



(51) International Patent Classification:

E21B 33/12 (2006.01) *E21B 43/25* (2006.01)
E21B 43/17 (2006.01) *E21B 23/06* (2006.01)

(21) International Application Number:

PCT/US2016/034581

(22) International Filing Date:

27 May 2016 (27.05.2016)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

14/723,831 28 May 2015 (28.05.2015) US

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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).

Declarations under Rule 4.17:

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

Published:

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

(54) Title: METHOD AND APPARATUS TO DELIVER A REAGENT TO A DOWNHOLE DEVICE

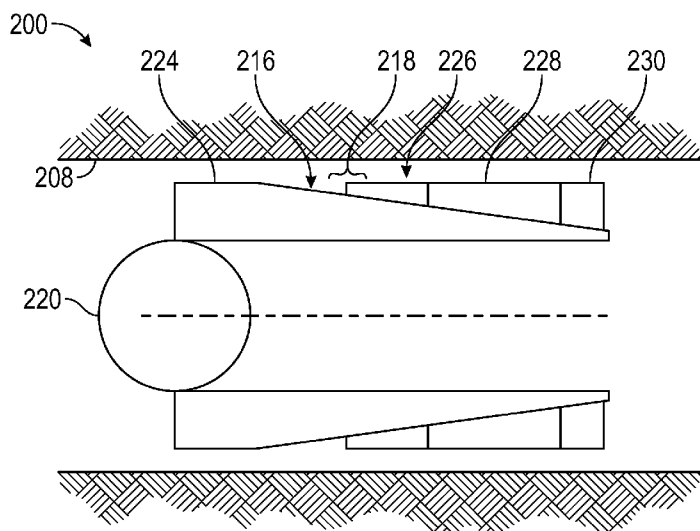


FIG. 2

(57) Abstract: In one aspect, a downhole device for use in a downhole environment is disclosed, including: a first material with a first degradation rate in the downhole environment and at least one cavity, wherein the at least one cavity contains a second material to degrade the first material at a second degradation rate when the second material is exposed to the downhole environment and the first material, the second degradation rate being higher than the first degradation rate. In certain embodiments, the second material is a solid second material. In certain embodiments, the second material is a gel second material. In certain embodiments the downhole device further includes a protective material to control exposure of the second material to the downhole environment.

METHOD AND APPARATUS TO DELIVER A REAGENT TO A DOWNHOLE DEVICE

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Application No. 14/723831, filed on May 28, 2015, which is incorporated herein by reference in its entirety.

BACKGROUND

Field of the Disclosure

[0002] This disclosure relates generally to degradable devices with reagents and systems that utilize the same for downhole applications.

Background of the Art

[0003] Wellbores are drilled in subsurface formations for the production of hydrocarbons (oil and gas). Hydrocarbons are trapped in various traps or zones in the subsurface formations at different depths. In many operations, such as fracturing, it is required to convey devices (such as packers, bridge plugs, etc.) in a downhole location to facilitate production of oil and gas. After such operations, conveyed devices must be removed or destroyed before following operations can begin. Such removal operations may be costly and/or time consuming. It is desired to provide a downhole device that can provide desired and predictable degradation characteristics without additional removal or treatment operations.

[0004] The disclosure herein provides degradable devices with reagents and systems using the same for downhole applications.

SUMMARY

[0005] In one aspect, a downhole device for use in a downhole environment is disclosed, including: a first material that degrades at a first rate when exposed to the downhole environment, and a second material protected from the downhole environment, wherein the second material when exposed to the downhole environment degrades the first material at a second rate greater than the first rate.

[0006] In another aspect, a method to degrade a downhole device in a downhole environment, is disclosed, including: providing a first material in the downhole environment; providing a second material protected from the downhole environment; degrading the first material at a first rate in response to exposure to the downhole

environment; exposing the second material to the downhole environment and the first material; and degrading the first material at a second rate in response to exposure to the downhole environment and the second material, wherein the second rate is greater than the first rate.

[0007] In another aspect, a downhole system for use in a downhole environment, is disclosed, including a casing string; and a downhole device associated with the casing string, including a first material that degrades at a first rate when exposed to the downhole environment, and a second material protected from the downhole environment, wherein the second material when exposed to the downhole environment degrades the first material at a second rate greater than the first rate.

