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(54) WELLBORE TREATMENT SYSTEM

BOHRLOCHBEHANDLUNGSSYSTEM

SYSTÈME DE TRAITEMENT DE PUITS DE FORAGE

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Description

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of, and claims priority to and the benefit of, U.S. Provisional Application Serial No. 62/296,308, filed February 17, 2016.

BACKGROUND OF THE INVENTION

1. Field of Invention

[0002] The present disclosure relates in general to a system and method of treating a subterranean wellbore. More specifically, the present disclosure relates to coupling a well treatment substance with energetic material and reacting the energetic material within a wellbore.

2. Description of Prior Art

[0003] Perforating systems are used for the purpose, among others, of making hydraulic communication passages, called perforations, in wellbores drilled through earth formations so that predetermined zones of the earth formations can be hydraulically connected to the wellbore. Perforations are needed because wellbores are typically lined with a string of casing and cement is generally pumped into the annular space between the wellbore wall and the casing. Reasons for cementing the casing against the wellbore wall includes retaining the casing in the wellbore and hydraulically isolating various earth formations penetrated by the wellbore. Sometimes an inner casing string is included that is circumscribed by the casing. Without the perforations oil/gas from the formation surrounding the wellbore cannot make its way to production tubing inserted into the wellbore within the casing.

[0004] Perforating systems typically include one or more perforating guns connected together in series to form a perforating gun string, which can sometimes surpass a thousand feet of perforating length. The gun strings are usually lowered into a wellbore on a wireline or tubing, where the individual perforating guns are generally coupled together by connector subs. Included with the perforating gun are shaped charges that typically include a housing, a liner, and a quantity of high explosive inserted between the liner and the housing. Different kinds of perforating guns are disclosed for example in US2013192829 and WO2016022111. When the high explosive is detonated, the force of the detonation collapses the liner and ejects it from one end of the charge at very high velocity in a pattern called a jet that perforates the casing and the cement and creates a perforation that extends into the surrounding formation. Each shaped charge is typically attached to a detonation cord that runs axially within each of the guns. Wellbore perforating sometimes is typically followed by hydraulic fracturing in order to promote production from the surrounding formation. The extreme pressures generated by the perforating jet often crush and compacts the reservoir rock around each of the perforations; which typically impedes inflow or injection to and from the reservoir. Moreover, the crushed zone can reduce the effective permeability of the reservoir rock by up to 75%. Acid is sometimes used to break down this crushed and compacted rock, and is usually pumped from surface and injected into the perforations.

SUMMARY OF THE INVENTION

[0005] Described herein is a method and system for wellbore operations according to claims 1 and 10. One example method includes deploying a downhole tool in the wellbore, where the downhole tool includes an additive casting made up of an energetic material and a crystalline anhydrous acid. The downhole tool is positioned adjacent an opening formed in a sidewall of the wellbore, and a reaction of the energetic material is caused to generate an expanding gas that drives the crystalline anhydrous acid into the opening thereby increasing a flow of hydrocarbons through the opening. The downhole tool can further include an explosive, and wherein the step of causing a reaction of the energetic material involves initiating detonation of the explosive so that detonation products of the explosive contact the energetic material at a temperature to initiate reaction of the energetic material. In an alternative, the energetic material is activated concurrent with forming perforations in a sidewall of the wellbore, so that the treatment substance is forced into the perforations by expanding gases created by activation of the energetic material. One embodiment of the downhole tool includes a perforating gun, and wherein the explosive comprises high explosive disposed in a plurality of shaped charges that are set radially inward from the additive casting, so that when high explosive in the shaped charges are detonated, detonation products are generated from detonation of the high explosive that contact the energetic material at a temperature to initiate reaction of the energetic material. In this example, detonation of the shaped charges form perforations in a sidewall of the wellbore, wherein a plurality of openings are formed in the sidewall of the wellbore, and wherein the perforations define the openings In an alternative, the additive casting is formed into an annular member that circumscribes a portion of the tool. In an optional embodiment, the additive casting is formed into a planar member and disposed inside a body of the tool. The acid optionally dissolves rock inside of the opening. The energetic material can be a propellant.

[0006] Also disclosed herein is an example of a downhole tool for use in operations in a wellbore and that is made up of a housing, explosive in the housing and that is strategically oriented, so that when the explosive is detonated, detonation products are formed that travel along a designated path, and an additive casting that is intersected by the designated path, the additive casting

formed from a solid matrix of a settable material, and an energetic material, and where a wellbore treatment material is embedded within the settable material, so that when a reaction in the energetic material is initiated in the wellbore, the wellbore treatment material is released into the wellbore. The wellbore treatment fluid can be an anhydrous crystalline acid that is reactive with rock that is intersected by a downhole perforation. In an alternative, the energetic material includes a substance that produces energy or pressurized gas when reacted and is selected from the group consisting of a propellant, an oxidizer, ammonium perchlorate, potassium perchlorate, and combinations thereof. An example of the housing is a perforating gun body, wherein the explosive comprises a high explosive within a shaped charge, and wherein detonating the high explosive forms openings in a sidewall of the wellbore. One embodiment of the additive casting is an annular member coupled with the housing. The downhole tool can further include a controller in communication with the explosive.

[0007] Another method of wellbore operations includes disposing an additive casting in the wellbore, the additive casting formed from an energetic material and wellbore treatment material combined in a solid matrix, and introducing the wellbore treatment material into an opening in a sidewall of the wellbore by initiating a reaction of the energetic material that releases the wellbore treatment material from the matrix, and generates a gas that drives the wellbore treatment material into the opening. The method can further include forming the opening by detonating a shaped charge downhole that is oriented to the sidewall. In one alternative, the additive casting is disposed in a path of detonation product discharged from the shaped charge, and wherein the detonation product is at a temperature that initiates the reaction of the energetic material. An example exists where the wellbore treatment material is a crystalline anhydrous acid that when in the wellbore reconstitutes as a liquid and reacts with rock inside of the opening. An example of the reactive material is a propellant.

