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(54) Title: HYDRAULIC ADJUSTMENT OF DRILL BIT ELEMENTS

(57) Abstract: In some embodiments, a drill bit element apparatus includes a hydraulically adjustable drill bit element disposed within a drill bit. A hydraulic fluid chamber substantially surrounds a portion of the drill bit element. The orientation of the drill bit element with respect to the drill bit may be adjusted by an increase or decrease of hydraulic fluid pressure in the chamber.

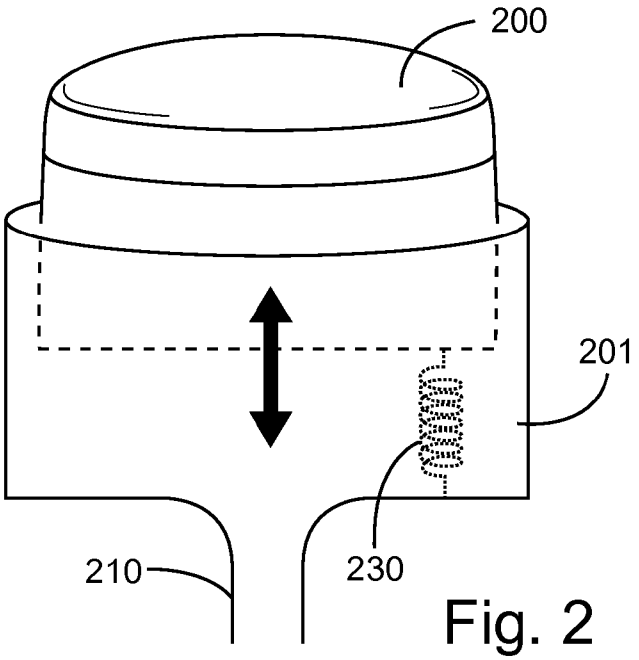


Fig. 2

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HYDRAULIC ADJUSTMENT OF DRILL BIT ELEMENTS

BACKGROUND

[0001] During a well drilling operation in a geological formation, different types of formations may call for the use of different drilling rates. To achieve a selected drilling rate or range thereof when advancing to a particular portion of a formation, the drill string may be removed (tripped out) from the borehole to replace the current drill bit with a different drill bit, such as with different depth of cut elements and/or cutters attributes. This may add to the cost of drilling a well, in terms of time and money.

BRIEF DESCRIPTION OF THE DRAWINGS

[0002] FIG. 1 is a diagram showing a perspective view of a drill bit with example hydraulically adjustable drill bit elements, according to aspects of the present disclosure.

[0003] FIG. 2 is a cross-sectional diagram showing an example of a hydraulically adjustable depth of cut element apparatus, according to aspects of the present disclosure.

[0004] FIG. 3 is a cross-sectional diagram showing another example of a hydraulically adjustable depth of cut element apparatus, according to aspects of the present disclosure.

[0005] FIG. 4 is a cross-sectional diagram showing another example of a hydraulically adjustable depth of cut element apparatus, according to aspects of the present disclosure.

[0006] FIG. 5 is perspective view showing another example of a hydraulically adjustable cutter apparatus, according to aspects of the present disclosure.

[0007] FIG. 6 is a cross-sectional diagram showing an example operation of hydraulically adjustable drill bit elements, according to aspects of the present disclosure.

[0008] FIG. 7 is a diagram showing an example drilling system with a closed hydraulic system for hydraulic drill bit element adjustment, according to aspects of the present disclosure.

[0009] FIG. 8 is a flowchart of an example method for operation of hydraulically adjustable drill bit elements, according to aspects of the present disclosure.

[0010] FIG. 9 is a block diagram of an example system operable to execute the methods herein, according to aspects of the present disclosure.

DETAILED DESCRIPTION

[0011] The present disclosure is directed in part to hydraulically adjustable drill bit elements that may be adjusted to provide varying rates of drilling through various geological formations. By adjusting the drill bit elements dynamically, either on command or automatically, drill bit damage and/or inefficiency may be reduced. Additionally, the present examples may reduce or eliminate the need to remove the drill string from the wellbore to manually adjust the drill bit.

[0012] FIG. 1 is a diagram showing a perspective view of a drill bit 110 with example hydraulically adjustable drill bit elements 100, 101, according to aspects of the present disclosure. A plurality of the hydraulically adjustable elements 100, 101 may be movably positioned within the drill bit 110. The illustrated example shows depth of cut elements 100 and cutters (e.g., polycrystalline diamond compact (PDC) cutters) 101.

[0013] For purposes of clarity and brevity, the following examples focus on adjusting only a single drill bit element 100, 101. However, one of ordinary skill in the art, after reviewing the information disclosed herein, will realize that any or all of the elements 100, 101 may be hydraulically adjusted in a substantially similar fashion, individually or substantially simultaneously.

[0014] FIG. 2 is a cross-sectional diagram showing an example of a hydraulically adjustable depth of cut element apparatus, according to aspects of the present disclosure. In this example, the depth of cut element 200 of the apparatus is adjustable in an outward direction.

[0015] At least a portion of the depth of cut element 200 is disposed in a chamber 201 that is sealed substantially around the portion of the depth of cut element 200. A hydraulic line 210 is coupled to the chamber 201 to provide a

path to add or remove hydraulic fluid from the chamber 201. Thus, when it is desired to extend the depth of cut element 200 in an outward direction with respect to the drill bit, additional hydraulic fluid is pumped into the chamber 201 in order to increase the fluid pressure in the chamber 201 and, thus, move the depth of cut element 200 outward from the drill bit.

[0016] When it is desired to retract the depth of cut element 200 into the chamber, at least some of the fluid is removed from the chamber 201 in order to decrease the fluid pressure within the chamber 201 and, thus, allow the depth of cut element 200 to be pushed, or pulled with spring force, at least partially back into the chamber 201. An external force such as external pressure from the formation being drilled may provide the force necessary to move the depth of cut element 200 at least partially back into the chamber 201. When the external formation pressure is substantially equal to the fluid pressure in the chamber 201, the depth of cut element 200 will stop retracting. By adjusting the amount of fluid pressure within the chamber 201, the amount of extension of the depth of cut element 200 may be adjusted.

[0017] In another example, the depth of cut element 200 may be pulled back into the chamber 201 by a spring force caused by an optional spring 230 coupled between the depth of cut element 200 and the chamber 201. When the spring force is greater than the hydraulic force pushing out, the spring may retract the depth of cut element 200 back into the chamber 201 until the spring force and the hydraulic force become substantially equal at a neutral position.

[0018] FIG. 3 is a cross-sectional diagram showing another example of a hydraulically adjustable depth of cut element apparatus, according to aspects of the present disclosure. This example uses a piston 340 in place of the hydraulic fluid chamber 201 of FIG. 2 and acts in substantially the same manner as the hydraulic fluid chamber 201. For example, increasing the hydraulic fluid pressure on the piston 340 in a sealed chamber 320 below the piston 340 may cause it to move outwards with respect to the drill bit, pushing the depth of cut element 300 outward as well. Releasing the hydraulic pressure may allow geological formation force or a spring force, such as the spring 230 of FIG. 2, to

push the hydraulic fluid back into the hydraulic line 310 and to retract the depth of cut element 300 back to a neutral position.