[0008] Examples of certain features of the apparatus and method disclosed herein are summarized rather broadly in order that the detailed description thereof that follows may be better understood. There are, of course, additional features of the apparatus and method disclosed hereinafter that will form the subject of the claims appended hereto.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The disclosure herein is best understood with reference to the accompanying figures, wherein like numerals have generally been assigned to like elements and in which:

FIG. 1 is a schematic diagram of an exemplary drilling system that includes downhole elements according to embodiments of the disclosure;

FIG. 2 is a schematic diagram of an exemplary downhole device for use in a downhole system, such as the one shown in **FIG. 1**, according to one embodiment of the disclosure;

FIG. 3 shows a partial view of an exemplary bottom sub for use with a downhole device, such as the downhole device shown in **FIG. 2** for use with a downhole system, according to one embodiment of the disclosure; and

FIG. 4 shows a partial view of an exemplary cone for use with a downhole device, such as the downhole device shown in **FIG. 2** for use with a downhole system, according to one embodiment of the disclosure.

DESCRIPTION OF THE EMBODIMENTS

[0010] **FIG. 1** shows an exemplary embodiment of a downhole system to facilitate the production of oil and gas. In certain embodiments, system **100** allows for

fracturing operations to facilitate production of oil and gas. System **100** includes a wellbore **106** formed in formation **104** with casing **108** disposed therein.

[0011] In an exemplary embodiment, a wellbore **106** is drilled from a surface **102** to a downhole location **110**. Casing **108** may be disposed within wellbore **106** to facilitate production. In an exemplary embodiment, casing **108** is disposed through multiple zones of production **Z1...Zn** in a downhole location **110**. Wellbore **106** may be a vertical wellbore, a horizontal wellbore, a deviated wellbore or any other suitable type of wellbore or any combination thereof.

[0012] To facilitate downhole operations, such as fracturing operations, bridge plugs **116a**, packers **116b**, or other suitable downhole devices are utilized within casing string **108**. In certain embodiments, such downhole devices **116a,b** are anchored to casing string **108** via an anchor assembly **118**. In certain embodiments, bridge plugs **116a** utilize an anchor assembly **118** and frac balls **120** to isolate zones **Z1...Zn** for fracturing operations. In certain embodiments, frac balls **120** are disposed at a downhole location **110** to obstruct and seal fluid flow in local zone **112** to facilitate flow to perforations **114** in conjunction with frac plugs **116a**. In certain embodiments, packers **116b** are utilized in conjunction with anchor assembly **118** to isolate zones **Z1...Zn** for fracturing operations.

[0013] In certain embodiments, frac fluid **124** is pumped from a frac fluid source **122** to a downhole location **110** to flow through perforations **114** in a zone **112** isolated by downhole device **116a,b**. Advantageously, fracturing operations allow for more oil and gas available for production.

[0014] After desired operations (such as fracturing operations) and before following operations, downhole devices **116a,b** are often removed or otherwise destroyed to allow the flow of oil and gas through casing **108**. In an exemplary embodiment, downhole devices **116a,b** are configured remain resident in casing **108** of local zone **112** until a predetermined time at which at least portions of downhole devices **116a,b** dissolve or degrade to facilitate the production of oil and gas. Advantageously, in an exemplary embodiment, the downhole devices **116a,b** herein utilize reagents conveyed with the downhole devices **116a,b** to accelerate degradation of downhole devices **116a,b** while allowing for suitable performance.

[0015] FIG. 2 shows a downhole device **216**, such as a bridge plug, packer, or any other suitable downhole device, for use downhole systems such as the system **100** shown in FIG. 1. In an exemplary embodiment, downhole system **200** includes downhole device **216** interfacing with casing **208** via anchor assembly **218** to anchor a downhole device

216. In certain embodiments, a frac ball **220** is used with downhole device **216** to isolate frac fluid flow within the wellbore.

