

(19)



(11)

EP 2 692 982 A2

(12)

EUROPEAN PATENT APPLICATION

(43)

Date of publication:
05.02.2014 Bulletin 2014/06

(51)

Int Cl.:
E21B 10/32 (2006.01)

(21)

Application number: **13155472.7**

(22)

Date of filing: **15.02.2013**

(84)

Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR**
Designated Extension States:
BA ME

(72)

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Priority: **01.08.2012 EP 12305953**

(71)

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Near-bit borehole opener tool and method of reaming

(57)

The present disclosure relates to a near-bit borehole opener (reamer) tool and a method of drilling a wellbore comprising: (a) disposing in the wellbore a tool string; (b) lowering and rotating the tool string and drilling a first portion of the wellbore having a first diameter with the drill bit, wherein at least one cutter assembly of a first borehole reamer is in a closed position; (c) reaming with a second borehole reamer a portion of the wellbore to a second diameter larger than the first diameter, wherein a rat hole portion of the wellbore is not reamed with the

second borehole reamer, said rat hole portion of the wellbore having the first diameter; (d) extending the at least one cutter assembly of the first borehole reamer; and (e) concurrently rotating and moving the first borehole reamer up or down in the rat hole portion of the wellbore with the first diameter and abrading and cutting away the wellbore wall contacted by the at least one cutter assembly of the first borehole reamer assembly, thereby enlarging the diameter of a portion of the rat hole portion of the wellbore.

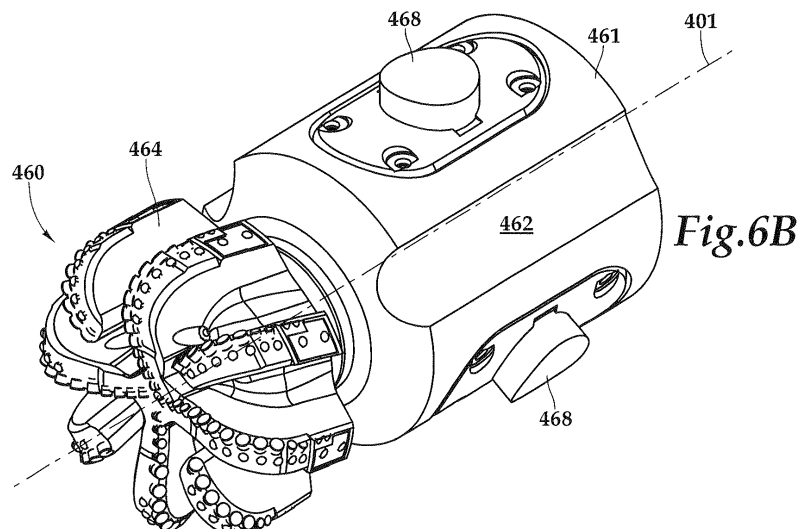


Fig.6B

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Description

BACKGROUND

[0001] During well drilling operations, a drill string is lowered into a wellbore. Typically, in conventional vertical drilling operations the drill string is rotated. The rotation of the drill string provides rotation to a drill bit affixed to the distal end of the drill string. If the wellbore is deviated from vertical, some prior art drilling systems use a downhole mud motor disposed in the drill string above the drill bit to rotate the bit instead of rotating the drill string to provide rotation to the drill bit.

[0002] Figure 1A illustrates an example of a deviated wellbore including a bottom hole assembly ("BHA") therein. A BHA 10 is shown drilling a borehole 2 in a subterranean formation 9. Bottom hole assembly 10 includes a drill bit 6, a first stabilizer 8, a roller cone-type under reamer 17 and a drilling assembly 12 in the order shown. The drilling assembly 12 includes a bent housing directional mechanism 14 and a downhole motor 16 to directionally drill borehole 2 with bit 6 and roller-cone type under reamer 17. Optionally, a second stabilizer 19 may be added to BHA 10 which may be located above (shown) or below drilling assembly 12. BHA is illustrated creating a borehole 2 in a subterranean formation 9. The borehole 2 includes a reduced diameter lower portion 3 sometimes referred to in the art as a "rat hole" or "pilot hole."

[0003] Fig. 1B illustrates another example of a drilling assembly. A BHA 25 is shown drilling a borehole 2 in a subterranean formation 9. Bottom hole assembly 25 includes bit 6, a radial piston-type under reamer 18, and a drilling assembly 12 including a downhole motor 16 and a bent housing directional mechanism 14. The borehole 2 includes a reduced diameter lower portion 3, sometimes referred to in the art as a "rat hole" or "pilot hole."

[0004] In recent years, rotary steerable systems ("RSS") have been developed to provide downhole rotation to the drill bit. In a rotary steerable system, the BHA trajectory is deflected while the drill string continues to rotate. As such, rotary steerable systems include two types: push-the-bit systems and point-the-bit systems. In a push-the-bit RSS, a group of expandable thrust pads extend laterally from the BHA to thrust and bias the drill string into a desired trajectory. In order for this to occur while the drillstring is rotated, the expandable thrusters extend from what is known as a geostationary portion of the drilling assembly. Geostationary components do not rotate relative to the formation while the remainder of the drillstring is rotated. While the geostationary portion remains in a substantially consistent orientation, the operator at the surface may direct the remainder of the BHA into a desired trajectory relative to the position of the geostationary portion with the expandable thrusters. An alternative push-the-bit rotary steering system has lateral thrust pads mounted on a body, which is connected to and rotates at the same speed as that of the rest of the BHA and drill string. The pads are cyclically driven, con-

trolled by a control module with a geostationary reference, to produce a net lateral thrust which is substantially in the desired direction.

[0005] The rotary steerable tools are generally programmed by an engineer or directional driller who transmits commands using surface equipment (typically using either pressure fluctuations in the mud column or variations in the drill string rotation) which the RSS tools understand and gradually steer in the desired direction.

[0006] Figures 2 and 2A illustrate one example of a rotary steerable system such as Halliburton's Geo Pilot System. The system 50 may include a flex power assembly 34 attached to a drill string 31. The system further includes in descending order a driver 32, a stabilizer 30, electronics module 28, hydraulics module 26, actuator 24, compensator 22, and extended gage bit 20.

[0007] In some implementations, a drill string using an RSS System, a lower portion of the drill string may include a measurement while drilling (MWD) and Logging While Drilling (LWD) telemetry tool section. MWD/LWD technology is well known in the prior art. In some implementations, the MWD/LWD system sends downhole data on the geologic formations penetrated by the wellbore and drilling performance data to the surface for evaluation. Transmission of information to or from the MWD tools typically uses mud pulse technology or, alternatively, other information transmission means.

