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(57) Abstract: A downhole friction control system comprises a downhole sub to attach to a drill string and a vibration component. The vibration component is mechanically coupled to the downhole sub to generate a selected vibration in the drill string when the downhole sub is attached to the drill string. Additional apparatus, methods, and systems are disclosed.

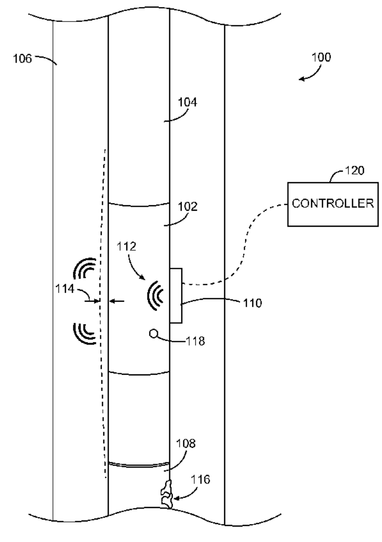

Fig. 1

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DOWNHOLE FRICTION CONTROL SYSTEMS AND METHODS

Background

[0001] Downhole friction often interferes with the operation of downhole tools. In some cases, friction arises due to the presence of dirt, sand, concrete, debris, or other solids in downhole fluids. While some conventional systems attempt to prevent the accumulation of debris, they fail to provide relief once debris or solids begin interfering with the operation of the tool. These accumulated solids can be difficult, if not impossible, to remove with conventional filter systems that cannot be cleaned or unplugged. Downhole friction can also occur as a result of tight tolerances, drag caused by sealing surfaces, or the use of downhole tools against rough surfaces, such as a downhole cutting tool. When a tool encounters issues associated with downhole friction, conventional methods to overcome the friction involve applying additional pressure to the tool, which can lead to tool degradation and damage.

Brief Description of the Drawings

[0002] The present disclosure may be better understood, and its numerous features and advantages made apparent to those of ordinary skill in the art by referencing the accompanying drawings. The use of the same reference symbols in different drawings indicates similar or identical items.

[0003] Figure 1 depicts an example downhole friction control system, in accordance with some embodiments.

[0004] Figure 2 depicts an example downhole friction control system in use with a ball valve in a closed position, in accordance with some embodiments.

[0005] Figure 3 depicts the example downhole friction control system of Figure 2 with the ball valve in the open position, in accordance with some embodiments.

[0006] Figure 4 is a flow diagram of an example method of downhole friction control, in accordance with some embodiments.

[0007] Figure 5 depicts an example system at a wireline site, in accordance with some embodiments.

[0008] Figure 6 depicts an example system at a drilling site, in accordance with some embodiments.

Detailed Description

[0009] Figure 1 depicts an example downhole friction control system 100, in accordance with some embodiments. The downhole friction control system 100 generally comprises a downhole sub 102 to attach to a drill string 104 to be placed in a wellbore 106. In some embodiments, the downhole friction control system 100 further comprises a downhole tool 108 coupled to the drill string. While the illustrated embodiment depicts the downhole tool 108 to be coupled to the drill string 104 further downhole than the downhole sub 104, in other embodiments, the downhole sub 102 may comprise a portion of the downhole tool 108, the downhole sub 102 may be coupled to the drill string 104 further downhole than the downhole sub 104, a combination of these, or the like. The downhole tool 108 may comprise any of a number of different types of tools including MWD (measurement while drilling) tools, LWD (logging while drilling) tools, and others.

[0010] The downhole friction control system 100 generally comprises a vibration component 110. The vibration component 110 is mechanically coupled to the downhole sub 102 to generate a selected vibration 112 in the drill string 104 when the downhole sub 102 is attached to the drill string 104. The vibration component 110 may comprise, for example, a flutter valve, a motor, a piezoelectric device, a combination of these, or the like. In at least one example, the vibration component 110 comprises a motor coupled to the drill string 104 and to an eccentric weight. In at least one embodiment, the vibration component 110 comprises a motor with a rotor that is off balance via a counterweight. In some examples, the vibration component 110 adjusts vibration by varying the speed of the motor or shifting the weight of the counterbalance, for example closer to or further from the center of rotation. In some embodiments, the vibration component 110 may comprise multiple elements capable of causing vibration. In some embodiments, the location at which the vibration component 110 is coupled to the downhole sub 102 is chosen based on the type of tool, the type of vibration component 110, the selected vibration 112, the type of solids that are expected downhole, a combination of these, or the like.

[0011] The selected vibration 112 may be selected based on any of a variety of criteria, for example, a desired level, a desired frequency, a desired lateral movement 114 of a portion of the friction control system 100, a desired reduction of operational friction of the downhole tool 108, a desired reduction of pressure at the downhole tool 108, to dislodge accumulated solids 116, to prevent accumulation of solids 116, a combination of these, or the like. In at least one embodiment, the selected vibration 112 is sufficient to impart a lateral movement 114 of at least 5 mm of a portion of the drill string 104. For example, in at least one embodiment, the selected vibration 112 applied to a 4-inch diameter drill string 104 achieves the intended lateral movement 114 (e.g., at least 5mm) of the drill string approximately one-half meter from the vibration component 110. In at least one embodiment, the selected vibration 112 is selected based on a desired vibration level. In some embodiments, the selected vibration 112 comprises a frequency of from about 20 Kilohertz to about 60 Kilohertz. In some embodiments, the selected vibration 112 is sufficient to dislodge accumulated solids 116 from certain components of the drill string 104, for example, filters, valves, the tool 108, pistons, screens, moving mandrels, a combination of these, or the like.