[0016] In an exemplary embodiment, anchor assembly **218** includes a wedge **224**, slip ring **228**, and bottom sub **230**. In certain embodiments, wedge **224** is forced downhole to force slip ring **228** outward against casing **208** to anchor against casing **208**. In certain embodiments, slip ring **228** can crack or otherwise separate as it is driven against casing **208**. In certain embodiments, wedge **224** is forced via a setting tool, explosives, or any other suitable means. In certain embodiments, downhole device **216** further utilizes a sealing member **226** to seal downhole device **216** against casing **208** and further resist movement. Sealing member **226** may similarly be driven toward casing **208** via wedge **224**. In certain embodiments, downhole device **216** can further utilize bottom sub **230** to interface against casing **208** and further resist movement.

[0017] In an exemplary embodiment, a substrate of one or more elements of downhole device **216** are formed of a degradable material to allow one or more elements of downhole device **216** to dissolve or degrade after a desired anchoring function is performed. In certain embodiments, the downhole temperature exposure to downhole device **216** varies from 100 to 350 degrees Fahrenheit at a particular downhole location for a given area. Advantageously, one or more elements of downhole device **216** as described herein may contain reagents conveyed with one or more elements of downhole device **216** to allow for rapid degradation of one or more elements of downhole device **216** after a desired time in certain downhole environments, while allowing suitable anchoring performance.

[0018] **FIG. 3** shows an exemplary embodiment of bottom sub **330**. While an illustrated embodiment depicts a bottom sub **330**, the features described herein are suitable for any element of downhole device **216**. In an exemplary embodiment, bottom sub **330** is formed of a substrate **331** and includes cavities **332**. In certain embodiments, bottom sub **330** is used with downhole devices as shown in **FIG. 2**. Advantageously, bottom sub **330** is a degradable device and includes a reagent **333** to be conveyed with bottom sub **330** to expedite degradation of bottom sub **330**, other elements of downhole device **216**, or any other suitable element formed of degradable materials. In an exemplary embodiment, any suitable elements of downhole device **216** can be utilized as described to convey reagent **333** and release reagent **333**.

[0019] In an exemplary embodiment, bottom sub **330** includes an upper face **334**, a lower face **336**, and one or more cavities **332**. Bottom sub **330** can be utilized with elements of one or more elements of downhole device **216** to provide reagent **333** to one or

more elements of downhole device **216**. In an exemplary embodiment, the features of bottom sub **330**, including upper face **344** and lower face **336** can be configured to interface with one or more elements of downhole device **216**.

[0020] In an exemplary embodiment, bottom sub is generally formed from substrate **331**. In an exemplary embodiment, substrate **331** is a degradable material. Advantageously, by forming one or more elements of downhole device **216** from a degradable material, a downhole device **216** may be remain resident downhole for a desired period of time, and then may be disintegrated to allow further operations without any obstructions. In an exemplary embodiment, substrate **331** and consequently bottom sub **330** can degrade at a first rate in response to conditions found in a downhole environment.

[0021] In certain embodiments, substrate **331** is formed from a corrodible metal such as a controlled electrolytic metallic, including but not limited to Intallic. Substrate **331** materials may include: a magnesium alloy, a magnesium silicon alloy, a magnesium aluminum alloy, a magnesium zinc alloy, a magnesium manganese alloy, a magnesium aluminum zinc alloy, a magnesium aluminum manganese alloy, a magnesium zinc zirconium alloy, and a magnesium rare earth element alloy. Rare earth elements may include, but is not limited to scandium, yttrium, lanthanum, cerium, praseodymium, neodymium, and erbium. In certain embodiments, substrate materials **331** are further coated with aluminum, nickel, iron, tungsten, copper, cobalt. In certain embodiments, substrate **331** materials are consolidated and forged. In certain embodiments, the elements can be formed into a powder and a substrate can be formed from pressed powder. In an exemplary embodiment, the material of substrate **331** is selected based on desired degradation characteristics of one or more elements of downhole device **216**.

[0022] In an exemplary embodiment, bottom sub **330** includes at least one cavity **332**. Cavities **332**, also referred to as pockets, can be of any shape, any number and disposed anywhere along elements of downhole device **216**. In an exemplary embodiment, cavities **332** can be disposed in non-integral portions of bottom sub **330**, such as non-load bearing portions. In certain embodiments, cavities **332** are not utilized in high stress areas to avoid unintentional or uncontrolled release of reagent **333**. In an exemplary embodiment, cavities **332** are sealed to control the release and interaction of reagent **333** with the downhole environment and substrate **331**.