[0008] In order to pass through the inside diameter of upper strings of casing already in place in the wellbore, often times the drill bit will be of such a size as to drill a smaller gage hole than may be desired for later operations in the wellbore. It may be desirable to have a larger diameter wellbore to enable running further strings of casing and allowing adequate annulus space between the outside diameter of such subsequent casing strings and the borehole wall for a good cement sheath. A conventional borehole opener (reamer) may be included in the drill string above the MWD tools and the rotary steerable tools. Note as used herein the term "borehole opener" is interchangeable with "under reamer." Because of the configuration of the tool string, it is not possible for the conventional reamer to reach the bottom of the wellbore. This leaves a smaller gage section of borehole that is referred to as a "rat hole" or alternatively a "pilot hole." This under gage rat hole section may be 60 to 90 feet in length.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] To enable a better understanding of the present invention, and to show how the same may be carried into effect, reference will now be made, by way of example only, to the accompanying drawings, in which:-

Fig. 1A illustrates a prior art example of a deviated wellbore including a BHA therein;

Fig. 1B illustrates another prior art example of a drilling assembly, showing a BHA drilling a borehole in

a subterranean formation;

Figs. 2 and 2A illustrate one prior art example of a rotary steerable system;

Fig. 3 illustrates one implementation of a tool string including a near-bit borehole enlargement tool;

Fig. 4 illustrates another embodiment wherein the near-bit borehole enlargement tool and drill bit are integrally combined;

Figs. 5A and 5B illustrate an enlarged perspective view of an exemplary combination near-bit hole opener (reamer) and drill bit;

Figs. 6A, 6B and 6C illustrate another embodiment of a combined near-bit borehole enlargement tool;

Figs. 7 and 8 illustrate additional embodiments wherein the body of the near-bit borehole enlargement tool has spiral body design including spiral water courses;

Fig. 9A illustrates simplified schematic of a tool string and a near-bit reamer of Figs. 5A, 5B, 6A to 6C, 7 or 8;

Fig. 9B illustrates the tool string of Fig. 9A pulled back up/back into the larger gage reamed portion of the borehole;

Fig. 9C illustrates the tool string of Fig. 9A after it has been used to enlarge the gage of a portion of the formerly reduced-gage rat borehole section; and
Fig. 10 illustrates mechanical elements of a conventional near-bit reamer.

DETAILED DESCRIPTION

[0010] The present disclosure includes a "near-bit reamer" disposed on the distal end of the tool string proximal to the drill bit. This near-bit cutting structure reamer may be less robust than the one of a primary conventional reamer (such as the reamers discussed in the above noted prior art references) because the near-bit reamer is only reaming the rat hole 3 portion of the wellbore that a conventional reamer cannot reach.

[0011] Referring now to Fig. 3, wherein one implementation of a tool string 100 including a near-bit borehole enlargement tool 200 is illustrated. Note as used herein the terms "borehole enlargement tool" and "borehole opener tool" are used interchangeably. The tool string 100 is attached to a drill string 101 that is suspended from a drilling rig (not shown). The tool string may include a conventional under reaming tool 104, e.g., a Halliburton model XR Reamer or UR type conventional under reamer.

[0012] In some implementations, below the conventional reamer 104 is disposed a Measurement While Drilling (MWD) tool string and/or a Logging While Drilling (LWD) Tool string section generally denoted as element 120. The MWD/LWD tool section 120 may include a HOC P4M Pulser 112 which is a communication device to receive RSS and MWD tool instructions and send data to a surface communication means.

[0013] The MWD/LWD tool section 120 may include one or more in-line stabilizer elements 114, 118 and 122.

The MWD/LWD tool section 120 further includes elements 116 and 124 that receive information on downhole data of the geologic formations penetrated by the wellbore and drilling performance data and transmit that data to the surface for evaluation, typically using mud pulse technology or other data transmission means.

[0014] Below the MWD tool section 120 is a flexible sub 130.

[0015] Disposed below the flexible sub 130 is the RSS tool string denoted generally as 140. For an exemplary RSS tool string, see Fig. 2.

[0016] In the present disclosure, below the RSS tool section 140 and the MWD/LWD tool section 120 is a near-bit reamer 200 which is disposed proximal to a conventional drill bit 150 that is disposed on the distal end of the tool string 100.

[0017] Referring to Fig. 4, therein is illustrated another embodiment of the present disclosure wherein the near-bit borehole enlargement tool ("NBR") and drill bit are integrally combined as element 360. In some implementations the fishing necks of an NBR tool are removed and the conventional pin and box connection of the NBR and drill bit are removed and the NBR tool is welded to the drill bit. (It will be understood that it is not necessary to modify actual existing NBR tools and drill bits to construct the combination tool 360. The elements of such a combination tool 360 may be manufactured and constructed in accordance with the design elements disclosed herein.) It will be understood that welding is only one method of securing the bit body to the reamer body. The bodies may be integrally cast as a single body or machined from a single casting or forging. Alternatively, the two bodies may be secured by other conventional connection means.

[0018] The alternative tool string 300 includes a conventional reamer 304. Various crossover subs and stabilizers 318 and 322 are disposed above the MWD tool 320 (e.g., Halliburton Evader Gyro). The MWD/LWD tool section 120 may include a HOC P4M Pulser 312 which is a communication device to receive RSS and MWD tool instructions and send data to a surface communication means.

[0019] Below the MWD tool section is a flexible sub 330.

[0020] Disposed below the flexible sub 330 is a RSS tool denoted generally as 340 (e.g., Halliburton Geo-pilot tool). Information on Halliburton's Geo-pilot system is contained in Figs. 2 and 2A and in the prior text herein describing Figs 2 and 2A.

[0021] In the present disclosure, below the RSS tool section 340 is an optional stabilizer sub 326. The combination bit and reamer 360 includes a short near-bit borehole enlargement tool (NBR) 362 welded to the body of a roller cone or PDC bit 364 disposed on the distal end of the tool string 100.

[0022] It will be understood that the present disclosure is not limited to the Halliburton product elements described above. The Halliburton product elements includ-

ed herein are exemplary products that may be used in the subject disclosure. However, other products of a similar nature manufactured by other manufacturers may be used as elements in the subject disclosure.

[0023] Figs. 5A and 5B illustrate an enlarged perspective view of an exemplary combination near-bit hole opener (reamer) and drill bit 360. The combination tool 360 includes a near-bit reamer 362 that includes a body section 361. The overall length L_1 of the body section is 40 inches or smaller. The overall length of the NBR tool 360 is L_2 of 60 inches or smaller. The reamer 362 includes a plurality of cutter elements 368 disposed on radial pistons 369 disposed inside the body 361. When the reamer 362 is actuated, the cutter elements 368 are moved radially outward from a central longitudinal axis 301 of the reamer 362 and contact the borehole wall. (It will be understood that other configurations of cutter elements may be used in the near-bit hole enlargement tool of the present disclosure.) As the reamer 362 is rotated by the rotation of the drill string 101, the cutter elements 368 abrade and cut away the formation, thereby expanding the diameter of the borehole.

[0024] Mechanical elements of a conventional near-bit reamer are illustrated in Fig. 10 (e.g., Halliburton NBR tool). The conventional NBR includes a box connection 1001, a pin connection 1002, a body 1006 portion of approximately 16 7/8 inches diameter and an overall length L_5 of 14.33 inches, a cutter 1010 is disposed on a piston that is adapted to move radially out of the body 1006 to engage the borehole wall. The overall diameter L_6 is about 16 7/8 inches.

[0025] Figures 6A, 6B and 6C illustrate another embodiment of a combined near-bit borehole enlargement tool 460. The combination tool 460 includes a drill bit 464 and a near-bit reamer 462 that includes a body section 461. The reamer 462 includes a plurality of cutter elements 468 disposed on radial pistons disposed inside the body 461. When the reamer 462 is actuated, the cutter elements 468 are moved radially outward from a central longitudinal axis 401 of the reamer 462 and contact the borehole wall. (It will be understood that other configurations of cutter elements may be used in the near-bit hole enlargement tool of the present disclosure.) As the reamer 462 is rotated by the rotation of the drill string 101, the cutter elements 468 abrade and cut away the formation, thereby expanding the diameter of the borehole. For a combination tool 460 sized to ream a hole diameter of 17.5 inches to an opening of 20 inches, the overall length L_3 of the body section 461 is about 40 inches. The overall length of the combination tool 460 for reaming a 20 inch hole is L_4 about 60 inches or smaller.

[0026] Figures 7 and 8 illustrate additional embodiments of the present disclosure wherein the body 761, 861 of the near-bit borehole enlargement tool 760 and 860 has spiral body design including spiral water courses 764 and 864 disposed in the outside of the body. The spiral water course provides the benefits over a linear longitudinal exterior water course of:

[0027] a. Optimized stabilization

[0028] b. Reduction of BHA vibrations, hence increasing cutter's lifetime

[0029] c. Better cleaning performance

[0030] The present disclosure further includes a method of using the near-bit borehole enlargement tool 200, 360, 460, 760 and 860 to open the reduced diameter portion rat hole 3 of the borehole 4.