[0012] In at least one embodiment, the tool 108 is coupled to the downhole sub 102, and the selected vibration 112 is sufficient to reduce operational friction between components of the downhole tool 108. For example, in a drilling operation, the amount of friction can be measured in terms of torque needed to turn the drill string, and when the torque becomes greater than some desired level, or increases at a greater rate than is expected, friction reduction can be employed until the torque is reduced by some desired amount. In at least one embodiment, the downhole tool 108 comprises a cutting tool, and the selected vibration 112 is sufficient to reduce the pressure of the cutting tool. In some embodiments, the selected vibration 112 increases efficiency of the downhole tool 108. For example, in the case of a cutting tool, application of the selected vibration 112 can allow the cutting tool to remove the same amount of material per unit period of time with reduced cutting pressure, thereby increasing the efficiency of the cutting tool. This can reduce the risk of damage or wear to the downhole tool 108 due to pressure.

[0013] In some embodiments, the downhole friction control system 100 comprises one or more sensors 118 to monitor one or more components of the downhole friction control system 100. For example, in at least one embodiment, one or more sensors 118 monitor the selected vibration 112 produced by the vibration component 110. In some embodiments, one or more sensors 118 monitor relative location of two or more surfaces or components. For example, in at least one embodiment, one or more sensors 118 monitor relative positions of two downhole movable surfaces, such that the one or more sensors 118 can identify operational friction issues based on whether the two downhole surfaces are moving relative to one another.

[0014] In some embodiments, the downhole friction control system 100 comprises a controller 120 in communication with the vibration component 110. In at least one embodiment, the controller 120 is located at a surface of the earth while in communication with the downhole vibration component 110. In some embodiments, the controller 120 is to adjust the selected vibration 112 (e.g., level, frequency, etc.). In at least one embodiment, the controller 120 is in communication with the one or more sensors 118, such that the controller 120 is to adjust the selected vibration 112 based on information received from the one or more sensors 118. For example, in at least one embodiment the one or more sensors 118 monitor relative positions of two downhole movable surfaces, and the controller 120 activates or increases the selected vibration 112 if the one or more sensors 118 identify that the two downhole movable surfaces are prevented from moving due to operational friction engagement. In some embodiments, the controller 120 stops, decreases, or otherwise adjusts the selected vibration 112 responsive to disengagement of the two downhole movable surfaces (for example, as indicated by the one or more sensors 118).

[0015] In some embodiments, the controller 120 controls the selected vibration 112 by adjusting the level of the vibration, frequency of the vibration, duration of the vibration, a combination of these, or the like. In at least one embodiment, the controller 120 adjusts the selected vibration 112 to target specific kinds of solids 116, based on the type of tool 108, or both. In at least one embodiment, a lookup table is used to target solids in a specific area of the drill string. In some embodiments, the controller 120 periodically references the lookup table to determine the selected vibration 112. In at least one embodiment, the controller 120 adjusts the selected vibration 112 according to a schedule, for example, activate a first selected vibration 112 for ten seconds, stop the vibration component 110 for one minute, activate a second selected vibration for thirty seconds, stop the vibration component 110 for ten seconds, and repeat. In at least one embodiment, the controller 120 starts, stops, or otherwise adjusts the vibration automatically in response to a signal from the one or more sensors 118 that a measurement exceeds a predetermined threshold. In some embodiments, the controller 120 can control the selected vibration 112 under one or more of a variety of modes, for example, variable amplitude, variable frequency, pulsing, cycling, ramping up, ramping down, a combination of these, or the like.

[0016] Figure 2 depicts an example downhole friction control system 200 in use with a ball valve 202 in a closed position, in accordance with some embodiments. In at least one embodiment, the ball valve 202 comprises at least a portion of a downhole cutting tool, used for example, to cut through coil tubing. In some embodiments, a downhole sub 204, attached to a drill string 206, comprises a portion of the downhole cutting tool. The ball valve 202 is shown in the closed position, such that an opening 208 is not positioned within the drill string 206, and such that the ball valve 202 is blocking flow within the drill string 206. To open the ball valve 202, pressure is applied to an open line 210, while a close line 212 is vented.

[0017] In at least one embodiment, one or more vibration components 214, 215 are coupled to the downhole sub 204. In some embodiments, the one or more vibration components 214, 215 are to generate a selected vibration 218 in the drill string 206. In at least one embodiment, the selected vibration 218 is selected to dislodge accumulated solids 220. In at least one embodiment, the selected vibration 218 is selected to reduce pressure at the ball valve 202. The one or more vibration components 214, 215 may each comprise an oscillating or fluttering device, a motor, a piezoelectric device, or the like. For example, in at least one embodiment, the vibration component 214 comprises a flutter valve, such that when pressure is applied to the open side 210, the flutter valve generates the selected vibration 218. In some embodiments, the selected vibration 218 generated by the flutter valve 214 is sufficient to dislodge accumulated solids 220. In some embodiments, the selected vibration 218 allows the ball valve 202 to open with less pressure applied to the open line 210. In some embodiments, a controller is used to adjust the selected vibration 218.

[0018] In the illustrated embodiment, the one or more vibration components 214, 215 comprise vibration motors or piezoelectric devices coupled to the downhole sub 204 on opposite sides of the ball valve 202. The one or more vibration components 214, 215 can operate alone or together to generate the selected vibration 218. In at least one embodiment, the selected vibration 218 generated by the vibration motors or piezoelectric devices 214, 215, is sufficient to dislodge accumulated solids 220. In some embodiments, the one or more vibration components 214, 215 generate the selected vibration 218 to reduce operational friction of the ball valve 202 as it opens.

[0019] Figure 3 depicts the example downhole friction control system 200 of Figure 2 with the ball valve 202 in the open position, in accordance with some embodiments. The ball valve 202 is shown in the open position, such that the opening 208 (see Fig. 2) is positioned within the drill string 206, and such that the ball valve 202 is permitting flow within the drill string 206. To close the ball valve 202, pressure is applied to the close line 212, while the open line 210 is vented. In at least one embodiment, the ball valve 202 comprises at least a portion of a downhole cutting tool, used for example, to cut through coil tubing 302.