[0023] In an exemplary embodiment, cavities **332** contain reagent **333**. Advantageously, reagent **333** is conveyed with one or more elements of downhole device **216** to allow reagent **333** to be released without additional operations. In an exemplary

embodiment, reagents **333** include, but are not limited to acidic oxides, acidic salts, neutral salts, and basic salts. Acidic oxides can include, but are not limited to sulfur dioxide, sulfur trioxide, chromium trioxide, phosphorus pentoxide, etc. Acidic salts can include, but are not limited to ammonium chloride, monosodium phosphate, sodium bisulfate, etc. Neutral salts can include, but are not limited to sodium chloride, sodium bromide, potassium chloride, potassium bromide, calcium chloride, calcium bromide, etc. Basic salts can include, but are not limited to sodium carbonate, sodium bicarbonate, etc. Any suitable reagent **333** can be selected in response to substrate **331** material, downhole environment conditions, and desired degradation rate.

[0024] In an exemplary embodiment, reagent **333** is stored as a solid. Advantageously, stored solid reagent **333** allows for high concentration levels of reagent **333** without unintentionally degrading substrate **331**. In certain embodiments, reagent **333** can be a gel substance, including, but not limited to a gelled acid. In other embodiments, reagent **333** can be a liquid.

[0025] In an exemplary embodiment, after a desired time in a downhole environment, substrate **331** of bottom sub **330** degrades at a first rate. As substrate **331** degrades, cavities **332** formed therein are exposed to the downhole environment. Accordingly, reagent **333** resident in cavities **332** are exposed to the fluids and conditions of the downhole environment. In an exemplary embodiment, reagent **333** mixes with fluids within the downhole environment to form an electrolytic fluid. In an exemplary embodiment, the resulting electrolytic fluid degrades substrate **331** at a second rate. In certain embodiments, the substrate **331** exposed to the electrolytic fluid formed from reagent **333** can degrade at a second rate 2 to 1000 times faster than substrate **331** degrading exposed to a downhole environment alone.

[0026] In certain embodiments, cavities **332** can include a protective material **338**. Protective material **338** can be a degradable material that degrades at a different rate than substrate **331** to control the mixing and release of reagent **333** and further prevent undesired release of reagent **333**. In certain embodiments, protective material **338** can cover portions of cavity **332**, all of cavity **332**, or portions or all of reagent **333**. Protective material **338** can include, but is not limited to polyurethane, Teflon, etc. In certain embodiments, protective material **338** can include a gel with a controlled or otherwise predetermined degradation. In certain embodiments, protective material **338** can include enteric coatings that are stable at low pH levels but can quickly degrade in neutral or alkaline environments.

[0027] FIG. 4 shows an exemplary embodiment of wedge 424. Similarly, wedge 424 can include cavities 432 with reagent 433. Similarly, cavities 432 can be disposed in non-integral portions of wedge 424 such as non-load bearing portions. In certain embodiments, the cavities 432 are lined with protective lining 438. In an exemplary embodiment, wedge 424 is formed of degradable substrate 431, having an upper face 440 and a lower face 442.

[0028] Therefore, in one aspect, a downhole device for use in a downhole environment is disclosed, including: a first material that degrades at a first rate when exposed to the downhole environment, and a second material protected from the downhole environment, wherein the second material when exposed to the downhole environment degrades the first material at a second rate greater than the first rate. In certain embodiments, a cavity is formed in the first material, wherein the cavity contains the second material. In certain embodiments, the second material is a solid second material. In certain embodiments, the second material is a gel second material. In certain embodiments the downhole device further includes a protective material to control exposure of the second material to the downhole environment. In certain embodiments, the protective material is formed of at least one of a group consisting of: Teflon and polyurethane. In certain embodiments, the second material is formed of at least one of a group consisting of: acidic oxides, acidic salts, neutral salts, and basic salts. In certain embodiments, the at least one cavity is disposed in a non-load bearing portion of the first material. In certain embodiments, the at least one cavity is disposed in a non-integral portion of the first material. In certain embodiments, the downhole device is a bottom sub. In certain embodiments, the downhole device is a cone.

