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(54) **A CORE ORIENTATION TOOL**

(57) A core orientation tool 10 for providing an indication of orientation of a core sample 112 comprises an electronic orientation device 20, which upon receipt of a trigger signal, logs one or more indications of orientation of the tool 10. A trigger system 24 provides trigger signals to the electronic device 20 based one or both of (a) de-

tecting one or more downhole events and (b) the effluxion of time. The downhole events relate to the action of core breaking and may include detecting: uphole motion of the tool; and, cessation of drilling and commencement of drilling.

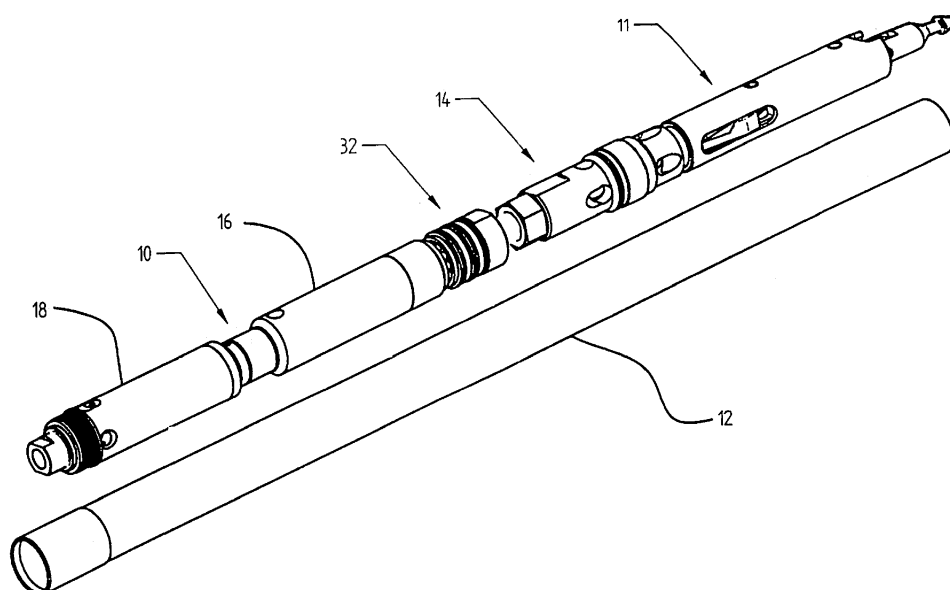


Figure 1

Description

Field of the Invention

[0001] The present invention relates to a core orientation tool that can provide directional characteristics of a geological core sample extracted from the subsurface.

Background of the Invention

[0002] Core sampling is used to allow geological surveying of the subsurface for various purposes including exploration and/or mine development. An analysis of the material within the core sample provides information of the composition of the subsurface. However in order to accurately interpret the information obtained from the core sample, it is necessary to have knowledge of the orientation of the core sample relative to the subsurface from which it was extracted.

[0003] Applicant has developed numerous devices, systems and methods for orientating a core sample including a method of orientating a core sample described in co-pending Australian patent application no. 2006901298; an orientation head described in International publication No. WO 07/109848; a core orientation system described in International publication No. WO 07/1137356; and an orientation device for a core sample described in International publication No. WO 03/038232; the contents of each of which is incorporated herein by way of reference.

[0004] The present invention is the result of Applicant's further research and development in the field of core orientation.

[0005] It is to be understood that, if any prior art publication is referred to herein, such reference does not constitute an admission that the publication forms a part of the common general knowledge in the art, in Australia or any other country.

[0006] In the claims of this application and in the description of the invention, except where the context requires otherwise due to express language or necessary implication, the words "comprise" or variations such as "comprises" or "comprising" are used in an inclusive sense, i.e. to specify the presence of the stated features but not to preclude the presence or addition of further features in various embodiments of the invention.

Summary of the Invention

[0007] According to a first aspect of the present invention there is provided a core orientation tool for providing an indication of *in situ* orientation of a core sample extracted from a borehole by a core drill the tool comprising:

an electronic orientation system coupled with the core drill, the electronic orientation system configured, upon receiving a trigger signal, to log one or more first indications of orientation of the tool; and,

a trigger system that provides the trigger signal upon detecting one or more downhole events associated with operation of the core drill.