[0020] In the illustrated embodiment, the coil tubing is positioned inside the drill string 206, such that it extends through the opening 208 of the ball valve 202. In at least one embodiment, when pressure is applied to the close line 212, and the open line 210 is vented, an edge of the opening 208 of the ball valve 202 cuts the coil tubing 302. In such an embodiment, the vibration component 215 can comprise a flutter valve or other oscillating device, such that as pressure is applied to the close line 212, the flutter valve generates the selected vibration 218, to increase the efficiency of the cutting ball valve 202. In some embodiments, one or more vibration components 214, 215 comprise motors or piezoelectric devices to generate the selected vibration 218 to increase the efficiency of the cutting ball valve 202. In at least one embodiment, the selected vibration 218 allows the cutting ball valve 202 to cut the coiled tubing 302 at the same speed, or in the same amount of time, with reduced pressure applied to the close line 212. In at least one embodiment, the selected vibration 218 is sufficient to dislodge accumulated solids 220. In at least one embodiment, the selected vibration 218 is selected to reduce operational friction of the ball valve 202 as it closes.

[0021] Figure 4 is a flow diagram of an example method 400 of downhole friction control, in accordance with some embodiments. As a matter of convenience, the method 400 is described with reference to the downhole friction control system 100 of Figure 1. At block 402 a downhole tool 108 is operated. For example, in at least one embodiment, the downhole tool 108 comprises a cutting tool and is operated to cut a downhole object. In at least one embodiment, the downhole tool 108 is located proximate to a downhole sub 102 comprising a vibration component 110. In at least one embodiment, the vibration component is coupled to the downhole sub 102. In some embodiments, the vibration component 102 is mechanically coupled to a portion of a drill string. In some embodiments, the downhole sub 102 comprises a portion of the downhole tool 108.

[0022] At block 404, a selected vibration 112 is introduced by the vibration component 110 to reduce operational friction of the downhole tool 108. The vibration component 110 may comprise, for example, a flutter valve or other oscillating device, a motor coupled to the drill string and to an eccentric weight, one or more valves, a piezoelectric device, a combination of these, or the like, such that introducing the selected vibration 112 comprises actuating the vibration component 110. In at least one embodiment, introducing the selected vibration 112 comprises cycling hydraulic pressure via one or more valves. In at least one embodiment, the vibration component 110 generates a selected vibration 112 that represents a high frequency pulse. In at least one embodiment, introducing the selected vibration 112 increases the cutting efficiency of the downhole tool 108. For example, the tool 108 can cut the same amount of material per unit time with reduced cutting pressure by adding the selected vibration 112. In some embodiments, introducing the selected vibration 112 dislodges accumulated solids 116 at the downhole tool 108, drill string 104, downhole sub 102, another downhole component, a combination of these, or the like. In some embodiments, the selected vibration 112 is introduced before the tool 108 is operated.

[0023] At block 406 one or more downhole friction factors are monitored via one or more sensors 118. For example, in at least one embodiment, the one or more sensors 118 monitor relative positions of two or more downhole movable surfaces. In some embodiments, the sensors 118 measure two or more downhole movable surfaces prevented from moving due to operational friction engagement. In some examples, the one or more sensors 118 monitor the selected vibration 112 produced by the vibration component 110. In at least one embodiment, the one or more sensors 118 monitor the lateral movement or displacement 114 of one or more downhole components. In some embodiments, the one or more sensors 118 monitor one or more parameters associated with solids. For example, in some embodiments, the one or more sensors could monitor accumulation of solids, type of solids, location of solids, density of solids, speed of solid flow, a combination of these, or the like. Each of the actions shown in the method 400 are optional, and thus, some embodiments of the method 400 do not include monitoring the one or more downhole friction factors.

[0024] At block 408 the selected vibration 112 is controlled via a controller 120. In some embodiments, the controller 120 adjusts the selected vibration 112 responsive to information received from the one or more sensors 118. In some embodiments, the controller 120 adjusts the selected vibration 112 responsive to disengagement of surfaces monitored by the one or more sensors 118. In some embodiments, the controller 120 controls the selected vibration 112 by adjusting the level or frequency of vibration. In some embodiments the controller 120 adjusts the selected vibration 112 according to a preset mode or sequence. In some embodiments, the controller 120 controls the selected vibration 112 by stopping vibration, or initiating vibration at the vibration component. In at least one embodiment, the selected vibration 112 patterns are preset and do not include a controller 120 capable of adjusting the selected vibration 112.

[0025] Figure 5 is a diagram showing a wireline system 500 embodiment, and Figure 6 is a diagram showing a logging while drilling (LWD) system 600 embodiment. The systems 500, 600 may thus comprise portions of a wireline logging tool body 502 as part of a wireline logging operation, or of a down hole tool 602 as part of a down hole drilling operation.

[0026] Figure 5 illustrates a well used during wireline logging operations. In this case, a drilling platform 504 is equipped with a derrick 506 that supports a hoist 508. Drilling oil and gas wells is commonly carried out using a string of drill pipes connected together so as to form a drillstring that is lowered through a rotary table 510 into a wellbore or borehole 512. Here it is assumed that the drillstring has been temporarily removed from the borehole 512 to allow a wireline logging tool body 502, such as a probe or sonde, to be lowered by wireline or logging cable 514 (e.g., slickline cable) into the borehole 512. Typically, the wireline logging tool body 502 is lowered to the bottom of the region of interest and subsequently pulled upward at a substantially constant speed. The tool body 502 may include downhole friction control system 516 (which may include any one or more of the elements of systems 100, 200 or 300 of Figures 1-3).

[0027] During the upward trip, at a series of depths various instruments (e.g., co-located with the downhole friction control system 516 included in the tool body 502) may be used to perform measurements on the subsurface geological formations 518 adjacent to the borehole 512 (and the tool body 502). The measurement data can be communicated to a surface logging facility 520 for processing, analysis, and/or storage. The processing and analysis may include natural gamma-ray spectroscopy measurements and/or determination of formation density. The logging facility 520 may be provided with electronic equipment for various types of signal processing. Similar formation evaluation data may be gathered and analyzed during drilling operations (e.g., during

LWD/MWD (measurement while drilling) operations, and by extension, sampling while drilling).

