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[Continued on next page]

(54) Title: DOWNHOLE DIAGNOSTIC APPARATUS

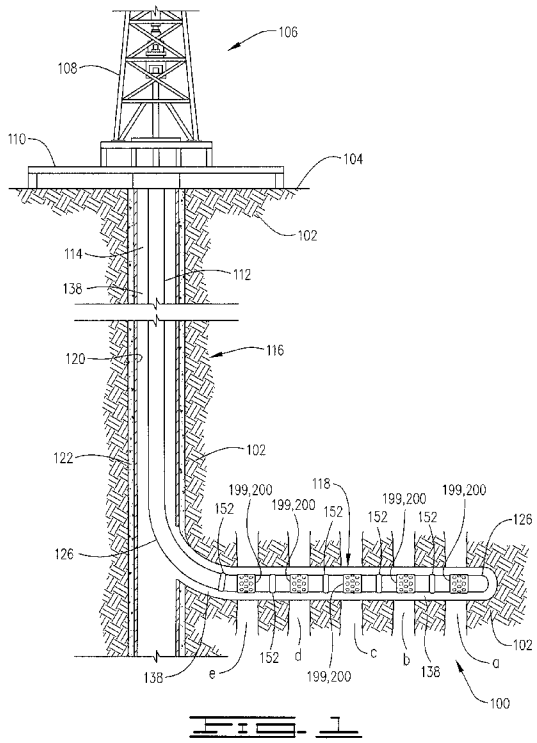


Fig. 1

(57) Abstract: A downhole apparatus for use in a wellbore. The apparatus has a housing that defines a central flow passage and a plurality of ports that extend through a wall of the apparatus and intersect the central flow passage. A tracer material is positioned in at least one of the ports and once positioned in at least one of the ports, the tracer material is exposed to the exterior of the housing and to fluid in the wellbore.

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DOWNHOLE DIAGNOSTIC APPARATUS

BACKGROUND

[0001] The present disclosure relates generally to downhole diagnostic apparatus for evaluating subterranean fluids.

[0002] A number of factors including but not limited to pressure, porosity, permeability, reservoir thickness and extent, and water saturation may affect production of hydrocarbons from a subterranean formation. Generally, to increase production from a well bore and/or to facilitate the flow of hydrocarbons from a subterranean formation, stimulation treatment operations, such as hydraulic fracturing, may be performed.

[0003] In hydraulic fracturing, a fracturing fluid may be introduced into a portion of a subterranean formation penetrated by a wellbore at a hydraulic pressure sufficient to create or enhance at least one fracture therein. Stimulating or treating the wellbore in such ways increases hydrocarbon production from the well.

[0004] In some wells, it may be desirable to individually and selectively create multiple fractures along a wellbore at a distance apart from each other, thereby creating multiple zones. The multiple fractures should have adequate conductivity so that the greatest possible quantity of hydrocarbons in an oil and gas reservoir can be drained/produced into the wellbore. When stimulating a formation from a wellbore, or completing the wellbore, especially those wellbores that are highly deviated or horizontal, it may be advantageous to create multiple zones.

[0005] Creating multiple zones may allow full wellbore access and increase hydrocarbon production; however, such operation may suffer from a variety of challenges depending on wellbore conditions such as production of water and gas, etc. Enhancement in methods and

apparatuses to overcome these challenges can further improve hydrocarbon production. Thus, there is an ongoing need to develop new methods and apparatuses to enhance hydrocarbon production.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] FIG. 1 is a schematic, partial cross-sectional view of a wellbore completion tool in an operating environment;

[0007] FIG. 2A is an embodiment of a treatment tool of the wellbore completion tool of FIG. 1;

[0008] FIG. 2B is a cross-sectional view of the treatment tool of FIG. 2A;

[0009] FIG. 2C is a plug having a recess with a tracer material positioned therein;

[00010] FIG. 2D is a cross section view of the plug of FIG. 2C;

[00011] FIG. 3A is an embodiment of a treatment tool of the wellbore completion tool;

[00012] FIG. 3B is a cross-sectional view of the treatment tool of FIG. 3A; and

[00013] FIG. 4 is a schematic, partial cross-sectional view of the wellbore completion tool of FIG. 1 with multiple fractures penetrating a plurality of zones.

DETAILED DESCRIPTION

[00014] In the drawings and descriptions that follow, like parts are typically marked throughout the specification and drawings with the same reference numerals, respectively. The drawn figures are not necessarily to scale. Certain features may be shown exaggerated in scale or in somewhat schematic form and some details of conventional elements may not be shown in the interest of clarity and conciseness. Specific embodiments are described in detail and are shown in the drawings, with the understanding that the present disclosure is to be considered exemplary and is not intended to be limiting. It is to be fully recognized that the

different teachings of the embodiments discussed herein may be employed separately or in any suitable combination to produce desired results.

[00015] Unless otherwise specified, use of the term "subterranean formation" shall be construed as encompassing both areas below exposed earth and areas below earth covered by water such as ocean or fresh water. The term "zone" as used herein refers to separate parts of the wellbore designated for treatment or production and may refer to an entire hydrocarbon formation or separate portions of a single formation such as horizontally and/or vertically spaced portions of the same formation.

[00016] Referring to FIG. 1, an embodiment of a wellbore servicing tool 100 is shown in an exemplary operating environment. As depicted, the operating environment comprises a drilling rig 106 that is positioned on earth's surface 104 and extends over and around a wellbore 114 that penetrates a subterranean formation 102 for the purpose of recovering hydrocarbons. Wellbore 114 may be drilled into subterranean formation 102 using any suitable drilling technique. Wellbore 114 may extend substantially vertically away from earth's surface 104 over a vertical wellbore portion 116, or may deviate at any angle from earth's surface 104 over a deviated or horizontal wellbore portion 118. In alternative operating environments, all or portions of wellbore 114 may be vertical, deviated, horizontal, and/or curved.

[00017] In some embodiments, a portion of vertical wellbore portion 116 is lined with a casing 120 that is secured into position against formation 102 in a conventional manner using cement 122. In alternative operating environments, horizontal wellbore portion 118 may be cased and cemented and/or portions of wellbore 114 may be uncased. In an alternative

embodiment, horizontal wellbore portion 118 may remain uncemented, but further integrate the use of packers 152, as explained further below.