[0008] According to a second aspect of the present invention there is provided a core orientation tool for providing an indication of *in situ* orientation of a core sample extracted from a borehole by a core drill the tool comprising:

an electronic orientation system coupled with the core drill, the electronic orientation system configured, upon receiving a trigger signal, to log one or more first indications of orientation of the tool; and, a trigger system that provides the trigger signal upon one or both of (a) detecting one or more downhole events associated with operation of the core drill, and (b) effluxion of time.

[0009] According to a third aspect of the present invention there is provided a core orientation tool for providing an indication of *in situ* orientation of a core sample extracted from a borehole by a core drill the tool comprising:

an electronic orientation system coupled with the core drill, the electronic orientation system configured to log one or more first indications of orientation of the tool; and, a trigger system that provides a trigger signal upon detecting one or more downhole events associated with operation of the core drill; and, wherein tool is configured to associate the one or more first indications of orientation with the trigger signal.

[0010] The trigger signal may be one of a plurality of trigger signals. Moreover, the tool may be further configured to log different first indications of orientation, for example dip, roll and azimuth upon receipt of different trigger signals.

[0011] The one or more downhole events may comprise respective physical events arising from motion of the tool or the drill in the borehole.

[0012] For example, the motion may comprise one or a combination of:

(a) motion in an uphole direction;

(b) a change in motion from motion having a linear component in a downhole direction to motion having no linear component;

(c) a change in motion from motion in a downhole direction to motion in an uphole direction;

(d) a change in motion from no linear motion to motion in an uphole direction;

(e) a change in characteristics of vibration motion on the tool or drill arising from the cessation or commencement of drilling;

(f) a change in speed of linear motion of the tool; and,

(g) a change in the rate or direction of rotation around the tool's longitudinal, lateral or normal axis.

(h) any change in velocity (speed and/or direction of movement).

[0013] The trigger signal may be provided upon detecting a predetermined sequence of downhole events such as a cessation of drilling followed by motion of the tool in an uphole direction.

[0014] The sequence of events may further comprise commencement of drilling prior to the cessation of drilling.

[0015] Other downhole events that may be detected by the electronic orientation device and used in producing the trigger signal comprise:

(a) detecting contact of a backend assembly to which the tool is coupled hitting a landing ring in the core drill;

(b) the backend assembly hitting a water table in the event that the drill is operated in the borehole below the water table;

(c) detecting release of the backend assembly from a wire line when initially inserting a core tube into the core drill;

(d) the core drill tagging a toe of the hole;

(e) an overshot hitting and latching onto the backend assembly;

(f) retrieval of the backend assembly from the drill hole; and,

(g) a change in the flow of fluid through or around the backend assembly.

[0016] Instead of utilising detected changes in vibration characteristics of the tool which are caused when the drill is cutting a core, the stopping and starting of drilling may be detected by sensing actual rotation of the core drill by using sensors or devices mounted on or adjacent to a rotating side of the backend assembly. Such devices may comprise an inductive RPM sensor, accelerometer or a gyroscope.

[0017] The tool may be further configured to log or record time between one or more of the downhole events, for example the time between cessation of drill and motion in an uphole direction; and/or time between cessation of drilling and the provision of the trigger signal. Such

information may be beneficial in accessing the accuracy or degree of confidence in the orientation readings. According to a further aspect of the present invention there is provided a core retrieval system for a core drill comprising:

a core tube having an uphole end and a downhole end, the downhole end provided with an opening for receiving a core sample cut by the core drill; and,

a core orientation tool in accordance with the first aspect of the present invention wherein the core orientation tool is coupled to the core tube at a location uphole of the downhole end of the core tube.

[0018] The core retrieval system may further comprise a backend assembly coupled to the uphole end of the core tube and wherein the core orientation tool is attached to the backend assembly uphole of the uphole end of the core tube.

[0019] A further aspect of the present invention provides a method of logging *in situ* orientation of a core sample extracted from the ground by a core drill comprising:

coupling an electronic core orientation device in a known spatial relationship to a core sample cut by the core drill;

configuring the electronic core orientation device to log one or more indications of orientation of the device upon receipt of a trigger signal; and,

providing the trigger signal upon detecting one or more downhole events associated with the operation of the core drill.

[0020] The downhole events may be indicative of a, or an imminent, core break.

[0021] Detecting of the one or more downhole events may comprise detecting an uphole motion of the device.