BRIEF DESCRIPTION OF DRAWINGS

[0008] Some of the features and benefits of the present invention having been stated, others will become apparent as the description proceeds when taken in conjunction with the accompanying drawings, in which:

Figure 1 is a partial side sectional view of an example of a wellbore treatment system for use in treating a wellbore.

Figure 1A is a side sectional view of an example of a shaped charge for use with the wellbore treatment system of Figure 1.

Figure 2 is a partial side sectional view of the wellbore treatment system forming perforations in the wellbore of Figure 1 and releasing a treatment fluid into the wellbore and the perforations.

Figure 3 is side partial sectional view of an alternate example of a wellbore treatment system for use in treating a wellbore.

Figure 4 is side partial sectional view of another alternate example of a wellbore treatment system for use in treating a wellbore.

[0009] While the invention will be described in connection with the preferred embodiments, it will be understood that it is not intended to limit the invention to that embodiment.

DETAILED DESCRIPTION OF INVENTION

[0010] The method and system of the present disclosure will now be described more fully hereinafter with reference to the accompanying drawings in which embodiments are shown. The method and system of the present disclosure may be in many different forms and should not be construed as limited to the illustrated embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey its scope to those skilled in the art. Like numbers refer to like elements throughout. In an embodiment, usage of the term "about" includes +/- 5% of the cited magnitude. In an embodiment, usage of the term "substantially" includes +/- 5% of the cited magnitude.

[0011] It is to be further understood that the scope of the present disclosure is not limited to the exact details of construction, operation, exact materials, or embodiments shown and described, as modifications and equivalents will be apparent to one skilled in the art. In the drawings and specification, there have been disclosed illustrative embodiments and, although specific terms are employed, they are used in a generic and descriptive sense only and not for the purpose of limitation.

[0012] An example of a well treatment system 10 is shown in a partial side sectional view in Figure 1. Here the system 10 is used for treating a wellbore 12 that intersects a formation 14. Wellbore 12 is lined with casing 16 which forms a barrier between formation 14 and inside of wellbore 12. Included with the example of the wellbore treatment system 10 is a perforating string 18 shown made up of a string of perforating guns 20_1-20_n, optional connector subs 22_1, 22_2 couple together adjacent guns 20_1-20_n. The guns 20_1-20_n of the illustrated embodiment include elongate gun bodies 24_1-24_n that have a generally curved outer surface and resemble a cylindrical shape. Charge tubes 26_1-26_n are depicted disposed within each of the gun bodies 24_1-24_n. Further in the example of Figure 1, shaped charges 28 are shown mounted within the charge tubes 26_1-26_n. Shown in a side sectional view in Figure 1A is an embodiment of a shaped charge 28, and which includes a case C, a liner L set in the case C, and high explosive HE between the case C and liner L. A detonating cord 29 extends within the perforating string 18 (Figure 1) and along a path that runs

adjacent a booster charge BC in each of the shaped charges 28. Initiating detonation of the detonating cord 29 forms a detonation wave that travels along a length of the detonation cord 29 and transfers to the booster charges to detonate the high explosive in the shaped charges 28. Example high explosives HE include compositions sold under trade designations HMX, HNS, RDX, PYX and TNAZ.

[0013] Further provided with the example well treatment system 10 of Figure 1 are examples of additive castings 30_1-30_n shown as annular members that encompass outer surfaces of the perforating gun bodies 24_1-24_n. A wireline 32 is shown mounted to an upper end of a perforating string 18 and is used for raising and lowering perforating string 18 within wellbore 12. Additionally, wireline 32 can provide a communication means between perforating string 18 and a surface truck 33 shown mounted on surface 34 and outside of the wellbore 12. In one alternative, a controller 35 is included, such as in surface truck 33, and that is in selective communication with wireline 32 for controlling operation of perforating string 18. In an optional embodiment, wireline 32 couples to a motorized reel (not shown) for raising/lowering wireline 32 in wellbore 12. In an example motorized reel mounts to surface truck 33. In a non-limiting example of operation, perforating string 18 communicates to surface truck 33 and/or controller 35 via wireline 32. Optionally, other means of conveying and signaling perforating string 18 may be employed, such as coiled tubing, cables, slick line, and the like.

[0014] Figure 2 shows in a side partial sectional view an example of the shaped charges 28 of Figure 1 having been detonated, such as from a signal via wireline 32 from surface truck 33 or controller 35, and which have formed perforations 36 that project radially out from the wellbore 12, through the casing 16, and into the formation 14. Openings 38 in the sidewall of each of the gun bodies 24_1-24_n are also formed by detonating the shaped charges 28. Referring back to Figure 1, in an example the additive castings 30_1-30_n are substantially solid members whose constituents include an energetic material and a treatment substance. Examples of the energetic material include any substance that produces energy or pressurized gas when reacted, such as a propellant, oxidizers, ammonium perchlorate, potassium perchlorate, any other reactive material, and combinations thereof. Examples of the treatment substance include anything used for treating the wellbore 12, such as an acid, crystalline acids, anhydrous acids, crystalline anhydrous acids, brine, a surfactant, a salt, a polysaccharide, corrosion inhibitors, and combinations thereof. Some examples of suitable crystalline anhydrous acids and salts that produce acids when dissolved include, but are not intended to be limited to, acetic anhydride, citric acid anhydride, sulfamic acid anhydride, benzoic acid, benzoic acid flakes, hydrochloric acid, hydrofluoric acid, phthalic acid, phthalic anhydride, terephthalic acid, terephthalic anhydride, sulfuric acid anhydride, polylactic acid, boric acid, ammonium bifluoride, potassium bifluoride, ethylenediaminetetraacetic acid, lactic acid, along with combinations and mixtures thereof. In an alternative, the treatment substance is encapsulated in a shell (not shown) that dissolves/degrades when exposed to conditions/fluids downhole. Examples exist wherein the treatment substances dissolve in connate fluid, water based drilling fluids, oil based drilling fluids, and combinations thereof.