[0031] It will be understood that other implementations of a combination bit and reamer may be used in the near-bit borehole enlargement tool of the present disclosure.

[0032] It is important to note that it is not desirable to place a conventional reamer directly above the bit and below the RSS and MWD/LWD for several reasons. In some conventional reamers a ball (plug) is pumped down the drill string and landed in the under reamer which activates the reamer arms. Placement of a conventional reamer below the RSS and MWD/LWD may prevent the ball/plug from passing through the RSS and MWD/LWD tools and reaching the conventional reamer to activate it. Additionally, it is not desirable to place a conventional under reamer below the RSS and MWD tools because the conventional under reamer is too long to allow the RSS tool to steer and/or propel itself properly.

[0033] Further, it is not desirable to place a conventional reamer below the RSS and LWD tools and ream as it is being drilled (to eliminate the creation of a rat hole) because the RSS and MWD/LWD tool strings need to be in contact with the wellbore walls in order to function. The RSS needs to contact the wellbore wall to direct the steering and it is desirable for the MWD/LWD tools to have the sensor elements of the tools in proximity to the borehole wall in order to obtain better quality formations data.

[0034] Additionally, it is not feasible to use a larger gage bit on the bottom to drill an oversized hole (to eliminate the creation of a rat hole) because the RSS and MWD/LWD tool strings need to be in contact with the wellbore walls in order to function. The RSS needs to contact the wellbore wall to direct the steering and it is desirable for the MWD/LWD tools to have the sensor elements of the tools in proximity to the borehole wall in order to obtain better quality formations data (to eliminate the creation of a rat hole) because the RSS and MWD/LWD tool strings need to be in contact with the wellbore walls in order to function. The RSS needs to contact the wellbore wall to direct the steering and it is desirable for the MWD/LWD tools to have the sensor elements of the tools in proximity to the borehole wall in order to obtain better quality formation data.

[0035] In prior art systems, in order to eliminate the rat hole, the entire drill string and tool string would have to be pulled from the wellbore and a trip would have to be made in the hole with a full gage bit or under reamer with a bull plug in the end and run to the bottom to drill/ream out the 60 to 90 foot rat hole section. This trip in and out of the wellbore with the drill string and an under reamer/larger gage bit to eliminate the rat hole costs many thousands of dollars of rig time.

[0036] Referring now to Fig. 9A, wherein is illustrated a simplified schematic of the tool string 100 and near-bit reamer 200, 360, 460, 760 and 860 of Figs. 5A, 5B, 6A to 6C, 7 and 8. Fig. 9A illustrates a conventional reamer 104 with cutting arms extended and wherein the upper portion 5 of borehole 4 has been reamed out to a desired larger gage than the lower reduced diameter portion under gage rat hole portion 3. The tool string 100 is disposed in the lower end of drill string 101. The tool string includes a conventional under reamer 104, an RSS section 140 and MWD section 120, the near-bit reamer 200 and the bit 150. As can be seen, the conventional reamer cannot reach the bottom of borehole 4 to enlarge the rat hole portion 3 of the hole because the reamer is disposed above the RSS section 140, the MWD section 120.

[0037] Fig. 9B illustrates the tool string 100 pulled up/back into the larger gage reamed portion of the borehole 4 and the conventional reamer's arms are closed and the near-bit reamer's cutting pads 208 are extended. (It will be understood that closing the conventional reamer's arms is optional because leaving the conventional reamer's arms open may provide stabilization for the bottom hole assembly as the near-bit borehole enlargement tool 200 is reaming down the rat hole in Fig 9C).

[0038] Fig. 9C illustrates the tool string 100 after it has been rotated and moved back down the borehole 4 to enlarge the gage of a portion of the formerly reduced gage rat hole section 3.

[0039] It will be understood that the present disclosure can be implemented without pulling up the tool string 100 out of the rat hole and then lowering the near-bit reamer with extended cutters to ream the hole by moving downward into the rat hole while the reamer is being rotated. Instead, the cutters of the near-bit reamer may be extended while the near-bit reamer is in the rat hole portion of the hole and the tool string rotated and pulled upward to ream the rat hole in an upward direction.

[0040] Note: The terms "raised" and "lowered" have been used herein to describe movement of the tool string; however, if the borehole 4 is deviated (e.g., horizontally, as wellbore 2 is illustrated in Figs. 1A and 1B), raising the tool string 100 would be understood to mean moving the drill string away from the distal end of the borehole 4 and lowering would be understood to mean moving the tool string 100 toward the distal end of the borehole 4.

[0041] Note: Figs. 9A, 9B and 9C are schematics that illustrate the cutters as pads on a piston; however, in other implementations the near-bit reamer may have arms with a reaming cone on each arm. Likewise, the upper conventional reamer 104 may have arms and roller cones or extendable pads.

[0042] In reaming operations for the rat hole section 3 of borehole 4, the tool string is pulled up out of the reduced diameter rat hole 3, and in some implementations circulation of mud is increased from a first flow rate during drilling with the conventional under reamer to a second predetermined flow rate which shears pins in the NBR reamer and opens the NBR cutters 208. The cutters 208

are extended away from the longitudinal axis 201 of the near-bit tool 200. The drill string is rotated and lowered back into the under gage rat hole section 3 and the near-bit reamer enlarges the under gage rat hole section. See Figs. 9B and 9C.

[0043] Advantages:

[0044] The near-bit borehole enlargement tool (NBR) 200, 360, 460, 760 and 860 may be used in combination with a conventional under reamer (e.g., the Halliburton XR or UR reamer). When used in a tool string combination including a conventional under reamer, the "NBR" may remain dormant during reaming work performed by the conventional reamer disposed above the MWD/LWD tools and the RSS tool. The "NBR" may be activated when the total depth of a section of the wellbore is reached to ream the rat hole section. The NBR combination with the conventional reamer provides using the conventional reamer to ream long distances in the borehole due to its robust cutting structure. The NBR of the present disclosure is very compact (made much shorter than the original "NBR") to reduce the rat hole distance at the bottom of a wellbore. The NBR tool of the present disclosure further provides:

[0045] 1. Easy steerability, as a function of the short length;

[0046] 2. Alternative helical stabilizing blades and helical mud ways instead of straight shape for:

[0047] a. Optimized stabilization;

[0048] b. Reduction of BHA vibrations, hence increasing cutter's lifetime; and

[0049] c. Better cleaning performance.

[0050] 3. Monobloc product for:

[0051] a. Stronger tool (possibility to eliminate the API connection between the Bit and the Reamer);

[0052] b. Cutting structure drilling performance optimization (combination of XR or UR and NBR concept);

[0053] c. Tool simplicity and parts count reduction; and

[0054] d. Stronger bit/reamer connection. Reduced loads (bending, side forces, and vibration) decrease connection failure risk.

[0055] 4. NBR structure better stabilized by means of the bit proximity to the reamer.

[0056] 5. NBR gets better well contact coverage (combination of the bit and the NBR might be close to 360°).

[0057] a. Perfect pilot hole fitting;

[0058] b. Suppress kick-off risk;

[0059] c. Reduce BHA vibrations;

[0060] d. Increase cutting efficiency; and

[0061] e. Increase cutter lifetime.

[0062] 6. Eliminates rig time and saves money - in prior art systems in order to eliminate the rat hole, the entire drill string and tool string would have to be pulled from the wellbore and a trip would have to be made in the hole with a full gage bit or under reamer with a bull plug in the end and run to the bottom to drill/ream out the 60 to 90 foot rat hole section. This trip in and out of the wellbore with the drill string and an under reamer/larger gage bit to eliminate the rat hole costs many thousands of dollars

of rig time.

