US 20120273187A1

(19) **United States**

(12) **Patent Application Publication**

(10) **Pub. No.: US 2012/0273187 A1**

(43) **Pub. Date: Nov. 1, 2012**

Hall et al.

(54) **DETECTING A REAMER POSITION THROUGH A MAGNET FIELD SENSOR**

(76) Inventors: **David R. Hall**, Provo, UT (US); **Scott Dahlgren**, Alpine, UT (US); **Jonathan Marshall**, Provo, UT (US)

(21) Appl. No.: **13/094,927**

(22) Filed: **Apr. 27, 2011**

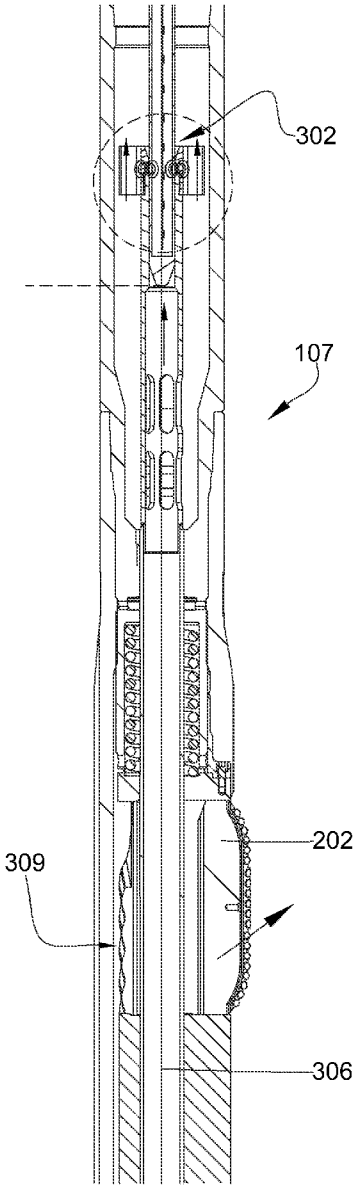
Publication Classification

(51) **Int. Cl.**
E21B 31/06 (2006.01)

(52) **U.S. Cl.** **166/66.5**

(57) **ABSTRACT**

In one aspect of the present invention, a tool string component comprises at least one end that attaches to an adjacent component in a through bore. The invention also comprises a laterally extending member disposed along a length of the tool string component. A magnetic mechanism is configured to sense an extension depth of the laterally extending member.



