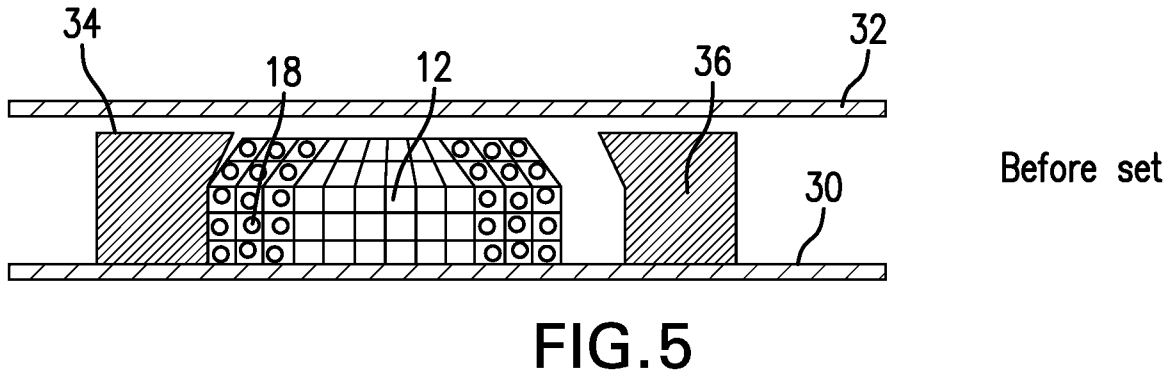
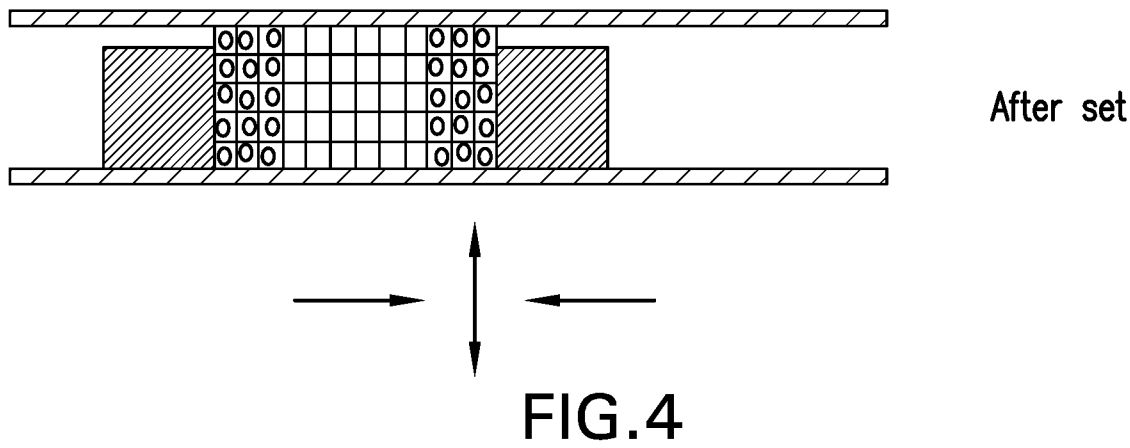
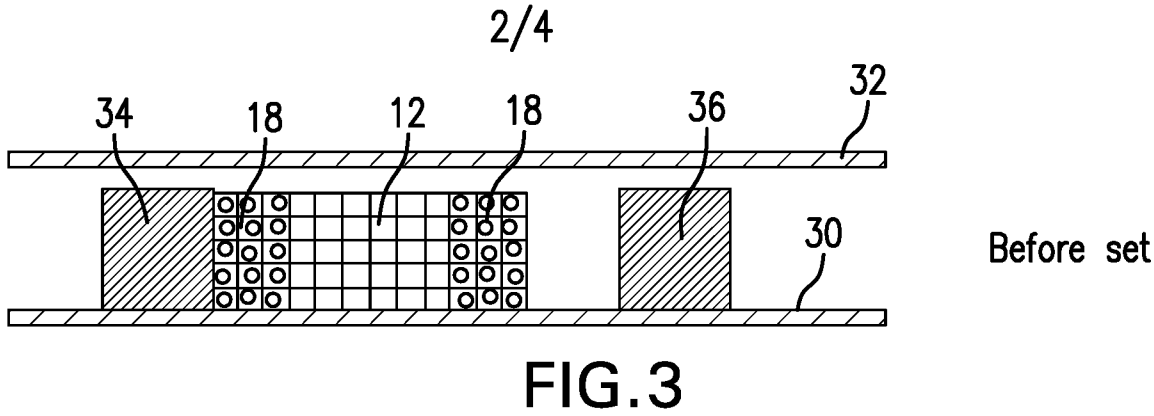
15. A borehole system (40) characterized by:

a borehole (42) in a subsurface formation (44);

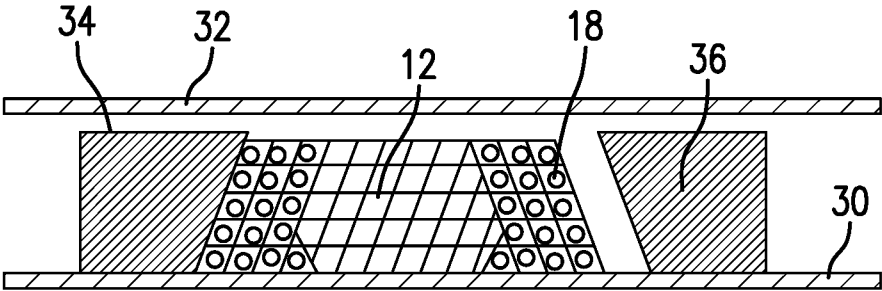
a string (46) in the borehole (42); and

a seal assembly (10) as claimed in claim 1 disposed within or as a part of the string(46).



