(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 565 369 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
06.03.2013 Bulletin 2013/10

(51) Int Cl.:
E21B 33/127 *(2006.01)*

(21) Application number: **11179546.4**

(22) Date of filing: **31.08.2011**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

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(54) Annular barrier with compensation device

(57) An annular barrier (1) to be expanded in an annulus (2) between a well tubular structure (3) and an inside wall (4) of a borehole downhole for providing zone isolation between a first zone and a second zone of the borehole, comprising a tubular part (6) for mounting as part of the well tubular structure, said tubular part having a longitudinal axis, an expandable sleeve (7) surrounding the tubular part and defining a space (13) being in fluid communication with an inside of the tubular part, each end (9,10) of the expandable sleeve being connected with the tubular part, and an aperture (11) for letting fluid into the space to expand the sleeve, wherein the barrier further comprises a compensation device (16) having a chamber in which a piston (18) is arranged dividing the chamber in a first and a second chamber part, the first chamber part (19) being in fluid communication with the space and the second chamber part (20) comprising gas.

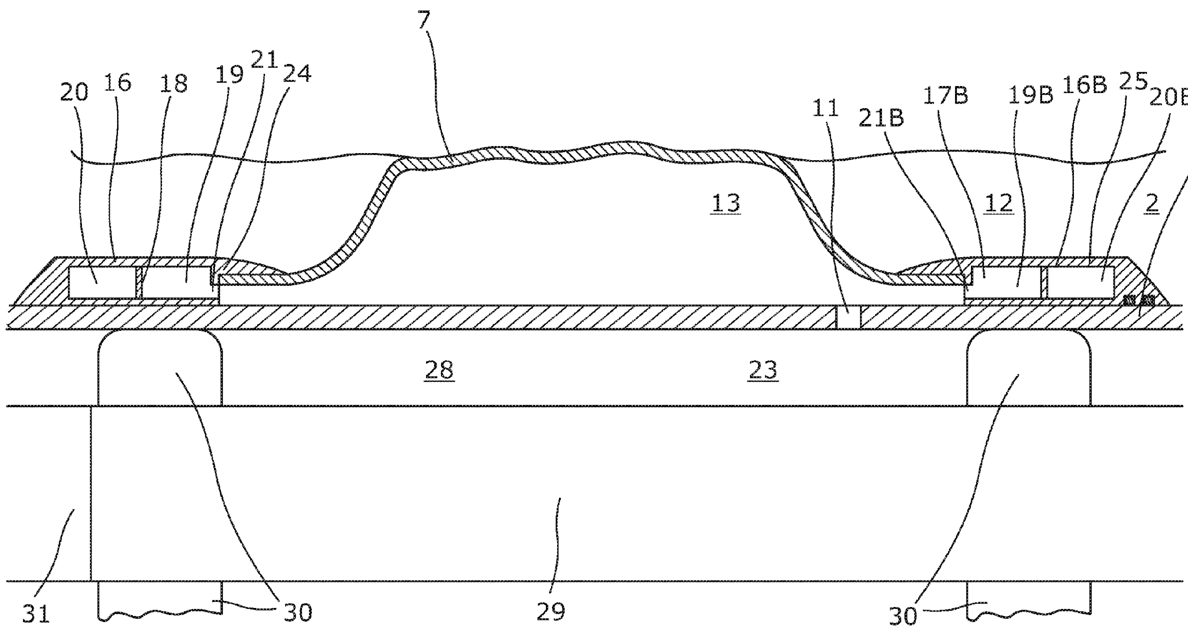

Fig. 6

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Description

Field of the invention

[0001] The present invention relates to an annular barrier to be expanded in an annulus between a well tubular structure and an inside wall of a borehole downhole for providing zone isolation between a first zone and a second zone of the borehole. The invention furthermore relates to a well system and to a method for maintaining a pressure within the annular barrier.

Background art

[0002] In wellbores, annular barriers are used for different purposes, such as for providing a barrier for flow between an inner and an outer tubular structure or between an inner tubular structure and the inner wall of the borehole. The annular barriers are mounted as part of the well tubular structure. An annular barrier has an inner wall surrounded by an annular expandable sleeve. The expandable sleeve is typically made of an elastomeric material, but may also be made of metal. The sleeve is fastened at its ends to the inner wall of the annular barrier.

[0003] In order to seal off a zone between an inner and an outer tubular structure or a well tubular structure and the borehole, a second annular barrier is used. The first annular barrier is expanded on one side of the zone to be sealed off, and the second annular barrier is expanded on the other side of that zone, and in this way, the zone is sealed off.

[0004] When expanded, annular barriers may be subjected to a continuous pressure or a periodic high pressure from the outside, either in the form of hydraulic pressure within the well environment or in the form of formation pressure. In some circumstances, such pressure may cause the annular barrier to collapse, which may have severe consequences for the area which the barrier is to seal off as the sealing properties are lost due to the collapse. A similar problem may arise when the expandable sleeve is expanded by means of e.g. a pressurised fluid. If the fluid leaks from the sleeve, the back pressure may fade, and the sleeve itself may thus collapse.

[0005] The ability of the expanded sleeve of an annular barrier to withstand the collapse pressure is thus affected by many variables, such as strength of material, wall thickness, surface area exposed to the collapse pressure, temperature, well fluids, etc.

[0006] The collapse rating currently achievable by the expanded sleeve within certain well environments is insufficient for all well applications. Thus, it is desirable to increase the collapse rating to enable annular barriers to be used in all wells, specifically in wells that experience a high drawdown pressure during production and depletion. The collapse rating may be increased by increasing the wall thickness or the strength of the material; however, this would increase the expansion pressure, which, as mentioned, is not desirable.

Summary of the invention

[0007] 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 wherein the collapse rating of the annular barrier is increased to withstand the conditions downhole to which it is exposed.

