(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
8 December 2016 (08.12.2016)

WIPO | PCT

(10) International Publication Number
WO 2016/195508 A1

(51) International Patent Classification:
E21B 34/06 (2006.01) *E21B 29/00* (2006.01)
E21B 33/12 (2006.01)

(21) International Application Number:
PCT/NO2016/050111

(22) International Filing Date:
31 May 2016 (31.05.2016)

(25) Filing Language: Norwegian

(26) Publication Language: English

(30) Priority Data:
20150701 1 June 2015 (01.06.2015) NO

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(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, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, 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, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, 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, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

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

(54) **Title**: DESTRUCTION MECHANISM FOR A DISOLVABLE SEALING DEVICE

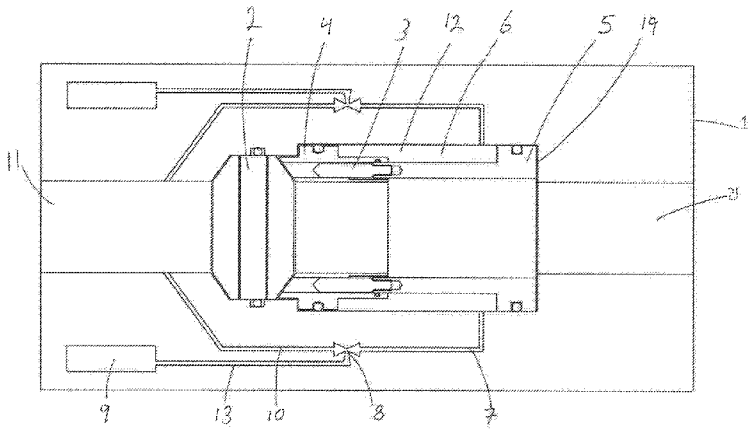


Fig 1

(57) **Abstract**: The present invention relates to a plug (1) comprising a crusher mechanism for a dissolvable sealing device, where the sealing device comprises one or more glass layers (2) positioned in a wellbore. The invention is characterized in that the glass (2) in a barrier phase bears against at least one seat or support sleeve (4) arranged axially displaceably in the wellbore, where the at least one seat or support sleeve (4) bears against the glass (2) by means of a supporting hydraulic fluid (6) found in a pressure support chamber (12), the seat or support sleeve (4) being arranged to be released, be displaced axially and to crush the glass (2) when the supporting hydraulic fluid (6) is released from its pressure support chamber (12).

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Destruction mechanism for a disolvable sealing device

The present invention relates to a crusher mechanism for a dissolvable sealing device.

Such dissolvable sealing devices may be used, for example, for pressure testing, where they also will function as barriers to the reservoir, in zone isolation or in borehole workover.

It is known to use plugs of a dissolvable material, such as glass, ceramic, salt, etc., where the plug may be removed or crushed after use in such a way as to leave behind very few remnants or fragments. Such plugs of a dissolvable material, if correctly configured, are removable with or without explosives in a predictable and safe manner.

Plugs comprising one or more glass layers stacked upon or above one another may be removed without the use of explosives by utilizing techniques that include percussion tools, spikes that are thrust into the dissolvable material, balls or other articles that serve to create tensions in the dissolvable material, or puncturing of the layer disposed between the two or more glass layers (if plugs comprise more than one glass layer), where the volume contains a film or a sheet of a material other than glass.

This layer between the two or more glass layers, comprising a film and/or a sheet of a material other than glass, may comprise a fluid, a plastic material, a rubber material, a felt material, a paper material, glue, grease, etc. The layer may be substantially solid or entirely or partially deformable/liquid. The volume between the glass layers, which may be provided with at least one of the aforementioned materials, will enable the plug to attain the desired strength and toughness during use by providing for the uptake of loads exerted on the plug in the form of a differential pressure between the under- and upper side of the plug. This may involve accommodation of loads in the form of load transfer, load distribution, or limitation of bulging as a result of frictional forces between two or more layers of glass or other suitable dissolvable or crushable materials.

If there is one glass layer, the plug during use must attain the desired strength and toughness through provision for the uptake of loads exerted on the plug in the form of a differential pressure between the under- and upper side of the one glass layer. This means that the one glass layer must be capable of receiving the entire load, both from above and below if required, on full load accommodation.