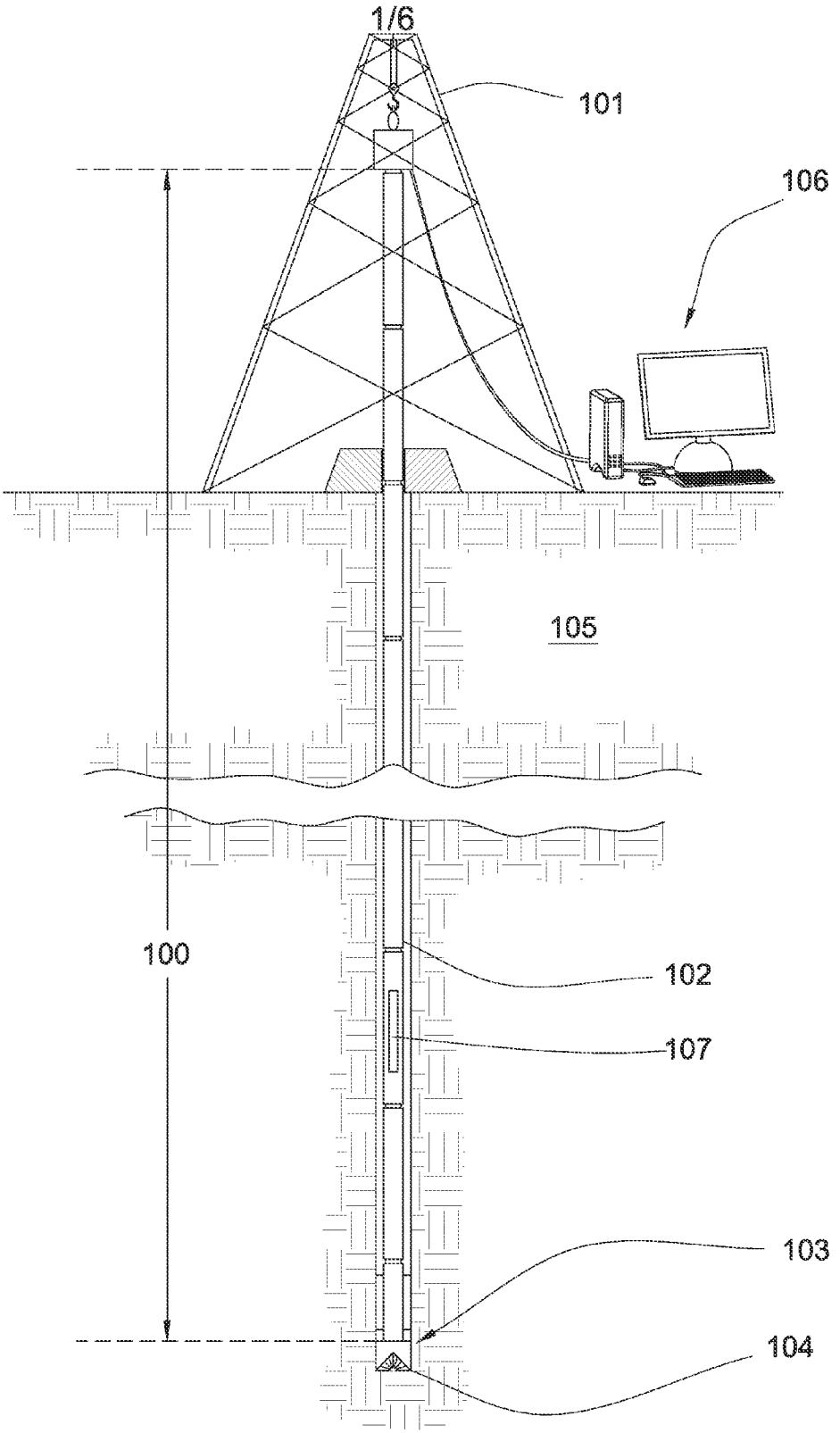


Fig. 1

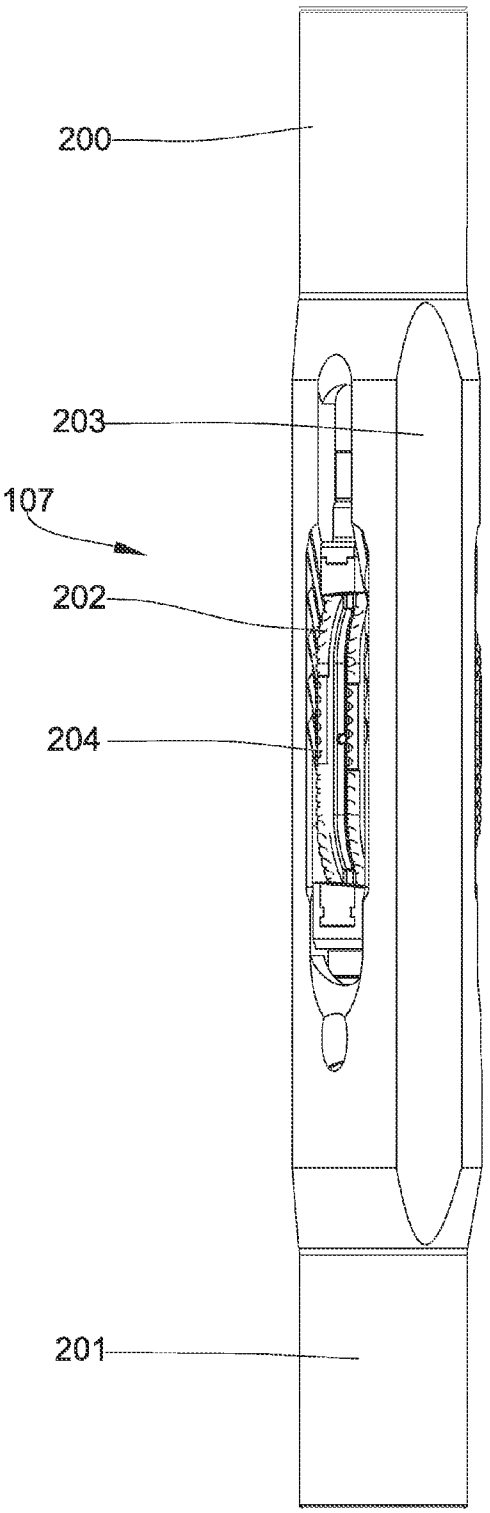


Fig. 2a

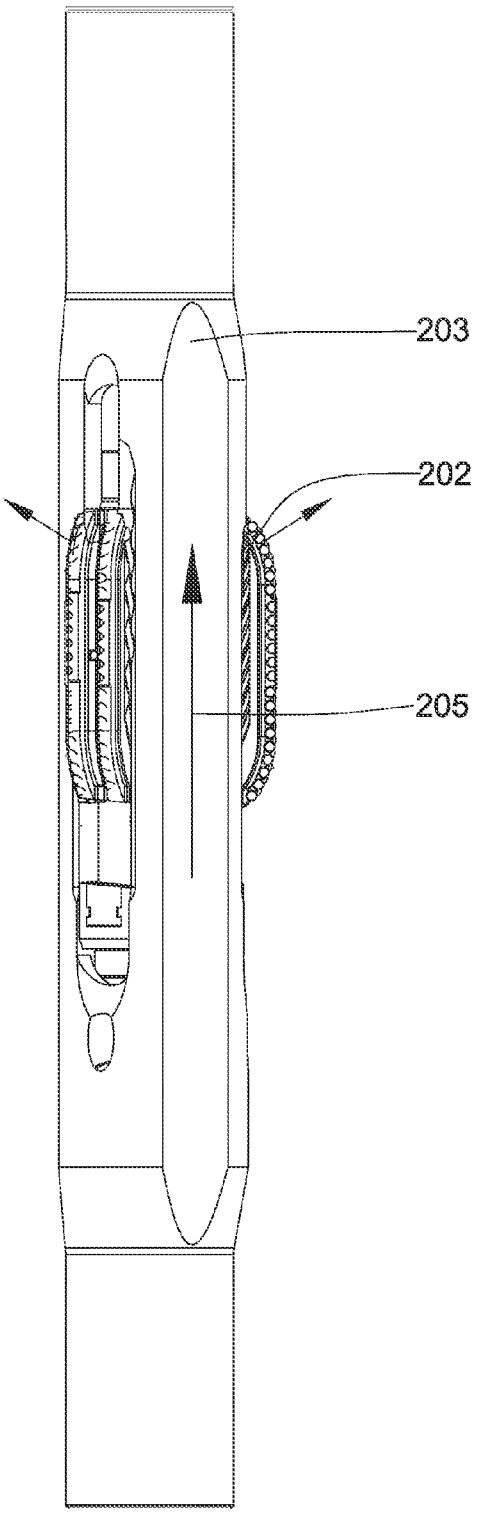


Fig. 2b

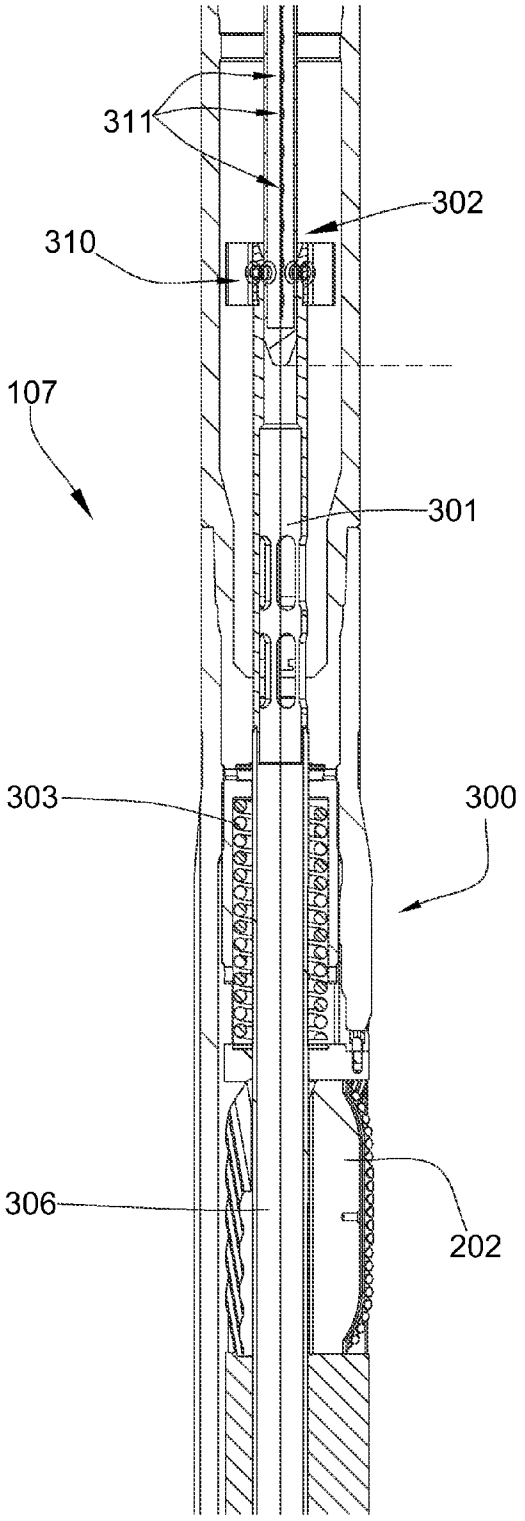


Fig. 3a

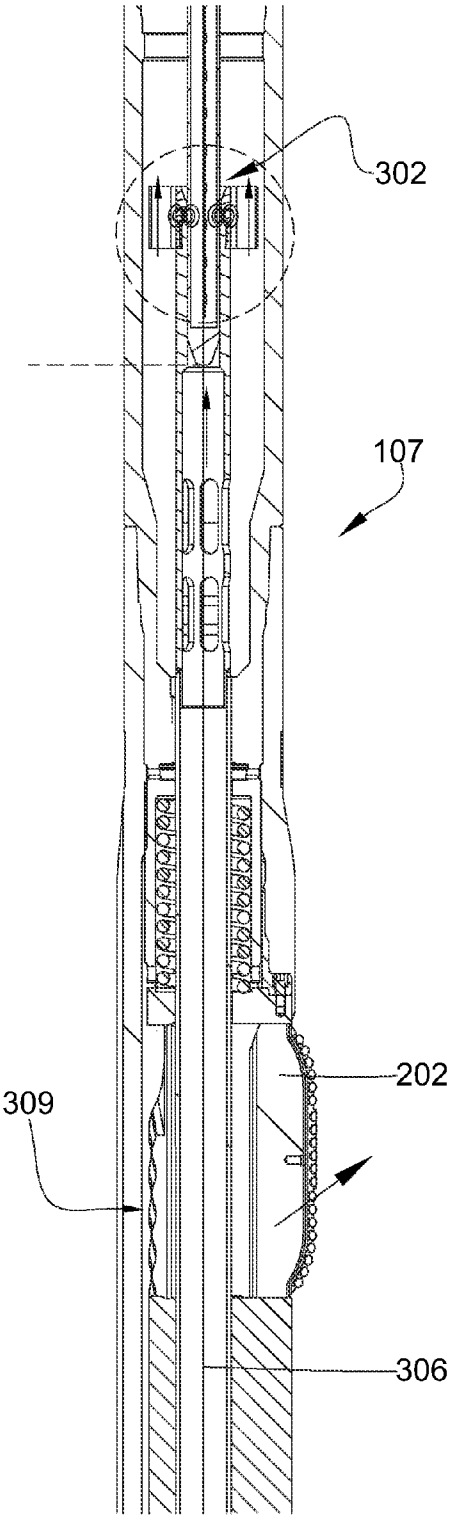


Fig. 3b

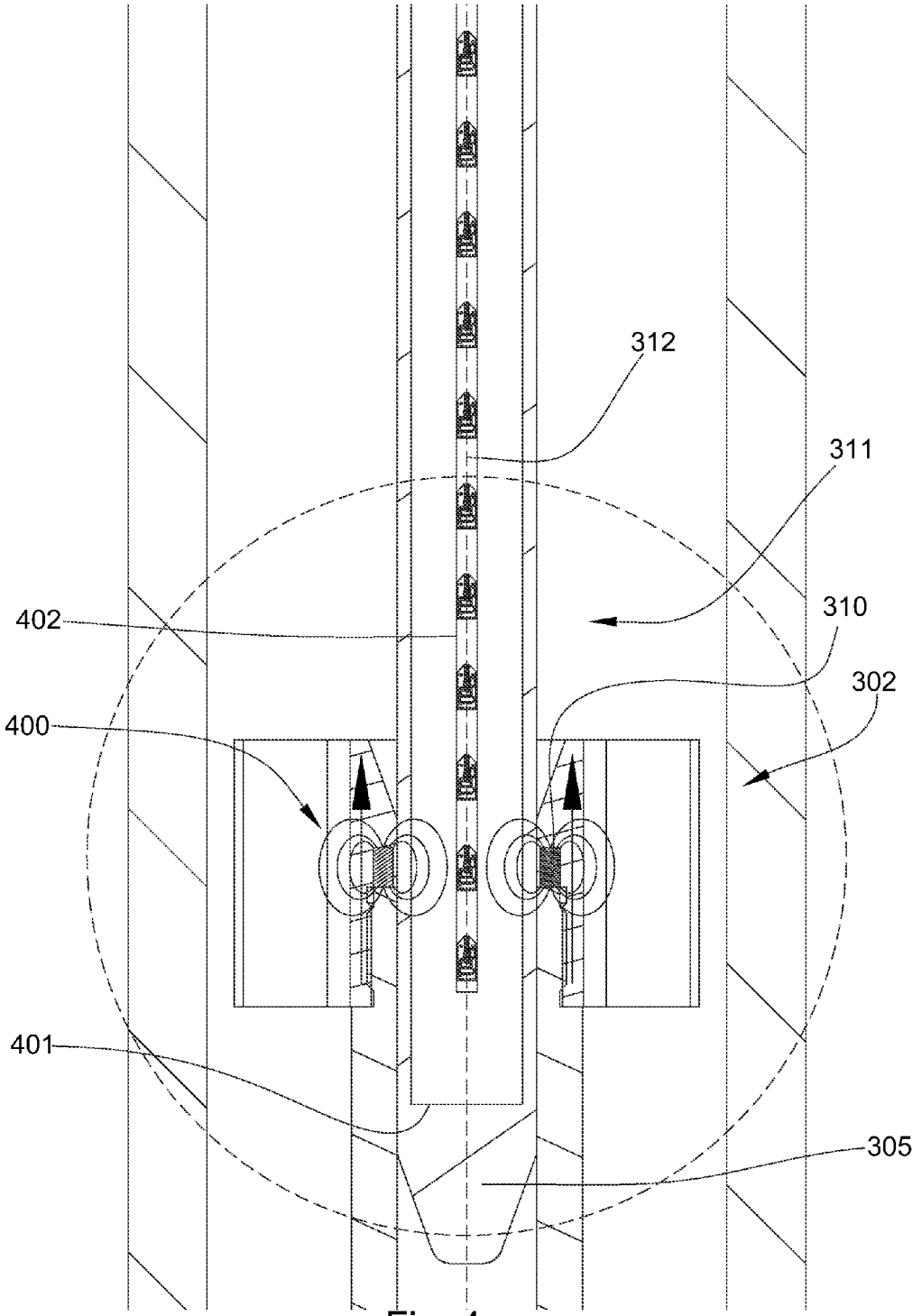


Fig. 4

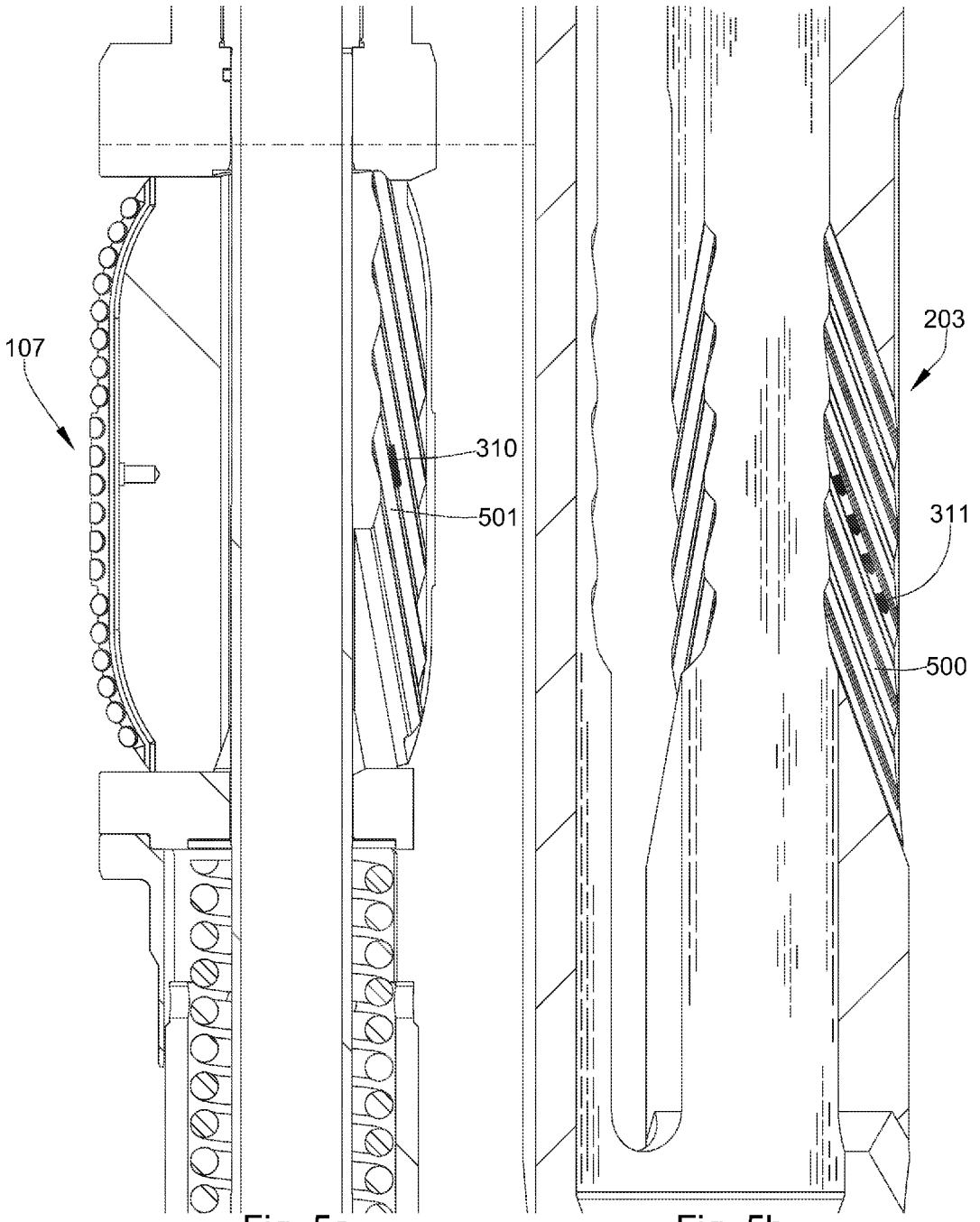


Fig. 5a Fig. 5b

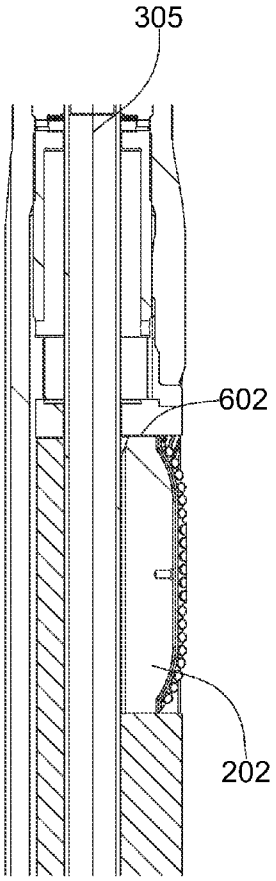


Fig. 6a

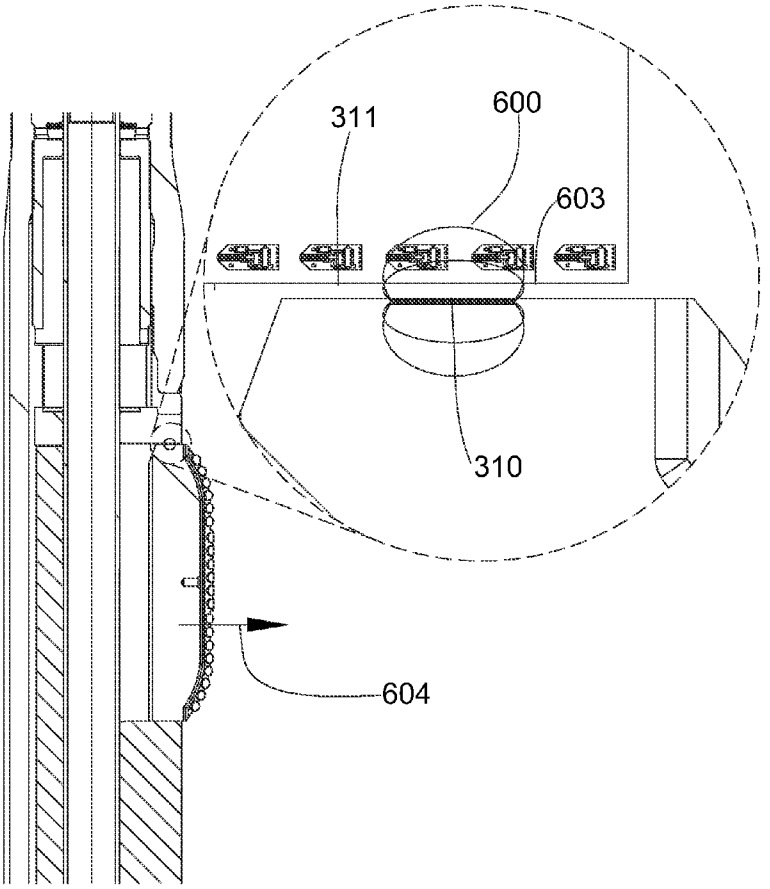


Fig. 6b

DETECTING A REAMER POSITION THROUGH A MAGNET FIELD SENSOR

BACKGROUND OF THE INVENTION

[0001] The present invention relates to the fields of oil, gas, and/or geothermal exploration and more particularly to the fields of expandable tools for downhole exploration. The prior art discloses expandable tools that are configured to centralize downhole tools within the well bore. The prior art also discloses expandable tools used to enlarge the diameter of a wellbore during drilling operations. Expandable tools of this type may contain blades which extend from the sides of a drill string and contact the bore wall.