[0028] In some embodiments, the tool body 502 is suspended in the wellbore by a wireline cable 514 that connects the tool to a surface control unit (e.g., comprising a workstation 522). The tool may be deployed in the borehole 512 on coiled tubing, jointed drill pipe, hard wired drill pipe, or any other suitable deployment technique.

[0029] Referring to Figure 6, it can be seen how a system 600 may also form a portion of a drilling rig 604 located at the surface 606 of a well 608. The drilling rig 604 may provide support for a drillstring 610. The drillstring 610 may operate to penetrate the rotary table 510 for drilling the borehole 512 through the subsurface formations 518. The drillstring 610 may include a Kelly 612, drill pipe 614, and a bottom hole assembly 616, perhaps located at the lower portion of the drill pipe 614. As can be seen in the figure, the drillstring 610 may include a downhole friction control system 618 (which may include any one or more of the elements of system 100, 200 or 300 of Figures 1-3).

[0030] The bottom hole assembly 616 may include drill collars 620, a down hole tool 602, and a drill bit 622. The drill bit 622 may operate to create the borehole 512 by penetrating the surface 606 and the subsurface formations 518. The down hole tool 602 may comprise any of a number of different types of tools including MWD tools, LWD tools, and others.

[0031] During drilling operations, the drillstring 610 (perhaps including the Kelly 612, the drill pipe 614, and the bottom hole assembly 616) may be rotated by the rotary table 510. Although not shown, in addition to, or alternatively, the bottom hole assembly 616 may also be rotated by a motor (e.g., a mud motor) that is located down hole. The drill collars 620 may be used to add weight to the drill bit 622. The drill collars 620 may also operate to stiffen the bottom hole assembly 616, allowing the bottom hole assembly 616 to transfer the added weight to the drill bit 622, and in turn, to assist the drill bit 622 in penetrating the surface 606 and subsurface formations 518.

[0032] During drilling operations, a mud pump 624 may pump drilling fluid (sometimes known by those of ordinary skill in the art as “drilling mud”) from a mud pit 626 through a hose 628 into the drill pipe 614 and down to the drill bit 622. The drilling fluid can flow out from the drill bit 622 and be returned to the surface 606 through an annular area 630 between the drill pipe 614 and the sides of the borehole 512. The drilling fluid may then be returned to the mud pit 626, where such fluid is filtered. In some embodiments, the drilling fluid can be used to cool the drill bit 622, as well as to provide lubrication for the drill bit 622 during drilling operations. Additionally, the drilling fluid may be used to remove subsurface formation cuttings created by operating the drill bit 622.

[0033] The workstation 522 and the controller 526 may include modules comprising hardware circuitry, a processor, and/or memory circuits that may store software program modules and objects, and/or firmware, and combinations thereof, as desired by the architect of the downhole friction control system 516, 618 and as appropriate for particular implementations of various embodiments. For example, in some embodiments, such modules may be included in an apparatus and/or system operation simulation package, such as a software electrical signal simulation package, a power usage and distribution simulation package, a power/heat dissipation simulation package, and/or a combination of software and hardware used to simulate the operation of various potential embodiments.

[0034] Thus, many embodiments may be realized. Some of these will now be listed as non-limiting examples.

[0035] In some embodiments, a system comprises a downhole sub to attach to a drill string and a vibration component mechanically coupled to the downhole sub to generate a selected vibration in the drill string when the downhole sub is attached to the drill string.

[0036] In some embodiments, the selected vibration comprises a selected level and/or frequency of vibration.

[0037] In some embodiments, the selected vibration is sufficient to impart a lateral movement of a portion of the drill string of at least 5 mm.

[0038] In some embodiments, the selected vibration comprises a frequency of from about 20 Kilohertz to about 60 Kilohertz.

[0039] In some embodiments, the selected vibration is selected to reduce the pressure of a downhole cutting tool.

[0040] In some embodiments, the system further comprises a downhole tool coupled to the drill string, wherein the selected vibration is selected to reduce operational friction between components of the downhole tool.

[0041] In some embodiments, the system further comprises a controller to adjust the selected vibration to dislodge debris accumulated at the downhole tool.

[0042] In some embodiments, the downhole sub comprises a portion of a downhole tool, the selected vibration being selectable to reduce operational friction of the downhole tool.

[0043] In some embodiments, the vibration component comprises a flutter valve.

[0044] In some embodiments, the vibration component comprises a motor.

[0045] In some embodiments, the vibration component comprises a piezoelectric device.

[0046] In some embodiments, a method comprises introducing, via a vibration component mechanically coupled to a portion of a drill string, a selected vibration to the drill string to reduce operational friction of a downhole tool.

[0047] In some embodiments, the method further comprises operating the downhole tool to cut a downhole object, wherein introducing the selected vibration increases cutting efficiency of the downhole tool.

[0048] In some embodiments, the method further comprises operating the downhole tool, wherein introducing the selected vibration dislodges accumulated debris from the downhole tool.

[0049] In some embodiments, introducing the selected vibration comprises actuating a flutter valve coupled to the drill string.

[0050] In some embodiments, introducing the selected vibration comprises actuating a motor coupled to the drill string and to an eccentric weight.

[0051] In some embodiments, introducing the selected vibration comprises actuating a piezoelectric device coupled to the drill string.

[0052] In some embodiments, introducing the selected vibration comprises cycling hydraulic pressure via one or more valves.

[0053] In some embodiments, the method further comprises monitoring relative positions of two downhole movable surfaces prevented from moving due to operational friction engagement, and adjusting the selected vibration responsive to disengagement of the two downhole movable surfaces.

[0054] In some embodiments, the method further comprises controlling the selected vibration by adjusting the level or frequency of vibration.