NO321976, filed on 21 November 2003, describes a glass plug comprising a plurality of layers or stratiform glass discs between which are provided layers of a material other than glass. NO321976 is the very first patent publication that describes a layered glass plug. NO321976 explains why there should be provided strata or layers, as disclosed above, between the glass discs of a material other than glass, and is included in its entirely in this document.

NO325431, filed on 23 March 2006, relates to an apparatus and method for crushing a dissolvable sealing device of the aforementioned type. NO325431 employs a relief chamber and an adjustable connecting means forming a fluid communication channel between the layer, the liquid film or the volume between the glass discs and relief chamber when the adjustable connecting means is set in an open position. When the adjustable connecting means is set in an open position, the content between the glass discs is «punctured» and evacuated, and the load on (one or more of) the glass layers exceeds what they are designed to tolerate, which causes them to rupture. In addition, the apparatus according to NO325431 comprises a plurality of pin devices which are arranged to apply point load stresses on the glass layers when the connecting means is readjusted, with the pin bodies additionally serving to ensure that the glass layers rupture in a safe manner when the connecting means is reset. Thus, the intended function of NO325431 is to provide for rupture of the plug through resetting of the connecting means to an open position so that the space between the glass layers is punctured and the pressure drops drastically and quickly. The pressure support function will thereby disappear, and the glass layers will be bent until they rupture and disintegrate, one by one. In addition, NO325431 discloses the possibility of arranging pins around the glass layers, where the pins are designed to produce point load stresses in the glass to weaken the strength of the glass layers. The way the pins' function is disclosed in NO325431, the pins have either a «passive» function, i.e., they are stationary and come into contact with the glass layers when these are bent or after the adjustable connecting means has been activated, or the pins are «actively» activated by means of the adjustable connecting means when it is activated, i.e., the pins are pushed against the glass layers and thereby produce point load stresses. In both cases, the point load stresses by the pins are produced as a causal effect of activation of the adjustable connecting means, since it is a precondition for the disclosed function of the plug that the space between the glass layers is punctured and the pressure falls drastically and quickly, with the glass layers thereby being bent and thus point loaded or, alternatively, that the sum of the tensions produced in the glass layers when the space between the glass layers is punctured/evacuated *and* the pins are pressed into the glass layers exceeds the level of tolerance of the glass layers so that they rupture. Thus, the pins do not function alone; they are dependent on the condition that the content between the glass layers is evacuated.

NO331150 discloses a crushable plug, for example of glass, which comprises a plurality of pin devices (spikes, claws, tips, points, compression ring) which are actuated to press radially into a glass layer so that it ruptures, said glass layer comprising pre-formed weakened points/areas that facilitate the crushing when the pin devices are pressed in against the plug. It is further disclosed in NO331150 that the weakened areas are formed by virtue of microfractures in the

glass, such as those caused by honing. If one examines Fig.3 in NO331150, one sees disclosed fractures that spread inwardly in the glass from the points of the pin devices. This type of fracture formation is what is assumed to have occurred when glass plugs of this kind are crushed. Since the glass layers are pulverized by crushing, it has thus not been evident how these glass layers were crushed. NO331150 shows a plug comprising one single glass layer. Although the description does not rule this out, NO331150 shows no embodimenst comprising several glass layers. NO331150 therefore provides no teaching as to how the disclosed solution could potentially be adapted to a plug comprising more than one glass layer.

The present invention relates to a crushable or dissolvable plug comprising one or more glass layers, optionally other suitable materials, where the plug is removed without the use of explosives, with the invention providing a crusher mechanism that is predictable, safe and easier to utilize.

In the following is given a detailed description of embodiments of the present invention, with reference to the attached drawings, wherein:

Fig. 1 shows an embodiment of the present invention prior to crushing, where the plug comprises several glass layers,

Fig. 2 shows a second embodiment of the present invention prior to crushing, where the plug comprises one glass body,

Fig. 3 shows a third embodiment of the present invention prior to crushing.