[0029] In another aspect, a method to degrade a downhole device in a downhole environment, is disclosed, including: providing a first material in the downhole environment; providing a second material protected from the downhole environment; degrading the first material at a first rate in response to exposure to the downhole environment; exposing the second material to the downhole environment and the first material; and degrading the first material at a second rate in response to exposure to the downhole environment and the second material, wherein the second rate is greater than the first rate. In certain embodiments, the method further includes forming a cavity in the first material; and providing the second material within the cavity. In certain embodiments, the second material is a solid second material. In certain embodiments, the second material is a gel second material. In certain embodiments, the method further includes controlling exposure of the second material to the downhole environment via a protective material. In

certain embodiments, the downhole device is a bottom sub. In certain embodiments, the downhole device is a cone.

[0030] In another aspect, a downhole system for use in a downhole environment, is disclosed, including a casing string; and a downhole device associated with the casing string, including a first material that degrades at a first rate when exposed to the downhole environment, and a second material protected from the downhole environment, wherein the second material when exposed to the downhole environment degrades the first material at a second rate greater than the first rate. In certain embodiments, a cavity is formed in the first material, wherein the cavity contains the second material.

[0031] The foregoing disclosure is directed to certain specific embodiments for ease of explanation. Various changes and modifications to such embodiments, however, will be apparent to those skilled in the art. It is intended that all such changes and modifications within the scope and spirit of the appended claims be embraced by the disclosure herein.

CLAIMS

1. A downhole device for use in a downhole environment, characterized by:
a first material that degrades at a first rate when exposed to the downhole environment; and
a second material protected from the downhole environment, wherein the second material when exposed to the downhole environment degrades the first material at a second rate greater than the first rate.
2. The downhole device of claim 1, wherein the second material is placed in at least one cavity formed in the first material.
3. The downhole device of claim 1 or 2, wherein the second material is one of: a solid material; and a gel.
4. The downhole device of any of the claims 1-3, further characterized by a protective material that controls exposure of the second material to the downhole environment.
5. The downhole device of claim 4, wherein the protective material is Teflon or polyurethane.
6. The downhole device of claim 4, wherein the second material is selected from a group consisting of: an acidic oxide; an acidic salt, a neutral salt, and a basic salt.
7. The downhole device of any of the claims 2-6, wherein the at least one cavity is disposed in a non-load bearing portion of the first material.
8. The downhole device of any of the claims 2-6, wherein the cavity is disposed in a non-integral portion of the first material.
9. The downhole device of any of the claims 1-8, wherein the downhole device is a bottom sub or a cone.
10. A method to degrade a downhole device in a downhole environment, comprising:
providing a first material in the downhole environment;
providing a second material protected from the downhole environment;
degrading the first material at a first rate in response to exposure to the downhole environment;
exposing the second material to the downhole environment and the first material; and
degrading the first material at a second rate in response to exposure to the downhole environment and the second material, wherein the second rate is greater than the first rate.
11. The method of claim 10, further comprising:
forming a cavity in the first material; and
providing the second material within the cavity.

12. The method of claim 10 or 11, wherein the second material is a solid material or a gel.

13. The method of any of the claims 10-12, further characterized by controlling exposure of the second material to the downhole environment via a protective material.

14. The method of any of the claims 10-13, wherein the downhole device is one of bottom sub; and a cone.

15. A downhole system having a casing string for use in a downhole environment, characterized by:

a downhole device associated with the casing string that includes:

a first material that degrades at a first rate when exposed to the downhole environment; and

a second material protected from the downhole environment and placed in a cavity in the first material when exposed to the downhole environment degrades the first material at a second rate greater than the first rate.