[0015] In a non-limiting example of operation, the shaped charges 28 of Figure 1 are oriented so that when explosives within the shaped charges 28 are detonated, detonation products generated by the detonation are directed towards the additive casting 30_1-30_n. An example of the detonation products includes gas at high pressure and or temperature that initiate a corresponding reaction of the energetic material in the additive casting 30_1-30_n. Reacting the energetic material releases the treatment substance from the additive casting 30_1-30_n. and into the wellbore 12. In the example of Figure 2, the treatment substance takes the form of a treatment fluid 40 when released from the castings 30_1-30_n. The treatment fluid 40 is shown in wellbore 12 and entering perforations 36. In one non limiting example, a crystalline acid, such as an anhydrous crystalline acid, was bound to an energetic gas generating material, such as potassium perchlorate and then molded to from castings 30_1-30_n and combined with the perforating gun bodies 24_1-24_n. As the propellant in the castings 30_1-30_n reacts to the detonation of the shaped charges 28, energy is generated, that in an example includes high velocity gases, that carries or urges the crystalline acid into the perforations 36, and where the acid begins to react with the crushed and compacted rock that surrounds the perforations 36. Depending on the acid blend, calcareous components of the crushed rock are dissolved, as well as the matrix itself. This results in a removal of the crushed and compacted rock, which reduces the overall formation skin. Optionally, a fuel, such as a plastic resin, can be used in combination with the energetic gas generating materials to enhance reaction of the propellant. Examples of the reaction of the propellant include combustion, burning, ignition, and detonation. Alternatively, the charge tubes 26_1-26_n could be formed from the cast material of the propellants/energetic material in the additive substance. Optionally, the combination of cast energetic material and treatment substance can be positioned within the gun bodies 24_1-24_n in any shape or form. The treatment method described herein can be performed with or without packers (not shown).

[0016] Figure 3 shows an alternate example of a well treatment system 10A where the perforating string 18A is disposed in wellbore 12 and shown having additive castings $30A_1$-$30A_n$ disposed within the annular gun bodies $24A_1$-$24A_n$. In this example, the additive castings $30A_1$-$30A_n$ are disk like members and placed adjacent the shaped charges 28A disposed within the gun bodies $24A_1$-$24A_n$. The operational sequence of the embodiment of the well treatment system 10A of Figure 3 is much

the same as that of the system 10 of Figure 1, that is detonation of the shaped charges $24A_1$-$24A_n$ in turn causes initiation of a reaction of the additive castings $30A_1$-$30A_n$, thereby releasing a treatment substance into the wellbore 12. However, other means of initiation reaction of the energetic material can be employed, such as electricity (*i.e.* via wireline 32) or from a detonation wave from detonation cord 29A in the perforating string 18A.

[0017] Another alternate example of a well treatment system 10B is shown in a side partial sectional view in Figure 4. In this example, the additive casting 30B is an elongate cylindrical member disposed on an end of wireline 32 and set within wellbore 12. Here, perforations 36 have already been formed within the formation 14. In this example, a signal from the surface truck 33 via wireline 32 makes it way to the additive casting 30B to initiate a reaction of the energetic material making up the casting 30B, and thereby releasing the treatment substance into the wellbore 12 and into perforations 36.

[0018] In one non-limiting example of forming an additive casting 30, the energetic material is bound to a settable material, combined with a wellbore treatment material, and then molded into a desired shape, such as the annular shape of the additive casting 30 of Figure 1. Example settable materials include thermosetting polymers, resins, thermosetting resins, acrylic resins, polyesters, vinyl esters, epoxy, polyurethane, phenolic resins, amino resins, furan resins, any other material that is moldable and then hardens, and combinations thereof. An alternate embodiment of forming the casting 30 includes mixing a liquid-form resin with a powdered composition of crystalline acid and a propellant, and molding the mixture into a disk or other shape. The propellant/acid disk is then placed adjacent to conventional shaped charges within a perforating gun assembly. Alternatively, the propellant/acid combination is cast as a cylinder (casting 30B of Figure 4) and conveyed downhole to treat a previously perforated wellbore. In this example, reaction of the propellant is initiated by means other than a shaped charge, such as by a detonating cord or other suitable initiator. Other components, such as wellbore treatment materials, which include acids, anhydrous acids, crystalline acids, and anhydrous crystalline acids, are optionally blended into the mixture of the energetic material and resin. Thus the gas generated by an oxidation process of the energetic material urges the acid into the perforations 36, and the energetic material is a conveyance or delivery method rather than a stimulation tool. In one alternate embodiment, the acid/energetic material composition is cast into tubes and placed inside perforation gun bodies 24_1-24_n (Figure 1).

[0019] One example propellant for use in the casings described above includes potassium perchlorate. In this example, detonating a perforating gun generates extreme pressure and heat that ignite the propellant material. As the propellant material combusts or burns a high-velocity gas is generated which carries the crystalline acid into the perforations. Inside the perforations the acid reconstitutes as a liquid acid that reacts with the crushed and compacted rock surrounding the perforation tunnels. Depending upon the type or blend of crystalline acid, the calcareous components of the crushed rock can be dissolved or the rock matrix itself can be removed. This eventually leads to the removal of crushed and compacted rock, thereby improving hydraulic communication between the formation 14 and wellbore 12 through the perforations 36 (Figure 2). A significant advantage realized by the present disclosure is that costly equipment for pumping wellbore treatment fluids downhole is not required. Another advantage is that the amount of wellbore treatment fluids or material can be greatly reduced as well as an excessive amount of wellbore treatment fluid is consumed when being pumped downhole. Typical acidizing treatment operations require many hundreds of liters of acid, whereas implementation of the presently disclosed technique is expected to require only grams of treatment substance.

[0020] The present invention described herein, therefore, is well adapted to carry out the objects and attain the ends and advantages mentioned, as well as others inherent therein. While a presently preferred embodiment of the invention has been given for purposes of disclosure, numerous changes exist in the details of procedures for accomplishing the desired results. For example, in an embodiment, additive castings 30_1-30_n of Figure 1 are inserted within the gun bodies 24_1-24_n. In another alternative, charge tubes 26_1-26_n are formed from the same material as 30_1-30_n. These and other similar modifications will readily suggest themselves to those skilled in the art, and are intended to be encompassed within the scope of the present invention as defined in the appended claims.