Fig. 1 shows an embodiment of a plug 1 having a crusher mechanism comprising several glass layers 2, where one or more spikes 3 either bear, entirely or partially, against one or more sides of glasses 2, or are mounted at a distance from glass 2. The embodiment in Fig. 1 shows that the spike or spikes are mounted at a distance from glass 2.

According to the embodiment shown in Fig. 1, the glasses 2 are supported by a support sleeve 4. Support sleeve 4 is arranged to be displaceable in an axial direction if there is a pressure support fluid 6 in a pressure support chamber 12. Pressure support chamber 12 is in communication with a relief chamber 9 for pressure support fluid 6. In the barrier phase for plug 1, pressure support fluid 6 will prevent the displacement of sleeve member 4 in an axial direction (toward the right in Fig. 1) as long as a valve 8 is closed. When valve 8 is opened, i.e., in a crushing phase, pressure support fluid 6 is released into relief chamber 9, and support sleeve 4 will be displaced in an axial direction (toward the right in Fig. 1) in such a way that the glasses are moved together with support sleeve 4 until the spike or spikes 3 strike and crush the glasses 2.

The spike or spikes 3 may be mounted in a separate sleeve member 5, which optionally may also be axially displaceable (toward the left in Fig. 1), but does not have to be. A potential advantage of having both support sleeve 4 and sleeve member 5 be displaceably mounted can be that the net acceleration between glasses 2 and spike or spikes 3 increases (i.e, they strike each other faster and harder), so that glasses 2 are crushed more predictably. Such an embodiment can thereby also enable the system to be constructed smaller, which conserves space.

It is understood that a further alternative embodiment may be that support sleeve 4 stays in fixed position and that only sleeve member 5, with spikes 3 mounted thereon, is axially displaced toward the left when pressure support fluid 6 is released from pressure support chamber 12.

Valve 8 may be mounted such that it is in communication with the upper side of the well tubing 11 (in contrast to the reservoir side 21). The valve is arranged such that when the pressure from the upper side 11 exceeds a certain level, then valve 8 opens for communication between pressure support chamber 12 and relief chamber 9 through channels 7 and 13. Valve 8 may also be controlled by other means, e.g., by pressure cycles, telemetry, or a signal of some kind.

Fig. 2 shows a corresponding embodiment as in Fig. 1, but here the plug has only one glass.

It is understood that plug 2 and various parts of the crusher mechanism comprise the sealing means in the form of O-rings and other relevant packings that are necessary in order for plug 2 to retain its seal during the barrier phase, at the same time as the crusher mechanism shall function as intended both during the barrier and the crusher phases (e.g., pressure support fluid 6 must under no circumstances be allowed to escape or leak out during the barrier phase).

Fig 3 shows an alternative embodiment of the invention. Here the spike or spikes 3 are diagonally mounted loosely at the glass (or glasses) 2, while a ball 14 functions as a power transmission means around a turn so that when an axial pin 15 is displaced (toward the right in Fig. 3), then spike 3 will move diagonally into glass 2.

This embodiment does not include a pressure support chamber, but instead comprises a chamber 18 having essentially a low or atmospheric pressure. Chamber 18 may contain air or another suitable gas.

An axially displaceable sleeve member 16 (displaceable toward the right in Fig. 3) is mounted in such a way that it, firstly, closes off a plurality of perforations **18** opening radially in toward the wellbore and, secondly, is in communication with a valve or release organ 22. In the barrier

phase, valve or release organ 22 can serve to close off either a pressure chamber (not shown) containing a fluid under high pressure (substantially higher than the pressure in chamber 18), or a channel opening in toward the wellbore. In the crushing phase, valve 17 is opened so that sleeve 16 is displaced sufficiently far to uncover the perforations 20 opening radially in toward the wellbore, as the pressure in the wellbore is then let in at the upper side of sleeve 16, and exerts a pressure against the annulus 19. Sleeve member 16 will thereby be displaced with great force against pin(s) 15, which via balls 14 causes spikes 3 to be driven into glass 2, which is thereby crushed.

Fig. 4 essentially corresponds to the embodiment shown in Fig. 3 after the glass has been crushed.