[0055] In the foregoing Detailed Description, it can be seen that various features are grouped together in a single embodiment for the purpose of streamlining the disclosure. This method of disclosure is not to be interpreted as reflecting an intention that the claimed embodiments require more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive subject matter lies in less than all features of a single disclosed embodiment. Thus the following claims are hereby incorporated into the Detailed Description, with each claim standing on its own as a separate embodiment.

[0056] Note that not all of the activities or elements described above in the general description are required, that a portion of a specific activity or device may not be required, and that one or more further activities may be performed, or elements included, in addition to those described. Still further, the order in which activities are listed are not necessarily the order in which they are performed. Also, the concepts have been described with reference to specific embodiments. However, one of ordinary skill in the art appreciates that various modifications and changes can be made without departing from the scope of the present disclosure as set forth in the claims below. Accordingly, the specification and figures are to be regarded in an illustrative rather than a restrictive sense, and all such modifications are intended to be included within the scope of the present disclosure.

[0057] Benefits, other advantages, and solutions to problems have been described above with regard to specific embodiments. However, the benefits, advantages, solutions to problems, and any feature(s) that may cause any benefit, advantage, or solution to occur or become more pronounced are not to be construed as a critical, required, or essential feature of any or all the claims. Moreover, the particular embodiments disclosed above are illustrative only, as the disclosed subject matter may be modified and practiced in different but equivalent manners apparent to those skilled in the art having the benefit of the teachings herein. No limitations are intended to the details of construction or design herein shown, other than as described in the claims below. It is therefore evident that the particular embodiments disclosed above may be altered or modified and all such variations are considered within the scope of the disclosed subject matter. Accordingly, the protection sought herein is as set forth in the claims below.

What is claimed is:

1. A system, comprising:

a downhole sub to attach to a drill string; and

a vibration component mechanically coupled to the downhole sub to generate a selected vibration in the drill string when the downhole sub is attached to the drill string.

2 The system of claim 1, wherein the selected vibration comprises a selected level and/or frequency of vibration.

3. The system of claim 1, wherein the selected vibration is sufficient to impart a lateral movement of a portion of the drill string of at least 5 mm.

4 The system of claim 3, wherein the selected vibration comprises a frequency of from about 20 Kilohertz to about 60 Kilohertz.

5. The system of claim 1, wherein the selected vibration is selected to reduce the pressure of a downhole cutting tool.

6. The system of claim 1, further comprising:

a downhole tool to couple to the drill string, wherein the selected vibration is selected to reduce operational friction between components of the downhole tool.

7. The system of claim 6, further comprising:

a controller to adjust the selected vibration to dislodge debris accumulated at the downhole tool.

8. The system of claim 1, wherein the downhole sub comprises a portion of a downhole tool, the selected vibration being selectable to reduce operational friction of the downhole tool.

9. The system of claim 1, wherein the vibration component comprises a flutter valve.

10. The system of claim 1, wherein the vibration component comprises a motor.

11. The system of claim 1, wherein the vibration component comprises a piezoelectric device.

12. A method, comprising:

introducing, via a vibration component mechanically coupled to a portion of a drill string, a selected vibration to the drill string to reduce operational friction of a downhole tool.

13. The method of claim 12, further comprising:

operating the downhole tool to cut a downhole object, wherein introducing the selected vibration increases cutting efficiency of the downhole tool.

14. The method of claim 12, further comprising:

operating the downhole tool, wherein introducing the selected vibration dislodges accumulated debris from the downhole tool.

15. The method of claim 12, wherein introducing the selected vibration comprises actuating a flutter valve coupled to the drill string.

16. The method of claim 12, wherein introducing the selected vibration comprises actuating a motor coupled to the drill string and to an eccentric weight.

17. The method of claim 12, wherein introducing the selected vibration comprises actuating a piezoelectric device coupled to the drill string.

18. The method of claim 12, wherein introducing the selected vibration comprises cycling hydraulic pressure via one or more valves.

19. The method of claim 12, further comprising:

monitoring relative positions of two downhole movable surfaces having a reduced relative movement range due to operational friction engagement; and

adjusting the selected vibration responsive to increase in the relative movement range of the two downhole movable surfaces.

20. The method of claim 12, further comprising:

controlling the selected vibration by adjusting the level or frequency of vibration.