Claims

1. A method of operations in a wellbore (12) comprising:

   deploying a downhole tool in the wellbore (12), the downhole tool comprising an additive casting (30_1-30_n, $30A_1$-$30A_n$, 30B) that comprises an energetic material and a crystalline anhydrous acid blended together with a resin;
   positioning the downhole tool at a designated depth in the wellbore (12); and
   causing a reaction of the energetic material to generate energy that drives the crystalline anhydrous acid into an opening formed in a sidewall of the wellbore (12) thereby increasing a flow of hydrocarbons through the opening.

2. The method of Claim 1, wherein the downhole tool further comprises an explosive, and wherein the step of causing a reaction of the energetic material com-

prises initiating detonation of the explosive so that detonation products of the explosive contact the energetic material at a temperature to initiate reaction of the energetic material.

3. The method of Claim 1, wherein the energy is from expanding gas produced by the reaction of the energetic material, and wherein the energetic material is reacted concurrent with forming perforations (36) in a sidewall of the wellbore (12), so that the treatment substance is forced into the perforations (36) by the expanding gas.

4. The method of Claim 3, wherein the downhole tool comprises a perforating gun, and wherein the explosive comprises high explosive disposed in a plurality of shaped charges (28, 28A) that are set radially inward from the additive casting, so that when high explosive in the shaped charges are detonated, detonation products are generated from detonation of the high explosive that contact the energetic material at a temperature to initiate reaction of the energetic material.

5. The method of Claim 4, wherein detonation of the shaped charges (28, 28A) form perforations (36) in a sidewall of the wellbore (12), wherein a plurality of openings are formed in the sidewall of the wellbore (12), and wherein the perforations (36) define the openings.

6. The method of Claim 1, wherein the additive casting is formed into an annular member that circumscribes a portion of the tool.

7. The method of Claim 1, wherein the additive casting is formed into a planar member and disposed inside a body of the tool.

8. The method of Claim 1, wherein the acid dissolves rock inside of the opening.

9. The method of Claim 1, wherein the energetic material comprises a propellant.

10. A downhole tool for use in operations in a wellbore (12) comprising:

a housing;
explosive in the housing and that is oriented, so that when the explosive is detonated, detonation products are formed that travel along a designated path; and
an additive casting (30_1-30_n, $30A_1$-$30A_n$, 30B) that is intersected by the designated path, the additive casting (30_1-30_n, $30A_1$-$30A_n$, 30B) comprising a solid matrix of a settable material, an energetic material and a crystalline anhydrous acid embedded within a resin so that when a reaction in the energetic material is initiated in the wellbore (12), the crystalline anhydrous acid is released into the wellbore (12).

11. The downhole tool of Claim 10, wherein the wellbore treatment material comprises an anhydrous crystalline acid that is reactive with rock that is intersected by a downhole perforation (36).

12. The downhole tool of Claim 10, wherein the energetic material comprises a substance that produces energy or pressurized gas when reacted and is selected from the group consisting of a propellant, an oxidizer, ammonium perchlorate, potassium perchlorate, and combinations thereof.

13. The downhole tool of Claim 10, wherein the housing comprises a perforating gun body, wherein the explosive comprises a high explosive within a shaped charge, and wherein detonating the high explosive forms openings in a sidewall of the wellbore (12).

14. The downhole tool of Claim 13, wherein the additive casting comprises an annular member coupled with the housing.

15. The downhole tool of Claim 10, further comprising a controller (35) in communication with the explosive.

Patentansprüche

1. Verfahren von Vorgängen in einem Bohrloch (12), umfassend:

Einsetzen eines Bohrlochwerkzeugs in das Bohrloch (12), wobei das Bohrlochwerkzeug ein additives Gussteil (30_1-30_n, $30A_1$-$30A_n$, 30B) umfasst, das ein energetisches Material und eine kristalline wasserfreie Säure umfasst, die mit einem Harz vermischt sind;
Positionieren des Bohrlochwerkzeugs in einer vorgesehenen Tiefe in dem Bohrloch (12); und
Bewirken einer Reaktion des energetischen Materials, um Energie zu erzeugen, welche die kristalline wasserfreie Säure in eine Öffnung treibt, die in einer Seitenwand des Bohrlochs (12) gebildet ist, wodurch ein Fluss von Kohlenwasserstoffen durch die Öffnung erhöht wird.

2. Verfahren nach Anspruch 1, wobei das Bohrlochwerkzeug ferner einen Sprengstoff umfasst und wobei der Schritt des Auslösens einer Reaktion des energetischen Materials das Einleiten der Detonation des Sprengstoffs umfasst, so dass Detonationsprodukte des Sprengstoffs mit dem energetischen Material bei einer Temperatur in Kontakt kommen, um

die Reaktion des energetischen Materials einzuleiten.

3. Verfahren nach Anspruch 1, wobei die Energie von expandierendem Gas stammt, das durch die Reaktion des energetischen Materials erzeugt wird, und wobei das energetische Material gleichzeitig mit dem Bilden von Perforationen (36) in einer Seitenwand des Bohrlochs (12) umgesetzt wird, so dass die Behandlungssubstanz durch das expandierende Gas in die Perforationen (36) gedrückt wird.

4. Verfahren nach Anspruch 3, wobei das Bohrlochwerkzeug eine Perforationskanone umfasst und wobei der Sprengstoff hochexplosiven Sprengstoff umfasst, der in einer Vielzahl von Hohlladungen (28, 28A) angeordnet ist, die von dem additiven Gussteil radial nach innen gesetzt sind, so dass, wenn hochexplosiver Sprengstoff in den Hohlladungen detoniert, Detonationsprodukte aus der Detonation des hochexplosiven Sprengstoffs erzeugt werden, die mit dem energetischen Material bei einer Temperatur in Kontakt kommen, um die Reaktion des energetischen Materials einzuleiten.

5. Verfahren nach Anspruch 4, wobei die Detonation der Hohlladungen (28, 28A) Perforationen (36) in einer Seitenwand des Bohrlochs (12) bildet, wobei eine Vielzahl von Öffnungen in der Seitenwand des Bohrlochs (12) gebildet wird und wobei die Perforationen (36) die Öffnungen definieren.