[00018] Drilling rig 106 comprises a derrick 108 with a rig floor 110 through which a tubing or work string 112 (e.g., cable, wireline, E-line, Z-line, jointed pipe, coiled tubing, casing, or liner string, etc.) extends downward from drilling rig 106 into wellbore 114 and defines an annulus 138 between work string 112 and wellbore 114.

[00019] Work string 112 delivers wellbore servicing tool 100 to a selected depth within wellbore 114 to perform an operation. The operation can include perforating casing 120 and/or subterranean formation 102, creating perforation tunnels and/or fractures (e.g., dominant fractures, micro-fractures, etc.) within subterranean formation 102, producing hydrocarbons from subterranean formation 102, and/or other completion operations. Drilling rig 106 comprises a equipment for extending work string 112 into wellbore 114 to position wellbore servicing tool 100 at the selected depth.

[00020] While the exemplary operating environment depicted in FIG. 1 refers to a stationary drilling rig 106 for lowering and setting wellbore servicing tool 100 within a land-based wellbore 114, one of ordinary skill in the art will readily appreciate that mobile workover rigs, wellbore servicing units (such as coiled tubing units), and the like may be used to lower wellbore servicing tool 100 into wellbore 114. It should be understood that wellbore servicing tool 100 may alternatively be used in other operational environments, such as within an offshore wellbore operational environment.

[00021] Tubing section 126 may also include a plurality of packers 152 placed adjacent a plurality of treatment tools 199. Packers 152 are disposed alternatingly with treatment tools 199 along the length of tubing section 126. Packers 152 (such as Halliburton Swellpacker®

Isolation Systems or ZoneGuard® Openhole Packers) function to form a seal in annulus 138 to stabilize tubing section 126. Packers 152 can be used either in an open or cased hole application. In alternative embodiments, instead of using packers 152, annulus 138 in horizontal wellbore portion 118 can be cemented which also act to seal and stabilize tubing section 126.

[00022] By way of a non-limiting example, FIG. 1 depicts five treatment tools 199 connected in-line with each other in tubing section 126. Each treatment tool 199 selectively treats a zone associated with horizontal wellbore portion 118 of subterranean formation 102. A zone may include any one of zones a, b, c, d or e. In some cases, more than one treatment tool 199 may be used to selectively treat a single zone. It will be appreciated that zones a, b, c, d and e, as depicted in FIG. 1 and FIG. 4, may be isolated from each other by packers 152, sealant compositions (e.g. cement) or combinations thereof.

[00023] As depicted in FIGS. 2A-2B each treatment tool 199 has a housing 200. Housing 200 includes wall 201 with an exterior surface 202, a through passage, or central flow passage 212 that extends between the housing's ends 204 and 206, and a plurality of orifices or ports 208 through wall 201 of housing 200. Ports 208 are spaced around exterior surface 202 of housing 200, and intersect central flow passage 212.

[00024] In an embodiment, housing 200 may have a moveable sleeve 260 disposed in central flow passage 212. Moveable sleeve 260 transitions between closed mode and open mode. The closed and open modes may be referred to as closed and open positions. In closed mode, moveable sleeve 260 blocks fluid flow between central flow passage 212 and ports 208. In open mode, moveable sleeve 260 has moved relative to ports 208 to allow fluid communication between central flow passage 212 and ports 208. To transition between

closed mode and open mode, moveable sleeve 260 may be ball drop activated. In alternative embodiments, moveable sleeve 260 may be mechanical shift activated, hydraulically activated, electrically activated, or combinations thereof. Examples of equipment that may be used for treatment tools 199 include, without limitation, the RapidStage® Sleeve System, the RapidForce® Sleeve System and the RapidStart® Initiator Sleeve System, which are all available from Halliburton Energy Services, Inc.

[00025] In the present disclosure, housing 200 has a tracer material 250 positioned adjacent exterior surface 202 of housing 200. Tracer material 250 functions to identify certain targeted fluids by releasing a detectable tracer element when exposed to a targeted fluid. The term "targeted fluid" refers to a fluid flowing from in the subterranean formation, such as hydrocarbons or water, that can be selectively identified using a tracer material such as tracer material 250. For example, in some embodiments, tracer material 250 may only release a detectable tracer element when exposed to water, while in other embodiments, tracer material 250 only releases a detectable tracer element when exposed to oil. Such a system allows an operator to determine where and in which zone water or oil is being produced along the wellbore 114. Concentrations of the tracer element in the total fluids produced can also be used to determine the percentage of the total water and total oil produced from each zone along wellbore 114.

[00026] Tracer material 250 may be positioned in ports 208 in a number of ways. FIGS. 2A-2C depict tracer material 250 positioned or housed within a plug 270 located in a portion of the ports 208. Plug 270 shown in FIG. 2C has a recess 272 filled with a tracer material, which can be tracer material 250. Plug 270 can come pre-manufactured with tracer material 250 positioned within recess 272. In other embodiments, tracer material 250 can be added to

recess 272 of plug 270 on-site by available known means. Plug 270 is configured to be positioned by threading or other known means within at least one port 208 of housing 200. For example, in a non-limiting way, FIG. 2C depicts plug 270 having external screw threads 274 to engage the internal screw threads of port 208. If ports 208 are not threaded, the plug 270 can be pressed or inserted by other means known in the art. In all embodiments tracer material 250 is placed such that a targeted fluid flowing from a zone will contact the tracer material 250 on the exterior of treatment tool 199. In other words, tracer material 250 faces away from central flow passage 212 of housing 200. Alternative to using a plug with tracer material housed there in, a plug may be inserted into an inner portion of some of the ports 208 to create a recess on the exterior surface 202, in which tracer material by be placed.

[00027] In some embodiments more than one tracer material, for example tracer materials 250 and 251, may be used. In such embodiments, tracer materials 250 and 251 will react with different targeted fluids. In other words, first and second tracer materials 250 and 251 will react and release detectable tracer elements when contacted by a first targeted fluid, for example water, and second targeted fluid, for example oil. This is shown for example in the tool 199 shown in FIGS. 3A and 3B, which includes a housing 300 with tracer materials 250 and 251 which is explained in more detail below.