Claims

1. A method of drilling a wellbore comprising:

(a) disposing in the wellbore a tool string including a drill bit on a distal end of the tool string, a first borehole reamer assembly having at least one cutter assembly, said first borehole reamer disposed adjacent to the drill bit, a downhole remote steering assembly disposed in the tool string above and proximal to the first borehole reamer assembly, and a second borehole reamer assembly with at least one cutter assembly disposed in the tool string above the downhole remote steering assembly;

(b) lowering and rotating the tool string and drilling a first portion of the wellbore having a first diameter with the drill bit, wherein the at least one cutter assembly of the first borehole reamer are in a closed position;

(c) reaming with the second borehole reamer a portion of the wellbore to a second diameter larger than the first diameter, wherein a rat hole portion of the wellbore is not reamed with the second borehole reamer, said rat hole portion of the wellbore having the first diameter;

(d) extending the at least one cutter assembly of the first borehole reamer; and

(e) concurrently rotating and moving the first borehole reamer up or down in the rat hole portion of the wellbore with the first diameter and abrading and cutting away the wellbore wall contacted by the at least one cutter assembly of the first borehole reamer assembly, thereby enlarging the diameter of a portion of the rat hole portion of the wellbore.

2. The method of claim 1 wherein the method further includes disposing a MWD/LWD assembly in the tool string above the downhole remote steering assembly and below the second borehole reamer; and/or wherein the first borehole reamer and the drill bit are joined to each other by welding before they are disposed in the tool string; and/or wherein a body of the first borehole reamer and a body of the drill bit are formed integrally; and/or wherein the cutter assemblies of the second borehole reamer are opened in step (b) and steps (b) and (c) are conducted concurrently; and/or wherein the method further includes: prior to beginning step (c) pulling up the tool string out of the rat hole portion of the wellbore and wherein in step (e) the first borehole reamer is rotated and moved in a downward direction into the rat hole thereby reaming a portion of the rat hole to a larger diameter.

3. A bottom hole assembly for use in a wellbore comprising:

a borehole reamer assembly including a body adapted at an upper end to be connected to a tool string including a downhole remote steering assembly, and at a lower end connected or adapted to be connected to a drill bit; said borehole reamer assembly further including at least one cutter assembly adapted to extend in a radial direction away from a longitudinal axis of the body, said cutter assembly further adapted to abrade and cut away the wellbore wall contacted, thereby enlarging the diameter of the wellbore in the area contacted by the cutter assembly.

4. The bottom hole assembly of claim 3 wherein the borehole reamer assembly adapted at a lower end to connect to a drill bit comprises a body of the borehole reamer welded at a lower end of the body to a drill bit body thereby forming a unitary reamer drill bit combination tool.

5. The bottom hole assembly of claim 3 wherein a body of the borehole reamer and a body of the drill bit are formed integrally.

6. The bottom hole assembly of any of claims 3 to 5 wherein the tool string further includes a MWD/LWD assembly disposed in the tool string above the downhole remote steering assembly.

7. The bottom hole assembly of claim 6 wherein the tool string further includes a second borehole reamer assembly disposed in the tool string above the downhole remote steering assembly or the MWD/LWD assembly; and/or wherein the tool string further includes a second borehole reamer assembly disposed in the tool string above both the downhole remote steering assembly and the MWD/LWD assembly.

8. A method of drilling a wellbore comprising:

(a) disposing in the wellbore a tool string including a drill bit on a distal end of the tool string, a borehole reamer assembly having at least one cutter assembly, said borehole reamer disposed adjacent to the drill bit;

(b) lowering and rotating the tool string and drilling a first portion of the wellbore having a first diameter with the drill bit, wherein the at least one cutter assembly of the borehole reamer is in a closed position;

(c) extending the at least one cutter assembly of the borehole reamer; and

(d) concurrently rotating and moving the bore-

hole reamer up or down in the rat hole portion of the wellbore with the first diameter and abrading and cutting away the wellbore wall contacted by the at least one cutter assembly of the borehole reamer assembly, thereby enlarging the diameter of a portion of the rat hole portion of the wellbore.

9. The method of claim 8 further including disposing a downhole remote steering assembly in the tool string above and proximal to the first borehole reamer assembly, and, optionally, further including disposing a MWD/LWD assembly in the tool string above the downhole remote steering assembly.

10. The method of claim 9 further including disposing a second borehole reamer assembly with at least one cutter assembly disposed in the tool string above the downhole remote steering assembly.

11. The method of any of claims 8, 9 or 10 further including joining the borehole reamer and the drill bit to each other by welding before they are disposed in the tool string.

12. The method of claims 8, 9 or 10 further including forming integrally a body of the borehole reamer and a body of the drill bit.

13. The method of claim 10 further including: prior to step (c), reaming with the second borehole reamer a portion of the wellbore to a second diameter larger than the first diameter, wherein a rat hole portion of the wellbore is not reamed with the second borehole reamer, said rat hole portion of the wellbore having the first diameter, and, optionally, further including opening cutter assemblies of the second borehole reamer and conducting said reaming with the second borehole reamer concurrently with step (b).

14. The method of any of claims 8 to 13 further including: prior to beginning step (c) pulling up the tool string out of the rat hole portion of the wellbore, wherein in step (e) rotating and moving the borehole reamer includes moving the borehole reamer in a downward direction into the rat hole thereby reaming a portion of the rat hole to a larger diameter.

15. A bottom hole assembly for use in a wellbore comprising:

a borehole reamer assembly including a body having an attachment structure for securing an upper end to a tool string including a downhole remote steering assembly, said borehole reamer connected or attachable at a lower end to a drill bit, said borehole reamer assembly further including at least one cutter assembly extending