[0008] 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 to be expanded in an annulus between a well tubular structure and an inside wall of a borehole downhole for providing zone isolation between a first zone and a second zone of the borehole, comprising

- a tubular part for mounting as part of the well tubular structure, said tubular part having a longitudinal axis,
- an expandable sleeve surrounding the tubular part and defining a space being in fluid communication with an inside of the tubular part, each end of the expandable sleeve being connected with the tubular part, and
- an aperture for letting fluid into the space to expand the sleeve,

wherein the barrier further comprises a compensation device having a chamber in which a piston is arranged dividing the chamber in a first and a second chamber part, the first chamber part being in fluid communication with the space and the second chamber part comprising gas.

[0009] Said gas may be nitrogen, neon, argon, krypton, or xenon.

[0010] In one embodiment, the compensation device may be arranged in the space between the expandable sleeve and the tubular part.

[0011] In another embodiment, the compensation device may be arranged as part of a connection part connecting the expandable sleeve with the tubular part.

[0012] Further, the annular barrier may comprise an additional connection part wherein a second compensation device is arranged.

[0013] Also, the chamber of the compensation device may be annular, surrounding the tubular part.

[0014] Said compensation device may have several chambers in which pistons are arranged.

[0015] This plurality of chambers may be spaced along a circumference of the tubular part.

[0016] Moreover, one end of the sleeve may be fixedly fastened to the tubular part and the other end may be slidably fastened to the tubular part, and the second chamber part containing the gas may be arranged closest to the fixedly connected end of the sleeve.

[0017] In addition, the second chamber part may comprise a valve accessible from the inside of the tubular part, allowing refill of the second chamber part with gas.

[0018] Furthermore, the piston may comprise sealing means to seal the second chamber part from the first chamber part.

[0019] The present invention also relates to a well system comprising the well tubular structure and the annular barrier described above.

[0020] The well system according the present invention may further have a tool comprising isolation means isolating an isolated part of the inside of the tubular part outside the aperture to pressurise the isolated part of the inside and the space to expand the expandable sleeve.

[0021] Said tool may further comprise a pumping device for pumping fluid from the inside of the tubular part being outside the isolated part and into the isolated part to expand the expandable sleeve.

[0022] Finally, the present invention relates to a method for maintaining a pressure within the annular barrier described above, comprising the steps of:

- expanding the expandable sleeve until the sleeve seals against the inside wall of the borehole,
- equalising the pressure inside the space when the temperature decreases or increases in the borehole by moving the piston and letting the gas in the second chamber part expand or diminish.

Brief description of the drawings

[0023] 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 with a compensation device in its unexpanded condition,

Fig. 2 shows the annular barrier of Fig. 1 in its expanded condition,

Fig. 3 shows the annular barrier of Fig. 1 in its expanded condition while the compensation device has equalised the pressure in relation to Fig. 2,

Fig. 4 shows a cross-sectional view of another embodiment of the annular barrier in a vertical well,

Fig. 5 shows a cross-sectional view of yet another embodiment of the annular barrier,

Fig. 6 shows a cross-sectional view of yet another embodiment of the annular barrier and a well system,

Fig. 7 shows a cross-sectional view of the connection part of yet another embodiment of the annular barrier, and

Fig. 8 shows a cross-sectional view of the compensation device.

[0024] 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.

Detailed description of the invention

[0025] Fig. 1 shows an annular barrier 1 to be expanded in an annulus 2 between a well tubular structure 3 and an inside wall 4 of a borehole 5 downhole for providing zone isolation between a first zone 8 and a second zone 12 of the borehole 5. The tubular structure 3 may be a production casing. The annular barrier 1 comprises a tubular part 6 mounted as part of the well tubular structure 3. The tubular part 6 has a longitudinal axis 14 coaxial with the longitudinal axis of the well tubular structure 3. The annular barrier 1 comprises an expandable sleeve 7 surrounding the tubular part 6 and defining a space 13 which is in fluid communication with an inside 23 of the tubular part 6. Each end 9, 10 of the expandable sleeve 7 is connected with the tubular part 6, one end being fixedly fastened to the tubular part and the other end being slidably fastened with the tubular part.

[0026] The annular barrier 1 has an aperture 11 for letting fluid into the space to expand the sleeve, the aperture 11 being arranged in the tubular part 6 so that the fluid is let directly into the space. In another embodiment, the aperture may be arranged so that the fluid is let from the inside of the tubular part through a connection part 15 fastening the expandable sleeve 7 with the tubular part. A valve may also be arranged in the aperture, such as a one-way valve, and when the aperture is the connection part also a two-way valve or three-way valve. The expandable sleeve is typically expanded by pressurising the well tubular structure 3 from the top of the well and in this way inflate several annular barriers at a time.

[0027] The annular barrier further comprises a compensation device 16 having a chamber 17 in which a piston 18 is arranged dividing the chamber 17 in a first chamber part 19 and a second chamber part 20. The first chamber part 19 is in fluid communication with the space 13 through an opening 21 and the second chamber part 20 comprises gas, such nitrogen. The gas may also be neon, argon, krypton, or xenon. The compensation device 16 is arranged in the space 13 between the expandable sleeve 7 and the tubular part 6.

[0028] In Fig. 2, the annular barrier 1 has been expanded by pressurising the inside of the tubular part and thus fluid is flowing into the aperture to pressurise the space 13 to expand the expandable sleeve 7. When the temperature drops in the annulus, then the pressure in the space may drop accordingly and thus cause a pressure drop in relation to the formation pressure and the pressure in the annulus. Thus, the temperature drop may cause the expandable sleeve to collapse locally, undermining its strength, and the pressure to make it collapse, also called the collapse pressure, is somewhat decreased. In order to avoid the pressure drop and thus the decrease in collapse pressure, the piston 18 of the compensation device moves towards the opening, as shown in Fig. 3, due to the pressure inside the first chamber part 19 being the same decreased pressure as the pressure inside the space 13. The gas inside the second chamber part 20 expands to equalise the pressure difference between the first and the second chamber part. In this way, the compensation device lets fluid out into the space to equalise the pressure until it is the same as the pressure before the temperature drop.

[0029] When the temperature increases in the borehole, the piston is forced to move to reduce the second chamber part 20, 20B due to the fact that the gas in the second chamber part diminishes to equalise the pressure inside the space.