[00028] The arrangement of ports 208 having plugs 270 with a tracer material, such as tracer materials 250 or 251, can vary. For example, in FIGS 2A-2B, housing 200 has three sections of nine radially positioned ports 208 with the center section of the nine radially positioned ports 208 each containing a plug 270 with tracer material 250. In other embodiments, plugs 270 may be positioned alternatingly between sections. While the embodiment of FIGS. 2A and 2B is described primarily with respect to a single tracer material 250, it is understood

that separate tracer materials 250 and 251 can be used, in which case a portion of ports 208 will include a tracer material 250 and a portion will include tracer material 251.

[00029] In an alternative embodiment, FIGS. 3A-3B depict a housing 300 with recesses 210 in addition to ports 208. FIGS. 3A-3B depict tracer materials 250 and 251 positioned or housed in recesses 210. Recesses 210 may be created by machining partially through a wall 301 of housing 300, which has outer surface 302. Housing 300 has first and second ends 304 and 306 with central flow passage 312 extending therebetween. Recesses 210 do not extend through wall 301 of housing 300. In some embodiments, tracer materials 250 and 251 may be molded or potted in recesses 210. In other embodiments, tracer materials 250 and 251 may be positioned in a separate container (not shown) that is inserted in recess 210.

[00030] The number and location of recess 210 on exterior surface 302 of housing 300 can vary. For example, in a non-limiting way, FIGS 3A-3B depict nine recesses 210 spaced around exterior surface 302 of housing 300 interposed between sections of nine spaced ports 208. In other embodiments, one or more recesses 210 can be positioned elsewhere on exterior surface 302 of housing 300.

[00031] In operation, and with reference to FIG. 4, a plurality of treatment tools 199 may be used in servicing the wellbore 114, for example, in a wellbore completion service. Generally, servicing wellbore 114 is carried out starting from a zone in the furthest or lowermost end of the wellbore and sequentially backwards toward the closest or uppermost end of the wellbore toward the surface. A tubing section 126 comprising a plurality of treatment tools 199 separated from each other by a plurality of packers 152 is disposed in wellbore 114. Treatment tools 199 are positioned adjacent a plurality of formation zones a, b, c, d and e to be treated so that one treatment tool 199 is placed adjacent each formation zone.

[00032] For ease of reference, treatment tools 199 of FIG. 4 will be referred to as treatment tools 199a – 199e. In some embodiments, treatment tools 199 of FIG. 4 may include housing 200 with one or more plugs 270 inserted into corresponding ports 208. In other embodiments, treatment tools 199 of FIG. 4 may include housing 300 with one or more recesses 210. In still other embodiments, treatment tools 199 of FIG. 4 may include housing 300 with one or more recesses 210 and one or more plugs 270 inserted into corresponding ports 208. It is understood that tracer materials 250 and/or 251 may be used in any of the above described embodiments. For example, a single tracer material, such as tracer material 250, or a plurality of tracer materials, such as tracer materials 200 and 251, may be used. Each tracer material, whether tracer material 250, 251 or another, is unique to the other tracer materials in the other zones.

[00033] In operation, packers 152 may be activated by available known means. Moveable sleeves 260 are in a closed position when lowered into wellbore 114. Once packers 152 are activated, the first zone a (typically the lowermost zone) is exposed by opening moveable sleeve 260 of housing 200 located adjacent zone a. As explained above, moveable sleeve 260 may be ball drop activated. In alternative embodiments, moveable sleeve 260 may be mechanical shift activated, hydraulically activated, electrically activated, or combinations thereof to allow or prevent fluid access from and to a zone.

[00034] A wellbore servicing fluid (such as a fracturing fluid) may be pumped down the wellbore 114 at sufficient pressure to perforate and/or fracture the first formation zone a. The wellbore servicing fluid may be pumped through the ports 208 at a velocity sufficient to form perforation tunnels and/or fractures 160 within the first formation zone a. A sufficient

volume of fracturing fluid may be pumped through the ports 208 to expand and/or propagate the fractures 160 in the formation.

[00035] Next, the second zone b may be exposed by any suitable method described herein, for example, through ball drop activation or mechanical shift activation. The wellbore servicing fluid is again pumped down the wellbore 114 at sufficient pressure to form perforation tunnels and/or fracture the second formation zone b. The procedure is repeated selectively and/or sequentially to service any selected and/or all formation zones a, b, c, d and e. During fracturing, the ports 208 are in fluid communication with the central flow passage 212 of housing 200.

[00036] For exemplary purposes, in FIG. 4, tracer materials 250 are used and may be referred to as tracer materials 250a – 250e. It is understood that tracer materials 251a – 251e may be utilized as well, either alone, or in combination with tracer materials 250a – 250e. Upon contact with a targeted fluid, each tracer material 250 and/or 251 releases a detectable tracer element that corresponds with the zone in which the tracer material 250 and/or 251 is located. In other words, the tracer material associated with each zone has a unique signature. For example tracer materials 250a will react with a first targeted fluid from zone a. The unique signatures of the tracer materials 250a-250e are such that that it can be determined from which zone the targeted fluid was produced.

[00037] Once the selected zones are perforated and/or fractured, targeted fluids from the zones flow through ports 208 and into central flow passages 212 of treatment tools 199. As explained above a targeted fluid refers to a fluid in the subterranean formation, such as hydrocarbons or water which can be selectively identified using tracer materials 250 and/or 251. As targeted fluids flow from each zone and into flow passage 212 of each treatment tool

199, the targeted fluids contact the tracer materials 250 and/or 251 placed adjacent the exterior surface 202 of each treatment tool 199.

[00038] As explained above, tracer materials for each zone have unique signatures, so upon contact with a targeted fluid the tracer material releases a detectable tracer element. By way of example, a detector device may be located at earth's surface 104 to collect and/or identify the tracer materials 250a-250e to determine from which zone a targeted fluid was produced.

[00039] With reference to FIG. 4, a targeted fluid that contacts a tracer material 250a in zone a will cause tracer material 250a in zone a to release a detectable tracer element 252a. Once tracer element 252a reaches earth's surface 104, the detector device can be used to determine that a certain targeted fluid is flowing from zone a. Likewise, a targeted fluid that contacts tracer materials 250b - 250e in zones b, c, d or e will cause the corresponding tracer materials 250b - 250e of each zone to release detectable tracer elements 252b - 252e respectively. Once tracer elements 252b – 252e reach earth's surface 104, the detector device can be used to determine the targeted fluids that correspond with each zone. The same process applies if tracer material 251, or both tracer materials 250 and 251, are utilized.

