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(71) Applicant: **Welltec Oilfield Solutions AG**
6300 Zug (CH)

(72) Inventor: **VASQUES, Ricardo**
6300 Zug (CH)

(74) Representative: **Dragsted Partners A/S**
Rådhuspladsen 16
1550 Copenhagen V (DK)

(54) **ANNULAR BARRIER**

(57) The present invention relates to an annular barrier for providing zonal isolation in an annulus downhole between a well tubular metal structure and another well tubular metal structure or a wall of a borehole, comprising a tubular metal part configured to be mounted as part of a well tubular metal structure, the tubular metal part having an outer face, an opening and an axial extension along the well tubular metal structure, an expandable metal sleeve surrounding the tubular metal part, the first expandable metal sleeve having a circumferential groove, a first end and a second end, each end of the expandable metal sleeve being connected with the outer face of the tubular metal part, wherein the annular barrier further comprises an anchoring element arranged in the circumferential groove, the anchoring element comprising a first anchoring part at least partly overlapping a second anchoring part in a radially direction perpendicular to the axial extension so that an inner face of the first anchoring part at least partly abuts an outer face of the second anchoring part. Moreover, the present invention also relates to a downhole completion system.

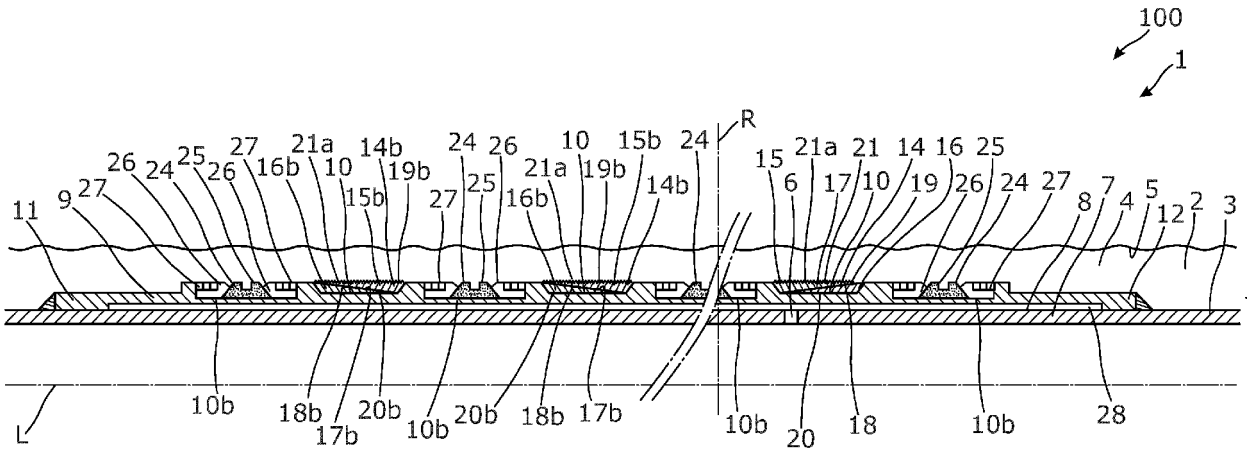

Fig. 1

EP 4 112 874 A1

Description

[0001] The present invention relates to an annular barrier for providing zonal isolation in an annulus downhole between a well tubular metal structure and another well tubular metal structure or a wall of a borehole. Moreover, the present invention relates to a downhole completion system.

[0002] Annular barriers are used downhole for providing isolation of one zone from another in an annulus in a borehole of a well between a well tubular metal structure and the borehole wall or another well tubular metal structure. When the annular barrier has been set, e.g. when an expandable metal sleeve has been expanded, the temperature may vary. Thus, the well tubular metal structure with annular barriers will increase in length if the temperature increases and likewise the length of the well tubular metal structure will decrease if the temperature decreases, e.g. the temperature will decrease during fracturing with sea water. During such length variations, the axial load on the expandable metal sleeve will vary and tests have shown that the annular barriers cannot withstand high axial load when the differential pressure across the expandable metal sleeve is low, i.e. when the pressure inside the annular barrier is low compared to the pressure in the annulus.

[0003] It is an object of the present invention to wholly or partly overcome the above disadvantages and drawbacks of the prior art. More specifically, it is an object to provide an improved annular barrier able to withstand higher axial load than known annular barriers when the differential pressure across the expandable metal sleeve of the annular barrier is low.

[0004] The above objects, together with numerous other objects, advantages and features, which will become evident from the below description, are accomplished by a solution in accordance with the present invention by an annular barrier for providing zonal isolation in an annulus downhole between a well tubular metal structure and another well tubular metal structure or a wall of a borehole, comprising:

- a tubular metal part configured to be mounted as part of a well tubular metal structure, the tubular metal part having an outer face, an opening and an axial extension along the well tubular metal structure,
- an expandable metal sleeve surrounding the tubular metal part, the first expandable metal sleeve having a circumferential groove, a first end and a second end, each end of the expandable metal sleeve being connected with the outer face of the tubular metal part,

wherein the annular barrier further comprises an anchoring element arranged in the circumferential groove, the anchoring element comprising a first anchoring part at least partly overlapping a second anchoring part in a radially direction perpendicular to the axial extension so that an inner face of the first anchoring part at least partly abuts an outer face of the second anchoring part.