6. Verfahren nach Anspruch 1, wobei das additive Gussteil zu einem ringförmigen Element geformt wird, das einen Abschnitt des Werkzeugs umschreibt.

7. Verfahren nach Anspruch 1, wobei das additive Gussteil in ein planares Element geformt und innerhalb eines Körpers des Werkzeugs angeordnet wird.

8. Verfahren nach Anspruch 1, wobei die Säure Gestein innerhalb der Öffnung auflöst.

9. Verfahren nach Anspruch 1, wobei das energetische Material ein Treibmittel umfasst.

10. Bohrlochwerkzeug zur Verwendung in einem Bohrloch (12), umfassend:

ein Gehäuse;
Sprengstoff in dem Gehäuse, der so ausgerichtet ist, dass, wenn der Sprengstoff detoniert, Detonationsprodukte gebildet werden, die sich entlang eines vorgesehenen Pfades bewegen; und ein additives Gussteil (30_1-30_n, $30A_1$-$30A_n$, 30B), das durch den vorgesehenen Pfad geschnitten wird, wobei das additive Gussteil (30_1-30_n, $30A_1$-$30A_n$, 30B) eine feste Matrix aus einem härtbaren Material, ein energetisches Material und eine kristalline wasserfreie Säure, eingebettet in ein Harz, umfasst, so dass, wenn eine Reaktion in dem energetischen Material in dem Bohrloch (12) eingeleitet wird, die kristalline wasserfreie Säure in das Bohrloch (12) freigesetzt wird.

11. Bohrlochwerkzeug nach Anspruch 10, wobei das Bohrlochbehandlungsmaterial eine wasserfreie kristalline Säure umfasst, die mit Gestein reagiert, das von einer Bohrlochperforation (36) geschnitten wird.

12. Bohrlochwerkzeug nach Anspruch 10, wobei das energetische Material eine Substanz umfasst, die bei Reaktion Energie oder druckbeaufschlagtes Gas erzeugt und ausgewählt ist aus der Gruppe bestehend aus einem Treibmittel, einem Oxidationsmittel, Ammoniumperchlorat, Kaliumperchlorat und Kombinationen davon.

13. Bohrlochwerkzeug nach Anspruch 10, wobei das Gehäuse einen Perforationskanonenkörper umfasst, wobei der Sprengstoff einen hochexplosiven Sprengstoff innerhalb einer Hohlladung umfasst und wobei das Detonieren des hochexplosiven Sprengstoffs Öffnungen in einer Seitenwand des Bohrlochs (12) bildet.

14. Bohrlochwerkzeug nach Anspruch 13, wobei das additive Gussteil ein ringförmiges Element umfasst, das mit dem Gehäuse gekoppelt ist.

15. Bohrlochwerkzeug nach Anspruch 10, ferner umfassend eine Steuerung (35) in Kommunikation mit dem Sprengstoff.

Revendications

1. Procédé d'opérations dans un puits de forage (12) comprenant :

le déploiement d'un outil de fond de trou dans le puits de forage (12), l'outil de fond de trou comprenant un coulage additif (30_1-30_n, $30A_1$-$30A_n$, 30B) qui comprend un matériau énergétique et un acide anhydre cristallin mélangés conjointement avec une résine ;
le positionnement de l'outil de fond de trou au niveau d'une profondeur désignée dans le puits de forage (12) ; et
le fait d'amener une réaction du matériau énergétique pour générer de l'énergie qui entraîne l'acide anhydre cristallin dans une ouverture formée dans une paroi latérale du puits de forage (12) ce qui augmente un écoulement d'hydro-

carbures à travers l'ouverture.

2. Procédé selon la revendication 1, dans lequel l'outil de fond de trou comprend en outre un explosif, et dans lequel l'étape consistant à amener une réaction du matériau énergétique comprend le déclenchement d'une détonation de l'explosif de sorte que des produits de détonation de l'explosif viennent en contact avec le matériau énergétique à une température pour déclencher une réaction du matériau énergétique.

3. Procédé selon la revendication 1, dans lequel l'énergie provient d'un gaz en expansion produit par la réaction du matériau énergétique, et dans lequel le matériau énergétique est mis en réaction parallèlement à la formation de perforations (36) dans une paroi latérale du puits de forage (12), de sorte que la substance de traitement est forcée dans les perforations (36) par le gaz en expansion.

4. Procédé selon la revendication 3, dans lequel l'outil de fond de trou comprend un canon de perforation, et dans lequel l'explosif comprend un explosif fort disposé dans une pluralité de charges profilées (28, 28A) qui sont placées radialement vers l'intérieur à partir du coulage additif, de sorte que lorsque les explosifs forts dans les charges profilées sont mis à feu, des produits de détonation sont générés à partir de la détonation de l'explosif fort lesquels viennent en contact avec le matériau énergétique à une température pour déclencher une réaction du matériau énergétique.

5. Procédé selon la revendication 4, dans lequel la détonation des charges profilées (28, 28A) forme des perforations (36) dans une paroi latérale du puits de forage (12), dans lequel une pluralité d'ouvertures sont formées dans la paroi latérale du puits de forage (12), et dans lequel les perforations (36) définissent les ouvertures.

6. Procédé selon la revendication 1, dans lequel le coulage additif est formé en un élément annulaire qui entoure une partie de l'outil.

7. Procédé selon la revendication 1, dans lequel le coulage additif est formé en un élément plan et disposé à l'intérieur d'un corps de l'outil.

8. Procédé selon la revendication 1, dans lequel l'acide dissout la roche à l'intérieur de l'ouverture.

9. Procédé selon la revendication 1, dans lequel le matériau énergétique comprend un propulseur.

10. Outil de fond de trou pour utilisation dans des opérations dans un puits de forage (12) comprenant :

un logement ;
un explosif dans le logement et qui est orienté, de sorte que lorsque l'explosif est mis à feu, des produits de détonation sont formés lesquels se déplacent le long d'un trajet désigné ; et
un coulage additif (30_1-30_n, $30A_1$-$30A_n$, 30B) qui est traversé par le trajet désigné, le coulage additif (30_1-30_n, $30A_1$-$30A_n$, 30B) comprenant une matrice solide d'un matériau durcissable, d'un matériau énergétique et d'un acide anhydre cristallin intégré dans une résine de sorte que lorsqu'une réaction dans le matériau énergétique est déclenchée dans le puits de forage (12), l'acide anhydre cristallin est libéré dans le puits de forage (12).