[0019] Both of the examples in FIGs. 2 and 3 may use separate hydraulic fluid return lines. One line may supply the hydraulic pressure while the other line may be a return line to return the hydraulic fluid to a hydraulic fluid reservoir when the depth of cut element 200, 300 and/or the piston 340 returns to the chamber 201, 301.

[0020] FIG. 4 is a cross-sectional diagram showing another example of a hydraulically adjustable depth of cut element apparatus, according to aspects of the present disclosure. In this example, the depth of cut element 400 is hydraulically adjustable in a side-to-side direction with respect to the drill bit.

[0021] A lower portion of the depth of cut element 400 is disposed between two chambers 401, 402 that are sealed to retain their respective hydraulic fluid. Each chamber 401, 402 is coupled to one or more dedicated hydraulic lines 410, 411 that enable adjustment of the amount of fluid and, thus, the fluid pressure in each chamber 401, 402. The example of FIG. 4 shows each chamber 401, 401 having only a single fluid line but other examples may use one line for supplying fluid while a second line may be a return line to return fluid to a reservoir. Each chamber 401, 402 is located substantially opposite the other with respect to the depth of cut element 400.

[0022] In order to move the depth of cut element 400 from the left side of the apparatus to the right side, fluid is added to the left chamber 402 through the dedicated hydraulic fluid line 411. This increases the fluid pressure in the left chamber 411. As the fluid is added to the left chamber 411, the fluid pressure in the right dedicated hydraulic fluid line 410 is released (i.e., decreased fluid pressure) so that the movement of the depth of cut element 400 into the right chamber 401 allows the lower portion of the depth of cut element 400 to push the fluid from the right chamber 401 back to a hydraulic reservoir of the system (not shown).

[0023] In another example, the individual chambers may be replaced with individual hydraulically actuated pistons 421, 422. By increasing the hydraulic pressure on one piston 422 while simultaneously reducing the hydraulic pressure

on the other piston 421, the pistons 421, 422 may move the depth of cut element 400 in a substantially similar manner using the sealed chambers 401, 402. In both examples, the hydraulic pressure is released on the opposing side by using that side as a hydraulic fluid return line, as shown in the system of FIG. 7 and discussed subsequently.

[0024] In yet another example, the depth of cut element 400 may be returned by a spring force on one side of the apparatus. For example, a spring 430 may be coupled to the depth of cut element 400 and impart a spring force on the element 400. The hydraulic pressure from either a piston 421 or fluid pressure in the chamber 401 may overcome the spring force and thus, move the depth of cut element 400 in the opposite direction from the force. Once that hydraulic pressure is released, the spring 430 may pull the depth of cut element 400 back to a neutral position of substantial equilibrium between spring and hydraulic forces.

[0025] In yet another example, the examples of FIGs. 2-4 may be combined such that a depth of cut element may be both moved back and forth along the drill bit as well as outward from the drill bit.

[0026] FIG. 5 is a perspective view showing an example of a hydraulically adjustable cutter apparatus, according to aspects of the present disclosure. In an example, the cutter element 500 may comprise a PDC cutter element or some other type of cutter element used in a drill bit. The cutter element 500 is mounted (e.g., to the drill bit) by a mount 550 located substantially close to the cylindrical axis 540 of the element 500.

[0027] The hydraulically adjustable cutter apparatus includes the cutter element 500 disposed above two chambers 501, 502 that are adjacent and sealed off from each other. The chambers 501, 502 may be part of the cutter element 500 or a respective rear portion of the cutter element 500 may be disposed within each chamber 501, 502. Each chamber 501, 502 includes a respective hydraulic fluid line 510, 511. As an example of operation, when the fluid pressure increases in a particular chamber 501, the pressure increases the size of that chamber 501 and, thus, increases pressure against the respective portion of the cutter element 500 within that chamber 501. The reduced pressure in the other

chamber 502 reduces the size of that chamber 502 and allows rotation of the cutter element 500 about the cylindrical axis 540 . The rotation about the cylindrical axis 540 has the effect of rotating a cutting edge 530 of the cutter element 500. The direction of rotation can be reversed by increasing the fluid pressure in the other chamber 502 to push on the respective portion 506 of the cutter element 500 while reducing the pressure in the particular chamber 501.

[0028] For example, if it was desired to rotate the cutting edge 530 clockwise (as viewed from the rear), the first hydraulic line 511 would act as an input to increase the fluid pressure in its respective chamber 502. The second hydraulic line 510 would act as a return line for returning the hydraulic fluid in its respective chamber 501 to a hydraulic reservoir of the system. Thus, the increased pressure in the first chamber 502 and the lack of pressure in the second chamber 501 would cause the cutting element 500 to rotate about the central axis 540, thus rotating the cutting edge 530.

[0029] FIG. 6 is a cross-sectional diagram showing an example operation of hydraulically adjustable drill bit elements, according to aspects of the present disclosure. For purposes of brevity, the illustrated example shows both a depth of cut element 600 and a cutter element 610 operating adjacent to each other in a drill bit. Other examples may use only one or the other of these elements. Still other examples may use multiple depth of cut elements 600 and/or multiple cutter elements 610.

[0030] Using one or more of the above-described examples, the depth of cut element 600 may be adjusted up or down or side-to-side in order to adjust the drilling slope of the drill bit through the formation 630. Additionally, extending the depth of cut element 600 may slow the rate of drilling by reducing the amount of cutter element 610 exposure to the formation 630. For example, if the formation 630 is difficult to penetrate, extending the depth of cut element 600 may reduce damage on the cutter element 610.

[0031] Similarly, the cutter element (e.g., PDC) 710 may be adjusted in or out (e.g., tilted) during a drilling operation in order to change the drilling rate using one or more of the above-described examples. If the cutter face 620 is non-planer, rotating the cutter element 610 about its cylindrical axis may have the

effect of tilting the cutter face 620, thus increasing the drilling rate through softer formations 630.

[0032] FIG. 7 is a diagram showing an example drilling system with a closed hydraulic system for hydraulic drill bit element adjustment, according to aspects of the present disclosure. The system includes one or more drill bit element apparatuses (e.g., depth of cut element apparatus, cutter element apparatus) (not shown) disposed in the drill bit 700. The system of FIG. 7 is for purposes of illustration only as other drilling systems or hydraulic systems may be used to adjust the drill bit elements as disclosed herein. An example of a drill bit with drill bit elements can be seen in FIG. 1 and discussed previously.

[0033] A drilling rig 702 is disposed over a well 706 on the surface 804 of a subsurface formation 814 and may provide support for a drill string 790 including a drill bit 700 with hydraulically adjustable drill bit elements (e.g., any of the elements described above, including depth of cut elements and cutter elements). The drill string 790 may operate to penetrate the rotary table 710 for drilling the borehole 712 through the subsurface formations 714.