[0005] In addition, the anchoring element may be a circumferential anchoring element.

[0006] Moreover, the inner face of the first anchoring part and the outer face of the second anchoring part may be inclined in relation to the axial extension. By having the inner face of the first anchoring part and the outer face of the second anchoring part inclined in relation to the axial extension, it is obtained that when at least part of the expandable metal sleeve moves in one direction along the axial direction then the first anchoring part moves in an opposite direction along the inclined outer face of the second anchoring part, and the first anchoring part is then forced radially outwards anchoring the expandable metal sleeve even further to the another well tubular metal structure or the wall of the borehole.

[0007] Furthermore, the first anchoring part and the second anchoring part may be one monolithic whole.

[0008] Additionally, the first anchoring part and the second anchoring part may be one monolithic whole, the first anchoring part and the second anchoring part forming a key ring where the first anchoring part is one end of key ring and the second anchoring part is the other end of the key ring.

[0009] Also, the first anchoring part may form one monolithic whole, the second anchoring part forming a second monolithic whole.

[0010] Further, the first anchoring part may be shaped as a first slit ring, the second anchoring part being shaped as a second slit ring.

[0011] Moreover, the first anchoring part may further comprise an outer face, the second anchoring part comprising an inner face, and the outer face of the first anchoring part comprising friction enhancing means and faces the another well tubular metal structure or the wall of the borehole.

[0012] In addition, the friction enhancing means may be spikes or grooves.

[0013] Also, the outer face of the first anchoring part may have at least one groove in which a spring element is arranged.

[0014] Furthermore, the inner face of the second anchoring part may have at least one groove in which a spring element is arranged.

[0015] Additionally, the inner face of the first anchoring part and the outer face of the second anchoring part may have a lower friction between them than between the inner face of the of the second anchoring part and the circumferential groove.

[0016] Moreover, the inner face of the second anchoring part may have at least one groove in which a spring element is arranged.

[0017] In addition, the anchoring element may comprise a third anchoring part having an outer face abutting a second inner face of the first anchoring part, so that the first anchoring part is arranged intermediate the third anchoring part and the second anchoring part, and the

inner face of the third anchoring part and the inner face of the second anchoring part face and abut the circumferential groove.

[0018] Furthermore, the outer face of the third anchoring part may be inclined in an opposite direction than that of the outer face of the second anchoring part.

[0019] Also, the second inner face of the first anchoring part may be inclined corresponding to the inclined outer face of the third anchoring part.

[0020] According to the present invention, the annular barrier may further comprise a second anchoring element comprising a first anchoring part at least partly overlapping a second anchoring part in a radially direction perpendicular to the axial extension so that an inner face of the first anchoring part at least partly abuts an outer face of the second anchoring part, the inner face of the first anchoring part and the outer face of the second anchoring part being inclined in relation to the axial extension in an opposite direction than that of the first anchoring element.

[0021] Thus, the inner face of the first anchoring part of the first anchoring element may be inclined facing upwards towards the top of the well, the inner face of the first anchoring part of the second anchoring element being inclined facing downwards away from the top of the well. By having a first anchoring element with an inclined inner face of the first anchoring part in one direction and a second anchoring element with an inclined face of the first anchoring part in an opposite direction, the annular barrier can withstand axial loads in both directions along the axial extension as the first anchoring element is activated when the axial load is in one direction, and the second anchoring element is activated when the axial load pulls in the opposite direction.

[0022] Also, the expandable metal sleeve may have a second circumferential groove in which a sealing unit is arranged.

[0023] Additionally, the sealing unit may comprise of sealing element e.g. of elastomer.

[0024] Moreover, the sealing unit may further comprise a back-up ring shaped element and a key ring element.

[0025] Furthermore, the expandable metal sleeve may comprise at least two sealing units and the anchoring element is arranged between two sealing units.

[0026] Finally, the present invention also relates to a downhole completion system comprising an annular barrier and a well tubular metal structure.

[0027] The invention and its many advantages will be described in more detail below with reference to the accompanying schematic drawings, which for the purpose of illustration show some non-limiting embodiments and in which:

Fig. 1 shows a cross-sectional view of an annular barrier having sealing units and anchoring elements,

Fig. 2 shows a cross-sectional view of another annular barrier having an anchoring element,

Fig. 3 shows a cross-sectional view of part of an expandable metal sleeve having a groove in which an anchoring element is arranged,

Fig. 4 shows a cross-sectional view of part of another expandable metal sleeve having a groove in which another anchoring element with springs is arranged,

Fig. 5 shows a cross-sectional view of part of another annular barrier having a groove in the expandable metal sleeve which another anchoring element with springs is arranged,

Fig. 6 shows a cross-sectional view of part of another expandable metal sleeve having a groove in which another anchoring element with an inclination in an opposite direction of the anchoring element shown in Fig. 3 is arranged,

Fig. 7 shows a cross-sectional view of part of yet another expandable metal sleeve having a groove in which another anchoring element comprises a first, second and third anchoring part,

Fig. 8 shows a cross-sectional view of part of yet another expandable metal sleeve having a groove in which another anchoring element comprises a first, second and third anchoring part and springs in each of the parts, and

Fig. 9 is a schematic diagram of Axial load on an annular barrier in relation to differential pressure across the expandable metal sleeve.