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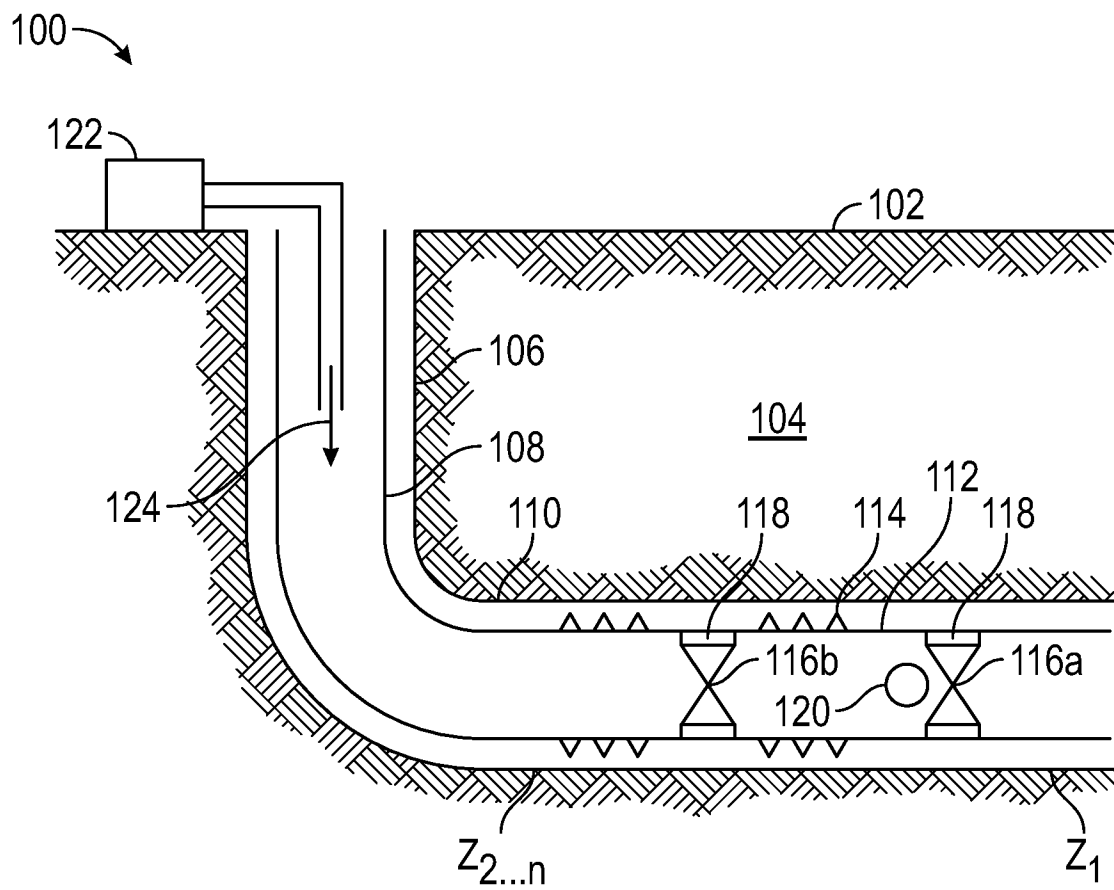