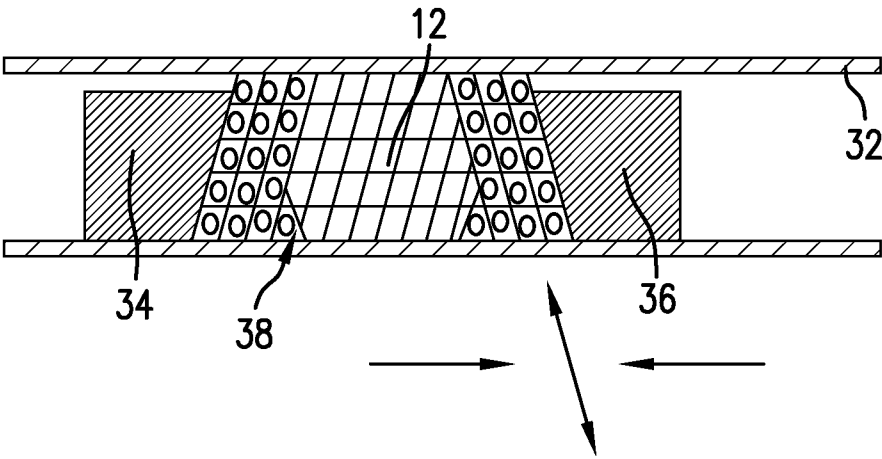


3/4



Before set

FIG.7



After set

FIG.8

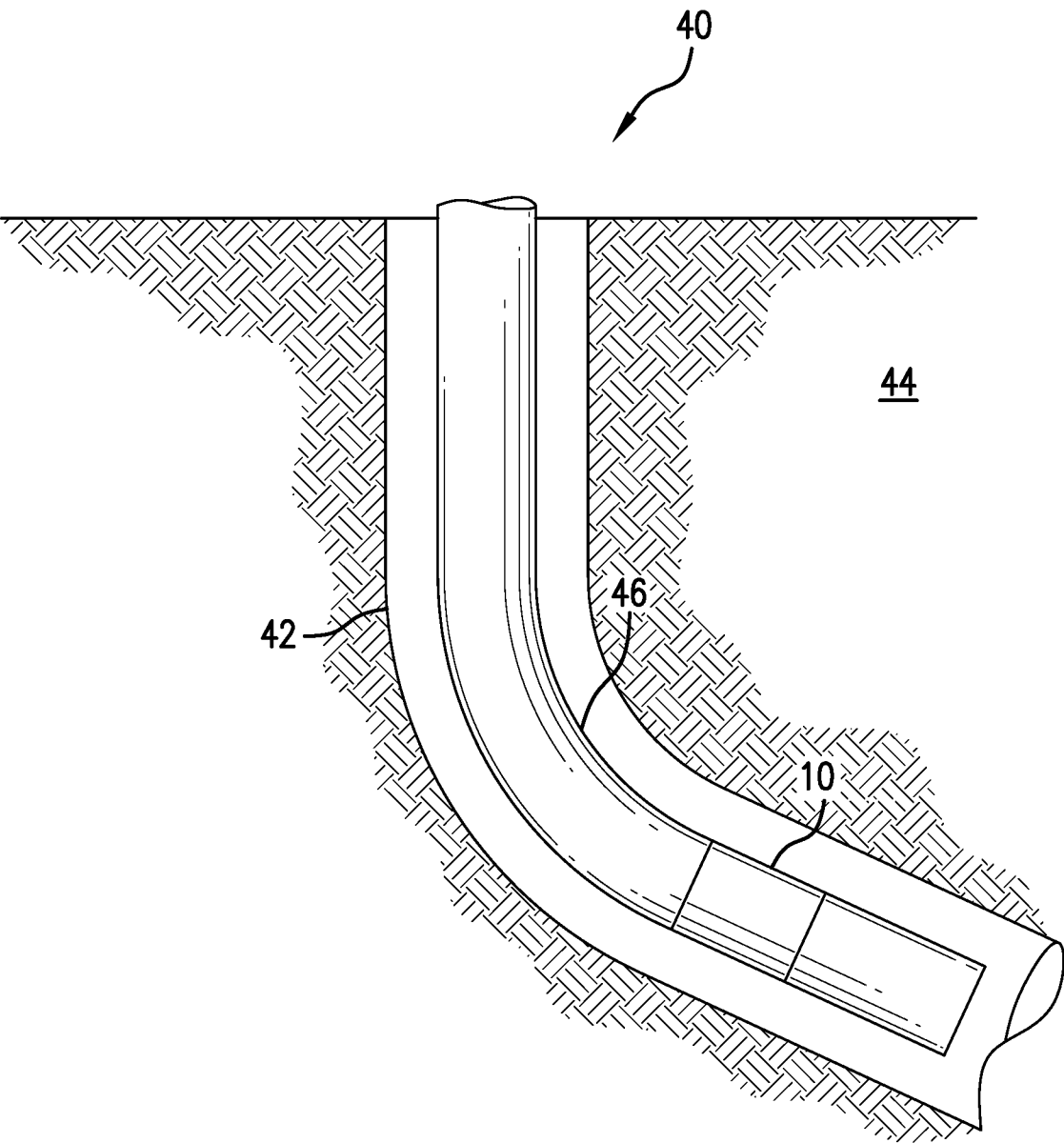


FIG.9

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2024/031240

A. CLASSIFICATION OF SUBJECT MATTER E21B 33/12(2006.01)i; E21B 33/129(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(2006.01); B33Y 80/00(2015.01); E21B 33/122(2006.01); F01D 11/00(2006.01); F16J 15/02(2006.01); F16J 15/20(2006.01); F16K 25/00(2006.01) 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: borehole, string, seal, backup, lattice, conformable resilient material, rigidity		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2017-0342797 A1 (HALLIBURTON ENERGY SERVICES, INC.) 30 November 2017 (2017-11-30) paragraphs [0021], [0023]-[0025], [0028], [0030] and figures 1-4	1-2,5-15
Y		3-4
Y	US 2022-0049571 A1 (HALLIBURTON ENERGY SERVICES, INC.) 17 February 2022 (2022-02-17) paragraph [0031] and figure 4C	3-4
A	EP 3567221 A1 (SIEMENS AKTIENGESSELLSCHAFT) 13 November 2019 (2019-11-13) paragraphs [0032]-[0038] and figures 2-3	1-15
A	US 2015-0069711 A1 (JOHNSON et al.) 12 March 2015 (2015-03-12) paragraphs [0060], [0062] and figures 4A-4C, 6A-6B	1-15
A	US 2023-0091259 A1 (SCHLUMBERGER TECHNOLOGY CORPORATION) 23 March 2023 (2023-03-23) paragraphs [0065]-[0070] and figures 11A-11B	1-15
☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents: “A” document defining the general state of the art which is not considered to be of particular relevance “D” document cited by the applicant in the international application “E” earlier application or patent but published on or after the international filing date “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 06 September 2024		Date of mailing of the international search report 06 September 2024