[0028] All the figures are highly schematic and not necessarily to scale, and they show only those parts which are necessary in order to elucidate the invention, other parts being omitted or merely suggested.

[0029] Fig. 1 shows a cross-sectional view of an annular barrier 1 in an unexpanded condition for providing zonal isolation in an annulus 2 downhole between a well tubular metal structure 3 and another well tubular metal structure 3b, as shown in Fig. 2, or a wall 5 of a borehole 4, as shown in Fig. 1. The annular barrier comprises a tubular metal part 7 mounted as part of the well tubular metal structure 3. The tubular metal part has an outer face 8, an opening 6 and an axial extension L along the well tubular metal structure. The annular barrier 1 comprises an expandable metal sleeve 9 surrounding the tubular metal part 7, where the first expandable metal sleeve has a circumferential groove 10, a first end 11 and a second end 12, and each end of the expandable metal sleeve are connected with the outer face of the tubular metal part. The annular barrier 1 further comprises an anchoring element 14 arranged in the circumferential groove, and the anchoring element comprises a first anchoring part 15 at least partly overlapping a second anchoring part 16 in a radially direction perpendicular to the

axial extension L so that an inner face 17 of the first anchoring part 15 at least partly abuts an outer face 18 of the second anchoring part 16. The anchoring element 14 is a circumferential anchoring element extending all the way around the expandable metal sleeve 9, and the anchoring element 14 may be slit so that the anchoring element can be mounted in the groove.

[0030] In order to provide an increased anchoring during axial load, the inner face 17 of the first anchoring part 15 and the outer face 18 of the second anchoring part 16 are inclined in relation to the axial extension. Thus when the temperature changes, and at least part of the expandable metal sleeve moves in one direction along the axial direction, indicated with arrow A in Fig. 3, the first anchoring part moves in an opposite direction along the inclined outer face of the second anchoring part, as indicated with arrow B in Fig. 3, and the first anchoring part is then forced radially outwards, as indicated with dashed lines in Fig. 3, anchoring the expandable metal sleeve even further to the another well tubular metal structure or the wall of the borehole.

[0031] In the diagram of Fig. 9, the axial load on the annular barrier as a function of the differential pressure is illustrated with full lines. By having an annular barrier according to the invention with an anchoring element, the axial load is not reduced when the differential pressure is low as in prior art annular barriers which is indicated by dotted lines.

[0032] In Fig. 1, the first anchoring part 15 forms one monolithic whole and the second anchoring part 16 forms a second monolithic whole. The first anchoring part is shaped as a first slit ring, and the second anchoring part is shaped as a second slit ring in order to be able to widen and thus to be mounted in the groove. First, the second anchoring part 16 is widened and moved along the outer face of the expandable metal sleeve 9 and into the circumferential groove 10, and then the first anchoring part 15 is widened and moved along the outer face of the expandable metal sleeve 9 until reaching the circumferential groove 10 and being arranged circumferenting the second anchoring part, so that the inclined inner face of the first anchoring part and the inclined outer face of the second anchoring part abut.

[0033] The first anchoring part further comprises an outer face 19 facing the another well tubular metal structure 3b, as shown in Fig. 2, or the wall 5 of the borehole 4, as shown in Fig. 1, and the second anchoring part 16 comprises an inner face 20 facing and abutting the circumferential groove 10. The outer face 19 of the first anchoring part 15 comprises friction enhancing means 21, such as spikes 21a, as shown in Fig. 1, or provided by grooves 21b, as shown in Fig. 2.

[0034] In Fig. 1, the annular barrier 1 further comprises a second anchoring element 14b comprising a first anchoring part 15b at least partly overlapping a second anchoring part 16b in a radially direction perpendicular to the axial extension L so that an inner face 17b of the first anchoring part at least partly abuts an outer face 18b of the second anchoring part. The inner face 17b of the first anchoring part 15b and the outer face 18b of the second anchoring part 16b are inclined in relation to the axial extension L in an opposite direction than that of the first anchoring element. The first anchoring element 14 has inclined faces which when mirrored around line R correspond to the inclined faces of the second anchoring element 14b. By having first anchoring elements 14 with inclined faces in one direction and second anchoring elements with inclined faces in an opposite direction as shown in Fig. 1, the annular barrier 1 can withstand axial loads in both directions along the axial extension L as the first anchoring elements 14 are activated when the axial load is in one direction, and the second anchoring elements 14b are activated when the axial load pulls in the opposite direction.

[0035] The expandable metal sleeve 9 of the annular barrier 1 has a second circumferential groove 10b in which a sealing unit 24 is arranged. The sealing unit comprises a sealing element 25 e.g. of elastomer or polymer, a back-up ring shaped element 26 on each side of the sealing element and a key ring element 27 surrounding part of the back-up ring. The expandable metal sleeve comprises several sealing units, and each anchoring element is arranged between two sealing units.

[0036] In Fig. 2, the first anchoring part 15 and the second anchoring part 16 are one monolithic whole. The first anchoring part 15 and the second anchoring part 16 forms a key ring 34 where the first anchoring part is one end of key ring and the second anchoring part is the other end of the key ring 34. The key ring unwinds as the expandable metal sleeve 9 is expanding, and when expanded, the first anchoring part will not fully overlap the second anchoring part along the whole circumference of the expandable metal sleeve.