[00040] Accordingly, the scope of protection is not limited by the description set out above but is only limited by the claims which follow. Each and every claim is incorporated into the specification as an embodiment of the present disclosure. Thus, the claims are a further description and are an addition to the embodiments of the present disclosure.

What is claimed:

1. A downhole apparatus for use in a wellbore penetrating a subterranean formation, comprising:

a housing defining a central flow passage and a plurality of ports through a wall thereof intersecting the central flow passage; and

a tracer material positioned in at least one of the ports, the tracer material being exposed to the exterior of the housing.

2. The apparatus of claim 1, wherein the tracer material releases a detectable tracer element as a targeted fluid flows from the subterranean formation to the wellbore and contacts the tracer material.

3. The apparatus of claim 1, wherein a plurality of the ports have tracer materials therein.

4. The apparatus of claim 3, wherein a first portion of the tracer materials release a detectable tracer element as a first targeted fluid flows from the subterranean formation and contacts the tracer materials, and a second portion of the tracer materials release detectable tracer elements when a second targeted fluid flows from the subterranean formation and contacts the second portion of the tracer materials.

5. The apparatus of claim 1, further comprising cement disposed between an exterior surface of the housing and the wellbore.

6. The apparatus of claim 3, further comprising a plug positioned on an interior section of the ports that carry tracer material, the tracer material being positioned in an exterior section of the ports.

7. The apparatus of claim 6, wherein the plug isolates the tracer material from the central flow passage of the housing.

8. The apparatus of claim 6, wherein the plug is threadable into the ports.

9. The apparatus of claim 1, further comprising a sliding sleeve moveable from a closed position in which the sleeve covers the ports, and an open position in which the ports are covered.

10. A downhole system for use in a wellbore intersecting a plurality of zones comprising:

a tubing string positioned in the wellbore;

a plurality of treatment tools connected in the tubing string wherein at least some of the zones have a treatment tool associated therewith, each of the treatment tools comprising

a housing defining a central flow passage therethrough and a plurality of ports intersecting the central flow passage;

a sliding sleeve moveable from a closed position in which flow through the ports is blocked to an open position in which flow through the ports is permitted;

tracer material disposed in a plurality of recesses in the housing, wherein the tracer material will release detectable tracer elements upon contact with a targeted fluid, and wherein the targeted fluid and tracer elements will flow into the central flow passage through the ports when the treatment tool is in the open position.

11. The downhole system of claim 10, wherein each treatment tool comprises at least two distinct tracer materials, and wherein the first and second tracer materials release detectable tracer elements when contacted by first and second targeted fluids respectively.

12. The downhole tool of claim 11, wherein each of the plurality of treatment tools comprise at least first and second tracer materials for reacting with first and second targeted fluids from the zone associated therewith, and wherein the signatures of the tracer materials associated with each zone are distinct from the signatures of the tracer materials in treatment tools associated with any other zone.

13. The downhole tool of claim 10, wherein a plug is inserted in a portion of the ports to fill an inner portion thereof, the recesses comprising the exterior portion of the ports in which the plugs are inserted.

14. A downhole tool for use in a wellbore comprising:

a treatment tool connected in a tubing in the well and associated with a zone intersected by the wellbore, the treatment tool comprising:

a housing defining a plurality of ports through a wall thereof and a central flow passage; and

a sliding sleeve disposed in the housing and moveable from a closed position which covers the ports to an open position in which the ports are uncovered,

wherein the treatment tool releases a detectable tracer element into the central flow passage upon contact with a targeted fluid from a zone intersected by the wellbore, and wherein the detectable tracer element provides information about the targeted fluid flowing from the zone.

15. The downhole tool of claim 14, wherein the treatment tool selectively releases different detectable tracer elements based upon the type of fluid produced from the zone.

16. The downhole tool of claim 14 wherein the wellbore intersects a plurality of zones, each zone having a treatment tool associated therewith and wherein the detectable tracer elements released by the treatment tools provide information about the targeted fluid and the zone from which the fluid was produced.

17. The downhole tool of claim 16 further comprising:

a tracer material positioned in at least a portion of the ports in the treatment tool, wherein the tracer material releases the detectable tracer element upon contact with the targeted fluid.

18. The downhole tool of claim 16, comprising first and second tracer materials, the first and second tracer materials being positioned in at least a portion of the ports, wherein the first tracer material releases detectable tracer elements upon contact with a first targeted fluid, and the second tracer material releases a detectable tracer element upon contact with a second targeted fluid.

19. The downhole tool of claim 16, wherein the first and second detectable tracer elements of each treatment tool have a unique signature relative to the first and second detectable tracer elements of any other treatment tool.

20. The downhole treatment tool of claim 16, further comprising:

plugs positioned in at least a portion of the ports, wherein the plugs have a tracer material positioned therein and wherein the tracer material releases the detectable tracer element upon contact with the targeted fluid.