Name and mailing address of the ISA/KR Korean Intellectual Property Office 189 Cheongsa-ro, Seo-gu, Daejeon 35208, Republic of Korea Facsimile No. +82-42-481-8578		Authorized officer PARK, Tae Wook Telephone No. +82-42-481-3405

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/US2024/031240

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
US	2017-0342797	A1	30 November 2017	BR	112017015592	A2	13 March 2018
				BR	112017015592	B1	23 August 2022
				CN	107208470	A	26 September 2017
				CN	107208470	B	13 November 2020
				GB	2548535	A	20 September 2017
				GB	2548535	B	12 May 2021
				NO	20171245	A1	25 July 2017
				SG	11201705100	A	28 July 2017
				US	10060217	B2	28 August 2018
				WO	2016-133498	A1	25 August 2016
US	2022-0049571	A1	17 February 2022	AU	2019-437799	A1	01 July 2021
				BR	112021014937	A2	28 September 2021
				CA	3124473	A1	01 October 2020
				CA	3124473	C	03 October 2023
				GB	2594842	A	10 November 2021
				GB	2594842	B	01 February 2023
				NO	20210935	A1	21 July 2021
				SG	11202106449	A	29 July 2021
				US	12055008	B2	06 August 2024
				WO	2020-197560	A1	01 October 2020
EP	3567221	A1	13 November 2019	None			
US	2015-0069711	A1	12 March 2015	AU	2013-266885	A1	20 November 2014
				AU	2013-266885	B2	11 August 2016
				BR	112014028231	A2	27 June 2017
				BR	112014028231	B1	13 October 2020
				CA	2873725	A1	28 November 2013
				CA	2873725	C	21 March 2017
				CA	2956602	A1	28 November 2013
				CA	2956602	C	15 May 2018
				CN	104321369	A	28 January 2015
				CN	104321369	B	13 March 2018
				DK	2852633	T3	09 December 2019
				EP	2852633	A1	01 April 2015
				EP	2852633	A4	13 January 2016
				EP	2852633	B1	25 September 2019
				MY	168423	A	09 November 2018
				US	2013-0313780	A1	28 November 2013
				US	8952105	B2	10 February 2015
				US	9453577	B2	27 September 2016
				WO	2013-176792	A1	28 November 2013
US	2023-0091259	A1	23 March 2023	WO	2023-049094	A1	30 March 2023