[0037] In Fig. 2, the expandable metal sleeve 9 has several grooves 10, 10b, and between these grooves, other "empty" grooves are arranged so that the anchoring element and the sealing units 24 are arranged with the same distance along the axial extension L.

[0038] Each end of the expandable metal sleeve 9 is connected with the outer face 8 of the tubular metal part 7, e.g. by means of a connection part 38 and/or by means of weld as shown in Fig. 1. In Fig. 2, the annular barrier 1 further comprises a valve assembly 33 fluidly connected with the opening 6 and the expandable space 28 so as to fluidly connect the opening and the expandable space during expansion of the expandable metal sleeve 9 and close the fluid connection after the expandable metal sleeve has been properly expanded. The valve assembly 33 may in the second position open for a fluid connection between the annulus and the expandable space 28 in order to equalise the pressure therebetween.

[0039] In order to enhance the initial anchoring, the outer face 19 of the first anchoring part 15 has two grooves 23 in which a spring element 22 is arranged, as shown in Fig. 4. During expansion of the expandable metal sleeve 9, the spring elements 22 are compressed and

after the expansion is finalised, the spring elements 22 will slightly decompress due to the small "spring-back-effect" after expansion of metal. The spring elements 22 are thus always in contact with the wall of the borehole, and when the axial load starts, the spring elements will ensure that the first anchoring part will move along the inclined outer face of the second anchoring part 16, and thus the first anchoring part 15 will be forced radially outwards as illustrated by the dotted lines in Fig. 3. Another way is shown in Fig. 5, where the inner face 20 of the second anchoring part 16 has two grooves 23 in which a spring element 22 is arranged. When the spring elements 22 are arranged in the inner face 20, the spring elements 22 force both the second anchoring part 16 and the first anchoring part 15 outwards so the first anchoring part is in contact/engagement with the wall of the borehole or another well tubular metal structu re.

[0040] The inner face 17, 17b of the first anchoring part 15, 15b and the outer face 18, 18b of the second anchoring part 16, 16b have a low friction between them so that no substantial force is lost in order for the anchoring parts to slide in relation to each other. Thus, the inner face of the first anchoring part and the outer face of the second anchoring part have a lower friction between them than between the inner face of the second anchoring part and the circumferential groove.

[0041] In Figs. 3-5, the circumferential groove 10 has inclined end faces 35 and in Figs. 6-8, the end faces are perpendicular to the axial extension L. When having perpendicular end faces, as in Figs. 6-8, the second anchoring part 16 is more restricted than in Figs. 3-5. The inclined outer face of the second anchoring part ends at the top of the groove so that the first anchoring part is not restricted by the end faces of the groove and is thus not prevented from sliding further past the end of the outer face of the second anchoring part if needed.

[0042] In Figs. 7 and 8, the anchoring element 14, 14b of the annular barrier 1 comprises a third anchoring part 31 having an outer face 32 abutting a second inner face 17a of the first anchoring part, so that the first anchoring part is arranged intermediate the third anchoring part and the second anchoring part, and the inner face of the third anchoring part and the inner face of the second anchoring part face and abut the circumferential groove. In Fig. 8, the outer face 19 of the first anchoring part 15 comprises two grooves 23 in which a spring element 22 is arranged and both the inner face 20 of the second anchoring part 16 and an inner face 36 of the third anchoring part 31 comprise two grooves 23 in which a spring element 22 is arranged.

[0043] Fig. 1 further discloses a downhole completion system 100 comprising the aforementioned annular barrier 1 and a well tubular metal structure 3.

[0044] By "fluid" or "well fluid" is meant any kind of fluid that may be present in oil or gas wells downhole, such as natural gas, oil, oil mud, crude oil, water, etc. By "gas" is meant any kind of gas composition present in a well, completion or open hole, and by "oil" is meant any kind of oil composition, such as crude oil, an oil-containing fluid, etc. Gas, oil and water fluids may thus all comprise other elements or substances than gas, oil and/or water, respectively.

[0045] By "casing" or "well tubular metal structure" is meant any kind of pipe, tubing, tubular, liner, string, etc., used downhole in relation to oil or natural gas production.

[0046] Although the invention has been described above in connection with preferred embodiments of the invention, it will be evident to a person skilled in the art that several modifications are conceivable without departing from the invention as defined by the following claims.

Claims

1. 1. An annular barrier (1) for providing zonal isolation in an annulus (2) downhole between a well tubular metal structure (3) and another well tubular metal structure (3b) or a wall (5) of a borehole (4), comprising:

- a tubular metal part (7) configured to be mounted as part of a well tubular metal structure (3), the tubular metal part having an outer face (8), an opening (6) and an axial extension (L) along the well tubular metal structure,
- an expandable metal sleeve (9) surrounding the tubular metal part, the first expandable metal sleeve having a circumferential groove (10), a first end (11) and a second end (12), each end of the expandable metal sleeve being connected with the outer face of the tubular metal part,

wherein the annular barrier further comprises an anchoring element (14) arranged in the circumferential groove, the anchoring element comprising a first anchoring part (15) at least partly overlapping a second anchoring part (16) in a radially direction perpendicular to the axial extension so that an inner face (17) of the first anchoring part at least partly abuts an outer face (18) of the second anchoring part.

2. An annular barrier according to claim 1, wherein the inner face of the first anchoring part and the outer face of the second anchoring part are inclined in relation to the axial extension.