[0002] U.S. Pat. No. 7,314,099 to Dewey et al., which is herein incorporated by reference for all it contains, discloses an expandable downhole tool comprising a tubular body having an axial flow bore extending there through, at least one moveable arm, and a selectively actuatable sleeve that prevents or allows the at least one moveable arm to translate between a collapsed position and an expanded position. A method of expanding the downhole tool comprises disposing the downhole tool within the wellbore, biasing the at least one moveable arm to a collapsed position corresponding to an initial diameter of the downhole tool, flowing a fluid through an axial flow bore extending through the downhole tool while preventing the fluid from communicating with a different flow path of the downhole tool, allowing the fluid to communicate with the different flow path by introducing an actuator into the wellbore, and causing the at least one moveable arm to translate to an expanded position corresponding to an expanded diameter of the downhole tool.

[0003] U.S. Patent App. 2008/0128175 to Radford, et al., which is herein incorporated by reference for all that it contains, discloses an expandable reamer apparatus for drilling a subterranean formation including a tubular body, one or more blades, each blade positionally coupled to a sloped track of the tubular body, a push sleeve and a drilling fluid flow path extending through an inner bore of the tubular body for conducting fluid there through. Each of the one or more blades includes at least one cutting element configured to remove material from a subterranean formation during reaming. The push sleeve is disposed in the inner bore of the tubular body and coupled to each of the one or more blades so as to effect axial movement thereof along the track to an extended position responsive to exposure to a force or pressure of drilling fluid in the flow path of the inner bore.

BRIEF SUMMARY OF THE INVENTION

[0004] In one aspect of the present invention, a tool string component comprises at least one end that attaches to an adjacent component in a through bore. The invention also comprises a laterally extending member disposed along a length of the tool string component. A magnetic mechanism is configured to sense an extension depth of the laterally extending member.