Alternatively, valve or release organ 22 may comprise a spring member (not shown) which is held in restraint, whereby, upon being released, it shoves sleeve member 16 sufficiently far to uncover the perforations 18 opening radially in toward the wellbore.

Valve or release organ 22 may be controlled by, e.g., pressure cycles, telemetry, or a signal of some kind. A so-called ticker device may be an example of an organ which is triggered by means of pressure cycles.

Various aspects pertaining to the present invention, where some have already been mentioned above, are disclosed in the following:

According to one embodiment of the present invention, glass 2 in a barrier phase bears against at least one seat or support sleeve 4 arranged axially displaceably in the wellbore, where the at least one seat or support sleeve 4 bears against glass 2 by means of a supporting hydraulic fluid 6 found in a pressure support chamber 12, the seat or support sleeve 4 being arranged to be released, displaced axially, and to crush the glass 2 when the supporting hydraulic fluid 6 is released from its pressure support chamber 12.

The supporting hydraulic fluid may be locked in chamber 12 by means of a valve, bursting disc, shear pin, interchangeable part or a similar releasable mechanism 8. Other releasable mechanisms might also be contemplated.

Releasable mechanism 8 may also be triggered by means of a desired number of well pressure cycles from the the well or by means of another signal. The releasable mechanism 8 may be, for example, a ticker device.

In the crushing phase, releasable mechanism 8 permits supporting hydraulic fluid to flow out into one or more relief chambers 9. The pressure in the one or more relief chambers should, in that event, be lower than the pressure in the pressure support chamber, in which case the pressure in the one or more relief chambers 9 may be approximately atmospheric, but does

not have to be. Releasable mechanism 8, e.g., a valve, may be mounted in such a way that after releasing the supporting pressure fluid , if this results in displacement of sleeve member 5 toward the left past channel 7, it opens through channel 10 and toward the well pressure in wellbore 11. In that event, sleeve member 5 will be subjected to strong pressure against annulus 19, whereupon the movement of the sleeve member is accelerated substantially and will strike the spike or spikes 3 with a powerful (more powerful) force.

According to another embodiment of the crusher mechanism, where glass 2 in a barrier phase also bears against at least one seat or support sleeve 4, the glass is crushed by the second sleeve member (16) being displaced when it is released.

It shall be understood that the phrase «the glass» is intended to denote one or more glass elements.

Between the at least one seat or support sleeve 4 and the second sleeve member 16, there may be arranged a fluid-filled chamber 18 having a lower pressure than the well pressure.

Alternatively, between the at least one seat or support sleeve 4 and the second sleeve member 16, there may be arranged a fluid-filled chamber 18 having a higher pressure than the well pressure.

The at least one seat or support sleeve 4 may be fixedly mounted in relation to the wellbore, but does not have to be. If there is a supporting hydraulic fluid 6 in chamber 18, then the seat or support sleeve 4 will remain stationary against the glass in the barrier phase. The fluid-filled chamber 18 may have a substantially lower pressure than the well pressure.

Chamber 18 may contain air or another suitable gas.

Sleeve member 5; 16 may be arranged such that, in the barrier phase, it covers over a plurality of perforations 20 opening radially in toward the wellbore. In this case, sleeve member 5; 16 in the crushing phase may be arranged such that it uncovers a plurality of perforations 20 opening radially in toward the wellbore when sleeve member 5; 16 is displaced, thereby producing an additional powerful push against the annulus 19 of the sleeve, which causes the crusher device to strike more forcefully against the glass.

Also in this second embodiment the releasable mechanism may be triggered by means of a desired number of well pressure cycles from the well or another signal. The releasable mechanism 8 may be a so-called ticker device.

The releasable mechanism 8 can, in the crushing phase, cause the supporting hydraulic fluid to flow out into one or more relief chambers 9. This embodiment is not shown per se, but it shares features that are shown in Fig. 1-2 and 3-4, respectively. In this case the pressure in the

one or more relief chambers 9 may be lower than in the fluid-filled chamber 18, for example -- but not necessarily -- approximately atmospheric.

Also in this second embodiment the crusher device may comprises spike means 3 which may include one or more of the group: spikes, pins, pegs, knives and annular casings.