[0034] During drilling operations, a mud pump 732 may pump drilling fluid (sometimes known by those of ordinary skill in the art as "drilling mud") from a mud pit 734 through a hose 736, into the casing 718, and down to the drill bit 700. The drilling fluid can flow out from the drill bit 700 and be returned to the surface 704 through an annular area740 between the casing 718 and the sides of the borehole 712. The drilling fluid may then be returned to the mud pit 734, where such fluid is filtered. In some examples, the drilling fluid may be used to cool the drill bit 700, as well as to provide lubrication for the drill bit 700 during drilling operations. Additionally, the drilling fluid may be used to remove subsurface formation cuttings created by operating the drill bit 700.

[0035] A workstation 754 having a controller 796 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. The workstation 754 and controller 796 may be configured to control the direction, depth, rate, and diameter of the wellbore drilling by executing instructions (e.g., see method of FIG. 8) in order to control the hydraulic

pressure and, thus, control the hydraulically adjustable drill bit elements. An example workstation 754 and controller 796 may be realized by the system of FIG. 9.

[0036] In the closed hydraulic portion of the drilling system, a drill bit element in the drill bit 700 is coupled to hydraulic lines 770 that lead from a hydraulic pump 720 to the element. In one example, the hydraulic pump 720 is disposed in the drill bit such that the hydraulic lines 770 extend to the depth of cut elements or cutters. The hydraulic lines 770 include a line that functions as a hydraulic pressure line to provide the hydraulic pressure to adjust the drill bit element and a line that functions as a return line that enables the hydraulic fluid to return to a reservoir in the pump 720. These lines 770 may switch functions depending on the movement desired from the drill bit elements, as seen previously. While the hydraulic pump 720 and downhole control logic 753 are shown in the drill string, these elements may also be disposed in the drill bit 700. The surface workstation 754 and controller 796 may communicate with the downhole control logic 753 via a mud pulse, electromagnetic (EM) pulse, telemetry cable, or some other way of communicating downhole.

[0037] Operation of the hydraulically adjustable drill bit elements may be controlled from the surface workstation 754, from control logic 753 downhole in the drill string, or from a combination of both the workstation 754 and the downhole control logic 753. As an example operation, the workstation 754 and/or the downhole control logic 753 may control the drill bit elements during a logging while drilling (LWD) or measure while drilling (MWD) operation. For example, the LWD or MWD operation may monitor the rate of drilling, the vibrations while drilling, and/or the formation 714 composition in determining when to extend, retract, move, or otherwise control the hydraulically adjustable drill bit elements.

[0038] An example system may combine the examples illustrated herein in any combination. For example, a drill bit may comprise only an adjustable depth of cut element or an adjustable cutter. Each of these elements may be one or more of different examples of each of the depth of cut element examples or each of the cutter examples. Another example may combine both depth of cut elements and

adjustable cutter elements in a single drill bit using any of the examples disclosed herein.

[0039] FIG. 9 is a flowchart of an example method for operation of hydraulically adjustable drill bit elements, according to aspects of the present disclosure. The illustrated example may be executed as a set of instructions by the system of FIG. 10. This method may be part of a LWD/MWD operation.

[0040] In block 901, drilling parameters are monitored during the drilling operation and/or LWD/MWD operation. The drilling parameters may include rate of drilling, vibrations experienced while drilling, formation composition, torque, and/or weight on bit, among others. In response to at least one or more of these drilling parameters, the control circuitry may control the hydraulic fluid pressure to adjust one or more of the drill bit elements, in block 903.

[0041] For example, the drilling torque is high due to a dense geological formation that may have been encountered. In such a scenario, the depth of cut element may be extended to decrease the drilling slope and, thus reduce the torque on the drill bit cutting elements in response to the measured drilling parameters. At the same time or alternatively, the cutter elements may be rotated to also reduce wear on the cutting edges in response to the drilling parameters. The orientation of the drill bit elements can be adjusted with respect to the drill bit.

[0042] FIG. 10 is a block diagram of an example system 1000 operable to execute the methods herein, according to aspects of the present disclosure. The system 1000 may include circuitry (e.g., a controller or workstation) 1020, a memory 1030, a communications unit 1035, and an interface unit 1060 coupled together over a bus 1037.

[0043] The circuitry 1020 may be realized as a processor or a group of processors that may operate independently depending on an assigned function. The circuitry 1020 may include control circuitry such as one or more microprocessors.

[0044] The memory 1030 may include volatile and/or non-volatile memory. For example, the memory may include read only memory (ROM), random

access memory (RAM) (e.g., SRAM, DRAM), flash, optical drives, and/or magnetic disk storage (e.g., hard drives).

[0045] The communications unit 1035 may include downhole communications for appropriately located sensors in a wellbore. The sensors may be located on the drill bit. Such downhole communications can include a telemetry system. The communications unit 1035 may use combinations of wired communication technologies and wireless technologies at frequencies that do not interfere with on-going measurements.

[0046] The bus 1037 may provide electrical conductivity among the components of the system 1000. The bus 1037 may include an address bus, a data bus, and a control bus, each independently configured or in an integrated format. The bus 1037 may be realized using a number of different communication mediums that allows for the distribution of components of the system 1000. The bus 1037 can include a network. Use of the bus 1037 can be regulated by the circuitry 1020.

[0047] The system 1000 may be arranged to control operation of the hydraulically adjustable drill bit elements and execute steps to perform the method of FIG. 9. The system 1000 may control the hydraulic pressure of the hydraulic pump 820 and, thus, control the adjustment of the drill bit elements.

[0048] The interface unit(s) 1060 may allow a user to interface, control, and/or monitor the operation of the drilling and hydraulic system 864 or components distributed within the system 1000. The interface units 1060 may take the form of monitors, key boards, and/or touchscreen displays. Many embodiments may thus be realized, and the elements of several will now be listed in detail.

[0049] Example 1 is an apparatus comprising: a hydraulically adjustable drill bit element movably positioned within a drill bit; and a hydraulic fluid chamber substantially surrounding a portion of the drill bit element wherein a change of hydraulic fluid pressure in the chamber adjusts a position of the drill bit element with respect to the drill bit.

[0050] In Example 2, the subject matter of Example 1 can optionally include wherein the hydraulic fluid chamber comprises a piston configured to move in

response to the change of the hydraulic fluid pressure and contact the drill bit element in order to adjust the position of the drill bit element.

[0051] In Example 3, the subject matter of Examples 1-2 can optionally include wherein the drill bit element comprises a depth of cut element.

[0052] In Example 4, the subject matter of Examples 1-3 can optionally include wherein the drill bit element comprises a cutter element.

[0053] In Example 5, the subject matter of Examples 1-4 can optionally include wherein the hydraulic fluid chamber is configured to adjust the drill bit element in an outward or an inward direction from the drill bit.

[0054] In Example 6, the subject matter of Examples 1-5 can optionally include wherein the hydraulic fluid chamber is configured to adjust the drill bit element in a side-to-side direction with respect to the drill bit.

[0055] In Example 7, the subject matter of Examples 1-6 can optionally include wherein the hydraulic fluid chamber is configured to adjust the drill bit element in a rotationally around its central axis.