[0030] In Fig. 4, the annular barrier 1 is arranged in a vertical part of the well. The second chamber part 20 is arranged closest to the fixedly connected end of the expandable sleeve 7. By having the compensation device inside the space 13 and the second chamber part 20 arranged closest to the fixedly connected end of the expandable sleeve, any leak of gas 40 in the compensation device 16 will result in the accumulation of gas 40 in the top part of the space 13. By having the gas arranged in the top part, the gas will still have the ability to expand and thus equalise the pressure during a temperature drop in the fluid in the annulus.

[0031] The annular barrier 1 may also be arranged in the horizontal part of the well and then the gas will accumulate underneath the expandable sleeve closest to the borehole wall 4 and will, in the same way as in Fig. 4, have the ability to expand and thus equalise the pressure.

[0032] In Fig. 5, the compensation device is arranged as part of the fixed connection part 24 connecting the expandable sleeve 7 with the tubular part 6, since the slidable connection part 25 slidably connecting the expandable sleeve with the tubular part moves during expansion and thus moves in relation to the aperture in the tubular part if the aperture is arranged in connection with the connection part, and thus the expansion fluid is let in through that connection part. The position of the aperture is thus optional.

[0033] In Fig. 6, the annular barrier comprises an additional connection part being the slidable connection part 25 in which a second compensation device 16B is arranged. The second compensation device 16B comprises a chamber 17B in which a piston 18B is arranged dividing the chamber 17B in a first chamber part 19B and a second chamber part 20B. The first chamber part 19B is in fluid communication with the space 13 through an opening 21B and the second chamber part 20B also comprises gas, such nitrogen. The gas may also be neon, argon, krypton, or xenon. The compensation device 16B is arranged in the space 13 between the expandable sleeve 7 and the tubular part 6.

[0034] As can be seen from the cross-sectional views of Figs. 1-6, the chamber is annular, surrounding the tubular part. Thus, the first chamber part 19, 19B and the second chamber part 20, 20B is also annular and the piston 18, 18B moving inside the chamber 17, 17B is a ring-shaped piston surrounding the tubular part 6.

[0035] In Fig. 7, the compensation device 16, 16B has a plurality of chambers 17, 17B spaced along a circumference of the tubular part and the connection part 15. A piston 18, 18B is arranged in each chamber 17, 17B diving the chamber into a first and a second chamber part as mentioned above. Fig. 7 is a cross-sectional view of the connection part 15, and by having several chambers instead of one annular chamber, the connection part becomes more rigid and solid and thus capable of withstanding the pressure difference occurring downhole and the bumping when lowering the well tubular structure in order to complete the well. In Fig. 8, an embodiment of the compensation device is shown. As can be seen, the piston 18, 18B comprises a sealing means 26, such as an O-ring to seal the second chamber part 20, 20B from the first chamber part 19, 19B. The second chamber part comprises a valve 27 accessible from the inside 23 of the tubular part in order to be able to refill the second chamber part 20, 20B with gas if needed later. The valve may be any kind of suitable valve.

[0036] The method for maintaining a pressure within the annular barrier 1 mentioned above is firstly to expand the expandable sleeve until the sleeve seals against the inside wall 4 of the borehole, and subsequently, when the temperature decreases or increases in the borehole, to equalise the pressure inside the space by moving the piston 18, 18B and let the gas in the second chamber part expand or diminish.

[0037] The expandable sleeve 7 has an outer face facing the wall 4 of the borehole. Different kinds of sealing elements may be arranged on the outer face to increase the sealing ability of the sleeve towards the wall of the borehole.

[0038] As can be seen in Fig. 6, the invention also relates to a well system 100 comprising the well tubular structure 3 and the annular barrier 1. The well system 100 further comprises a tool 29 having an isolation means 30 isolating an isolated part 28 of the inside 23 of the tubular part outside the aperture 11 to pressurise the isolated part 28 of the inside 23 and thus the space 13 to expand the sleeve. The isolation means 30 may be an inflatable elastomeric element or a metal packer. The tool further comprises a pumping device 31 for pumping fluid from the inside of the tubular part being outside the isolated part 28 and into the isolated part 28 to expand the expandable sleeve 7. The well system may also have several annular barriers 1.

[0039] The tool may also use coiled tubing for expanding the expandable sleeve of one annular barrier or two annular barriers at the same time. A tool with coiled tubing can pressurise the fluid in the well tubular structure without having to isolate a section of the well tubular structure.

However, the tool may need to plug the well tubular structure further down the borehole for the two annular barriers to be operated.

[0040] In one embodiment, the tool comprises a reservoir containing the pressurised fluid, e.g. when the fluid used for expanding the sleeve is cement, gas, or a two-component compound. The space 13 may also be prefilled with some kind of fluid, such as a hardening agent, cement or the like.

[0041] An annular barrier may also be called a packer or similar expandable means. The well tubular structure can be the production tubing or casing or a similar kind of tubing downhole in a well or a borehole. The annular barrier can be used both in between the inner production tubing and an outer tubing in the borehole or between a tubing and the inner wall of the borehole. A well may have several kinds of tubing and the annular barrier of the present invention can be mounted for use in all of them.

[0042] The valve may be any kind of valve capable of controlling flow, such as a ball valve, butterfly valve, choke valve, check valve or non-return valve, diaphragm valve, expansion valve, gate valve, globe valve, knife valve, needle valve, piston valve, pinch valve, or plug valve.

[0043] The expandable tubular metal sleeve may be a cold-drawn or hot-drawn tubular structure.

[0044] When the expandable sleeve 3 of the annular barrier 1 is expanded, the diameter of the sleeve is expanded from its initial unexpanded diameter to a larger diameter. The expandable sleeve 3 has an outside diameter D and is capable of expanding to an at least 10% larger diameter, preferably an at least 15% larger diameter, more preferably an at least 30% larger diameter than that of an unexpanded sleeve.

[0045] Furthermore, the expandable sleeve 3 has a wall thickness t which is thinner than a length L of the expandable sleeve, the thickness preferably being less than 25% of the length, more preferably less than 15% of the length, and even more preferably less than 10% of the length.