It shall be understood that the various spike means may be tangentially, radially, diagonally and/or longitudinally mounted, or combinations of these. The annular casings may be formed with sharp edges or the like, but they do not have to be, since a hard blow against the glass can in itself be sufficient to crush the glass securely.

Figures 3 and 4 show that the releasable mechanism **17** may be positioned behind the second sleeve member 16, such that releasable mechanism 17 serves to push against an annulus 19 on second sleeve member 16 in the crushing phase.

Alternatively, the releasable mechanism 17 may be arranged in communication with the fluid-filled chamber 18 such that sleeve member 4; 16 in the crushing phase is displaced by being drawn by a negative pressure when releasable mechanism 17 permits fluid 6 to flow out from chamber 18 into the one or more relief chambers 9. Such an embodiment is basically shown in Figures 1 and 2, but it requires that the seat or support sleeve 4 remains stationary or is displaced substantially more slowly than sleeve member 5 and that the spike or spikes have a sufficient stroke length to strike the glass with sufficient force and security.

Patent Claims

1. Crusher mechanism for a dissolvable sealing device, wherein the sealing device comprises one or more glass layers (2) positioned in a wellbore, characterized in that the glass (2) in a barrier phase bears against at least one seat or support sleeve (4) arranged axially displaceably in the wellbore, where the at least one seat or support sleeve (4) bears against the glass (2) by means of a supporting hydraulic fluid (6) found in a pressure support chamber (12), the seat or support sleeve (4) being arranged to be released, displaced axially and to crush the glass (2) when the suppporting hydraulic fluid (6) is released from its pressure support chamber (12).

2. Crusher mechanism according to claim 1, wherein the supporting hydraulic fluid is locked in the chamber (12) by means of a valve, bursting disc, shear pin, interchangeable part or a similar releasable mechanism (8).

3. Crusher mechanism according to claim 3, wherein the releasable mechanism (8) is triggered by means of of a desired number of well pressure cycles from the well (1) or by means of another signal.

4. Crusher mechanism according to claim 3, wherein the releasable mechanism (8) is a ticker device.

5. Crusher mechanism according to one of the claims 2-3, wherein the releasable mechanism (8) in the crushing phase permits supporting hydraulic fluid to flow out into one or more relief chambers (9).

6. Crusher mechanism according to claim **5**, wherein the pressure in the one or more relief chambers (9) is lower than in the pressure support chamber (12).

7. Crusher mechanism according to claim 5, wherein the pressure in the one or more relief chambers (9) is approximately atmospheric.

8. Crusher mechanism according to one or more of the preceding claims, wherein the seat sleeve or support sleeve (4) in a crushing phase is released and axially displaced such that a crusher device (3) comes into contact with and crushes the glass (2), where the

crusher device (3) may comprise one or more of the group: spikes, pins, pegs, knives and annular casings.

9. Crusher mechanism for a dissolvable sealing device, wherein the sealing device comprises one or more glass layers (2) positioned in a wellbore,

characterized in that the glass (2) in a barrier phase bears against at least one seat or support sleeve (4), where a second sleeve member (16) through release and displacement causes crushing of the sealing device.

10. Crusher mechanism according to claim 9, wherein the at least one seat or support sleeve (4) is fixedly mounted in relation to the wellbore.

11. Crusher mechanism according to claim 9, wherein there is found between the at least one seat or support sleeve (4) and the second sleeve member (5; 16) a fluid-filled chamber (18) having a lower pressure than the well pressure.

12. Crusher mechanism according to claim 9, wherein there is found between the at least one seat or support sleeve (4) and the second sleeve member (5; 16) a fluid-filled chamber (18) having a higher pressure than the well pressure.

13. Crusher mechanism according to claim 9, wherein there is found between the at least one seat or support sleeve (4) and the second sleeve member (5; 16) a chamber (18) containing a supporting hydraulic fluid (6).

14. Crusher mechanism according to claim 11 or 12, wherein the chamber (18) contains air or another suitable gas.

15. Crusher mechanism according to one of the claims 9-14, wherein the second sleeve member (5; 16) in the barrier phase covers over a plurality of perforations (20) opening radially in toward the wellbore.