[0022] The detecting of the downhole event may comprise detecting a cessation of drilling prior to detecting the uphole motion of the device. The detecting may further comprise detecting commencement of drilling prior to detecting cessation of drilling. Further, the detecting may comprise detecting a cessation of downhole movement of the device prior to detecting the commencement of drilling.

[0023] In one embodiment the tool comprises a switch that is activated by the tool, a downhole device such as an inner barrel assembly to which the tool is attached, or the drill, tagging the toe of the borehole. The switch may comprise a Hall effect switch, an optical switch, a pressure switch, and a mechanically operated electrical switch.

[0024] The first indications of orientation may comprise one or a combination of borehole dip, borehole azimuth,

core orientation, core dip and core azimuth.

[0025] According to a further aspect of the present invention there is provided a core retrieval system for a core drill comprising:

an inner core tube having an uphole end and an opposite downhole end provided with an opening for receiving a core cut by the core drill; and,
a core orientation tool coupled to the inner core barrel and movable inside the inner core tube in an uphole direction by abutment with the core, the core orientation tool comprising an electronic orientation device which upon receiving a trigger signal logs one or more first indications of orientation of the tool;
a trigger system that provides the trigger signal to the electronic orientation device; and
a core face orientation device which records rotational orientation of a core sample, wherein the electronic orientation device is in a known rotational position relative to the core face orientation device.

[0026] According to another aspect of the present invention there is provided a core retrieval system for a core drill comprising:

a core tube having an uphole end and an opposite downhole end provided with an opening for receiving a core sample cut by the core drill;
a core orientation tool coupled to the inner core tube and movable inside the inner core barrel in an uphole direction by abutment with the core sample, the core orientation tool comprising: an electronic orientation device which, upon receiving a trigger signal logs one or more first indications of orientation of the tool; and a trigger system that provides the trigger signal to the electronic orientation device.

[0027] A further aspect of the present invention provides a core orientation apparatus for providing an indication of orientation of a core sample extracted from a borehole by a core drill the apparatus comprising:

an electronic orientation device which upon receiving a trigger signal logs one or more first indications of orientation of the tool;

a trigger system that provides the trigger signal to the electronic orientation device; and

one or more secondary orientation devices which provide one or more second indications of orientation of the core or borehole, wherein the electronic orientation device is in a known rotational position relative to the one or more secondary orientation devices.

[0028] The trigger system may provide the trigger signal on the basis of effluxion of time from a reference time.

For example the reference time could be the time the tool is inserted into a core drill, or at a time when or after the core face orientation device records the orientation of the core face.

[0029] In an alternate embodiment, the trigger signal is delivered on multiple occasions during a period between the core orientation tool being inserted into the core drill and a time after the core face orientation device records the orientation of the core face.

[0030] In one embodiment, the trigger system provides the trigger signal to the electronic orientation device upon detecting one or more downhole events associated with the operation of the drill. The one or more downhole events may comprise one or more physical events arising from the motion of the tool in the borehole.

Brief Description of the Drawings

[0031] Embodiments of the present invention will now be described by way of example only with reference to the accompanying drawings in which:

Figure 1 is a schematic representation of an inner barrel assembly and core tube to which an embodiment of a core orientation tool is coupled;

Figure 2 is a cutaway view of the core orientation tool and adjacent parts of the inner barrel assembly to which it is coupled.

Figure 3 is a partially exploded schematic representation of a further embodiment of a core orientation tool in accordance with the present invention;

Figure 4 is a partially exploded representation of a third embodiment of the core orientation tool;

Figure 5 is a section view of the core orientation tool shown in Figure 4; and

Figure 6 depicts the use of a template for transferring indications of core orientation captured by the tool to a core.

Detailed Description of the Preferred Embodiment

[0032] Throughout this specification the term "orientation" is intended to mean one or more of "dip", "roll", and "azimuth" of an apparatus, tool, core sample, borehole, or other structure in relation to which orientation data is required or desired.

[0033] Further, the expression "electronic orientation device" is intended to denote an electronic device or system that utilises electronic sensors and transducers such as but not limited to accelerometers, inclinometers, gyroscopes and magnetometers.