[0046] The expandable sleeve 3 of the annular barrier 1 may be made of metal, polymers, an elastomeric material, silicone, or natural or synthetic rubber.

[0047] In order to increase the thickness of the sleeve 3, additional material may be applied (not shown) onto the expandable sleeve, e.g. by adding welded material onto the outer face.

[0048] In another embodiment, the thickness of the sleeve 3 is increased by fastening a ring-shaped part onto the sleeve (not shown).

[0049] In yet another embodiment, the increased thickness of the sleeve 3 is facilitated using a varying thickness sleeve 3 (not shown). To obtain a sleeve of varying thickness, techniques such as rolling, extrusion or die-casting may be used.

[0050] The fluid used for expanding the expandable sleeve may be any kind of well fluid present in the borehole surrounding the tool and/or the well tubular structure 3. Also, the fluid may be cement, gas, water, polymers, or a two-component compound, such as powder or particles mixing or reacting with a binding or hardening agent. Part of the fluid, such as the hardening agent, may be present in the cavity between the tubular part and the expandable sleeve before injecting a subsequent fluid into the cavity.

[0051] 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.

[0052] By a casing is meant any kind of pipe, tubing, tubular, liner, string etc. used downhole in relation to oil or natural gas production.

[0053] In the event that the tool is not submergible all the way into the casing, a downhole tractor can be used to push the tools all the way into position in the well. A downhole tractor is any kind of driving tool capable of pushing or pulling tools in a well downhole, such as a Well Tractor®. A downhole tractor may have wheels on arms projecting from a tool housing of the tractor, or driving belts for moving the tractor forward in the well.

[0054] Although the invention has been described in the above in connection with preferred embodiments of the invention, it will be evident for a person skilled in the art that several modifications are conceivable without departing from the invention as defined by the following claims.

Claims

1. An annular barrier (1) to be expanded in an annulus (2) between a well tubular structure (3) and an inside wall (4) of a borehole (5) downhole for providing zone isolation between a first zone and a second zone of the borehole, comprising

- a tubular part (6) for mounting as part of the well tubular structure (3), said tubular part having a longitudinal axis,
- an expandable sleeve (7) surrounding the tubular part and defining a space (13) being in fluid communication with an inside of the tubular part, each end (9, 10) of the expandable sleeve being connected with the tubular part, and
- an aperture (11) for letting fluid into the space to expand the sleeve,

wherein the barrier further comprises a compensation device having a chamber in which a piston is arranged dividing the chamber in a first and a second chamber part, the first chamber part being in fluid communication with the space and the second chamber part comprising gas.

2. An annular barrier according to claim 1, wherein the gas is nitrogen, neon, argon, krypton, or xenon.

3. An annular barrier according to claim 1 or 2, wherein the compensation device is arranged in the space between the expandable sleeve and the tubular part.

4. An annular barrier according to claim 1 or 2, wherein the compensation device is arranged as part of a connection part connecting the expandable sleeve with the tubular part.

5. An annular barrier according to claim 4, wherein the annular barrier comprises an additional connection part wherein a second compensation device is arranged.

6. An annular barrier according to any of the preceding claims, wherein the chamber is annular, surrounding the tubular part.

7. An annular barrier according to any of claims 1-5, wherein the compensation device has several chambers in which pistons are arranged.

8. An annular barrier according to any of the preceding claims, wherein one end of the sleeve is fixedly fastened to the tubular part and the other end is slidably fastened to the tubular part, and wherein the second chamber part containing the gas is arranged closest to the fixedly connected end of the sleeve.

9. An annular barrier according to any of the preceding claims, wherein the second chamber part comprises a valve accessible from the inside of the tubular part, allowing refill of the second chamber part with gas.

10. An annular barrier according to any of the preceding claims, wherein the piston comprises sealing means to seal the second chamber part from the first chamber part.

11. A well system comprising the well tubular structure and the annular barrier according to any of the claims 1-10.

12. A well system according claim 11, further having a tool (29) comprising isolation means (30) isolating an isolated part (28) of the inside (23) of the tubular part outside the aperture (11) to pressurise the isolated part (28) of the inside (23) and the space (13) to expand the expandable sleeve (7).

13. A well system according claim 12, wherein the tool further comprises a pumping device (31) for pumping fluid from the inside of the tubular part being outside the isolated part (28) and into the isolated part (28) to expand the expandable sleeve.

14. A method for maintaining a pressure within the annular barrier according to any of claims 1-10, comprising the steps of:

- expanding the expandable sleeve until the sleeve seals against the inside wall of the borehole,
- equalising the pressure inside the space when the temperature decreases or increases in the borehole by moving the piston and letting the gas in the second chamber part expand or diminish.