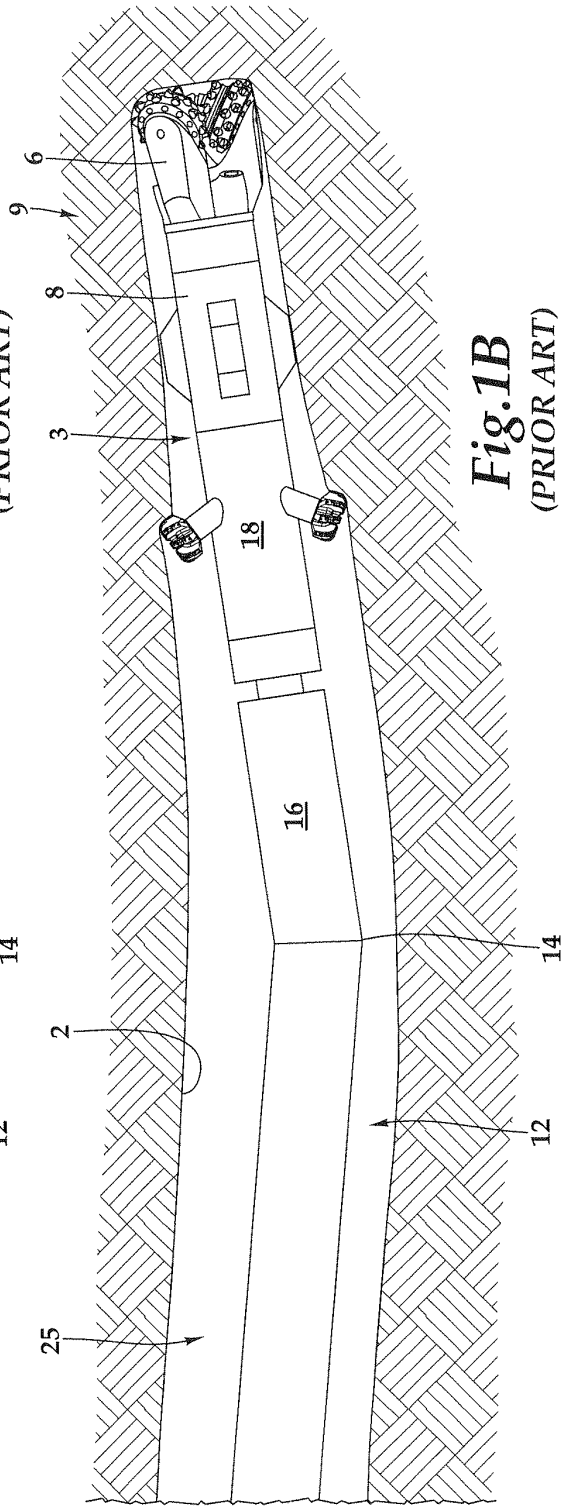
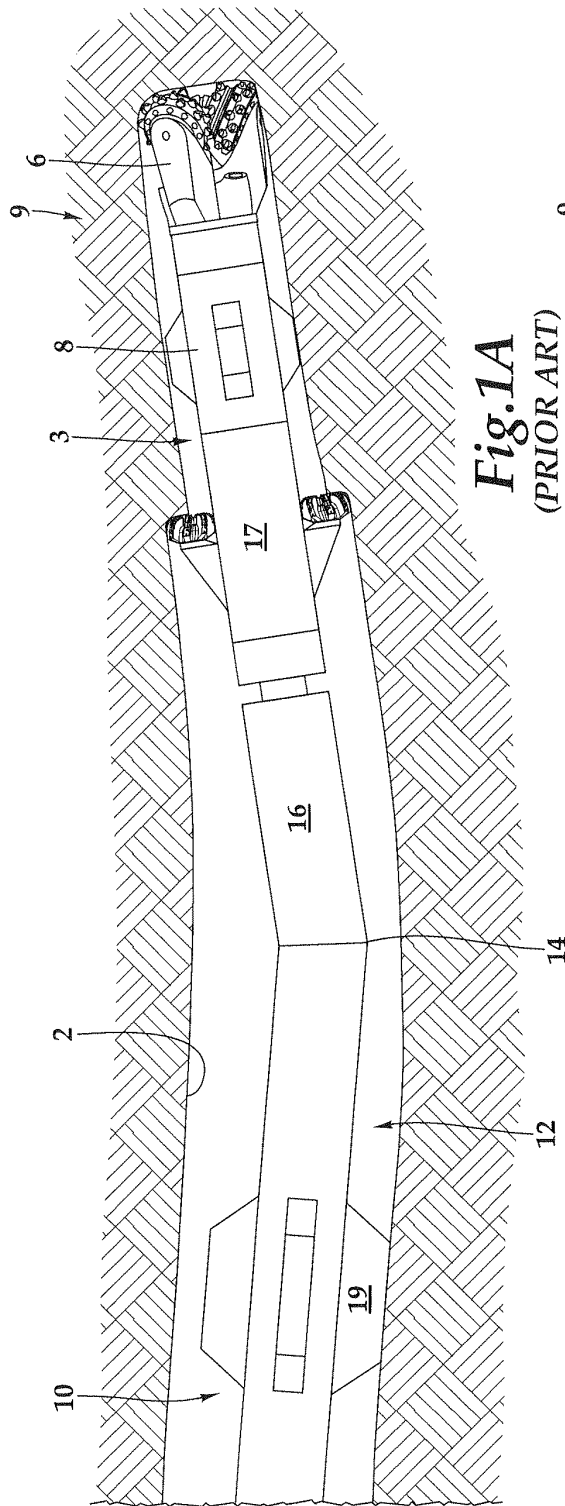
in a radial direction away from a longitudinal axis of the body, said cutter assembly further including at least one cutter element operable to abrade and cut away a wellbore wall contacted by the cutter, and thereby enlarge the diameter of the wellbore in the area contacted by the cutter.

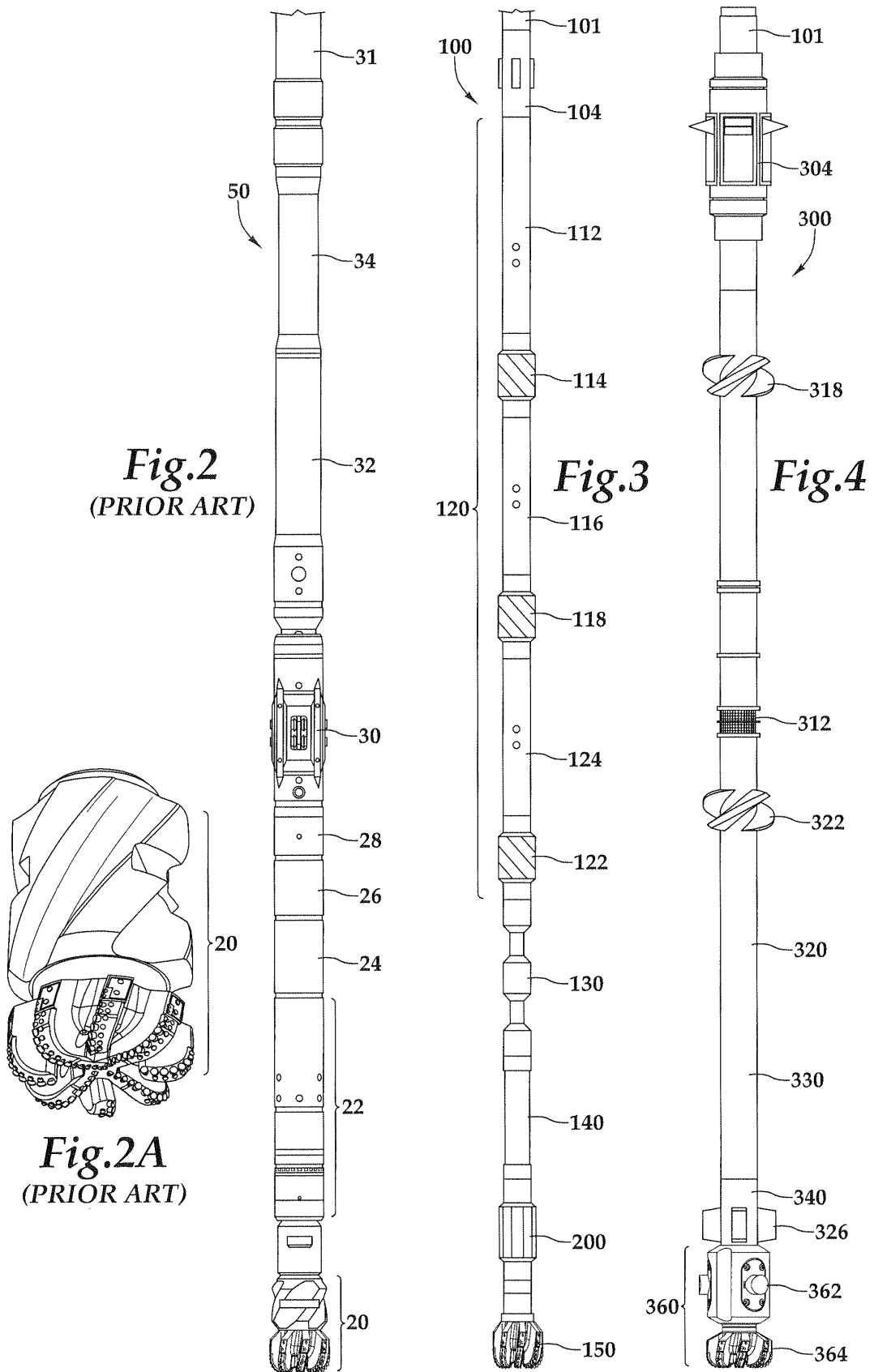
16. The bottom hole assembly of claim 15 wherein the borehole reamer assembly comprises a unitary reamer drill bit combination tool either (i) having a body of the borehole reamer welded at a lower end of the body to a drill bit, or (ii) having an integrally formed borehole reamer body and drill bit body.