[0056] In Example 8, the subject matter of Examples 1-7 can optionally include a spring disposed within the hydraulic fluid chamber, the spring coupled between the drill bit element and the hydraulic fluid chamber.

[0057] In Example 9, the subject matter of Examples 1-8 can optionally include wherein the hydraulic fluid chamber comprises a first fluid chamber disposed on a first side of the drill bit element, the apparatus further comprising: a second fluid chamber disposed on a second side of the drill bit element, the second side substantially opposite to the first side wherein increased hydraulic fluid pressure in the first chamber and decreased fluid pressure in the second chamber results in adjustment of the drill bit element towards the second chamber.

[0058] In Example 10, the subject matter of Examples 1-9 can optionally include wherein each of the first and second fluid chambers comprise a piston configured to contact the drill bit element.

[0059] In Example 11, the subject matter of Examples 1-10 can optionally include wherein the hydraulic fluid chamber comprises a first fluid chamber disposed adjacent to a second fluid chamber and substantially surrounding a

lower portion of the drill bit element, the apparatus further comprising: a respective surface area of the drill bit element, disposed in each of the first and second fluid chambers, configured to rotate the drill bit element about a central axis of the drill bit element.

[0060] Example 12 is a method for performing a drilling operation with a drill bit element apparatus, the method comprising: monitoring drilling parameters during the drilling operation in a geological formation; and controlling hydraulic fluid pressure, to adjust an orientation of drill bit elements disposed in a drill bit, in response to the drilling parameters.

[0061] In Example 13, the subject matter of Example 12 can optionally include wherein monitoring the drilling parameters comprises monitoring rate of drilling, vibrations experienced while drilling, formation composition, weight on bit, and/or torque.

[0062] In Example 14, the subject matter of Examples 12-13 can optionally include wherein monitoring the drilling parameters comprises performing a logging while drilling (LWD) or measure while drilling (MWD) operation.

[0063] In Example 15, the subject matter of Examples 12-14 can optionally include wherein controlling the hydraulic pressure, to adjust the drill bit elements disposed in the drill bit, in response to the drilling parameters comprises hydraulically extending or retracting a depth of cut element in response to the drilling parameters.

[0064] In Example 16, the subject matter of Examples 12-15 can optionally include wherein controlling the hydraulic pressure, to adjust the drill bit elements disposed in the drill bit, in response to the drilling parameters comprises hydraulically rotating a cutter element in response to the drilling parameters.

[0065] In Example 17, the subject matter of Examples 12-16 can optionally include wherein controlling hydraulic fluid pressure, to adjust drill bit elements disposed in a drill bit, in response to the drilling parameters comprises extending or retracting the drill bit element from the drill bit, the method further comprising: returning the drill bit element to a neutral position by a spring force, a hydraulic force, or a force from the geological formation.

[0066] Example 18 is a system comprising: a drilling rig disposed on a surface of a geological formation and configured to support a drill string having a drill bit with drill bit elements disposed therein; a hydraulic system coupled to the drill bit elements; and circuitry coupled to the hydraulic system and configured to control hydraulic pressure to the drill bit elements to adjust an orientation of the drill bit elements with respect to the drill bit.

[0067] In Example 19, the subject matter of Example 18 can optionally include wherein the hydraulic system comprises a closed hydraulic system with hydraulic pressure lines and return lines, the circuitry further configured to control hydraulic adjustment of the drill bit elements comprising a plurality of depth of cut elements and cutter elements by control of fluid flow in the hydraulic pressure lines and return lines.

[0068] In Example 20, the subject matter of Examples 18-19 can optionally include a hydraulic pump disposed in the drill string or the drill bit, wherein the hydraulic pressure lines, return lines, and circuitry coupled to the hydraulic system are disposed in the drill string or the drill bit.

[0069] 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.

Claims

What is claimed is:

1. An apparatus comprising:
a hydraulically adjustable drill bit element movably positioned within a drill bit; and
a hydraulic fluid chamber substantially surrounding a portion of the drill bit element wherein a change of hydraulic fluid pressure in the chamber adjusts a position of the drill bit element with respect to the drill bit.

2. The apparatus of claim 1, wherein the hydraulic fluid chamber comprises a piston configured to move in response to the change of the hydraulic fluid pressure and contact the drill bit element in order to adjust the position of the drill bit element.

3. The apparatus of claim 1, wherein the drill bit element comprises a depth of cut element.

4. The apparatus of claim 1, wherein the drill bit element comprises a cutter element.

5. The apparatus of claim 1, wherein the hydraulic fluid chamber is configured to adjust the drill bit element in an outward or an inward direction from the drill bit.

6. The apparatus of claim 1, wherein the hydraulic fluid chamber is configured to adjust the drill bit element in a side-to-side direction with respect to the drill bit.

7. The apparatus of claim 1, wherein the hydraulic fluid chamber is configured to adjust the drill bit element in a rotationally around its central axis.

8. The apparatus of claim 1, further comprising a spring disposed within the hydraulic fluid chamber, the spring coupled between the drill bit element and the hydraulic fluid chamber.

9. The apparatus of claim 1, wherein the hydraulic fluid chamber comprises a first fluid chamber disposed on a first side of the drill bit element, the apparatus further comprising:

a second fluid chamber disposed on a second side of the drill bit element, the second side substantially opposite to the first side wherein increased hydraulic fluid pressure in the first chamber and decreased fluid pressure in the second chamber results in adjustment of the drill bit element towards the second chamber.

10. The apparatus of claim 9, wherein each of the first and second fluid chambers comprise a piston configured to contact the drill bit element.

11. The apparatus of claim 1, wherein the hydraulic fluid chamber comprises a first fluid chamber disposed adjacent to a second fluid chamber and substantially surrounding a lower portion of the drill bit element, the apparatus further comprising:

a respective surface area of the drill bit element, disposed in each of the first and second fluid chambers, configured to rotate the drill bit element about a central axis of the drill bit element.

12. A method for performing a drilling operation with a drill bit element apparatus, the method comprising:

monitoring drilling parameters during the drilling operation in a geological formation; and

controlling hydraulic fluid pressure, to adjust an orientation of drill bit elements disposed in a drill bit, in response to the drilling parameters.

13. The method of claim 12, wherein monitoring the drilling parameters comprises monitoring rate of drilling, vibrations experienced while drilling, formation composition, weight on bit, and/or torque.

14. The method of claim 12, wherein monitoring the drilling parameters comprises performing a logging while drilling (LWD) or measure while drilling (MWD) operation.

15. The method of claim 12, wherein controlling the hydraulic pressure, to adjust the drill bit elements disposed in the drill bit, in response to the drilling parameters comprises hydraulically extending or retracting a depth of cut element in response to the drilling parameters.

16. The method of claim 12, wherein controlling the hydraulic pressure, to adjust the drill bit elements disposed in the drill bit, in response to the drilling parameters comprises hydraulically rotating a cutter element in response to the drilling parameters.