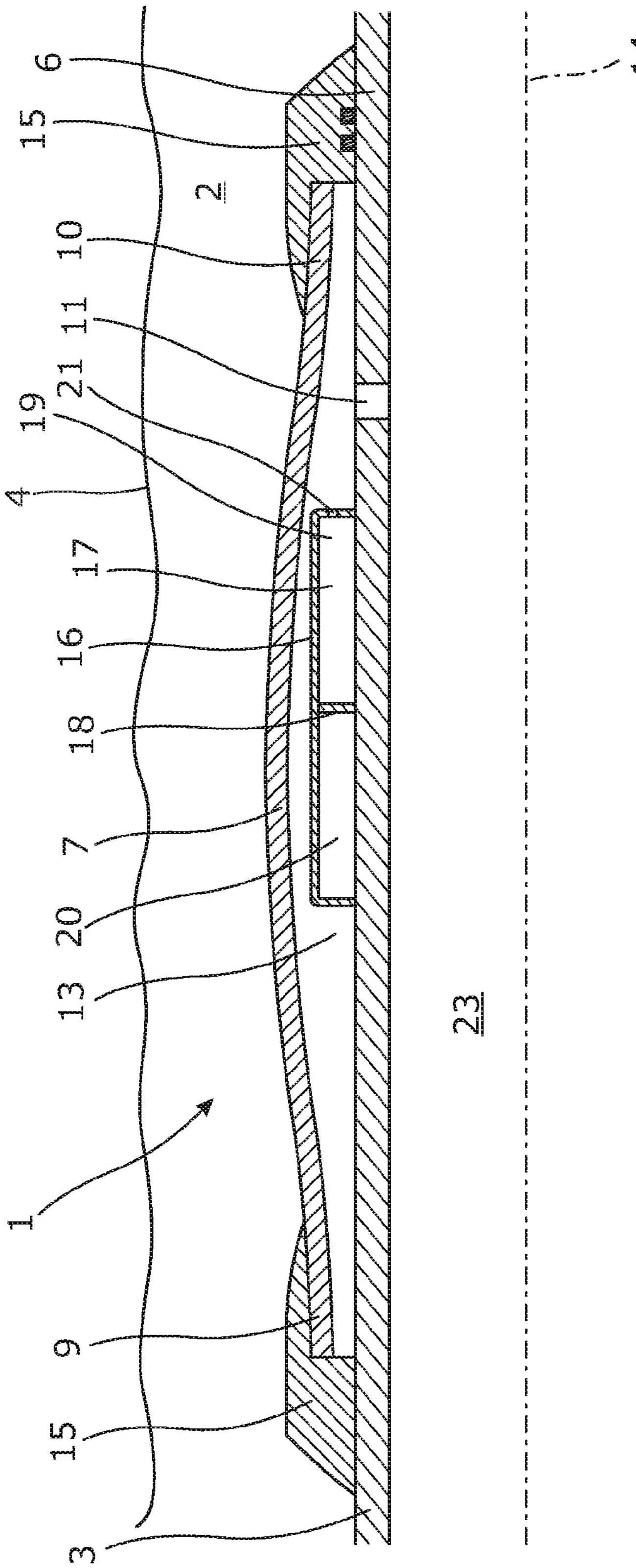

Fig. 1

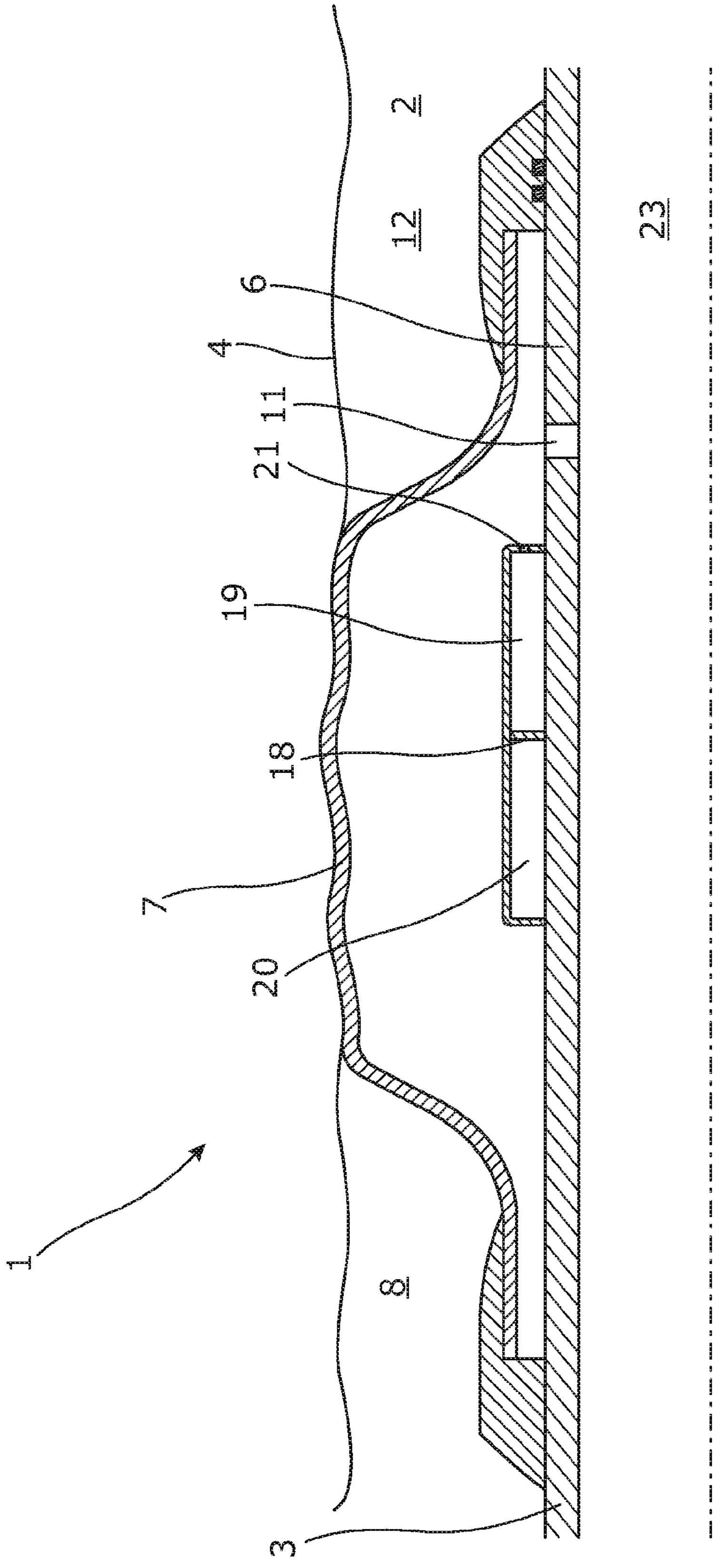

Fig. 2