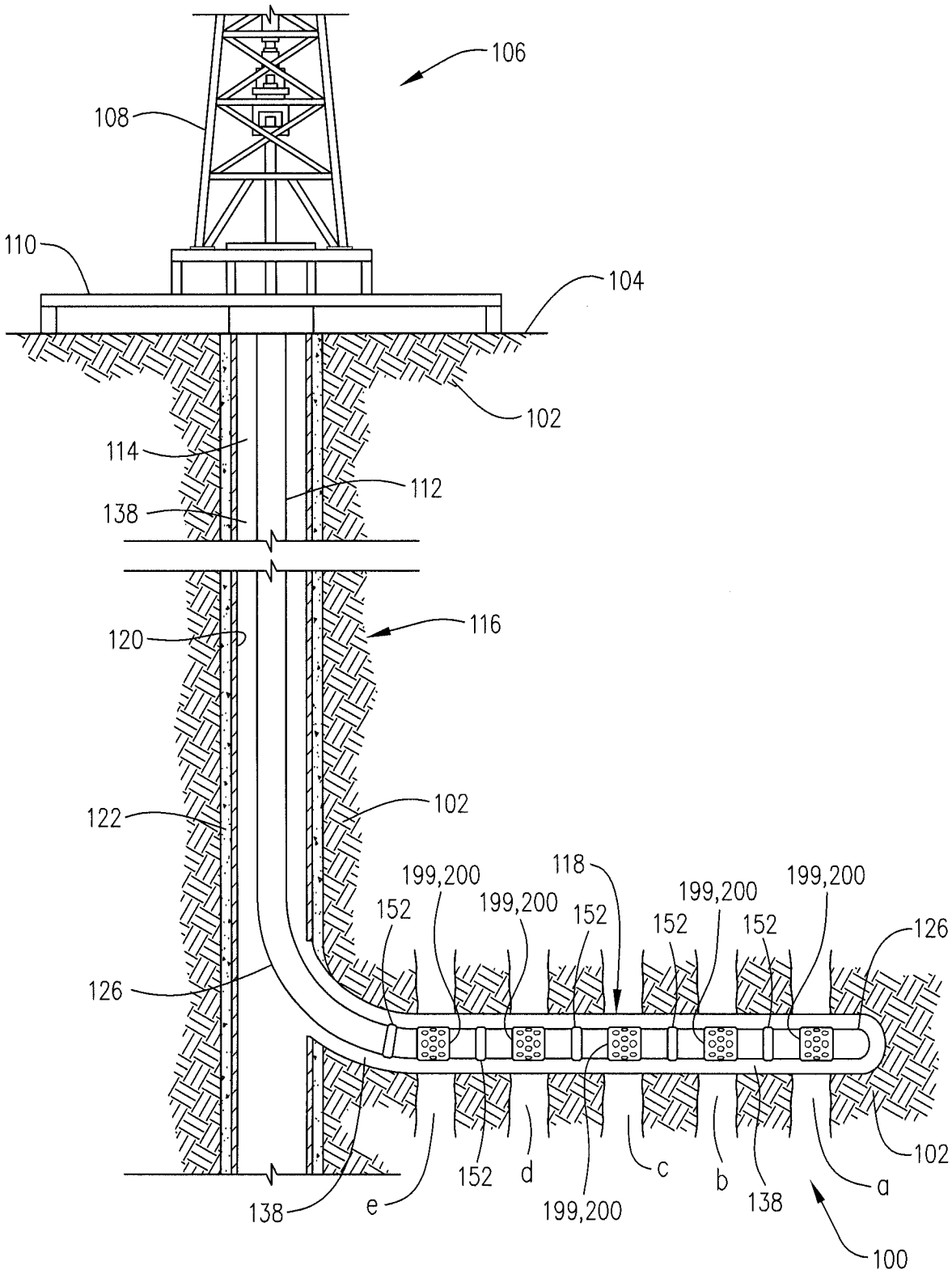

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FIG. 1

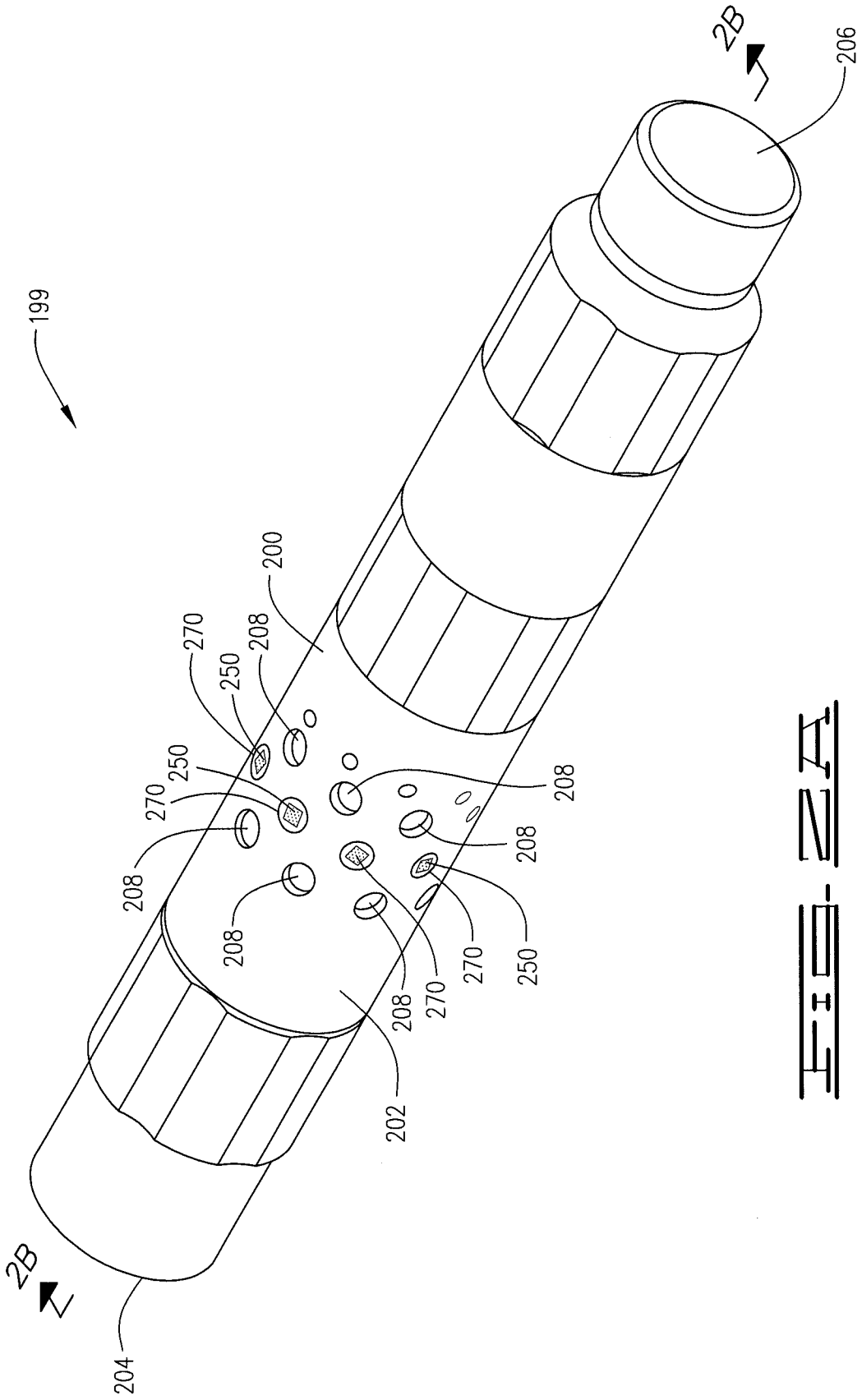

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FIG. 2A

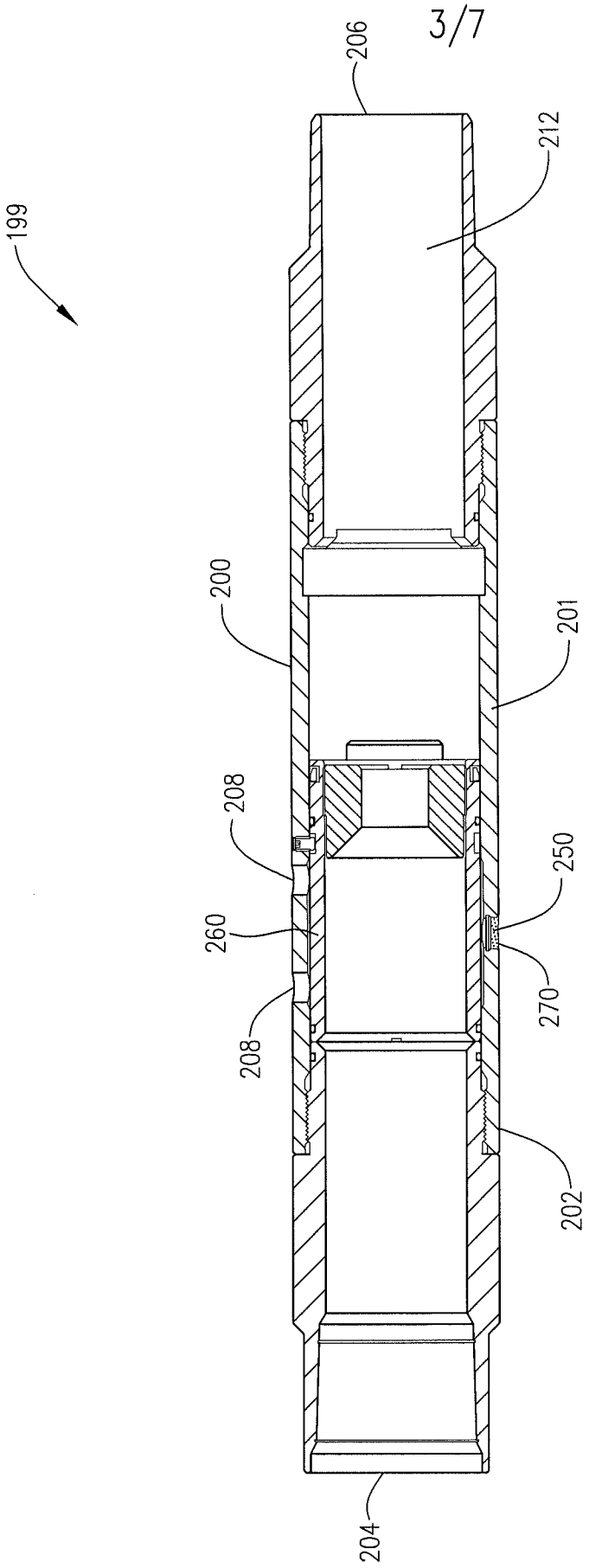


Fig. 2B

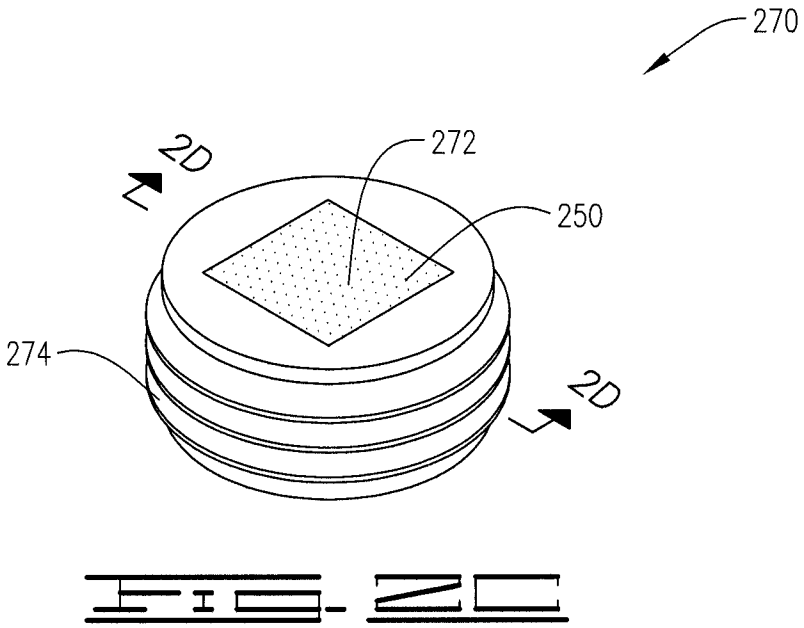


FIG. 2C

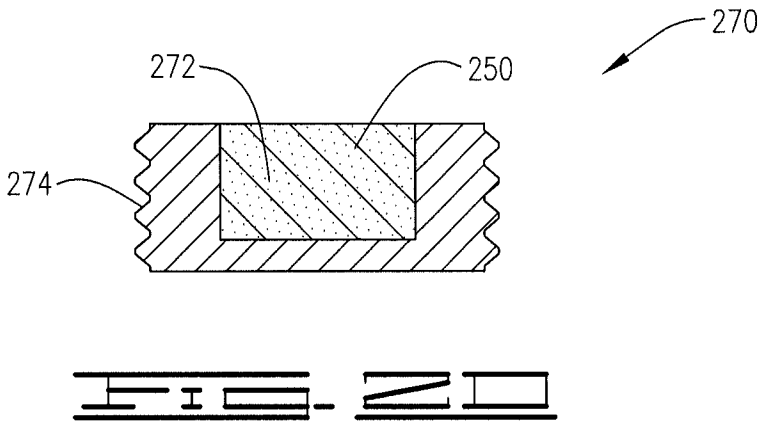


FIG. 2D

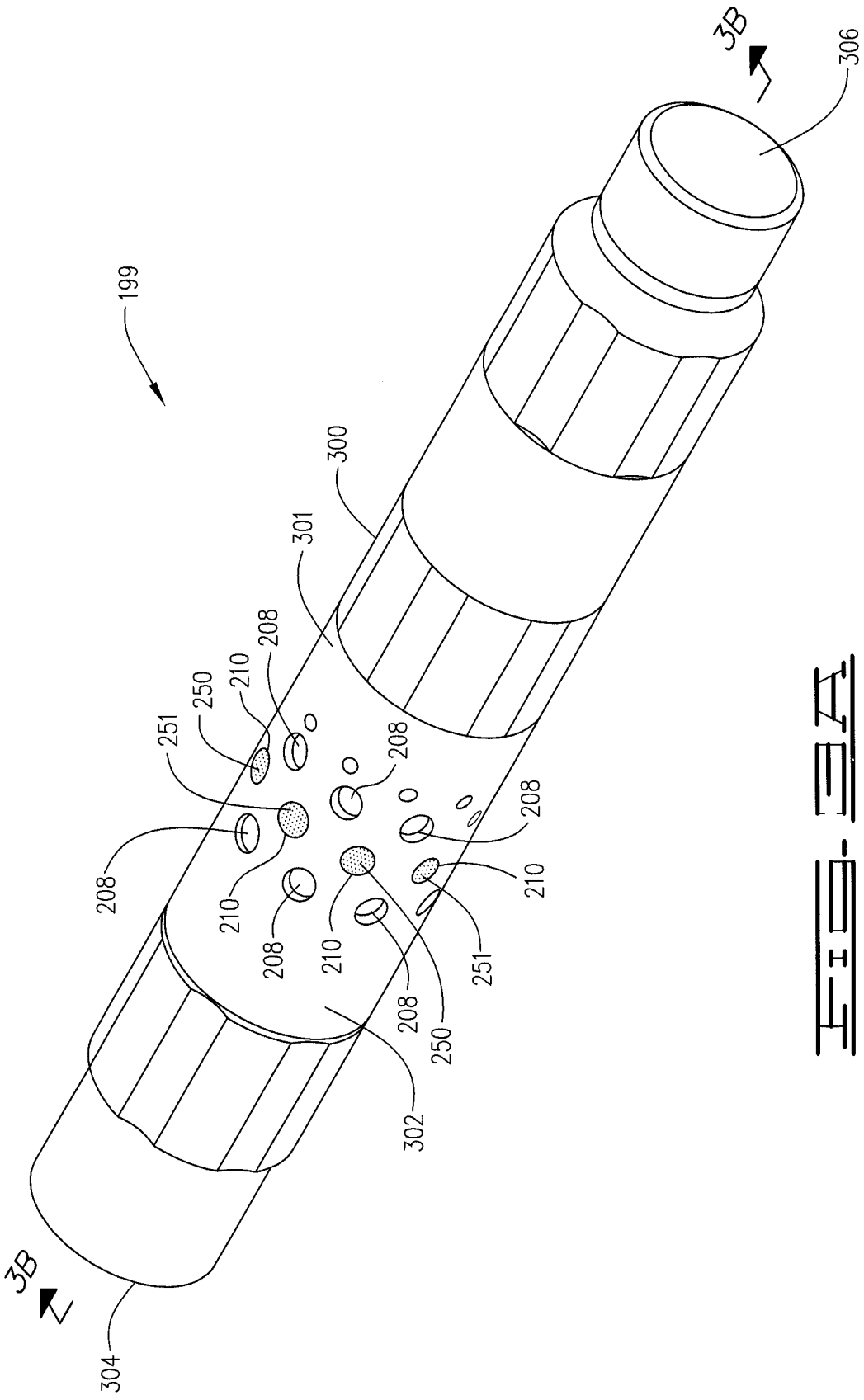

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FIG. 3A

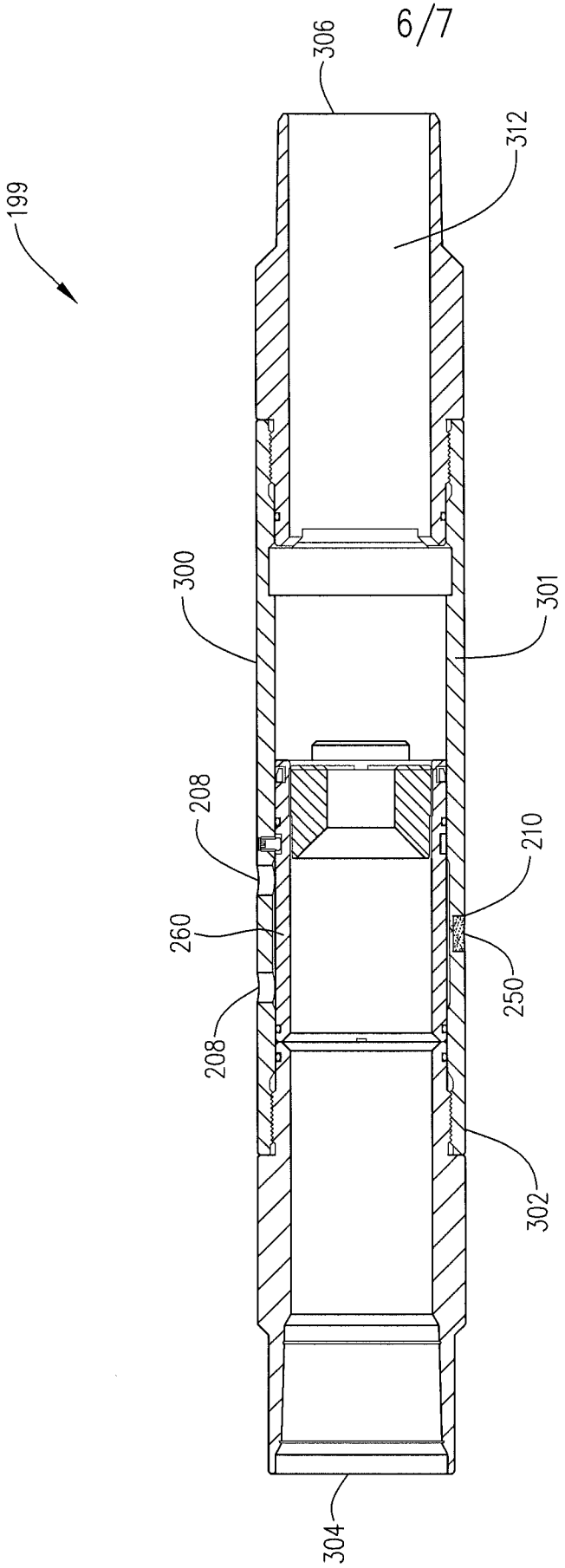


Fig. 3B