[0034] Throughout this specification the expression "downhole direction" is intended, unless the context

clearly suggests otherwise, a direction that increases distance along the hole away from a collar of the hole. Thus for example in a hole drilled directly downwards in the ground the downhole direction is the same as the direction of gravitational acceleration. Whereas in an uphole such as one drilled in a back of a tunnel, the downhole direction is in a direction opposite to the direction of gravitational acceleration.

[0035] Throughout this specification the expression "uphole direction" is intended, unless the context clearly suggests otherwise, a direction that decreases distance along the hole away from the collar of the hole. Thus for example in a hole drilled directly downwards in the ground the uphole direction is opposite the direction of gravitational acceleration. Whereas in an uphole such as one drilled in a back of a tunnel, the uphole direction is the same as the direction of gravitational acceleration.

[0036] Figures 1 and 2 illustrate an embodiment of a core orientation tool 10 in accordance with the present invention. The core orientation tool 10 is shown in association with an inner barrel assembly 11 which comprises a core tube 12 for receiving a core being cut by a core drill, and a backend assembly 14 that is attached to the core tube 12 for lowering and retrieving the core tube 12 from the core drill. The core tube 12 is of conventional construction while the backend assembly 14 is modified by the inclusion of an adaptor 16. The tool 10 is coupled at one end to the conventional core tube cap 18 of the backend assembly 14 with the adaptor 16 being used to couple an opposite end of the tool 10 to the remainder of the backend assembly 14. The tool 10 is in a known or measurable spatial relationship with the core tube 12. Further, as the core sample is rotationally fixed inside the core tube 12, at least shortly before and during a core breaking action, the orientation data relating to the core tube 12 can be related to the *in situ* orientation of the core sample.

[0037] The tool 10 comprises an electronic core orientation device or system 20 housed within a body 22 that is coupled to and between the core tube cap 18 and the adaptor 16. The electronic core orientation device 20 is configured to log one or more first indications of orientation of the tool (ie, core orientation) upon receiving of a trigger signal. To this end, the tool 10 includes a trigger system 24 that provides the trigger signal upon detecting one or more downhole events associated with the operation of the core drill. These events may particularly relate to the core breaking function of the core drill and/or various sequences of events expected prior to core breakage.

[0038] The system 20 comprises multiple sensors and transducers for sensing various events and orientation data of the tool 10 and core drill. The sensors may comprise for example accelerometers, gyroscopes, physical switches, magnetometers, vibration sensors, inclinometers, inductive RPM sensors, flow sensors and pressure sensors. Some of the sensors and transducers send information to the trigger system that analyses the infor-

mation to determine when to provide the trigger signal. Other sensors and transducers, notionally forming an orientation module 26, may be either in an idle state or continually providing data indicative of core and/or bore hole orientation, however these sensors and transducers are not activated and/or the orientation data is not logged until the trigger system 24 provides the trigger signal. It will be appreciated by those skilled in the art that some of the sensors and transducers that are used by the trigger system may also provide orientation data. The orientation system 20 may further comprise a transceiver 28 coupled to an antenna 30 to communicate with a handheld computer or other like device. The function of this will be explained in greater detail later in the specification.

[0039] Embodiments of the tool 10 are able to log in *situ* orientation data relating to the core and the borehole from which the core is extracted at a time shortly before or at core breakage. This is done by arranging a trigger system 24 to issue the trigger signal upon sensing particular events or sequences of events that are expected to occur when a core is broken from the ground. One or more of the downhole events relate to physical events arising from the motion of the tool 10 and indeed the core drill in the borehole. One of the telltale physical events of a core break is an uphole motion of the core drill and thus the tool 10. Accordingly the trigger system 24 may be configured to issue the trigger signal when sensors in the module 26 detect an uphole movement or acceleration or a change in direction of motion from a downhole direction to an uphole direction. While such motion is characteristic of a core break, other events or motions may also be sensed which increase the degree of confidence that the uphole motion is related to a core break. Examples of such events or motions include:

1. The backend assembly 14 being released at the collar of the borehole.
2. When the toe of the hole is below the water table, detecting the backend assembly 14 hitting the water table.
3. The backend assembly 14 contacting or hitting a landing ring within the core drill.
4. The commencement of drilling.
5. The cessation of drilling.
6. The breaking of the core itself.
7. An overshoot hitting and latching onto the backend assembly 14.