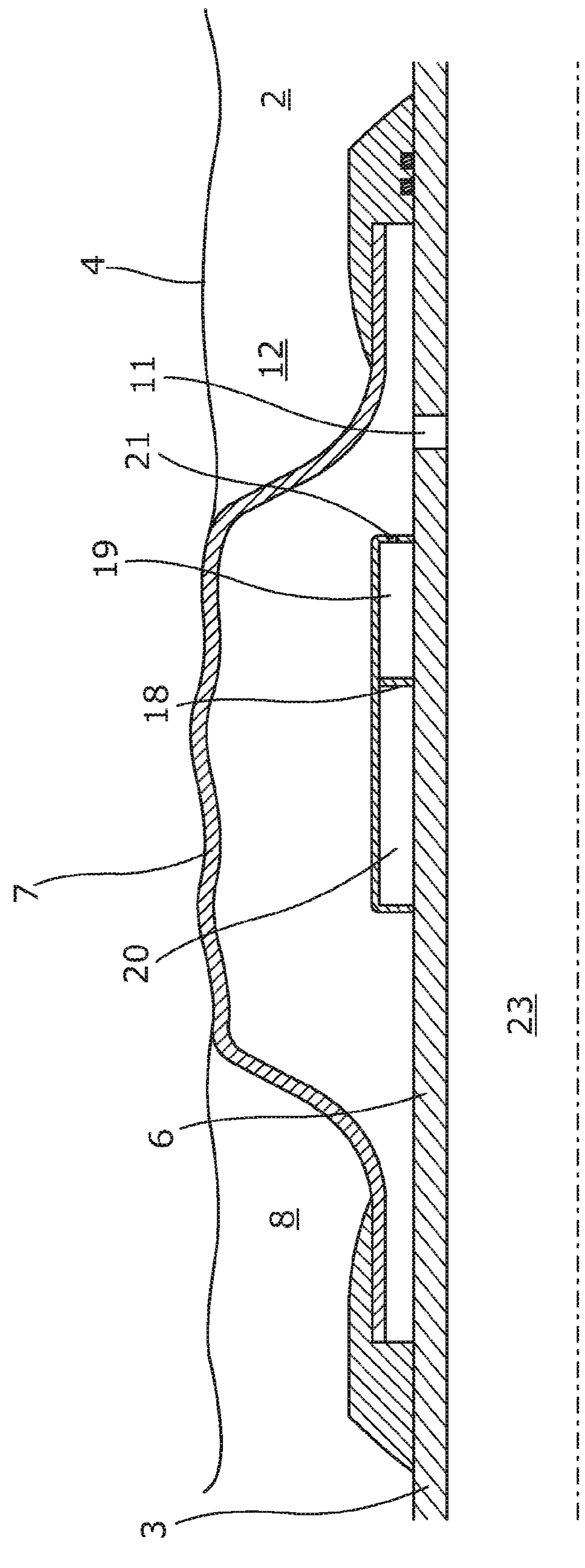

Fig. 3

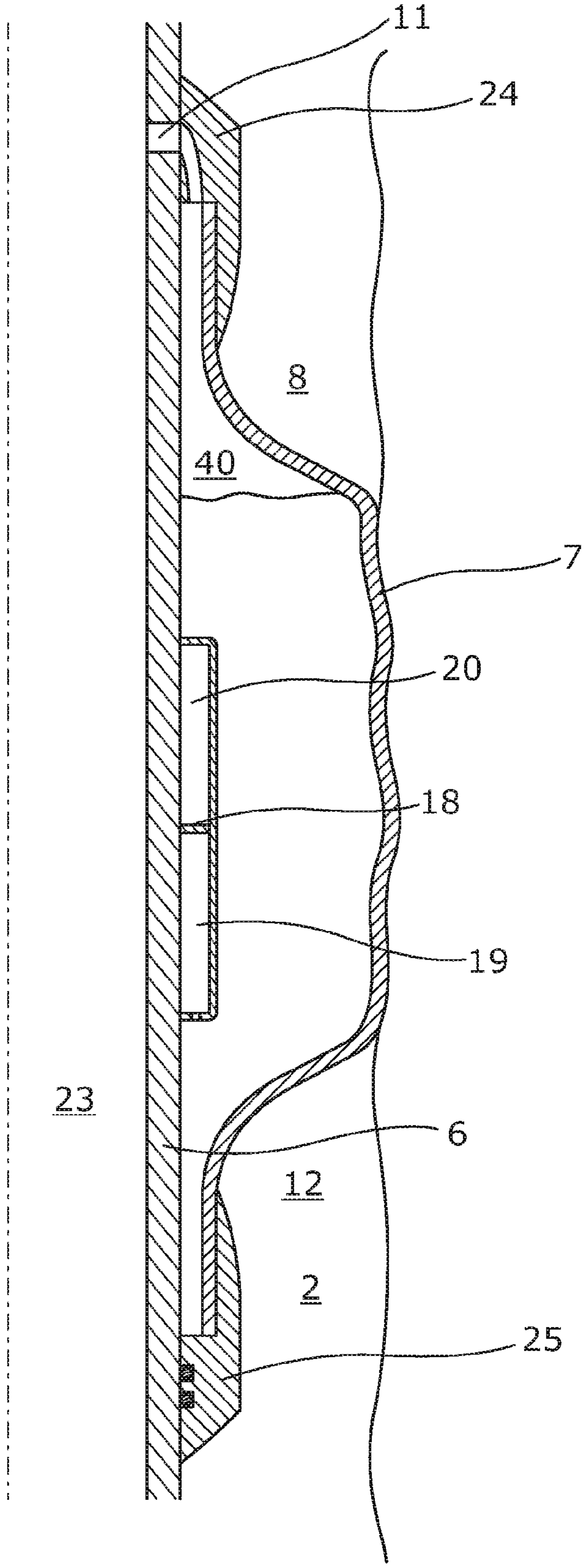

Fig. 4

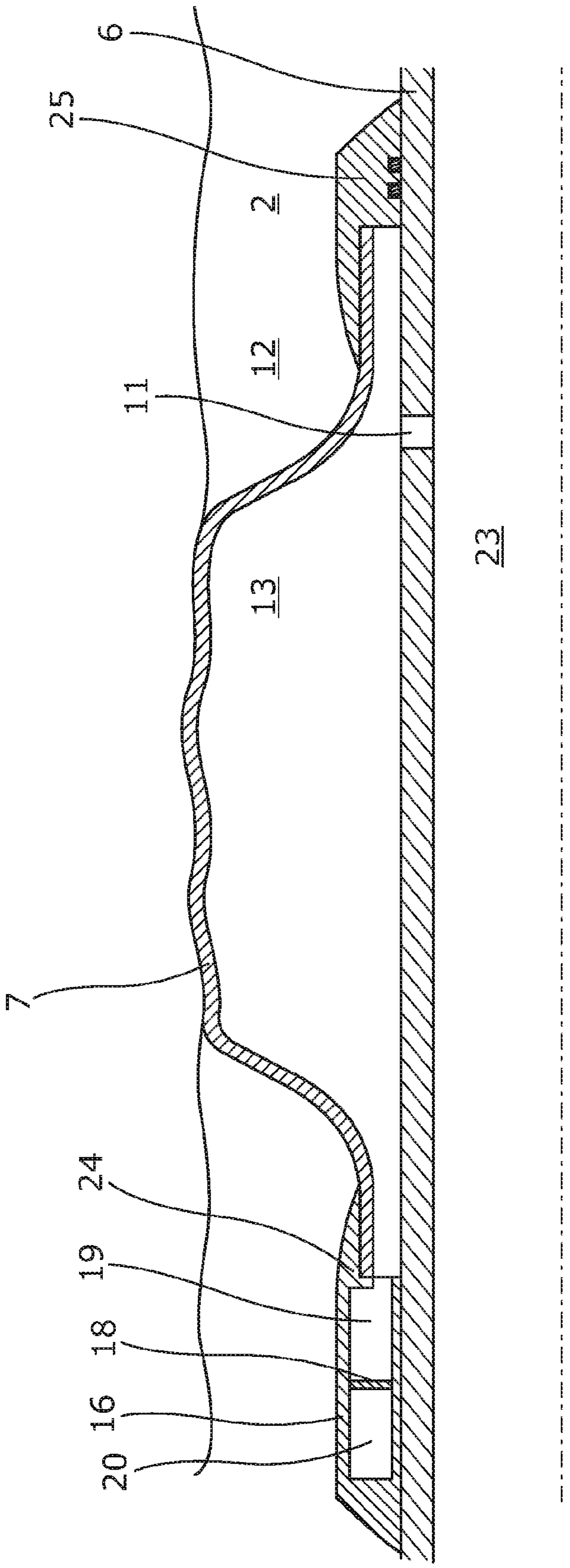