3. An annular barrier according to claim 1 or 2, wherein the first anchoring part and the second anchoring part are one monolithic whole.

4. An annular barrier according to any of claims 1-3, wherein the first anchoring part forms one monolithic whole, and the second anchoring part forms a second monolithic whole.

5. An annular barrier according to claim 4, wherein the first anchoring part is shaped as a first slit ring, and the second anchoring part is shaped as a second slit ring.

6. An annular barrier according to any of the preceding claims, wherein the first anchoring part further comprises an outer face (19), and the second anchoring part comprises an inner face (20), and the outer face of the first anchoring part comprises friction enhancing means (21) and faces the another well tubular metal structure or the wall of the borehole.

7. An annular barrier according to claim 6, wherein the friction enhancing means is spikes (21a) or grooves (21b).

8. An annular barrier according to any of claims 5-7, wherein the outer face of the first anchoring part has at least one groove (23) in which a spring element (22) is arranged.

9. An annular barrier according to claim 6, wherein the inner face of the first anchoring part and the outer face of the second anchoring part have a lower friction between them than between the inner face of the of the second anchoring part and the circumferential groove.

10. An annular barrier according to any of the preceding claims, wherein the inner face of the second anchoring part has at least one groove in which a spring element (22) is arranged.

11. An annular barrier according to any of the preceding claims, wherein the anchoring element comprises a third anchoring part (31) having an outer face (32) abutting a second inner face (17a) of the first anchoring part, so that the first anchoring part is arranged intermediate the third anchoring part and the second anchoring part, and the inner face of the third anchoring part and the inner face of the second anchoring part face and abut the circumferential groove.

12. An annular barrier according to any of the preceding claims, further comprising a second anchoring element (14b) comprising a first anchoring part (15b) at least partly overlapping a second anchoring part (16b) in a radially direction perpendicular to the axial extension so that an inner face (17b) of the first anchoring part at least partly abuts an outer face (18b) of the second anchoring part, the inner face of the first anchoring part and the outer face of the second anchoring part being inclined in relation to the axial extension in an opposite direction than that of the first anchoring element.

13. An annular barrier according to any of the preceding claims, wherein the expandable metal sleeve has a second circumferential groove (10b) in which a sealing unit (24) is arranged.

14. An annular barrier according to any of the preceding claims, wherein the expandable metal sleeve comprises at least two sealing units and the anchoring element is arranged between two sealing units.

15. Downhole completion system (100) comprising an annular barrier (1) according to any of claims 1-14 and a well tubular metal structure (3).

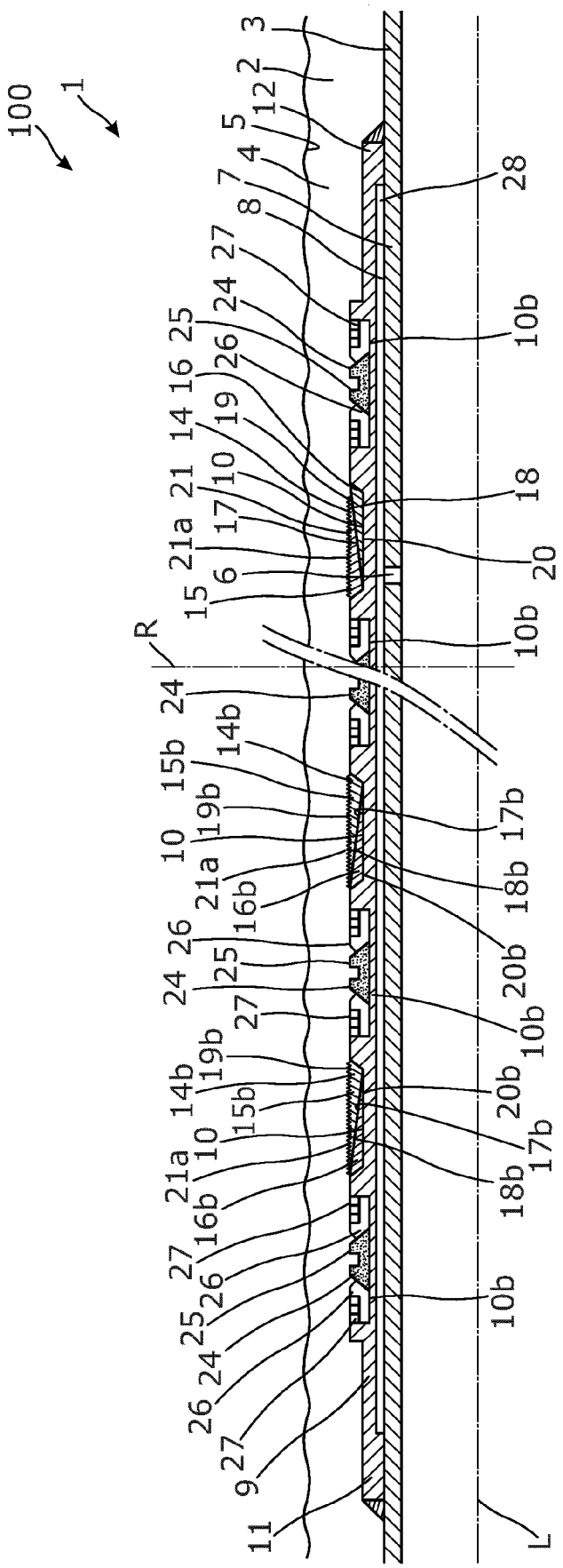
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Fig. 1