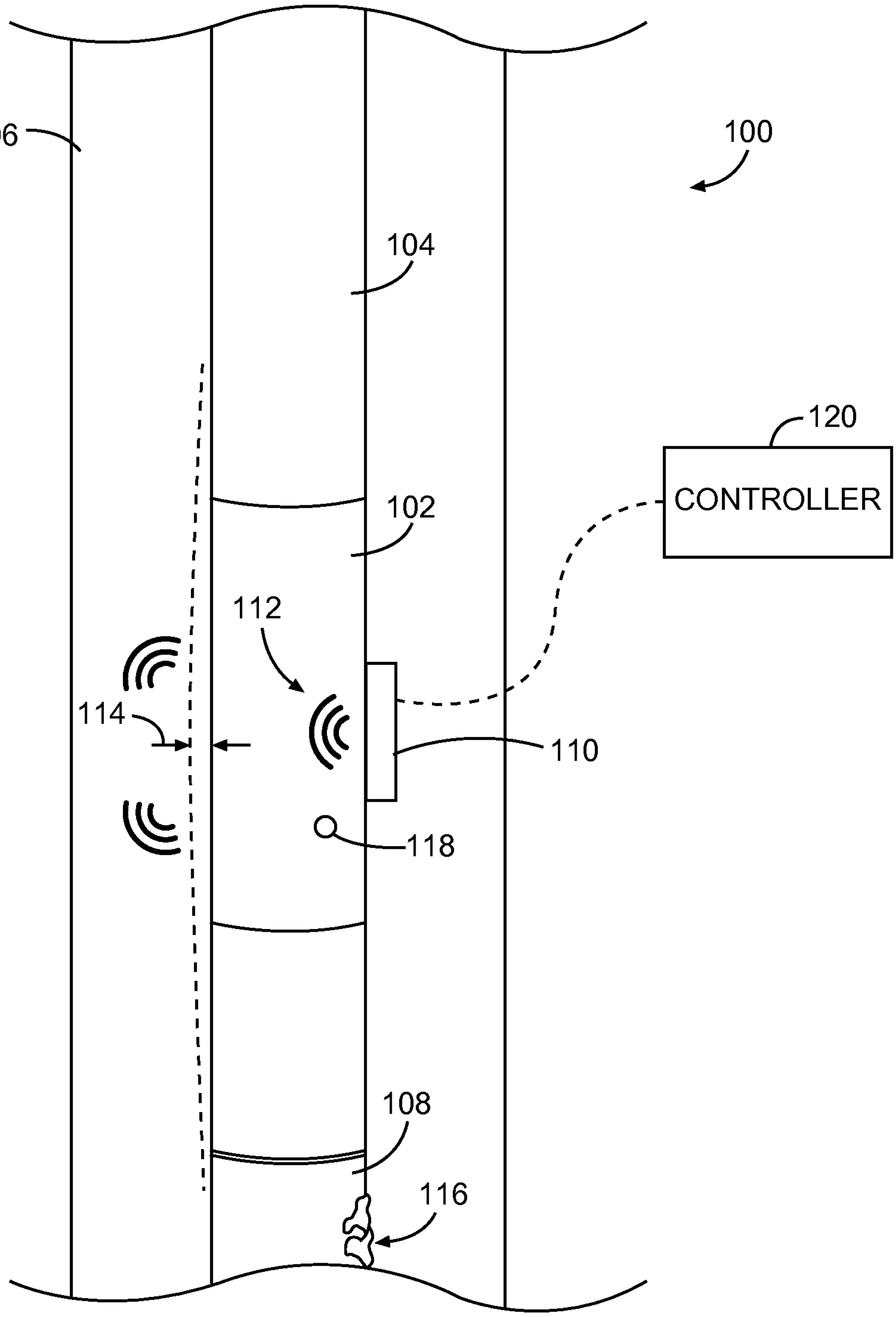

Fig. 1

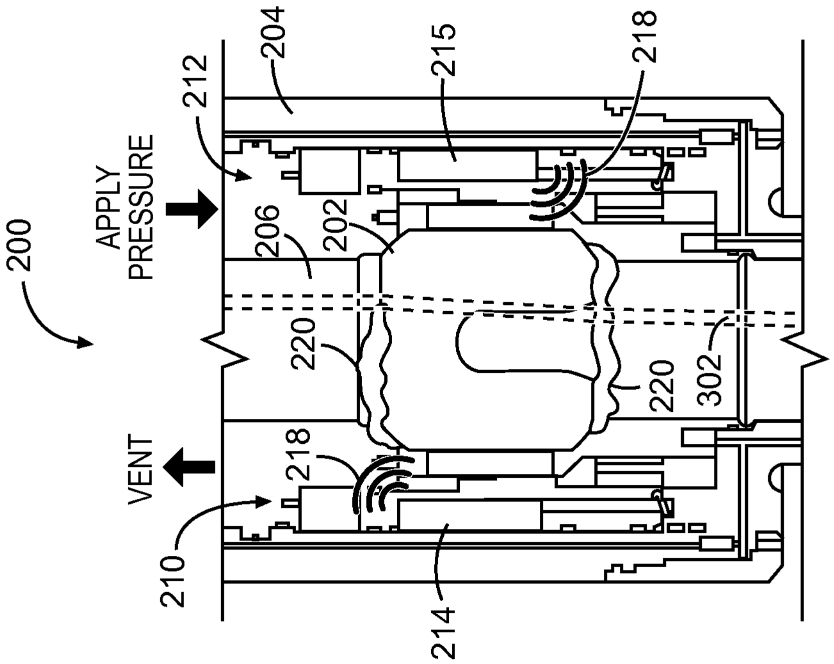
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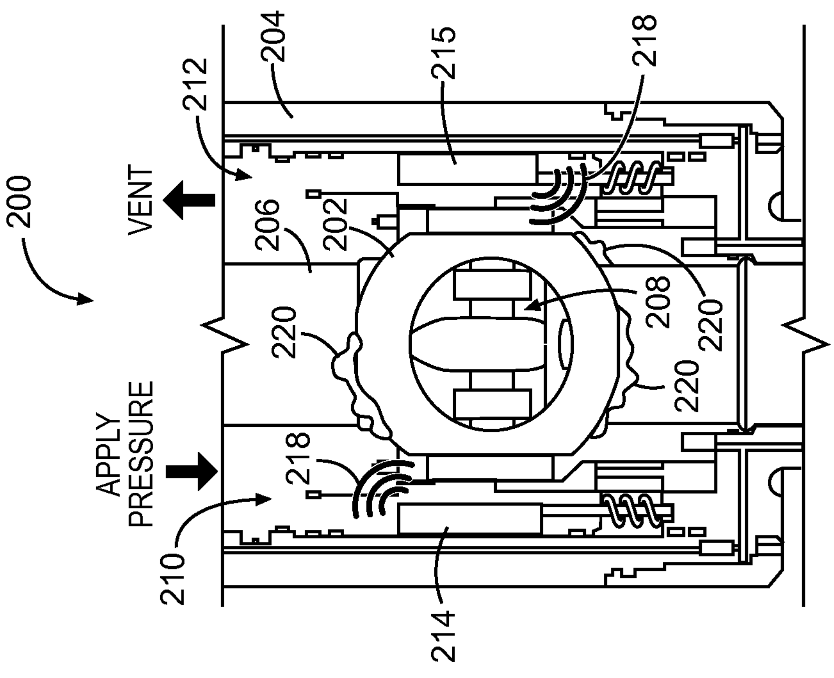
Fig. 3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APPLY PRESSURE
212
204
215
218
206
202
208
220
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220
220
218
210
214