[0005] The magnetic mechanism may comprise a magnet and at least one sensor. The sensor may be configured to be stationary with respect to the magnet. The magnet may also be configured to move as the laterally extending member changes its depth of extension. In some embodiments, that movement may be along an axis of the component. Also, in some embodiments, the sensor may be located near a central axis of the component and within the through bore.

[0006] The sensor may be communication with processing element that is configured to transmit data about the movement of the magnet to surface equipment or downhole tools. The processing element may process the data and send commands based off the data to adjust a depth of the extendable member.

[0007] The magnet and/or sensor may be located in the through bore. In such embodiments, the magnet and/or sensor may be isolated from drilling fluid flow in the through bore. In other embodiments, the magnets and sensors may be disposed on or proximate the laterally extending member. A member groove on the laterally extending member may interface with a sleeve groove on a slidable sleeve that supports the laterally extending member. The magnet and senors may be located on the member and sleeve grooves.

[0008] In some embodiments, the at least one sensor comprises a plurality of magnetometers linearly distributed within and along a length of the through bore. The magnet may be configured to move in a direction that follows the distribution of magnetometers as the laterally extending member moves. The magnetometers may be configured to determine the location of the magnet, which corresponds with the extension depth of the laterally extending member.

[0009] In other embodiments, the laterally extending member may be supported within a slot formed in an outer surface of the component, and the senor may be disposed proximate a surface of the slot wall.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. **1** is a cutaway view of an embodiment of a drilling operation.

[0011] FIG. **2***a* is an orthogonal view of an embodiment of a downhole tool.

[0012] FIG. **2***b* is an orthogonal view of another embodiment of a downhole tool.