11. Outil de fond de trou selon la revendication 10, dans lequel le matériau de traitement de puits de forage comprend un acide cristallin anhydre qui est réactif avec de la roche qui est traversée par une perforation de fond de trou (36).

12. Outil de fond de trou selon la revendication 10, dans lequel le matériau énergétique comprend une substance qui produit de l'énergie ou du gaz sous pression lorsqu'elle est mise en réaction et est choisie dans le groupe constitué d'un propulseur, d'un oxydant, de perchlorate d'ammonium, de perchlorate de potassium, et de combinaisons de ceux-ci.

13. Outil de fond de trou selon la revendication 10, dans lequel le logement comprend un corps de canon de perforation, dans lequel l'explosif comprend un explosif fort au sein d'une charge profilée, et dans lequel la détonation de l'explosif fort forme des ouvertures dans une paroi latérale du puits de forage (12).

14. Outil de fond de trou selon la revendication 13, dans lequel le coulage additif comprend un élément annulaire couplé au logement.

15. Outil de fond de trou selon la revendication 10, comprenant en outre un contrôleur (35) en communication avec l'explosif.

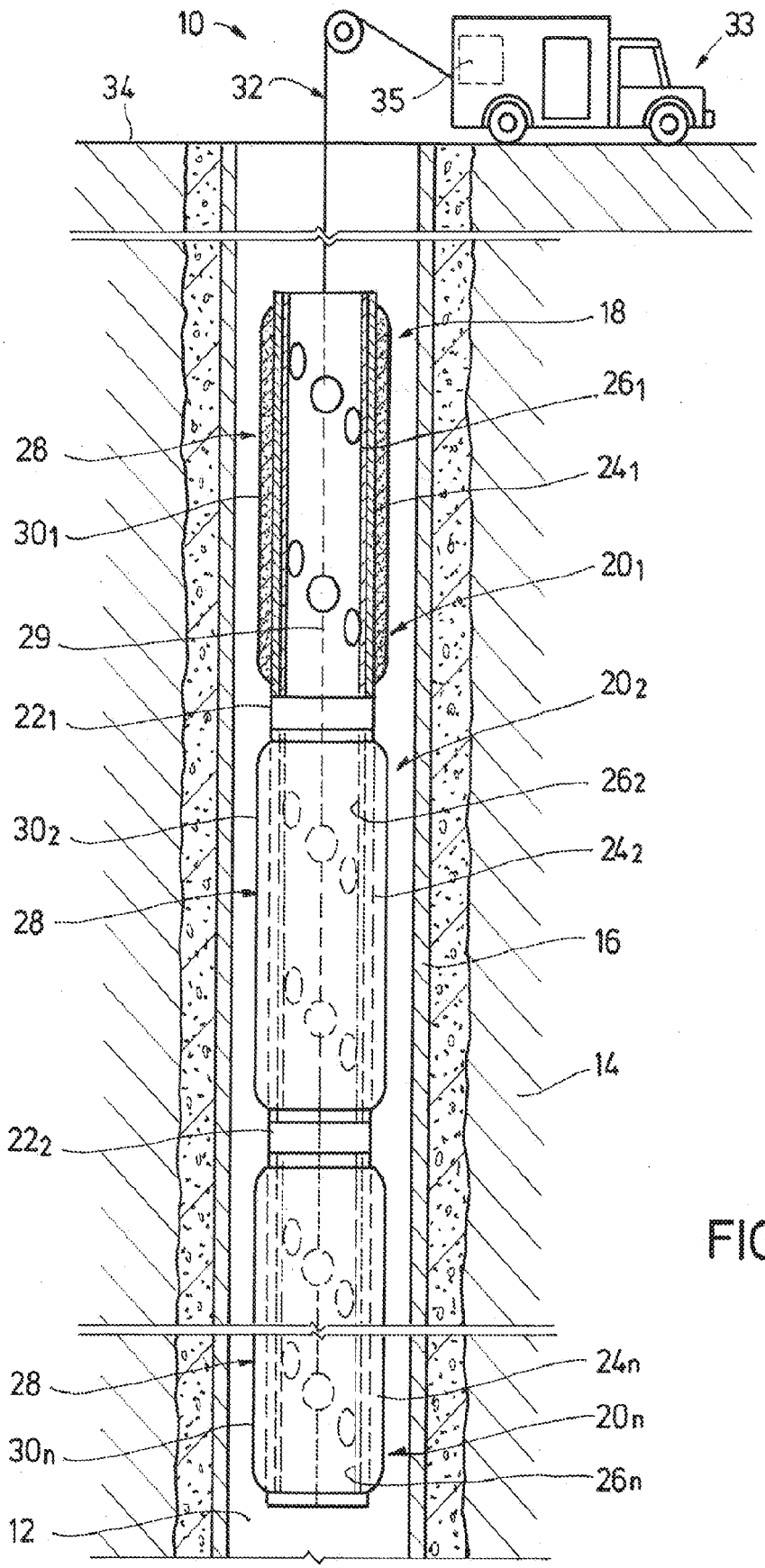

10
33
34
32
35
18
26_1
28
24_1
30_1
20_1
29
20_2
22_1
26_2
30_2
24_2
28
16
14
22_2
24_n
28
20_n
30_n
26_n
12