Fig. 2

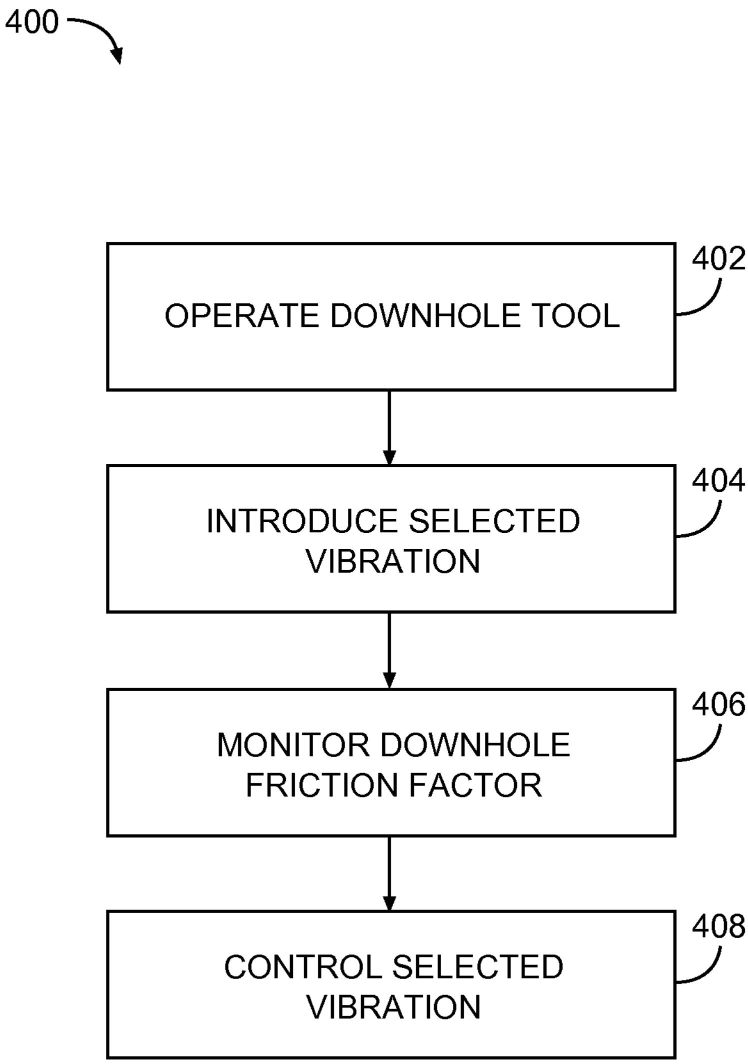

400
OPERATE DOWNHOLE TOOL
402
INTRODUCE SELECTED VIBRATION
404
MONITOR DOWNHOLE FRICTION FACTOR
406
CONTROL SELECTED VIBRATION
408