16. Crusher mechanism according to claim 15, wherein the second sleeve member (5; 16) in the barrier phase uncovers a plurality of perforations (20) opening radially in toward the wellbore by means of the displacement of the second sleeve member (5; 16).

17. Crusher mechanism according to claim 9, wherein the releasable mechanism (8) is triggered by means of a desired number of well pressure cycles from the well above the sealing device **(1)** or another signal.

18. Crusher mechanism according to claim 17, wherein the releasable mechanism (8) is a ticker device.

19. Crusher mechanism according to one of the claims 11, 16 or 17, wherein the releasable mechanism **(8)** in the crushing phase permits supporting hydraulic fluid to flow out into one or more relief chambers (9).

20. Crusher mechanism according to claim 19, wherein the pressure in the one or more relief chambers (9) is lower than in the fluid-filled chamber (18).

21. Crusher mechanism according to claim 19, wherein the pressure in the one or more relief chambers (9) is approximately atmospheric.

22. Crusher mechanism according to one of the preceding claims, wherein the second sleeve member (16) through its release and the axial displacement in a crushing phase causes a crusher device (3) to come into contact with and crush the glass (2), where said crusher device (3) may comprise one or more of the group: spikes, pins, pegs, knives and annular casings.

23. Crusher mechanism according to claim 22, wherein the spike or spikes (3) are diagonally arranged at the glass, where a ball (14) functions as a power transmission means around a turn when an axial pin (15) is struck by the sleeve member (5; 16) in the crushing phase.

24. Crusher mechanism according to one of the claims 9, 10, 12, 14-19, wherein the releasable mechanism **(17)** is positioned behind the second sleeve member (16) such that releasable mechanism **(17)** serves to push against an annulus (19) on the second sleeve member (16) in the crushing phase.

25. Crusher mechanism according to one of the claims 9, 11, 13-22, wherein the releasable mechanism **(17)** is arranged in communication with the fluid-filled chamber (18) such that the second sleeve member (16) in the crushing phase is displaced by being drawn

by a negative pressure when releasable mechanism (**17**) permits the fluid (6) to flow out from chamber (18) to the one or more relief chambers (9).

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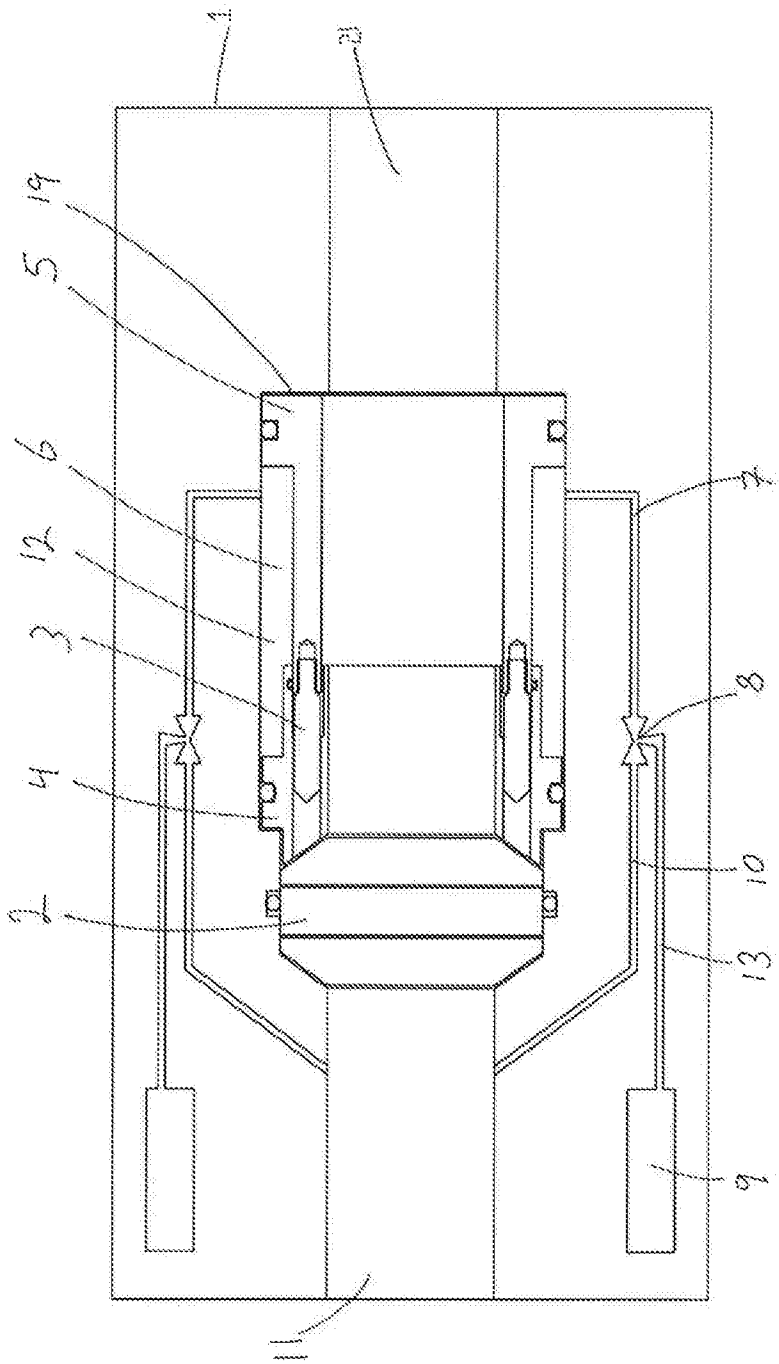