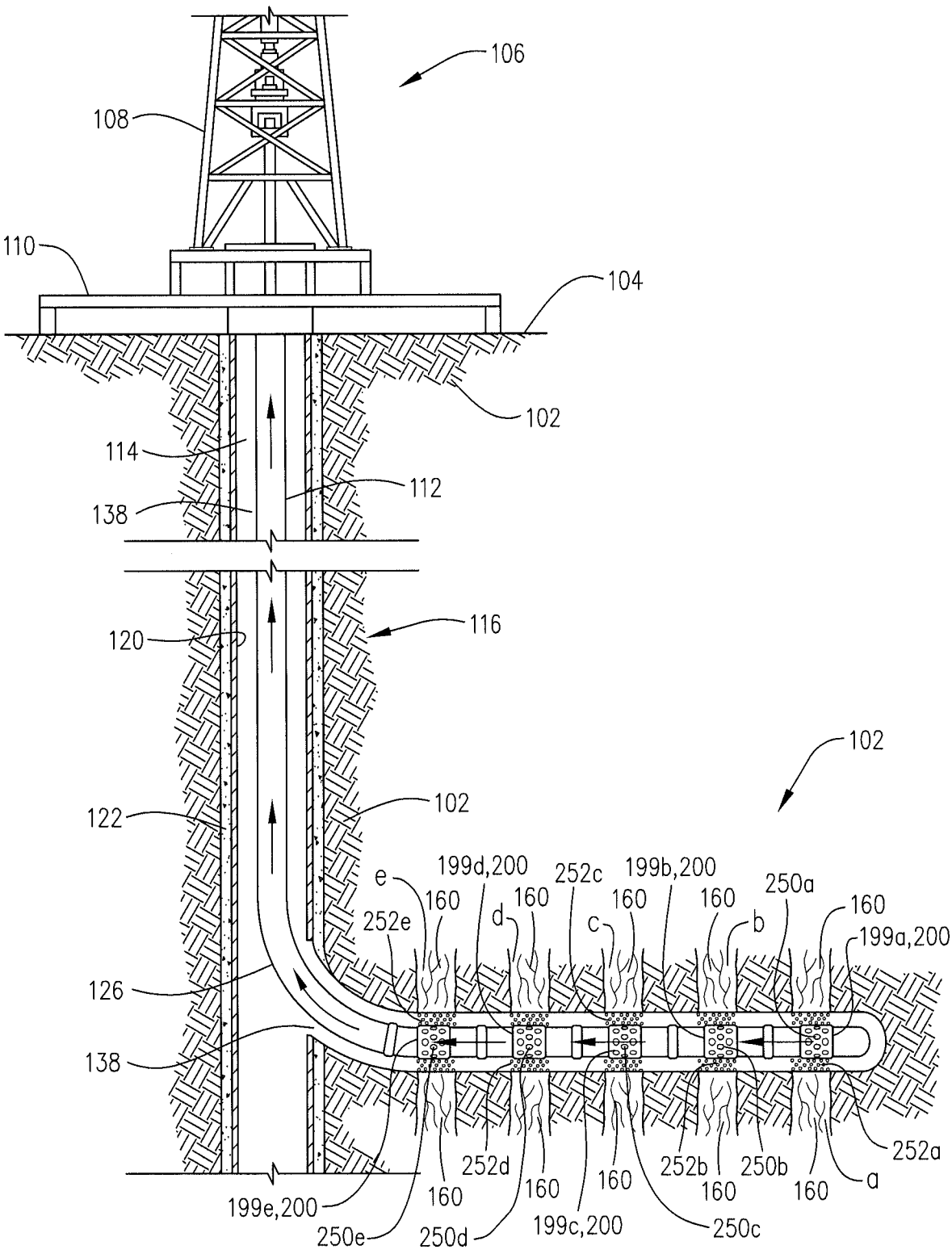

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160
199e,200
250e
250d
199c,200
250c

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/023734

A. CLASSIFICATION OF SUBJECT MATTER

E21B 47/00(2006.01)i, E21B 47/10(2006.01)i, E21B 43/16(2006.01)i, E21B 33/12(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 47/00; G01V 8/10; E21B 43/00; E21B 44/00; G01V 9/00; E21B 43/08; E21B 43/11; E21B 47/10; E21B 43/16; E21B 33/12

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: treatment tool, housing, port, tracer material, plug, and sliding sleeve

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2013-0075090 A1 (WOICESHYN, GLENN EDWARD) 28 March 2013 See paragraphs [0001], [0020]-[0028], [0032]-[0033], [0049]-[0053] and figures 1-4.	1-8
Y		9-20
Y	US 2015-0060056 A1 (KUMARAN et al.) 05 March 2015 See paragraphs [0067]-[0072] and figure 2.	9-20
A	US 2011-0239754 A1 (DYER et al.) 06 October 2011 See paragraphs [0011]-[0019] and figure 1.	1-20
A	US 2015-0013972 A1 (SAUDI ARABIAN OIL COMPANY) 15 January 2015 See paragraphs [0029]-[0032] and figures 2-4B.	1-20
A	US 5441110 A (SCOTT, III, GEORGE L.) 15 August 1995 See column 11, lines 37-49 and figure 9.	1-20

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 December 2016 (14.12.2016)	**14 December 2016 (14.12.2016)**

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2016/023734

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		WO 2015-006529 A2	15/01/2015
		WO 2015-006529 A3	07/05/2015
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		US 5413179 A	09/05/1995