17. The method of claim 12, wherein controlling hydraulic fluid pressure, to adjust drill bit elements disposed in a drill bit, in response to the drilling parameters comprises extending or retracting the drill bit element from the drill bit, the method further comprising: returning the drill bit element to a neutral position by a spring force, a hydraulic force, or a force from the geological formation.

18. A system comprising:

a drilling rig disposed on a surface of a geological formation and configured to support a drill string having a drill bit with drill bit elements movably positioned therein;

a hydraulic system coupled to the drill bit elements; and

circuitry coupled to the hydraulic system and configured to control hydraulic pressure to the drill bit elements to adjust an orientation of the drill bit elements with respect to the drill bit.

19. The system of claim 18, wherein the hydraulic system comprises a closed hydraulic system with hydraulic pressure lines and return lines, the circuitry further configured to control hydraulic adjustment of the drill bit elements comprising a plurality of depth of cut elements and cutter elements by control of fluid flow in the hydraulic pressure lines and return lines.

20. The system of claim 19, further comprising a hydraulic pump disposed in the drill string or the drill bit, wherein the hydraulic pressure lines, return lines, and circuitry coupled to the hydraulic system are disposed in the drill string or the drill bit.

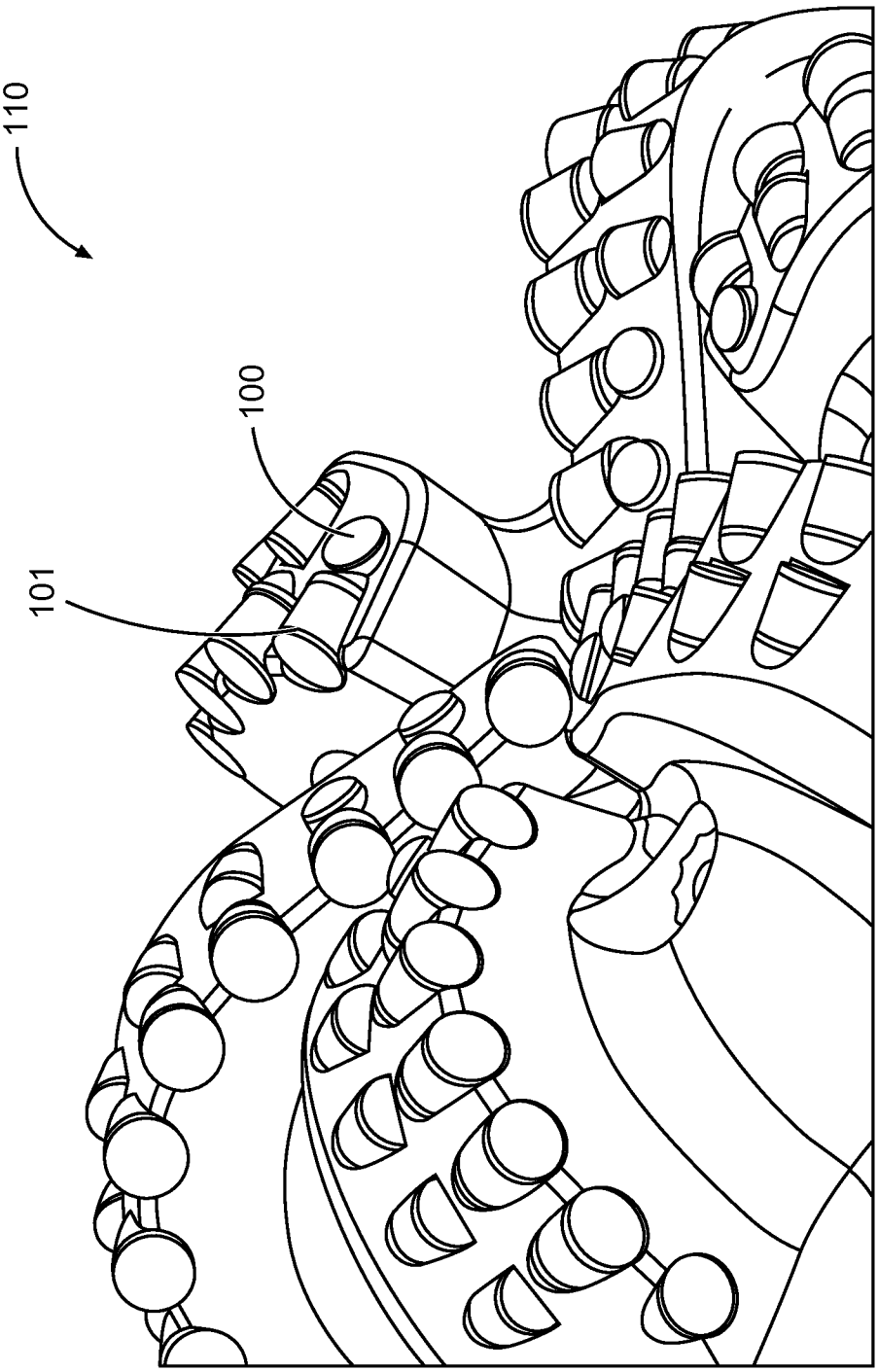


Fig. 1

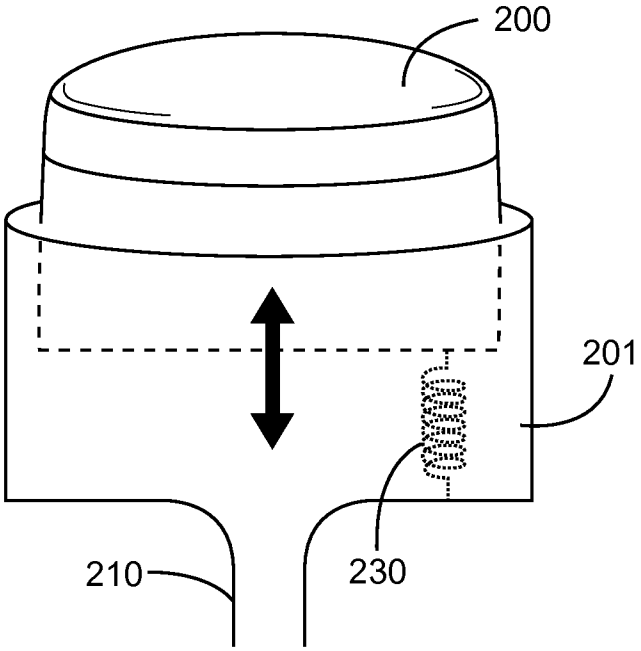


Fig. 2

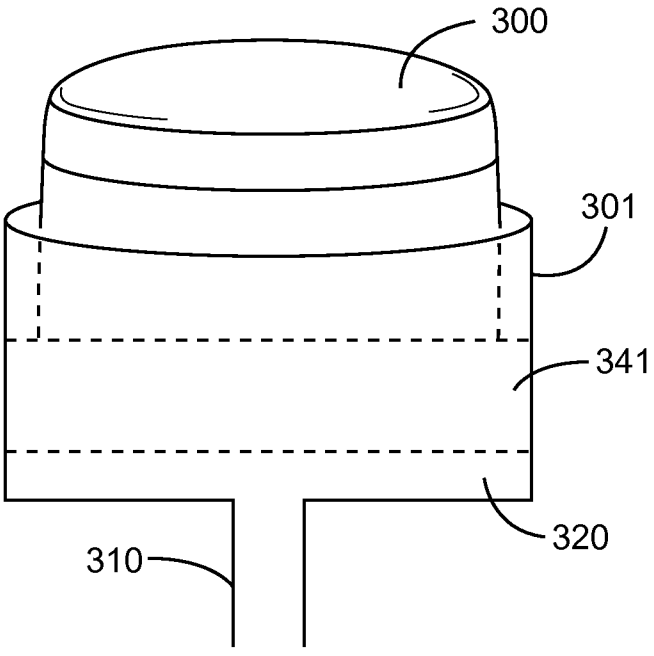


Fig. 3

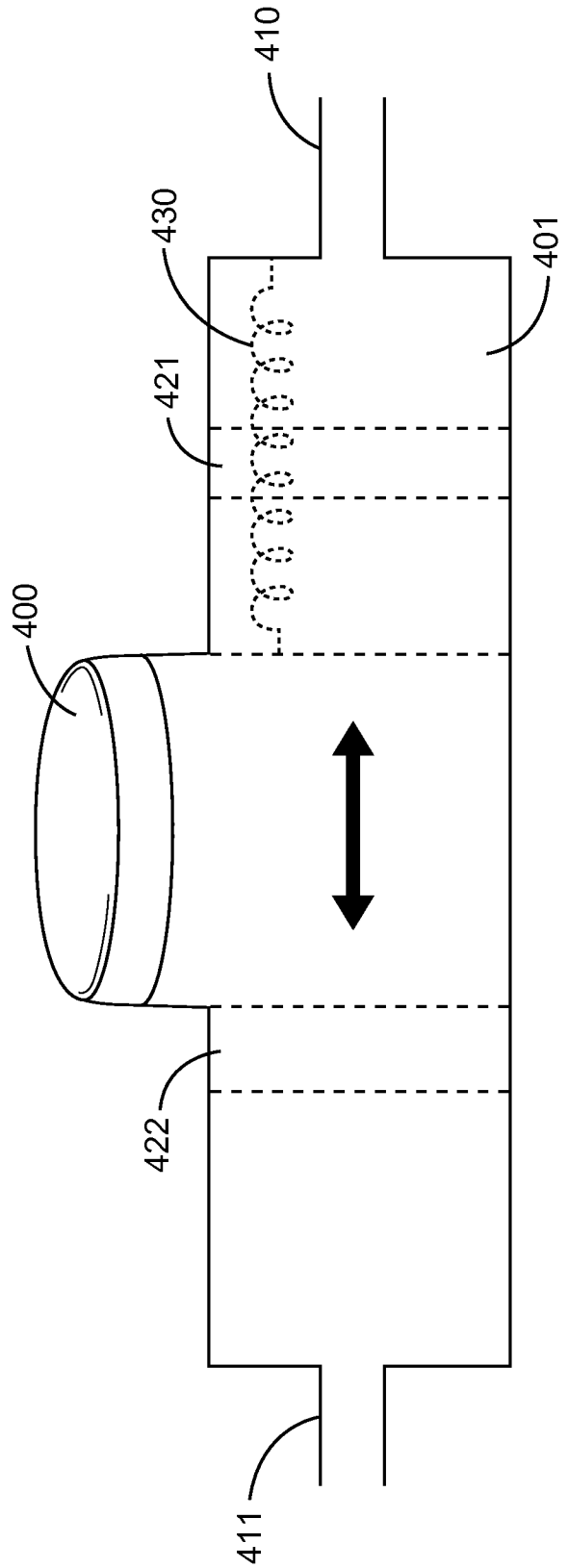


Fig. 4

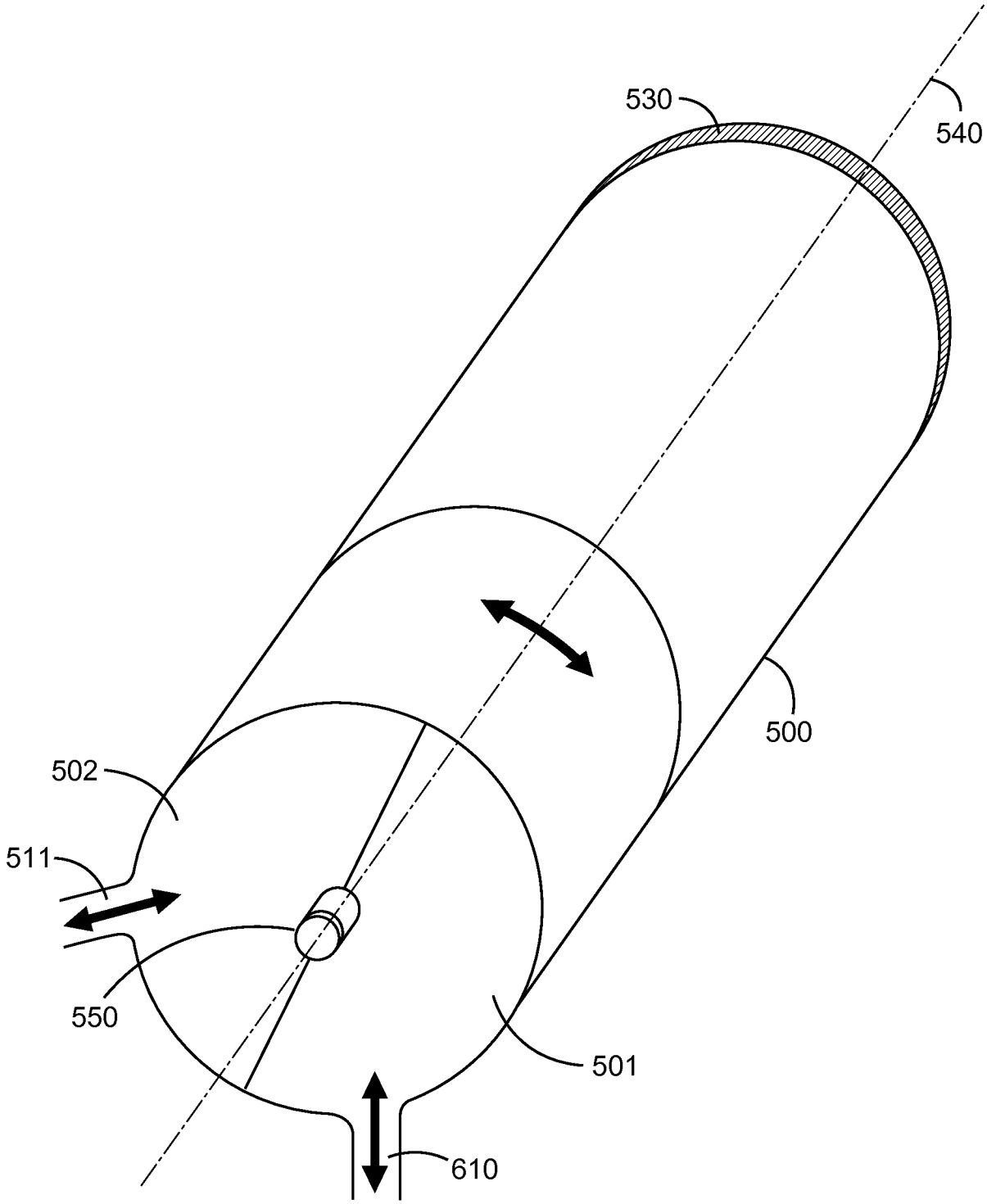


Fig. 5

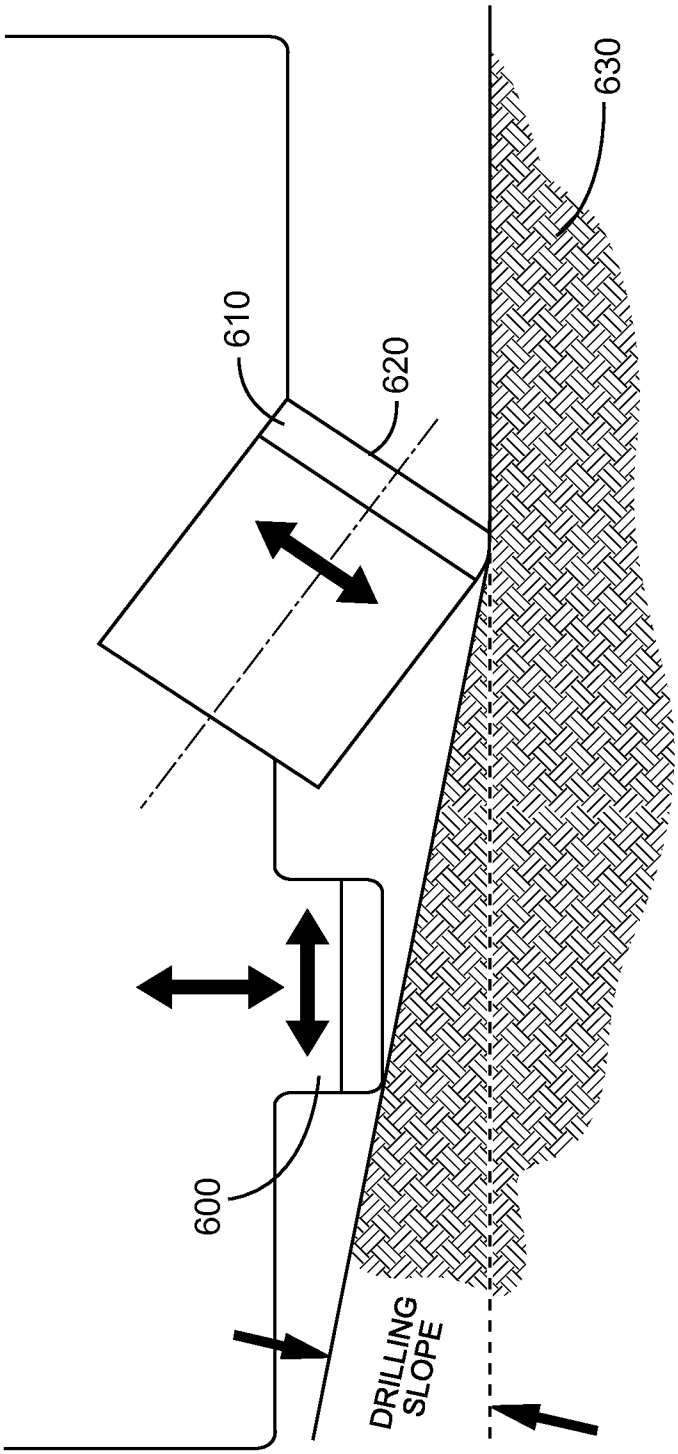


Fig. 6

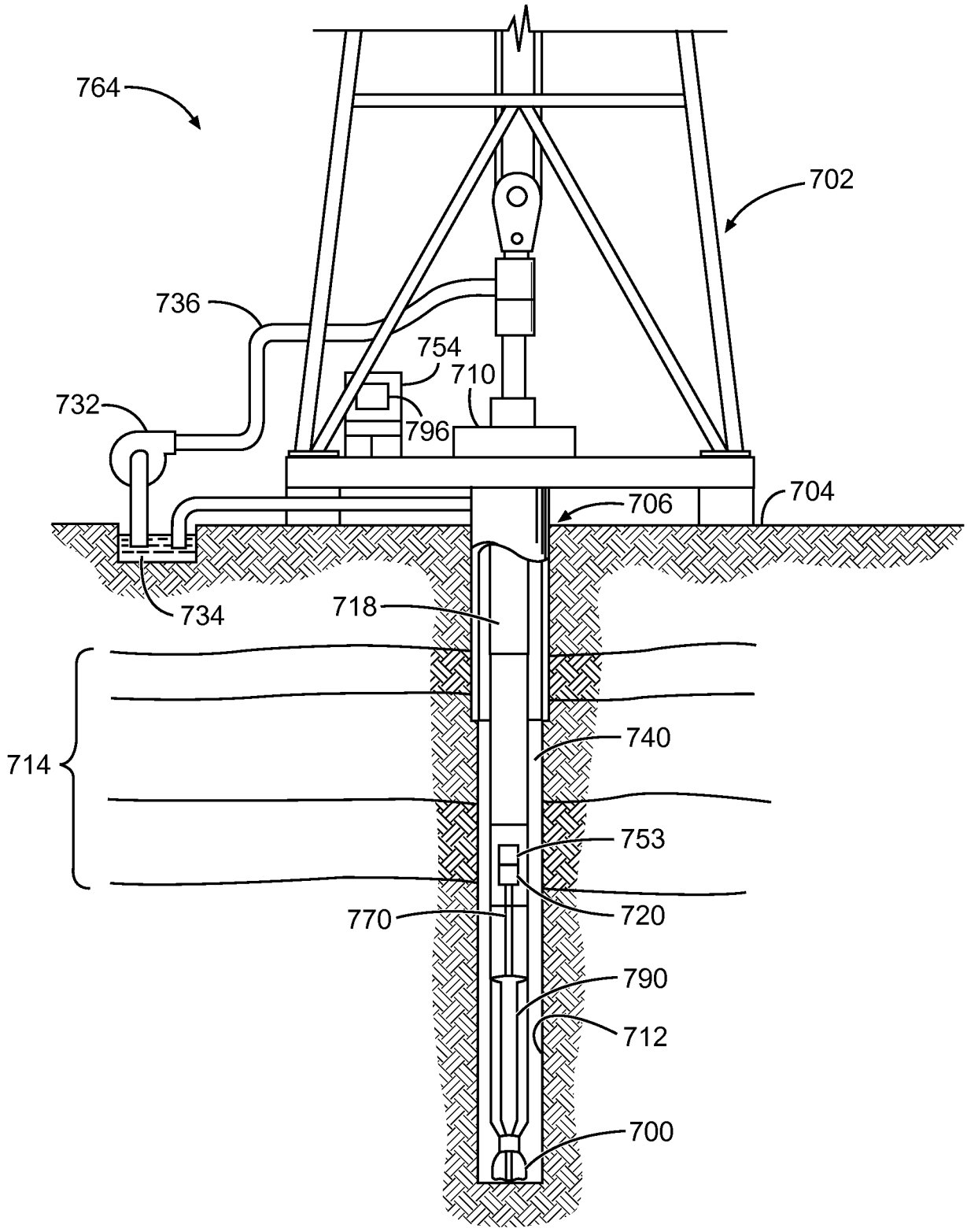

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Fig. 7

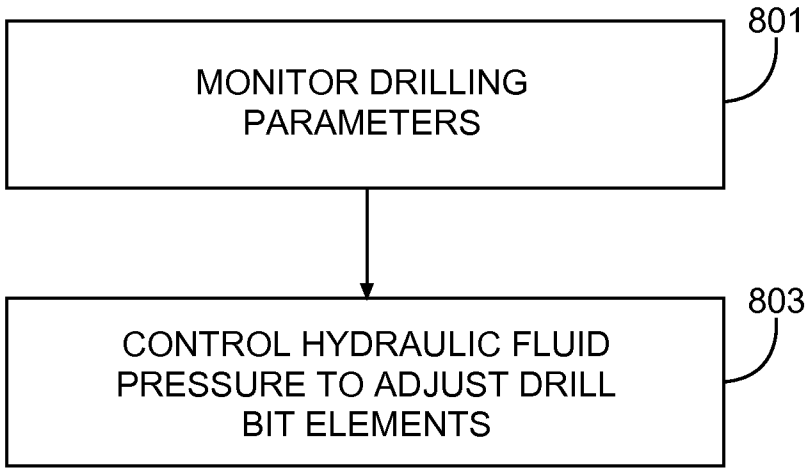

MONITOR DRILLING PARAMETERS
801