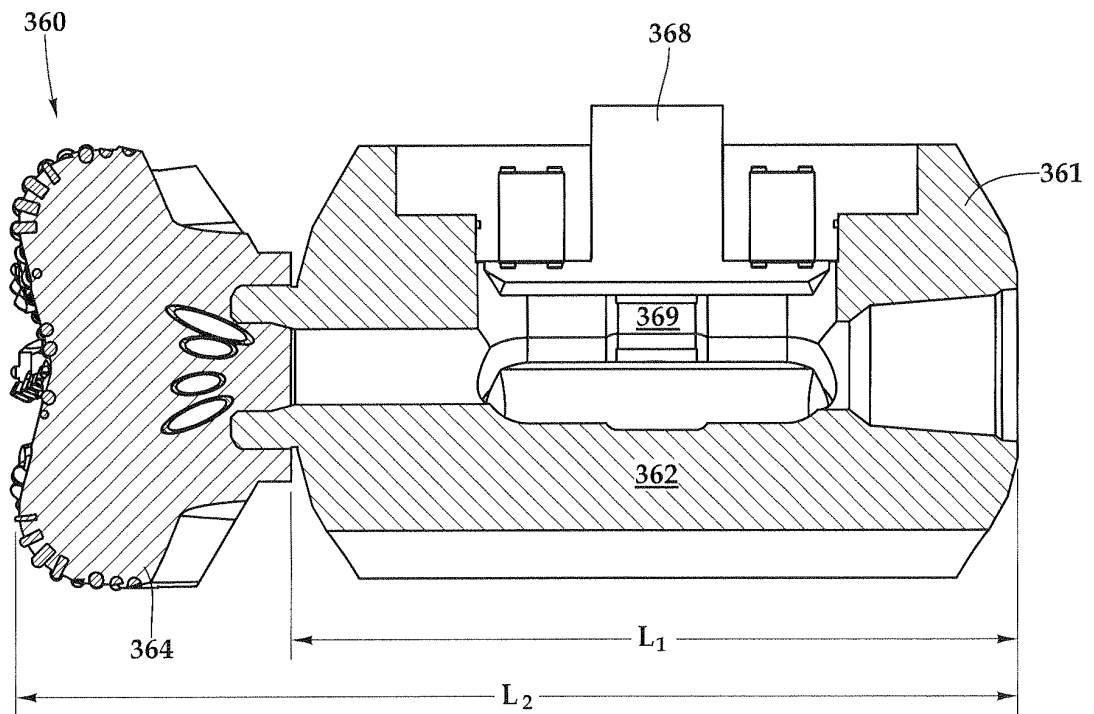
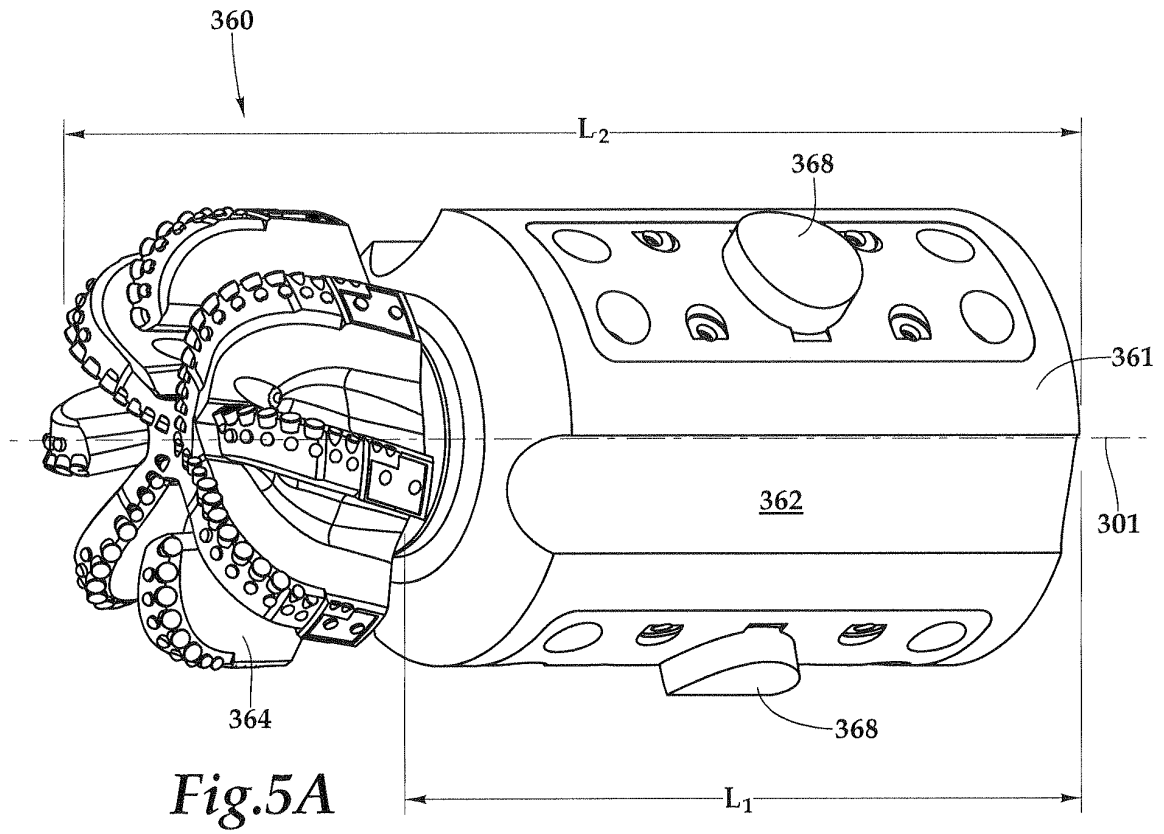
17. The bottom hole assembly of claim 15 or 16 further comprising a tool string including a MWD/LWD assembly disposed in the tool string above a downhole remote steering assembly.