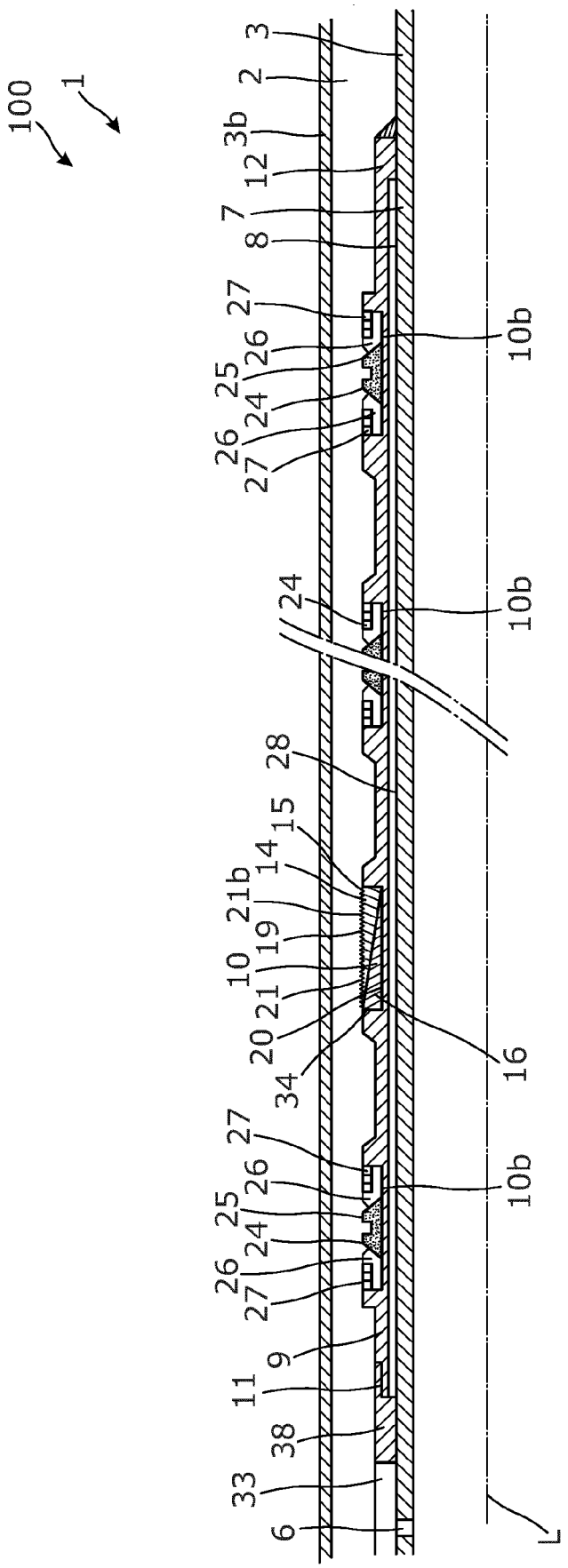
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Fig. 2