FIG. 1

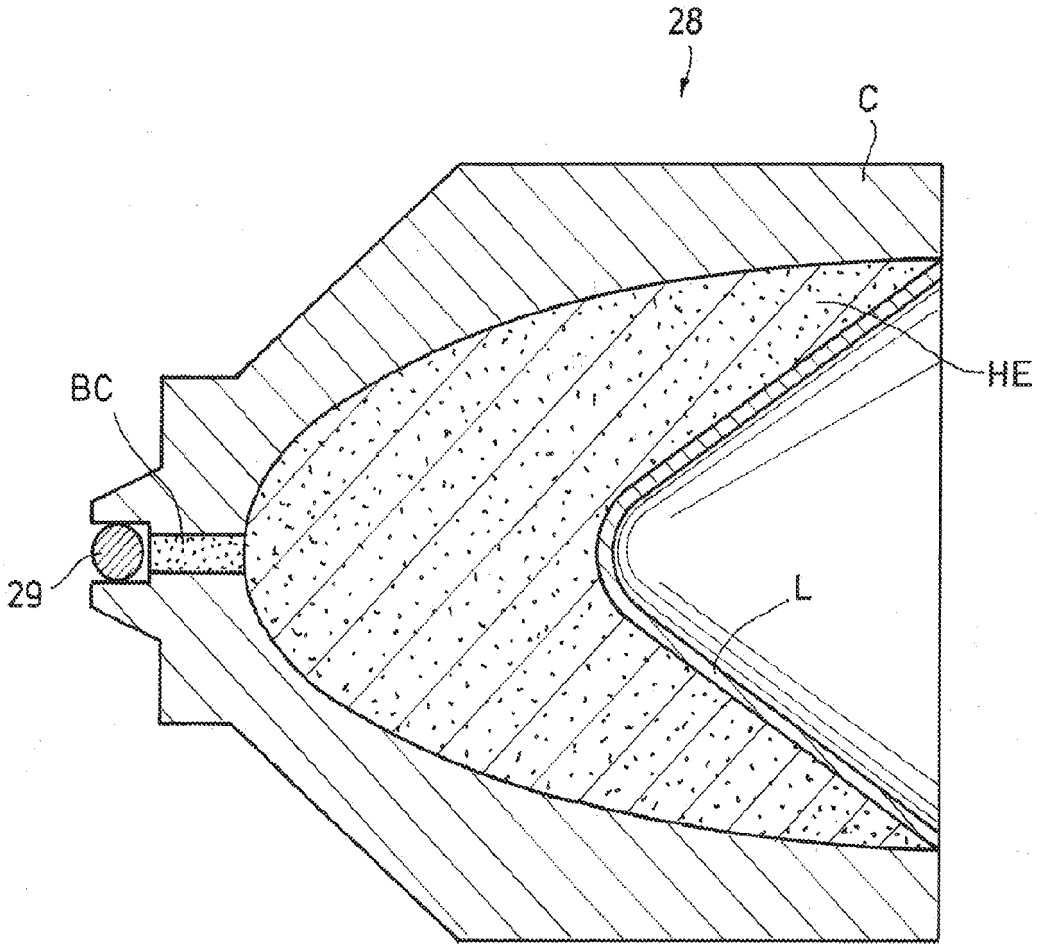


FIG. 1A

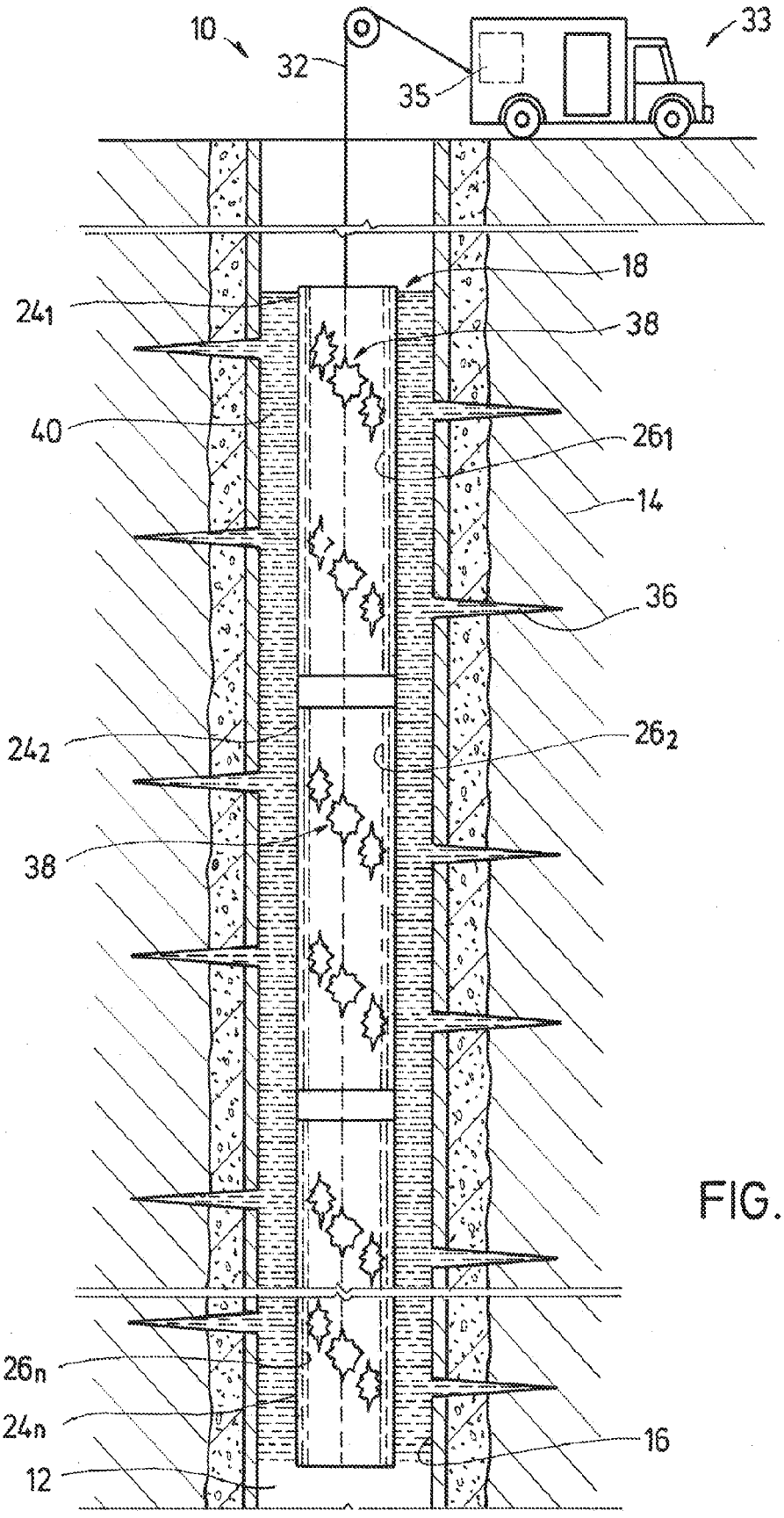
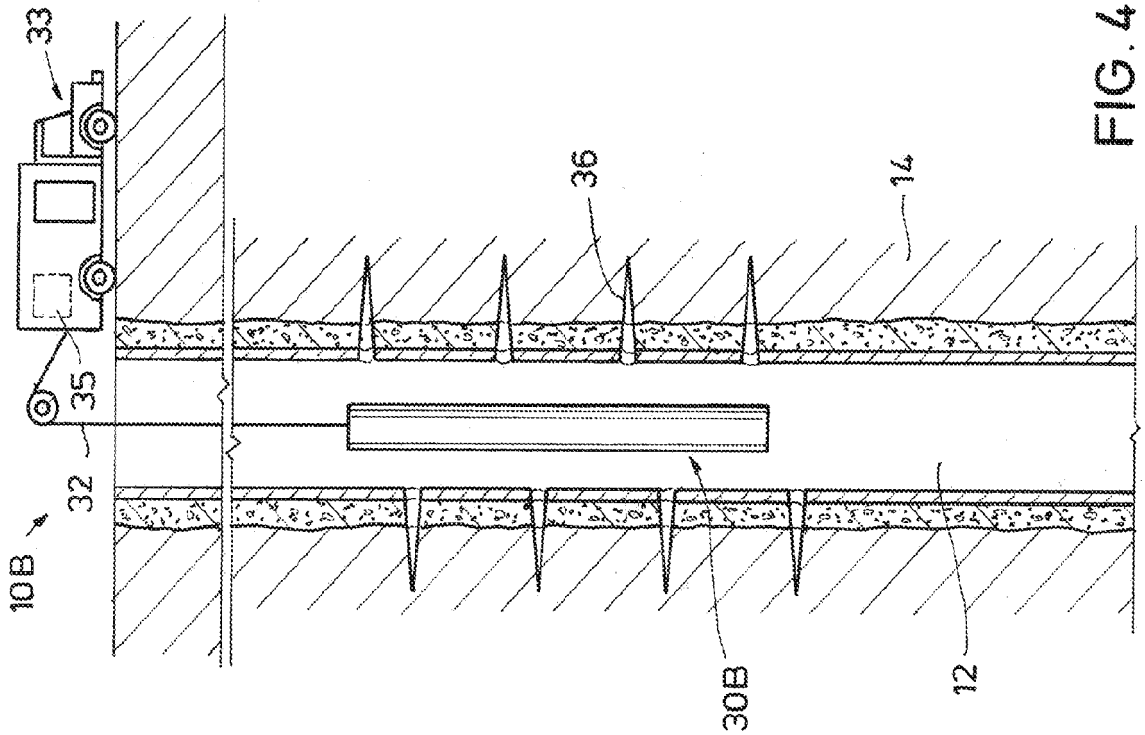