CONTROL HYDRAULIC FLUID PRESSURE TO ADJUST DRILL BIT ELEMENTS
803

Fig. 8

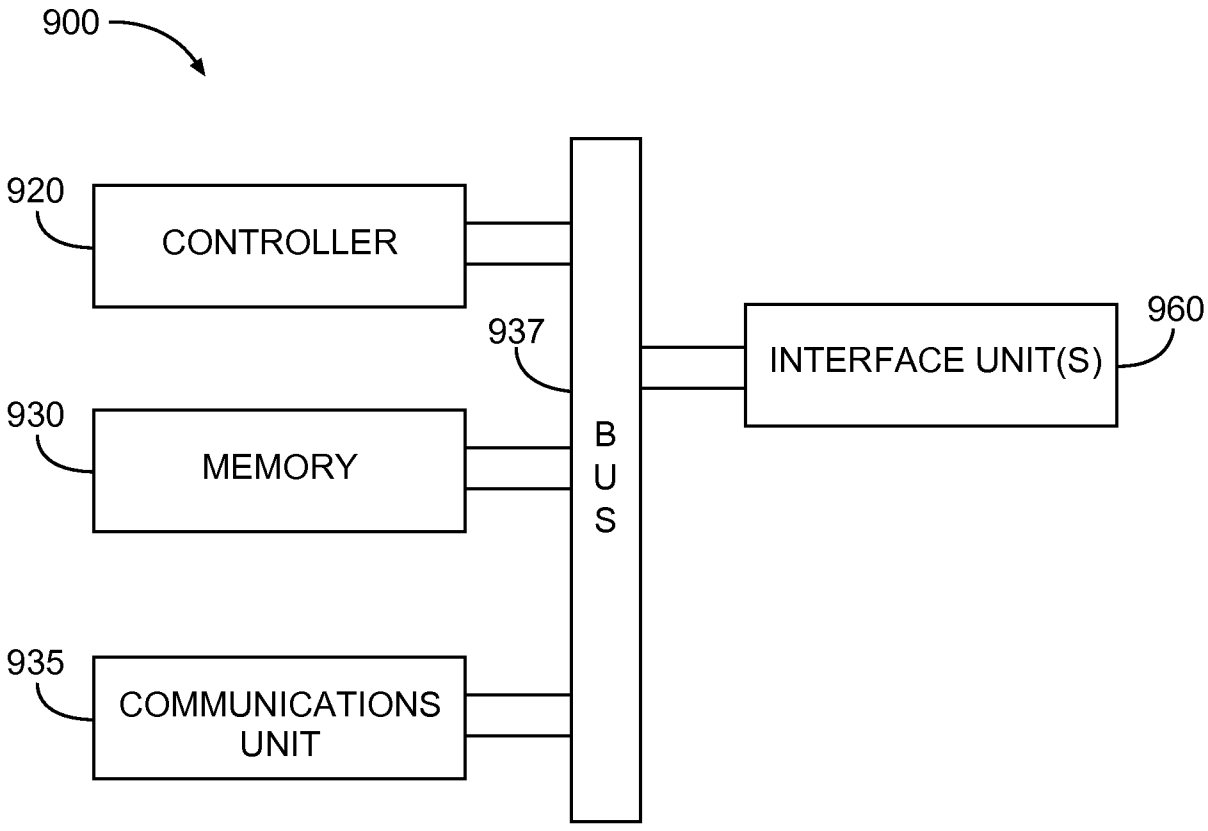

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CONTROLLER
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MEMORY
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COMMUNICATIONS UNIT
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BUS
INTERFACE UNIT(S)
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Fig. 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/018765

A. CLASSIFICATION OF SUBJECT MATTER

E21B 10/42(2006.01)i, E21B 10/43(2006.01)i, E21B 10/62(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 10/42; E21B 10/62; E21B 10/08; E21B 7/06; E21B 7/04; E21B 21/08; E21B 10/43

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:wellbore, adjustable, drill bit, fluid chamber, bit element, extend, retract, and rotate

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6142250 A (GRIFFIN et al.) 07 November 2000 See column 5, lines 53-59; column 11, lines 45-55; column 13, lines 4-44; claim 4 and figures 3, 17.	1,3-6,8
Y		2,7,9-20
Y	US 2014-0020956 A1 (COOLEY et al.) 23 January 2014 See paragraphs [0015], [0092]-[0094] and figures 4A-4B.	2,7,9-20
A	US 2010-0212964 A1 (BEUERSHAUSEN, CHAD J.) 26 August 2010 See paragraphs [0022]-[0023] and figures 3A-4B.	1-20
A	WO 2007-012858 A1 (SCHLUMBERGER HOLDINGS LIMITED et al.) 01 February 2007 See page 2, line 22 - page 3, line 22 and claims 1, 3.	1-20
A	US 2009-0107722 A1 (CHEN et al.) 30 April 2009 See paragraphs [0052]-[0063] and figures 1, 2A-2D.	1-20

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

☒ See patent family annex.

* Special categories of cited documents:
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"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
17 November 2015 (17.11.2015)	**17 November 2015 (17.11.2015)**

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2015/018765

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