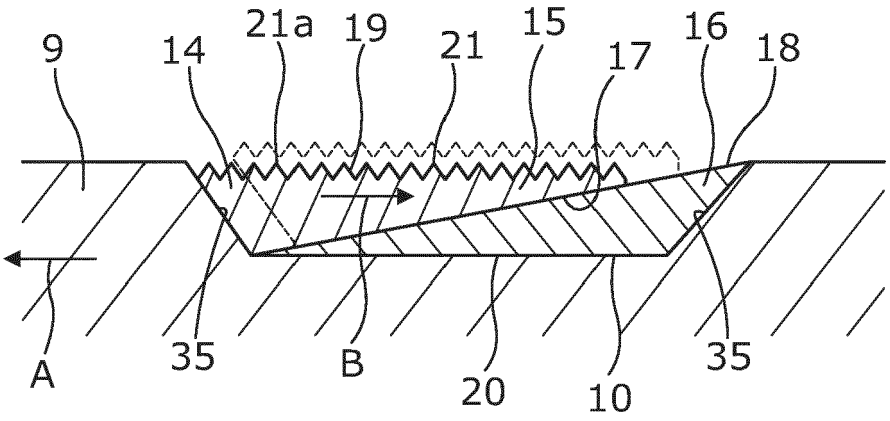

Fig. 3

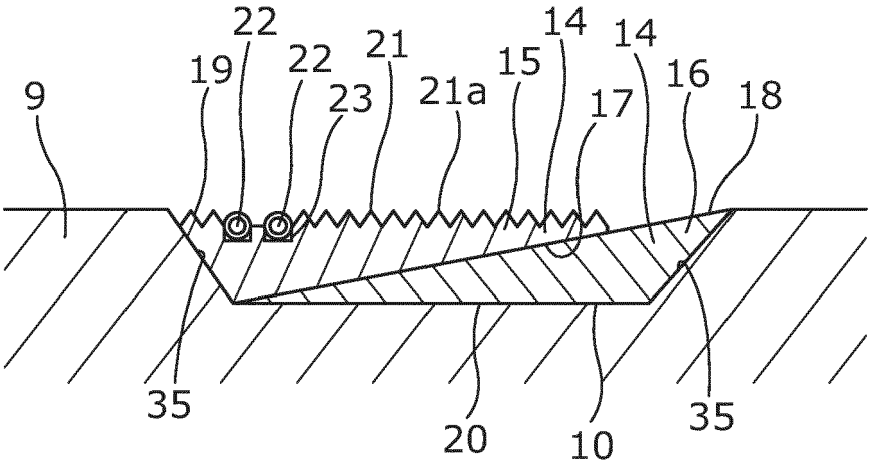

Fig. 4

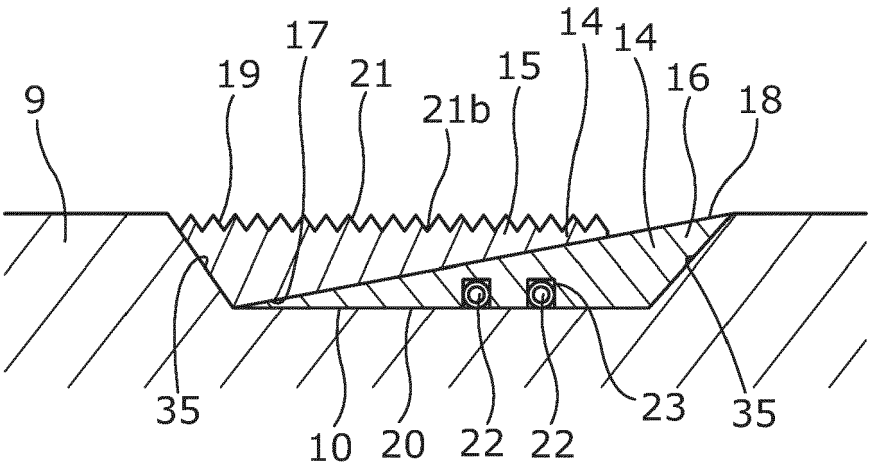

Fig. 5

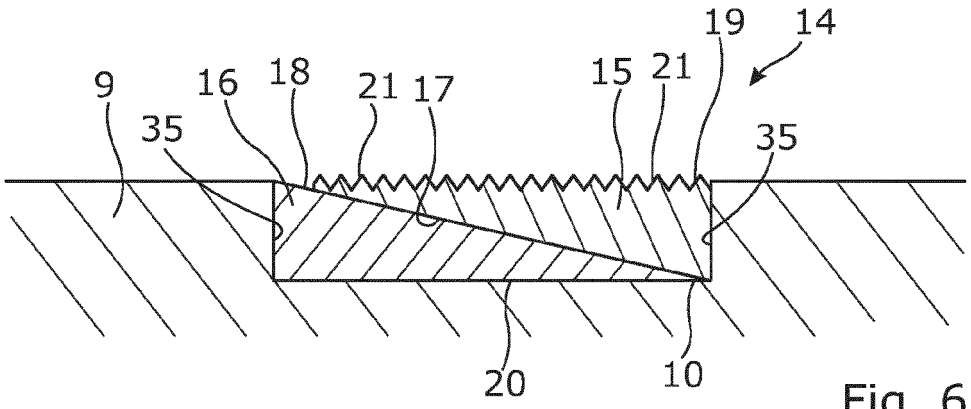

Fig. 6

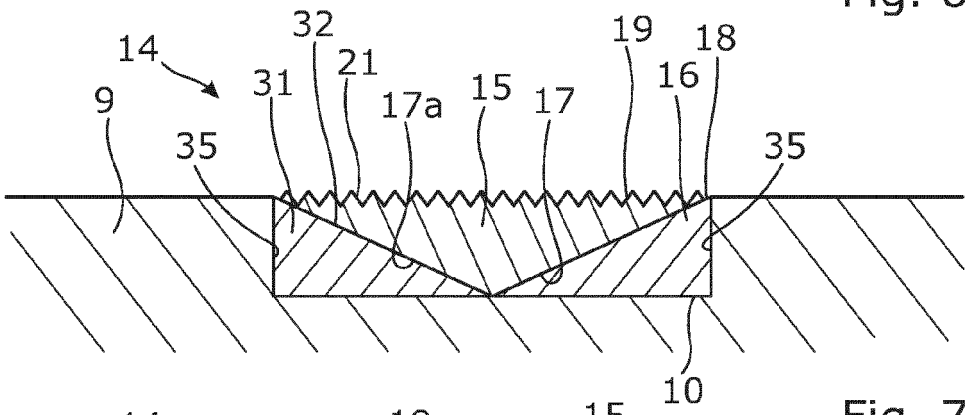

Fig. 7

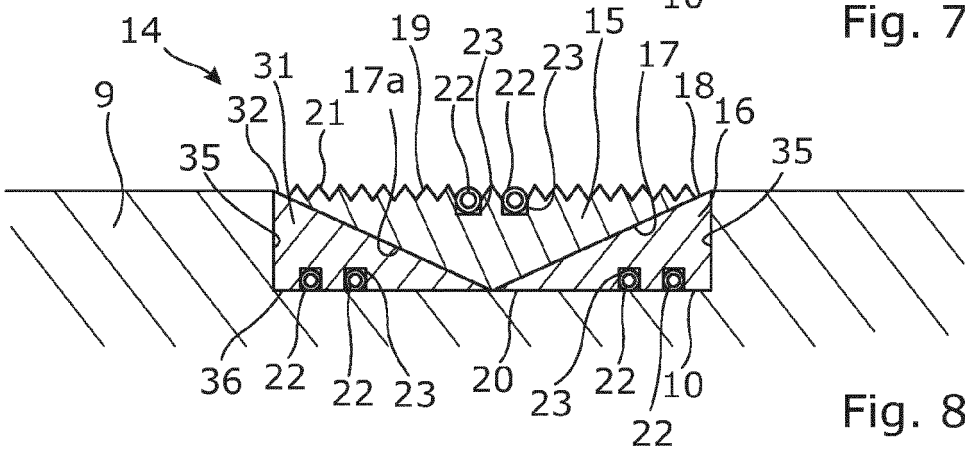

Fig. 8

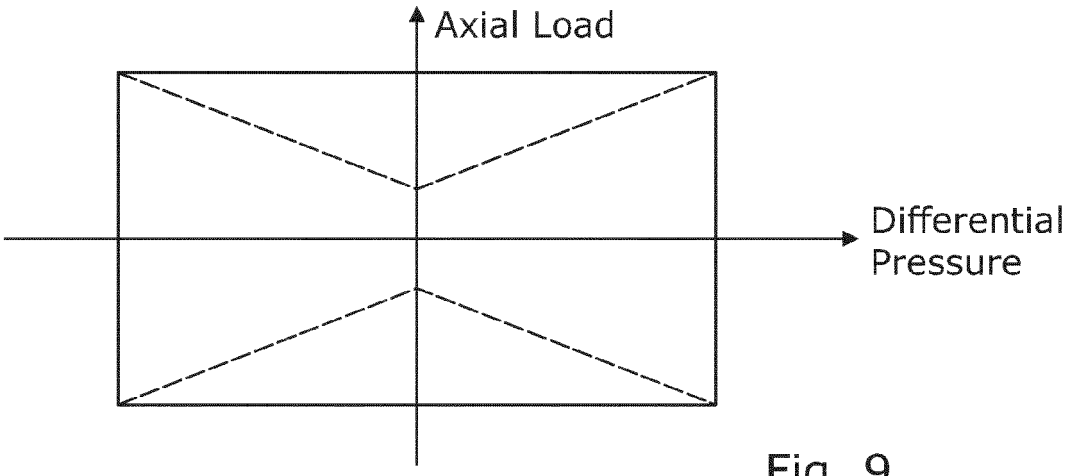

Fig. 9

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EUROPEAN SEARCH REPORT

Application Number
EP 21 18 2651

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y	WO 2018/029456 A1 (MORPHPACKERS LTD [GB]) 15 February 2018 (2018-02-15) * page 13, line 14 - page 16, line 2; figure 5 *	1-15	INV. E21B33/129 E21B33/124 E21B33/127
Y	US 4 942 925 A (THEMIG DANIEL J [US]) 24 July 1990 (1990-07-24) * column 4, line 48 - column 5, line 28; figure 2 *	1-15	
A	EP 2 586 963 A1 (WELLTEC AS [DK]) 1 May 2013 (2013-05-01) * paragraph [0032] - paragraph [0034]; figure 1 *	1-15	
A	US 2020/165892 A1 (VASQUES RICARDO REVES [CH] ET AL) 28 May 2020 (2020-05-28) * paragraph [0109]; figures 1,2 *	1-15	
A	US 2019/383114 A1 (VASQUES RICARDO REVES [CH]) 19 December 2019 (2019-12-19) * paragraph [0070]; figures 1,A,1B *	1-15	TECHNICAL FIELDS SEARCHED (IPC) E21B