Fig. 1

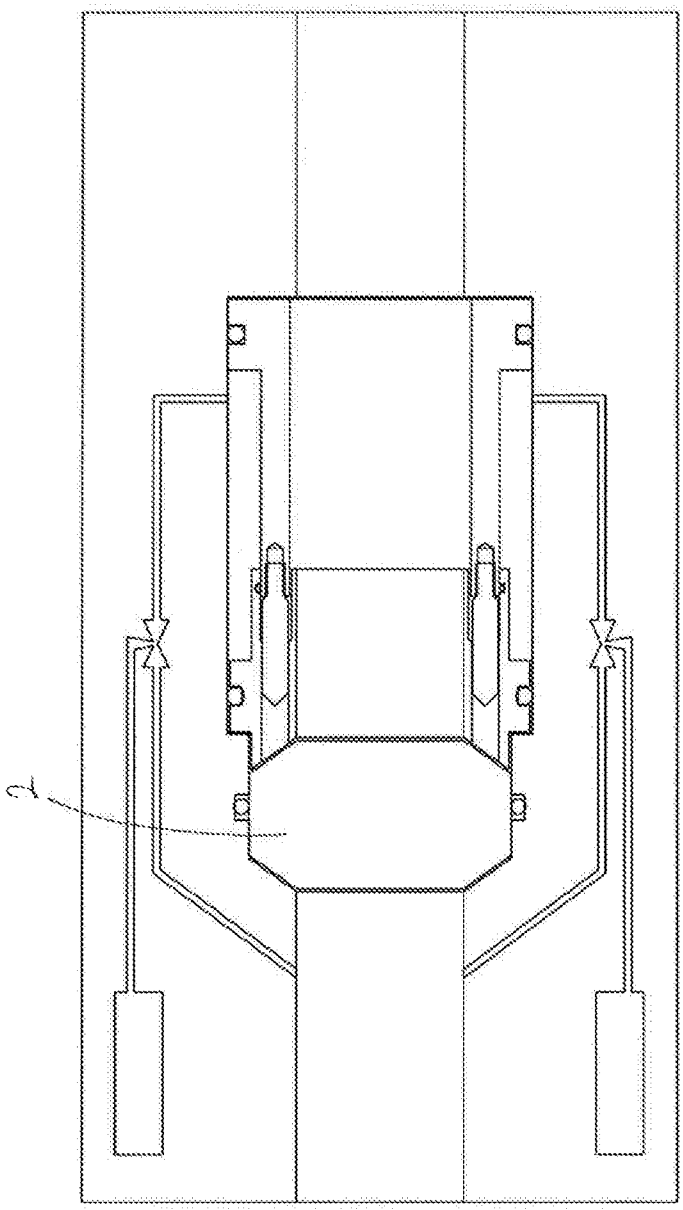


Fig. 2

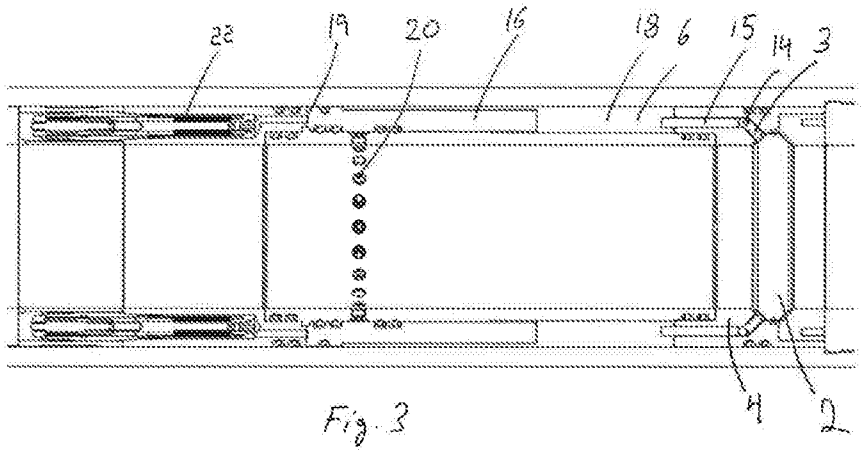


Fig. 3

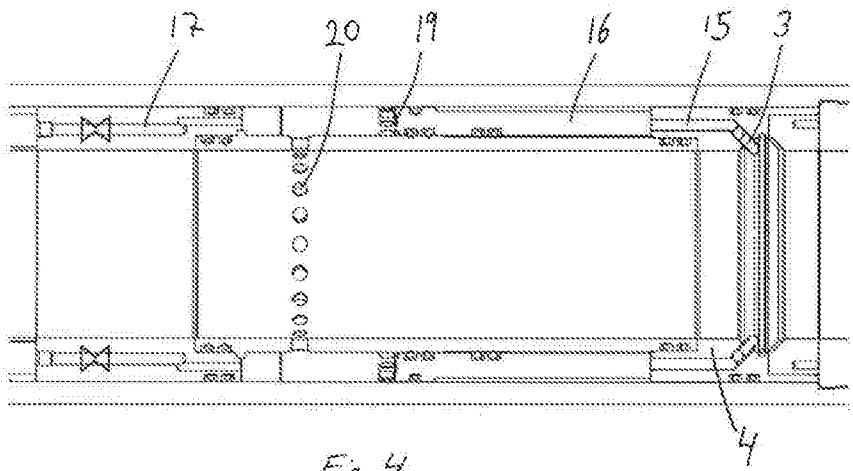


Fig. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/NO2016/050111

A. CLASSIFICATION OF SUBJECT MATTER
INV. E21B34/06 E21B33/12 E21B29/00
ADD.

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

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2009/110805 A1 (TCO AS [NO]; BRANDSDAL VIGGO [NO]) 11 September 2009 (2009-09-11) figures 1, 2	1-25
X	WO 2009/126049 A1 (TCO AS [NO]; BRANDSDAL VIGGO [NO]) 15 October 2009 (2009-10-15) page 10, lines 17-35; figures 2, 3, 6	1-25
X	WO 2014/154464 A2 (VOSSTECH AS [NO]) 2 October 2014 (2014-10-02) figures 1A-4E	1-25
X	WO 2009/116871 A1 (TCO AS [NO]; BRANDSDAL VIGGO [NO]; SEVATDAL SIGMUND [NO]; KROGENES KAR) 24 September 2009 (2009-09-24) figures 2-4	1-25

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
19 August 2016	30/08/2016

Name and mailing address of the ISA/	Authorized officer
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Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/NO2016/050111

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	WO 2012/060713 A1 (TCO AS [NO]; BRANDSDAL VIGGO [NO]) 10 May 2012 (2012-05-10) figure 5	1-25
A	EP 0 681 087 A2 (HALLIBURTON CO [US]) 8 November 1995 (1995-11-08) page 5, lines 28-29; figure 2C	1-25

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

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