[0013] FIG. **3***a* is a cross section of another embodiment of a downhole tool.

[0014] FIG. **3***b* is a cross section of another embodiment of a downhole tool.

[0015] FIG. **4** is a cross section of another embodiment of a downhole tool.

[0016] FIG. **5***a* is an orthogonal view of an embodiment of an expandable member.

[0017] FIG. **5***b* is an orthogonal view of an embodiment of an expandable member.

[0018] FIG. **6***a* is a cross section of another embodiment of an expandable member.

[0019] FIG. **6***b* is a cross section of another embodiment of an expandable member.

DETAILED DESCRIPTION OF THE INVENTION AND THE PREFERRED EMBODIMENT

[0020] FIG. **1** discloses an embodiment of a drilling operation comprising a drilling derrick **101** supporting a tool string **100** inside a borehole **102**. The drill string **100** may comprise a bottom hole assembly **103** that includes electronic equipment and an expandable tool **107**. Rotating the drill string **100** may also rotate a drill bit **103** and cause the drill bit **103** to degrade the bottom **104** of the borehole **102**. The expandable tool may ream a larger diameter in the borehole than formed by the drill bit. In other embodiments, the expandable tool may primarily centralize the tool string within the bore hole. In some embodiments, the expandable tool **107** may limit

drilling vibrations by stabilizing the drill string **100**. The tool string may incorporate a telemetry system for bi-directional communication between surface equipment **106** and downhole tools. For example, operators may input commands at the surface to control the extension depth of a laterally extending member. Also, downhole sensors may send data to the surface that indicates the current extension depth of the laterally extending members.

[0021] FIG. **2***a* discloses an embodiment of the expandable tool **107**. A proximal end **200** of the expandable tool **107** may connect to other downhole tool string components at tool joints. A distal end **201** of the tool may connect directly the bottom hole assembly, drill bit **104**, or other drill string components. In this embodiment, the expandable tool **107** may comprise a mandrel with a tubular body and an outer surface, a plurality of laterally extending members **202** disposed around the mandrel's outer surface, and a slidable sleeve **203**.

[0022] The slidable sleeve **203** comprises the plurality of blades **202** disposed in slots formed in the thickness of the sleeve. A plurality of axial segments may form the slidable sleeve **203**. The laterally extending members **202** may comprise a plurality of cutting elements **204** and may be configured to ream the borehole wall **102**. The laterally extending members **202** are depicted in the embodiment of FIG. **2***a* in a retracted position.

[0023] FIG. **2***b* discloses the slidable sleeve **203** configured to slide along a length of an outer diameter of the expandable tool **107**. The slidable sleeve **203** and the laterally extending members **202** may be connected such that as the slidable sleeve **203** slides along the expandable tool **107** in the direction of arrow **205**, the members **202** shift laterally out of the slot. Sliding the sleeve **203** in the reverse direction may retract the laterally extending members.

[0024] FIG. **3***a* discloses the laterally extending members **202** in a retracted position. The expandable tool **107** may comprise an actuating assembly **300** that controls the extension depth of the laterally extending members and a magnetic mechanism **302** that records the member's extension depth. The actuating assembly may depend on a dynamic force from the drilling fluid to extend the members. By opening valves located in the through bore, the actuating assembly may divert drilling fluid to engage the laterally extending members and push them out. A spring **303** may be disposed within the expandable tool and along the length of the tubular member. The spring may be configured to retract the laterally extending member **202** in the absence of the dynamic fluid force. However, in other embodiments, other electrical and/or mechanical assemblies may be used to control the extension depth of the members.

[0025] In the embodiment of FIG. **3***a*, the actuating assembly **300** comprises a central cylindrical structure **301** located within the through bore **306** and in mechanical communication with the spring. The central cylindrical structure is configured to translate along a length of the through bore as the spring moves. The central cylindrical structure may support magnets **310** that move with the central cylindrical structure, but with respect to sensors **311** that are axially fixed within the through bore. The combination of at least one of the sensors and the magnets may form the magnetic mechanism **302**.

[0026] FIG. **3***b* discloses the laterally extending member **202** extended, which compresses the spring **303** and shifts the central cylindrical structure with the associated magnets along the length of the expandable tool. A ramp **309** formed in the tool body **107** may cause the extending member **202** to extend radially as an axial force from the fluid is applied. One of the laterally extending members is removed for illustrative purposes to show the ramp **309**.

[0027] The valves may be controlled by downhole tools and/or surface equipments. Preferably, commands over a telemetry system to open the valve fully or partially. A telemetry system that may be compatible with the present invention is disclosed by U.S. Pat. No. 6,670,880, which is herein incorporated by reference for all that it contains. The execution of the commands sent to the valves may be confirmed through the recordings of the magnetic mechanism.

[0028] FIG. **4** discloses a detailed view of an embodiment of the magnetic mechanism **302**. In this embodiment, the magnetic mechanism **302** comprises a plurality of sensors **311** and a magnet **310**. The magnet **310**, annularly disposed about the sensors **305**, radiates a magnetic field **400** that is detected by the plurality of sensors **311**. The sensors **311** are rigidly attached to a rod **312** that is axially fixed to the through bore. The magnets, however, move with respect to the sensors as the laterally expendable members retract and expand.