FIG.2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35
32
10B
36
14
30B
12

FIG. 4

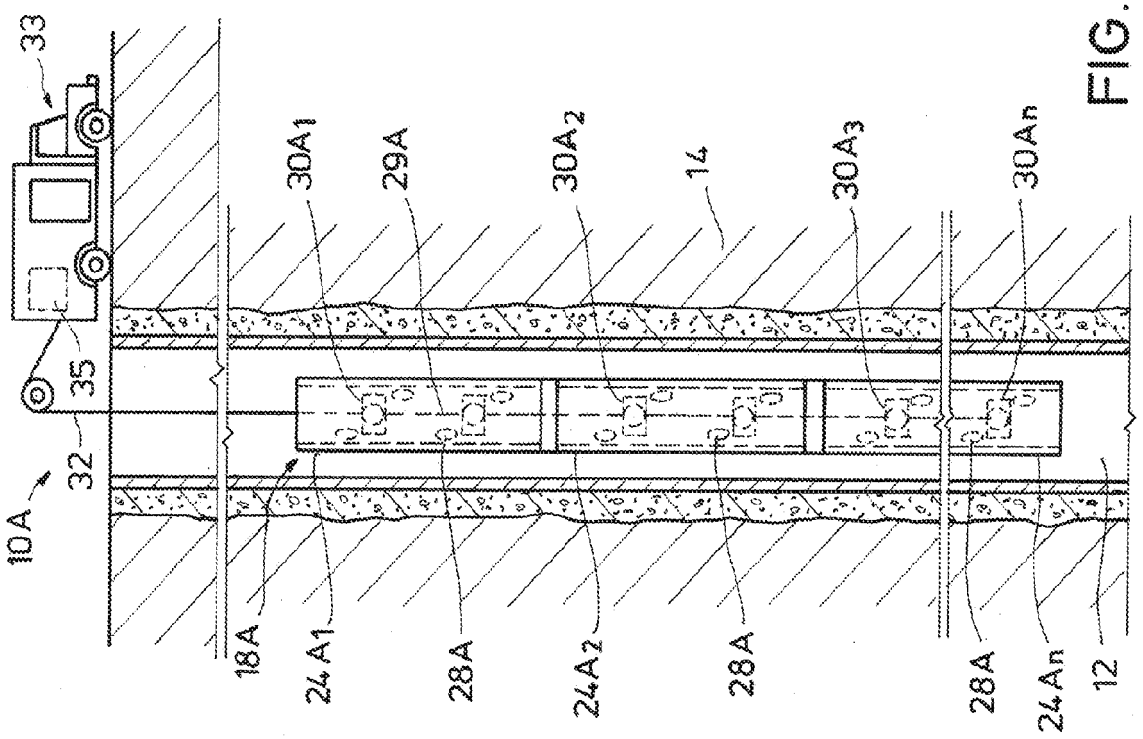
33
35
32
10A
30A1
29A
30A2
14
30A3
30An
18A
24A1
28A
24A2
28A
28A
24An
12

FIG. 3

REFERENCES CITED IN THE DESCRIPTION

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