Fig. 5

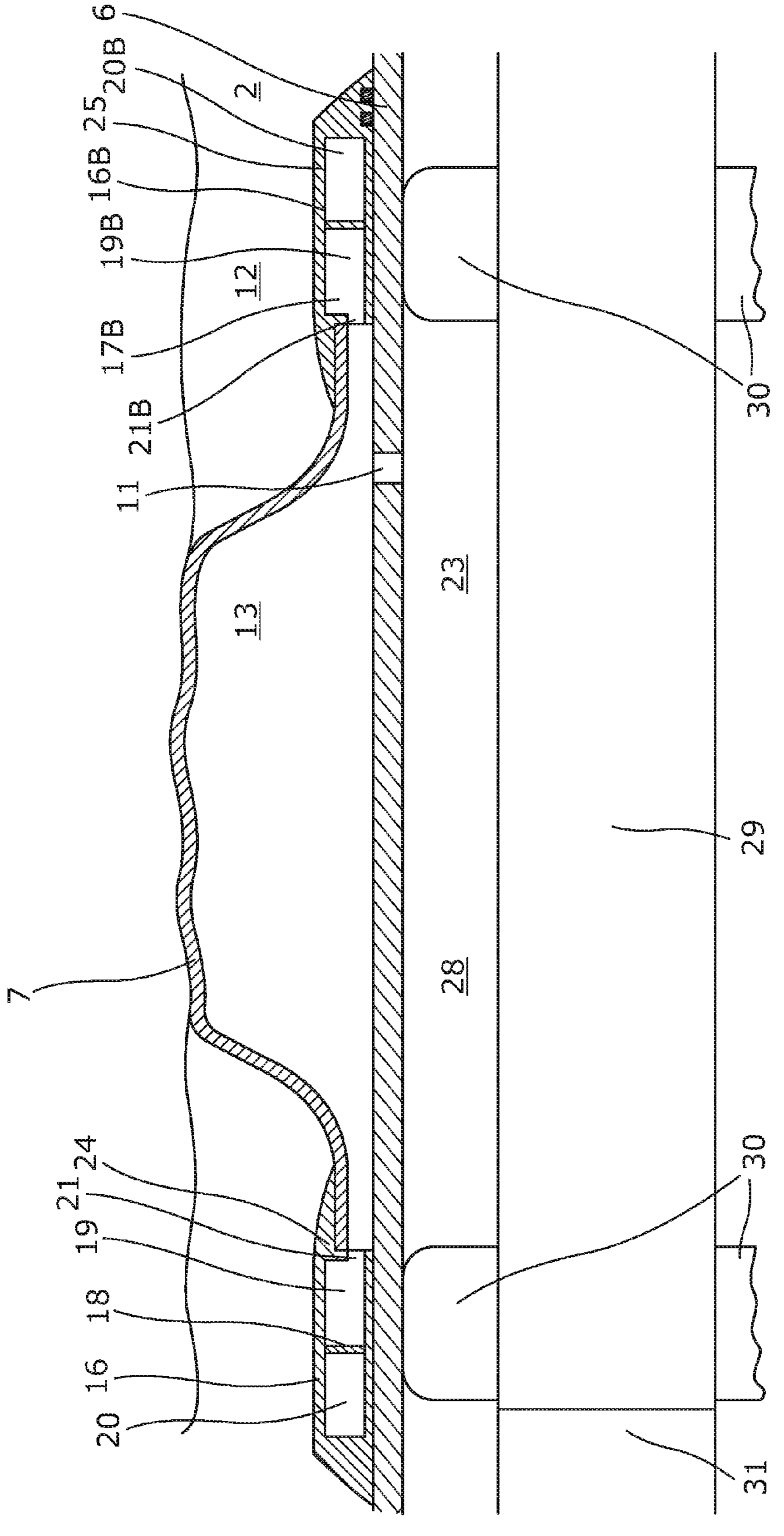
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Fig. 6