A	US 10 125 567 B2 (SCHLUMBERGER TECHNOLOGY CORP [US]) 13 November 2018 (2018-11-13) * abstract; figure 3 *	1-15	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	4 October 2021	Strømmen, Henrik

CATEGORY OF CITED DOCUMENTS

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2018029456 A1	15-02-2018	GB 2552799 A	14-02-2018
		US 2018045016 A1	15-02-2018
		WO 2018029456 A1	15-02-2018
US 4942925 A	24-07-1990	CA 2021518 A1	22-02-1991
		GB 2235939 A	20-03-1991
		US 4942925 A	24-07-1990
EP 2586963 A1	01-05-2013	AU 2012328387 A1	17-07-2014
		BR 112014008538 A2	18-04-2017
		CA 2852152 A1	02-05-2013
		CN 103874824 A	18-06-2014
		EP 2586963 A1	01-05-2013
		EP 2771540 A1	03-09-2014
		RU 2014118530 A	10-12-2015
		US 2014299334 A1	09-10-2014
		WO 2013060849 A1	02-05-2013
US 2020165892 A1	28-05-2020	US 2020165892 A1	28-05-2020
		WO 2020104671 A1	28-05-2020
US 2019383114 A1	19-12-2019	BR 112020024913 A2	09-03-2021
		CA 3102446 A1	26-12-2019
		CN 112219011 A	12-01-2021
		EP 3584403 A1	25-12-2019
		US 2019383114 A1	19-12-2019
		WO 2019243308 A1	26-12-2019
US 10125567 B2	13-11-2018	GB 2534439 A	27-07-2016
		US 2016102522 A1	14-04-2016
		WO 2016055775 A1	14-04-2016

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82