FIG. 1

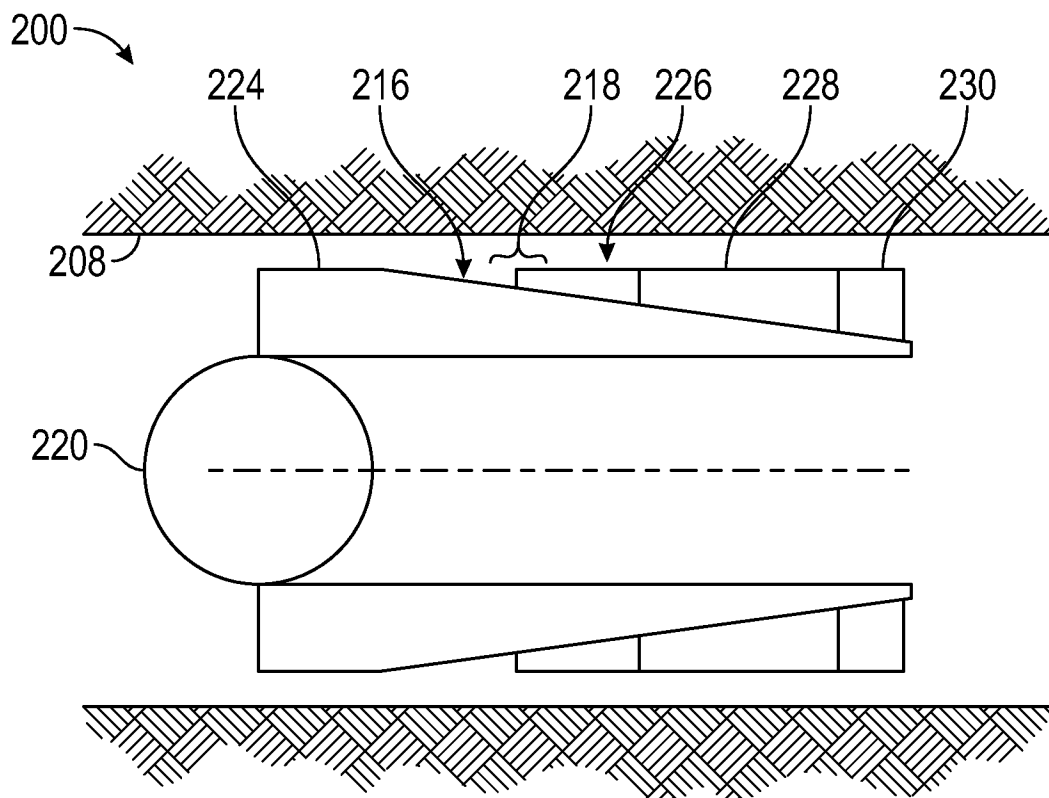


FIG. 2

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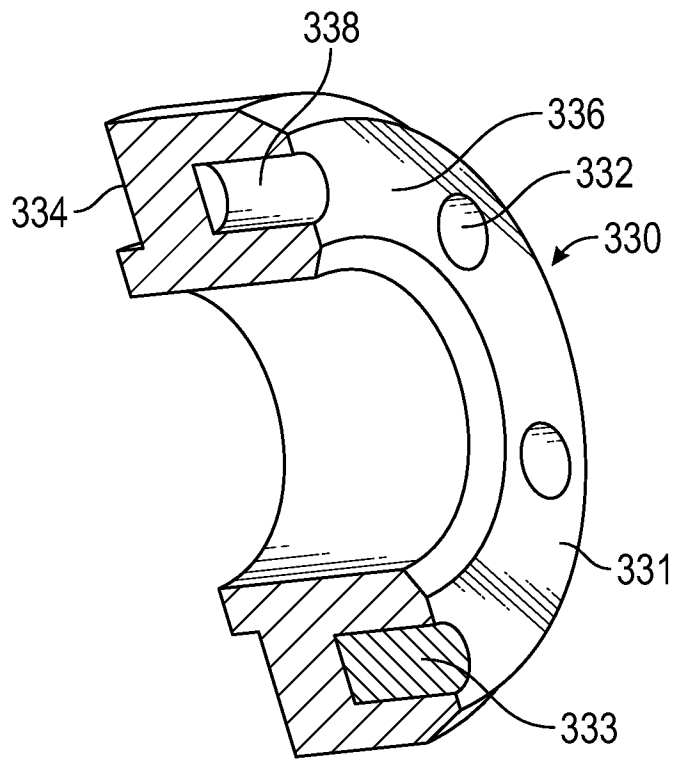