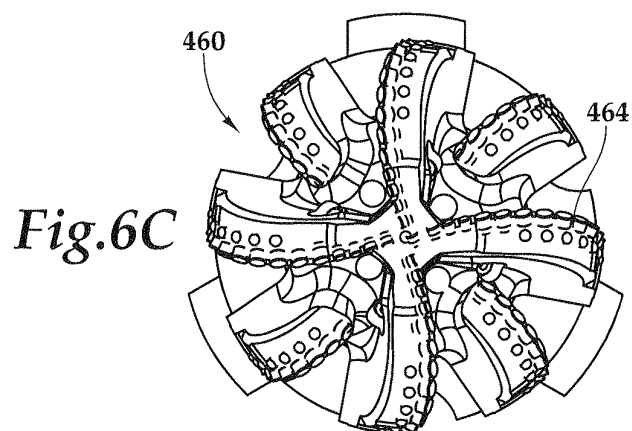
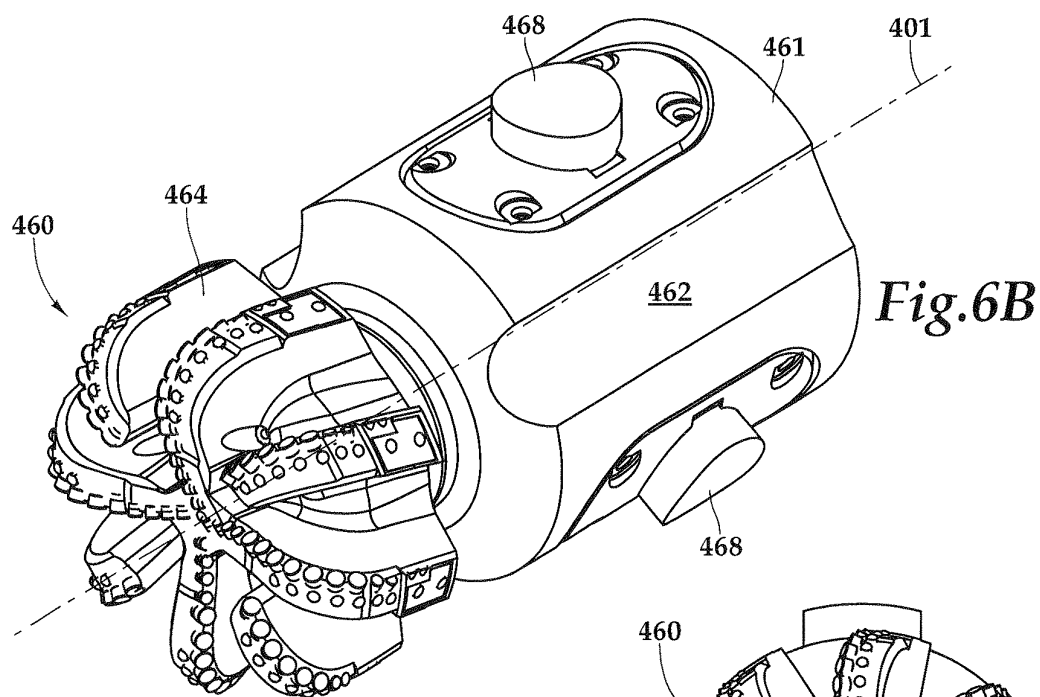
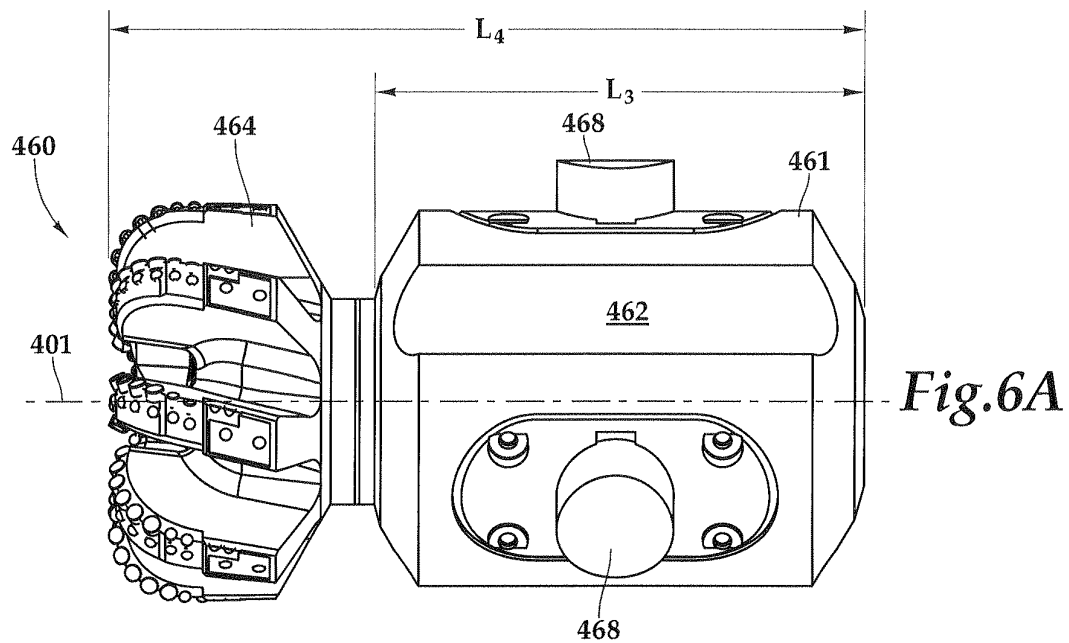
18. The bottom hole assembly of claim 17 wherein the tool string further includes a second borehole reamer assembly disposed in the tool string, either (i) above the downhole remote steering assembly or the MWD/LWD assembly, or (ii) above both the downhole remote steering assembly and the MWD/LWD assembly.

19. The bottom hole assembly of any of claims 15 to 18 wherein an overall longitudinal length of the borehole reamer assembly for reaming a 16 7/8 inches diameter hole is less than or equal to 60 inches.