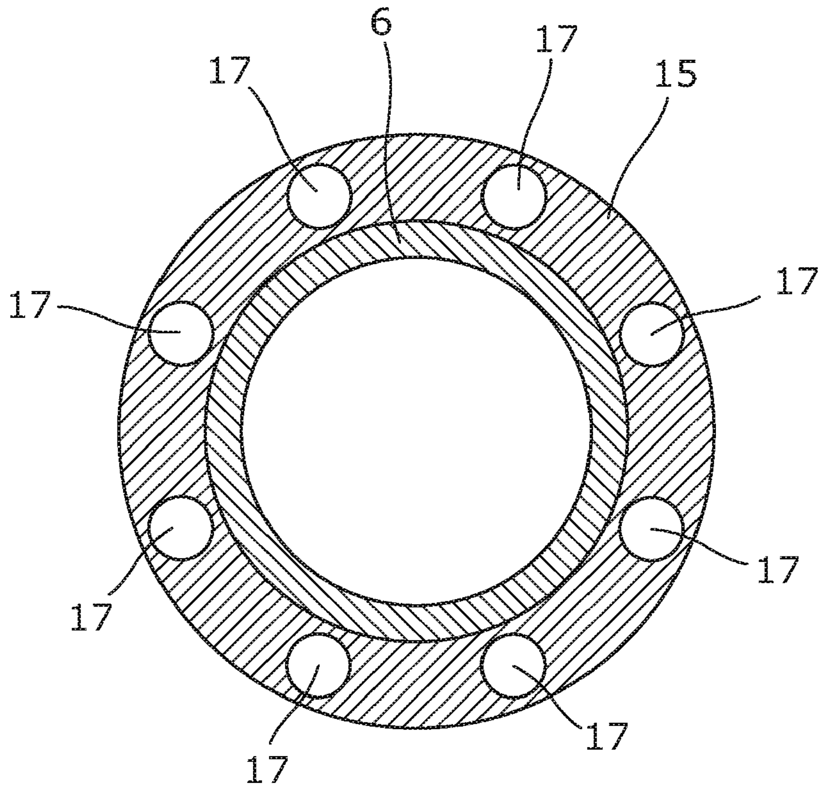

Fig. 7

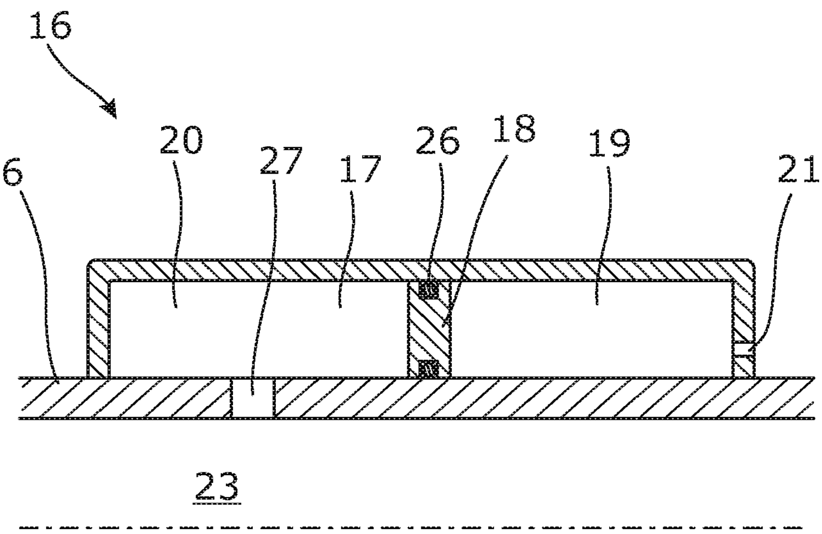

Fig. 8

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EUROPEAN SEARCH REPORT

Application Number
EP 11 17 9546

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 4 655 292 A (HALBARDIER FLOYD A [US]) 7 April 1987 (1987-04-07) * column 2, line 31 - column 6, line 19; figures 1-4 * * the whole document * -----	1,2,4-14	INV. E21B33/127
X	US 2007/056749 A1 (GAMBIER PHILIPPE [US] ET AL) 15 March 2007 (2007-03-15) * paragraphs [0034] - [0037]; figure 2 * * the whole document * -----	1,2,4-14	
X	WO 00/63523 A1 (WEATHERFORD LAMB [US]; HARDING RICHARD PATRICK [GB]) 26 October 2000 (2000-10-26) * figures 1-6 * -----	1,2,4-14	
A	WO 2008/060297 A2 (HALLIBURTON ENERGY SERV INC [US]; ALLISON DAVID B [US]; WEBB ALAN B [U) 22 May 2008 (2008-05-22) * page 9, line 13 - page 10, line 2; figures 6,12,13 * * the whole document * -----	3	TECHNICAL FIELDS SEARCHED (IPC) E21B
A	WO 2007/031723 A2 (PETROWELL LTD [GB]; MACLEOD IIAN MORRISON [GB]; REID STEPHEN [GB]; EGL) 22 March 2007 (2007-03-22) * the whole document * -----	1	
A	WO 98/36152 A1 (TECH LINE OIL TOOLS AS [NO]; DRECHSLER JAN [NO]; UNSGAARD TOM [NO]) 20 August 1998 (1998-08-20) * abstract * -----	1	
A	SU 1 113 514 A1 (INST BUROVOI TEKHNIK [SU]) 15 September 1984 (1984-09-15) * abstract; figures 1-3 * ----- -/--	1	

The present search report has been drawn up for all claims

2

Place of search	Date of completion of the search	Examiner
The Hague	13 January 2012	van Berlo, André

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A	GB 2 349 657 A (BAKER HUGHES INC [US]) 8 November 2000 (2000-11-08) * the whole document * -----	1	
			TECHNICAL FIELDS SEARCHED (IPC)

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