Fig. 4

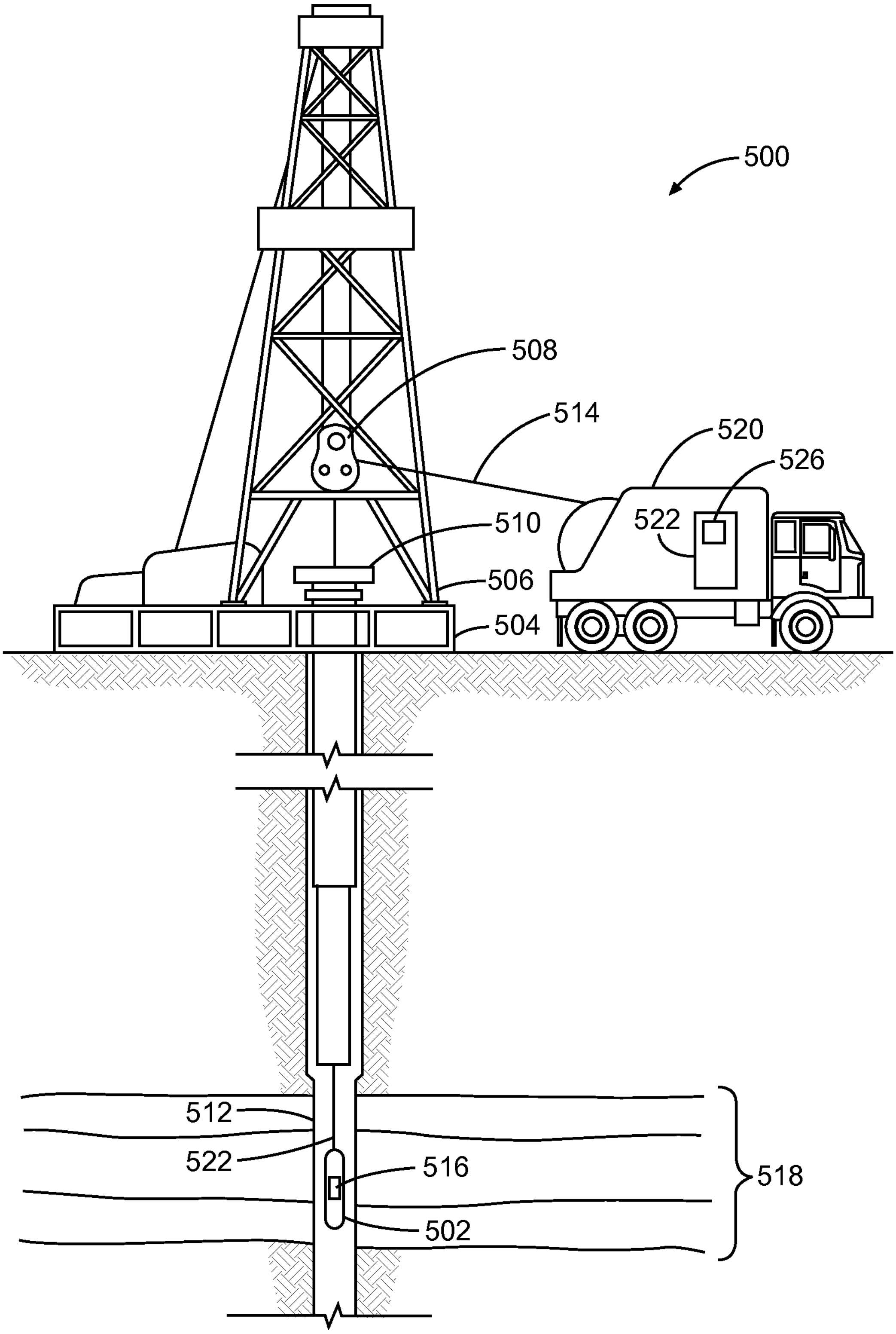
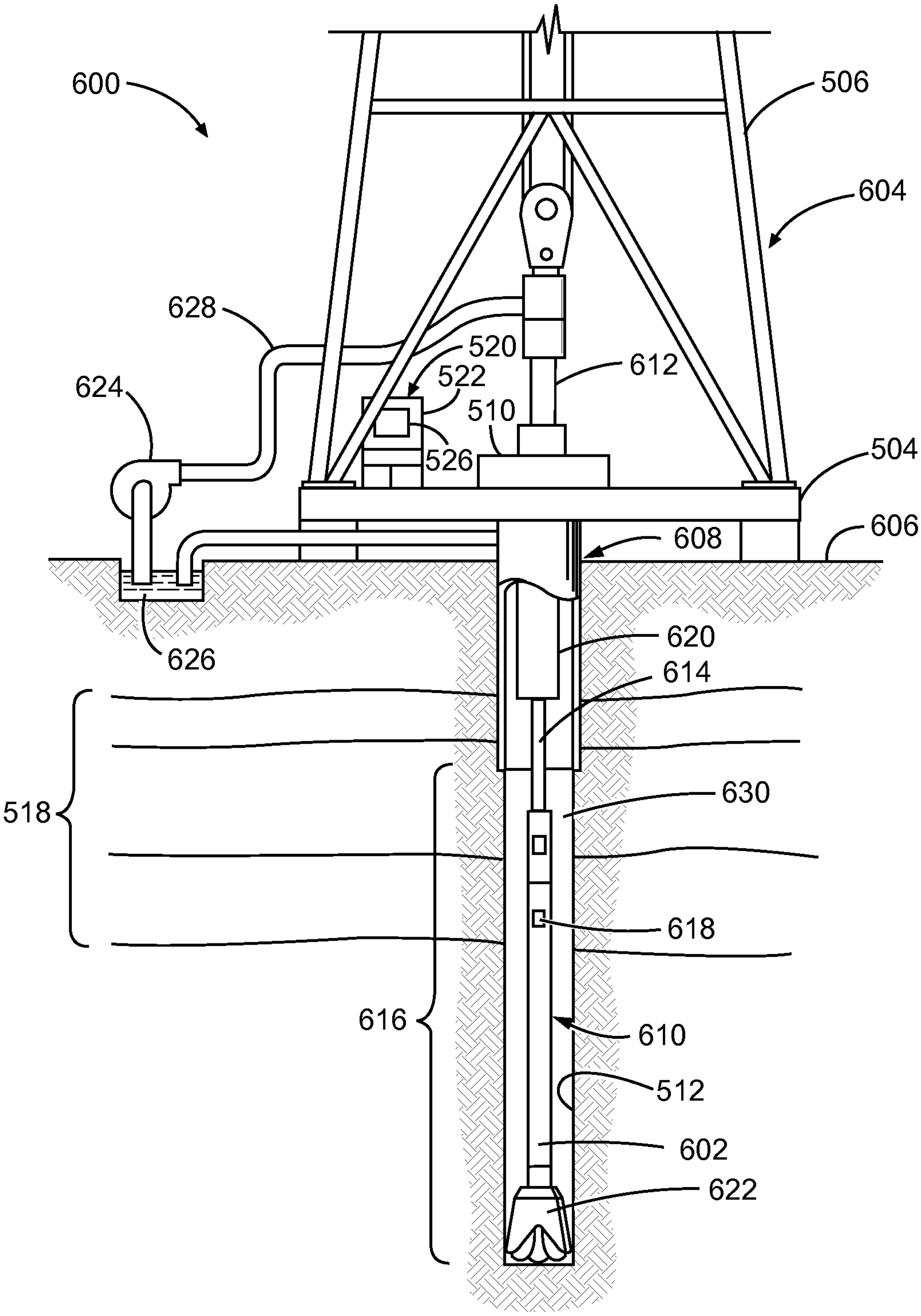


Fig. 5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628
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612
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504
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602
622

Fig. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/038351

A. CLASSIFICATION OF SUBJECT MATTER

E21B 7/24(2006.01)i, E21B 17/00(2006.01)i, E21B 12/00(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 7/24; E21B 23/14; E21B 34/06; E21B 43/00; E21B 31/00; E21B 28/00; E21B 23/00; E21B 17/00; E21B 12/00

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, drill string, select, vibration, friction

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2012-0247757 A1 (SWINFORD, JERRY L.) 04 October 2012 See paragraphs [0003]-[0008], [0028]-[0035], [0085]-[0088], [0097]; and figures 1-2.	1-20
A	US 2014-0069639 A1 (MACKENZIE et al.) 13 March 2014 See paragraphs [0004]-[0005], [0037]; and figure 11.	1-20
A	US 2014-0110134 A1 (SAUDI ARABIAN OIL COMPANY) 24 April 2014 See paragraphs [0002], [0006]-[0010], [0023]-[0029]; and figures 3-5.	1-20
A	US 4384625 A (ROPER et al.) 24 May 1983 See column 3, line 39 - column 4, line 38; column 6, line 42 - column 7, line 7; and figures 1-2.	1-20
A	EP 1239112 A2 (SCHLUMBERGER TECHNOLOGY B.V. et al.) 11 September 2002 See paragraphs [0001], [0008]-[0010], [0014]-[0024]; and figure 1.	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
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"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
04 March 2016 (04.03.2016)	**07 March 2016 (07.03.2016)**

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2015/038351

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