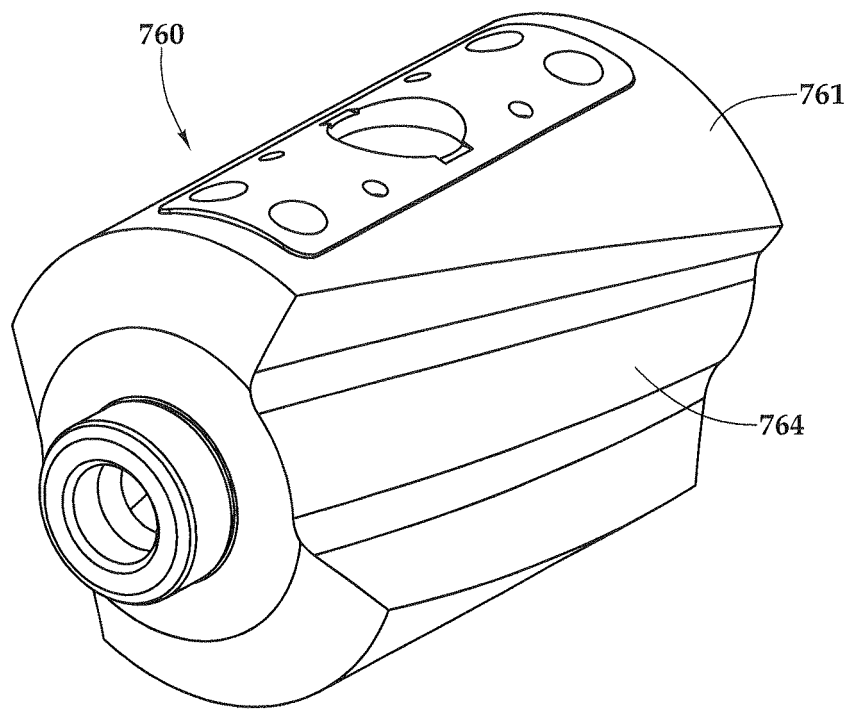


Fig.7

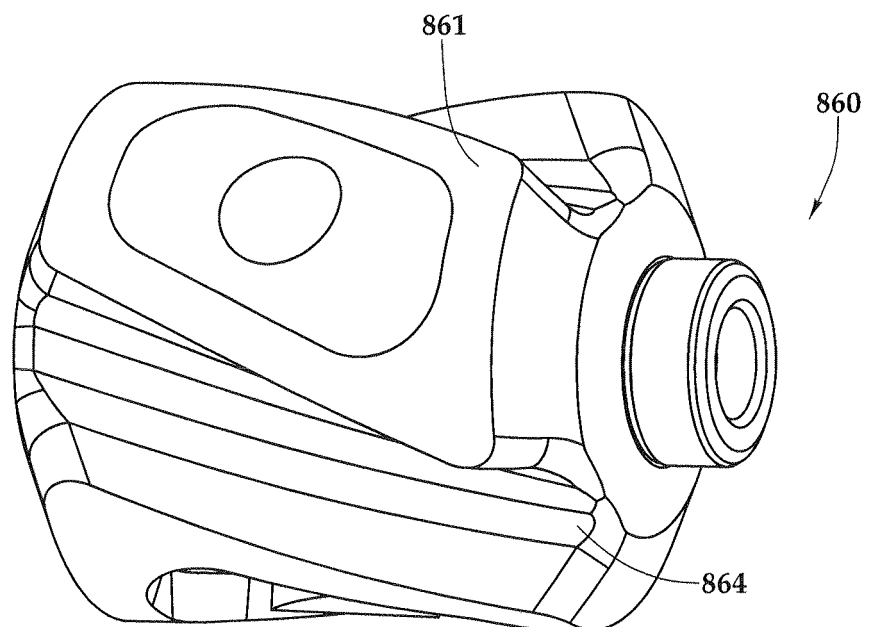
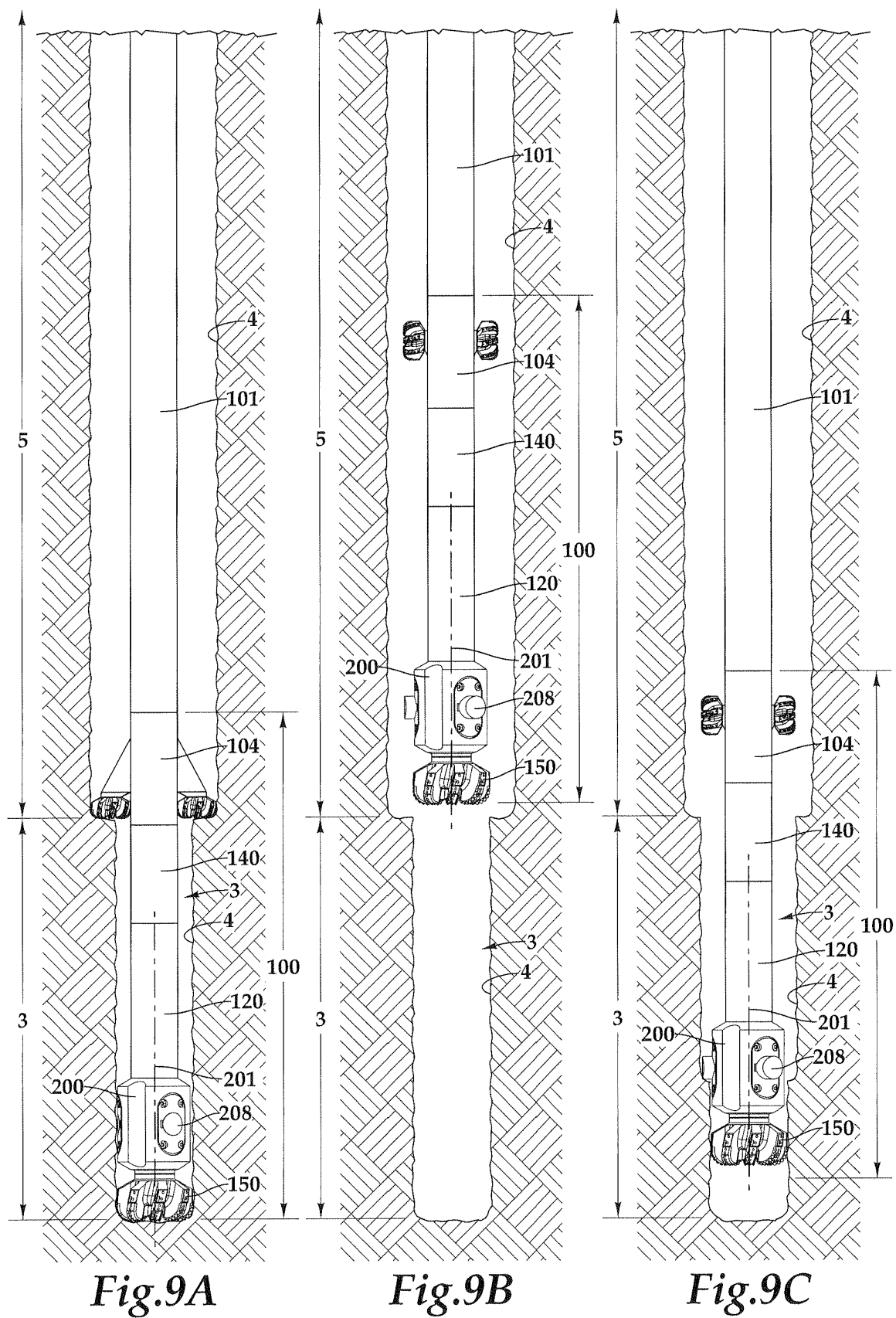


Fig.8



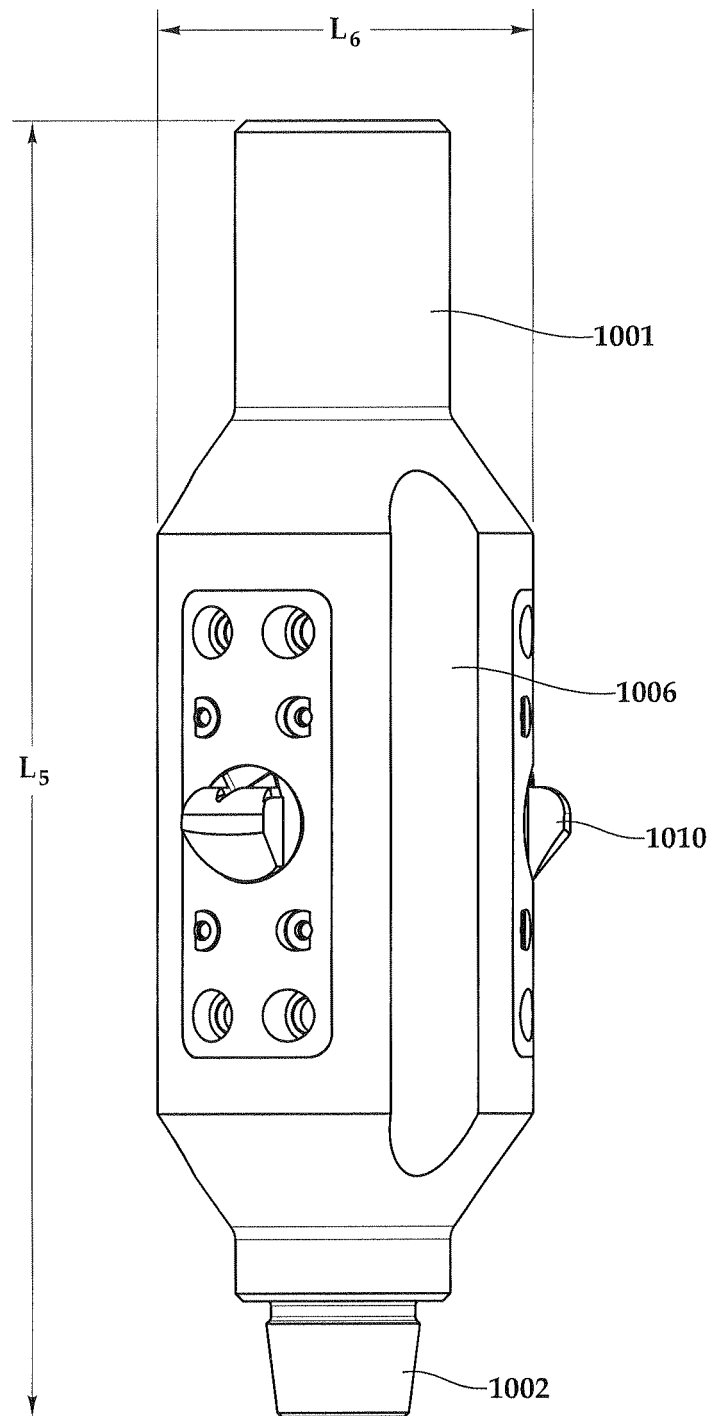


Fig.10