[0029] The sensors **311** may include a plurality of magnetometers **311**. The plurality of magnetometers **311** may sense the strength of the magnetic field **400** when in the field's vicinity. In some embodiments, the magnetic field **400** is focused, by a magnetic shield, toward the axis **305**.

[0030] The sensors **311** may be distributed along a length of the rod **312**. As the cylindrical structure and magnets **310** moves along the length of the through bore, the magnetic field **400** moves accordingly, and the location of the magnetic field correlates with the extension depth of the members. The sensors **311** may be in communication with a processing element that can transmit the data to downhole tools or to surface equipment. In some embodiments, the processing element may comprise enough intelligence to send commands directly to the valves to adjust a depth of the laterally extending member.

[0031] The magnets may be housed in a sealed compartment to protect the magnets from the abrasive forces of the drilling fluid. Also, the rod may be sealed to protect the sensors from the harsh downhole environment.

[0032] The sensors **311** may gauge extension depth by the strength of the magnetic field **400** on each magnetometer. Each magnetometer of the sensors **311** may detect an increasing magnetic field **400** as the magnet **310** approaches. For example, when the magnetometers on a first end **401** sense the magnetic field, the expandable tool **107** may be in a retracted position; and when the magnetometers on a distal end **402** detect the magnetic field **400**, the expandable tool **107** may be in an extended position. As the magnetic field **400** approaches the distal end **402** of the sensors **311**, the expandable tool **107** may approach maximum expansion.

[0033] In some embodiments, a single magnetic field detector may sense the position of the magnet. For example, the magnetic field sensor and associated instrumentation may be configured to detect the strength of the magnetic field. Thus, a weak magnetic field may indicate that the magnet is far from the magnetic field sensor, while a strong detected field may indicate that the magnet is closer. The instrumentation may be configured to determine the relative location based off of a continuum of field strengths.

[0034] FIGS. **5***a* and **5***b* discloses a magnet/magnetic source **310** located on a member groove **501** formed in the expandable member **107**. Corresponding sleeve grooves **500** located in the slot formed in the sleeve that supports the

members may comprise the sensors **311**. Thus, the relative position of the magnets and magnetometers may be used to determine the position of the laterally extending members. In some embodiments, the magnets may be positioned in the sleeve, and the sensors may be disposed within the sleeve.

[0035] FIG. **6** discloses an expandable tool **107** that translates laterally as indicated by arrow **604**. The magnet **310** may be disposed within any surface **602** that comes into contact or near contact with the member, and the magnetometers may be disposed within an adjacent surface **603** of the blade or vice versa.

[0036] Whereas the present invention has been described in particular relation to the drawings attached hereto, it should be understood that other and further modifications apart from those shown or suggested herein, may be made within the scope and spirit of the present invention.

What is claimed is:

1. A tool string component, comprising;

at least one end comprising an attachment to an adjacent tool string component and a through bore;

a laterally extending member disposed along a length of the tool string component; and

a magnetic mechanism configured to sense an extension depth of the laterally extending member.

2. The component of claim **1**, wherein the magnetic mechanism comprises a magnet and at least one sensor.

3. The component of claim **2**, wherein the at least one sensor is configured to be stationary with respect to the magnet.

4. The component of claim **2**, wherein the magnet is configured to move as the laterally extending member changes its depth of extension.

5. The component of claim **4**, wherein the magnet is configured to move along a length of the component.

6. The component of claim **2**, wherein the at least one sensor is located within the through bore.

7. The component of claim **2**, wherein the at least one sensor comprises a magnetometer.

8. The component of claim **2**, wherein the at least one sensor is communication with processing element that is configured to transmit data about the movement of the magnet to surface equipment or downhole tools.

9. The component of claim **8**, wherein the processing element is configured to process the data and send commands based off the data to adjust a depth of the extendable member.

10. The component of claim **2**, wherein the magnet or the at least one sensor is located in the through bore.

11. The component of claim **10**, wherein the magnet or at least one sensor is isolated from drilling fluid flow in the through bore.

12. The component of claim **2**, wherein a member groove on the laterally extending member interfaces a sleeve groove on a slidable sleeve of the component, wherein the magnet is located on the member and/or sleeve groove.

13. The component of claim **12**, wherein at least one sensor is located in the member and/or sleeve groove.

14. The component of claim **2**, wherein the at least one sensor comprises a plurality of magnetometers distributed within and along a length of the through bore, the magnet is configured to move in a direction that follows the distribution of magnetometers as the laterally extending member moves, and magnetometers are configured to determine the location of the magnet, which corresponds with the extension depth of the laterally extending member.

15. The component of claim **2**, wherein the magnet is disposed annularly about a linear distribution of sensors disposed along a length of the through bore.

16. The component of claim **2**, wherein the at least one sensor is axially fixed within the through bore.

17. The component of claim **2**, wherein the laterally extending member is supported within a slot formed in an outer surface of the component, the slot comprising a slot wall, and the magnet and/or senor is disposed proximate a surface of the slot wall.

18. The component of claim **1**, wherein the laterally expandable member is configured to ream a diameter of a well bore.

19. The component of claim **1**, wherein the laterally expendable member is configured to centralize component within a well bore.

* * * * *