FIG. 3

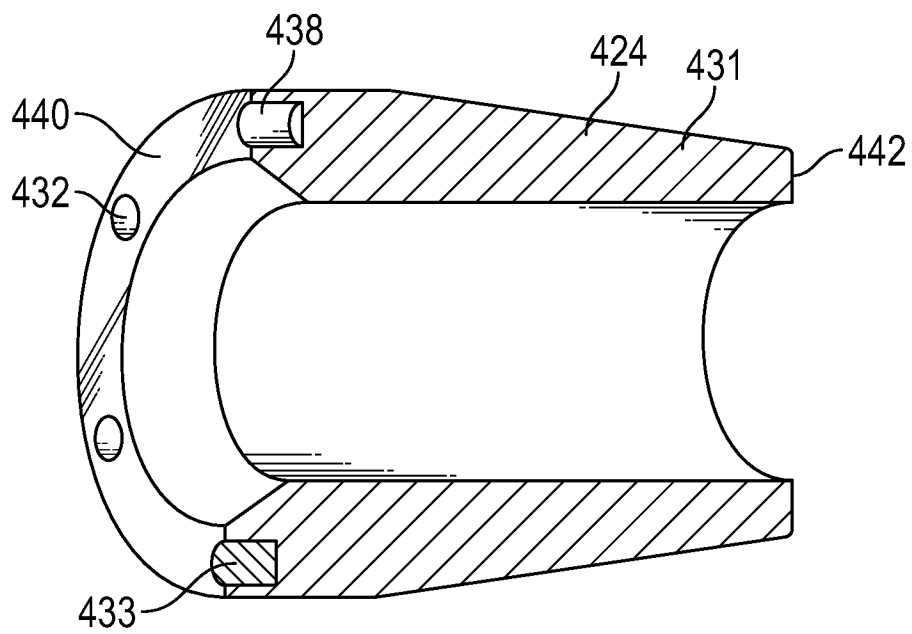


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/034581**A. CLASSIFICATION OF SUBJECT MATTER****E21B 33/12(2006.01)I, E21B 43/17(2006.01)I, E21B 43/25(2006.01)I, E21B 23/06(2006.01)I**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

E21B 33/12; E21B 34/06; E21B 19/10; E21B 41/00; E21B 29/00; E21B 23/00; E21B 43/17; E21B 43/25; E21B 23/06

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: downhole device, degrading, dissolve, bottom sub, reagent, degradable material, exposure, downhole environment and rapid

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2007-0107908 A1 (VAIDYA et al.) 17 May 2007 See paragraphs [0006], [0008], [0016], [0028], [0075]-[0077] and figures 6, 9.	1-15
A	US 2010-0294510 A1 (HOLMES, KEVIN C.) 25 November 2010 See abstract; paragraphs [0013]-[0023]; and figures 1-5.	1-15
A	US 2013-0327545 A1 (MARYA et al.) 12 December 2013 See abstract; paragraphs [0030]-[0035]; and figures 1-3.	1-15
A	US 2012-0292053 A1 (XU et al.) 22 November 2012 See paragraphs [0019]-[0025] and figures 1-3.	1-15
A	US 2014-0190705 A1 (HALLIBURTON ENERGY SERVICES, INC.) 10 July 2014 See paragraphs [0022]-[0025] and figure 1.	1-15



Further documents are listed in the continuation of Box C.



See patent family annex.

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"A" document defining the general state of the art which is not considered to be of particular relevance

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"&" document member of the same patent family

Date of the actual completion of the international search

31 August 2016 (31.08.2016)

Date of mailing of the international search report

02 September 2016 (02.09.2016)

Name and mailing address of the ISA/KR

International Application Division

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2016/034581

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2007-0107908 A1	17/05/2007	CA 2559111 A1 CA 2559111 C GB 2432377 A GB 2432377 B US 8231947 B2	16/05/2007 04/02/2014 23/05/2007 18/06/2008 31/07/2012
US 2010-0294510 A1	25/11/2010	AU 2010-249969 A1 AU 2010-249969 B2 BR P11011062 A2 CA 2762070 A1 CA 2762070 C GB 2482621 A GB 2482621 B US 8413727 B2 WO 2010-135115 A2 WO 2010-135115 A3	25/11/2010 30/04/2015 05/04/2016 25/11/2010 18/02/2014 08/02/2012 02/10/2013 09/04/2013 25/11/2010 24/03/2011
US 2013-0327545 A1	12/12/2013	US 9309742 B2 WO 2013-188126 A1	12/04/2016 19/12/2013
US 2012-0292053 A1	22/11/2012	AU 2012-256344 A1 CA 2834715 A1 CA 2834715 C CN 103547766 A US 8695714 B2 WO 2012-158261 A1	14/11/2013 22/11/2012 15/12/2015 29/01/2014 15/04/2014 22/11/2012
US 2014-0190705 A1	10/07/2014	AU 2014-385213 A1 WO 2015-134074 A1	11/09/2015 11/09/2015