[0040] For example, in addition to simply detecting an uphole motion of the tool 10 or the core tube 12 or core drill itself, the trigger system 24 may be arranged to issue the trigger signal upon the module detecting in sequence

commencement of drilling, cessation of drilling and a motion in an uphole direction. The sensing of the commencement and cessation of drilling may be via the use of vibration sensors in the module 26. It is known that during drilling as a core bit is bearing against rock, vibrations of known characteristics will be generated.

[0041] The trigger signal may be one of a plurality of trigger signals provided upon detection of different downhole events. That is a trigger signal may be provided when commencement of drill is detected, another when cessation of drilling is detected and another when an uphole motion of the tool 10 or drill is detected. Thus logging (recording) of data will commence prior to the breaking of the core. Additionally different orientation indications may be logged at different trigger signals. For example dip may be logged at when the trigger system detects drilling has stopped (e.g. detecting no rotation of the core drill following previously detecting the commencement of drilling; and core orientation may be logged upon the trigger system detecting a core lifter case gripping the core just prior to the core break.

[0042] The tool 10 and more particularly the electronic orientation system 20 comprises a memory device for storing logged data. The trigger signal may be considered to act as a pointer to identify the logged orientation data at the time the trigger signal(s) were provided so that the orientation data can be correlated to particular downhole event, particularly the core break.

[0043] Accordingly sensing a change in the characteristics of the vibrations would be indicative of the commencement and cessation of drilling. However this is not the only way in which the commencement and cessation of drilling may be sensed. As an alternate, sensors may be provided in the module 26 or trigger system 24 to sense the speed, direction or change in speed or direction of rotation of the core drill. For example upon commencement of drilling, the sensor will detect rotation of the core drill, while on cessation of drilling the sensor will subsequently detect a change in the speed of rotation and more particularly a zero speed of rotation. Such a sensor may comprise an inductive RPM sensor, accelerometer or gyroscope having a component on or adjacent a rotating section of the backend assembly 14, such as for example on an uphole side of bearing 32 of the backend assembly.

[0044] Other possible variations for detecting the commencement and cessation of drilling include by detecting flow of fluid through or around the backend assembly 14. In this regard, fluid is pumped through or around the core drill and backend assembly during drilling with the flow being cut off when drilling ceases. Therefore detecting a change in the flow of water will also be indicative of the cessation of drilling. Also while uphole motion may typically be sensed by an accelerometer, other types of sensors including optical sensors or lasers may be used for sensing motion in an uphole direction.

[0045] A substantive benefit of the tool 10 over other core orientation devices that rely on the logging of time to correlate orientation data to a core is that the tool 10

does not require the use of timers by human operators and is therefore less susceptible to error. The above described embodiment of the tool 10 may be considered as a "drop and forget" sensor which will automatically log core orientation data shortly before or at the time of a core break.

[0046] The tool 10 may be further configured to provide borehole azimuth and vertical core orientation relative to azimuth. It is known to use gyroscopes to obtain azimuth information when logging boreholes. However gyroscope technology is not suitable for use in downhole core orientation during the drilling process. The reasons for this include that the gyroscopes are prone to drift when operated for extended periods as would be required when lowering the gyroscope through the core drill; the inability for the gyroscope to maintain accurate orientation when exposed to sudden movements such as a shunt or vibration as typically would occur when dropping a backend assembly down a drill string; and, the need for the azimuth measurement to be made relative to a known reference point.

[0047] Notwithstanding the above limitations, an embodiment of the tool 10 may comprise a gyroscope 34 or similar device for logging azimuth and dip. This is enabled by the use of the trigger system 24 which will only trigger the gyroscope 34 to move from an off or idle state to a logging state at the same time as it supplies a trigger signal to the measurement module 26. Prior to the trigger system 24 providing the trigger signal, the gyroscope 34 is either off or in an idle state. Upon receipt of the trigger signal, the gyroscope 34 is activated to commence tracking changes in orientation.

[0048] As the inner barrel assembly 11 is being withdrawn from the core drill, the gyroscope 34 continues to tracking changes in orientation. Orientation of a collar of the borehole may be used as a known reference orientation. Thus changes in orientation since the issuance of the trigger signal can be related back to the collar orientation so as to enable determination of the azimuth of the tool 10 and the borehole at the toe of the hole substantially at the time of a core break. This in effect provides a single survey shot at the bottom of the hole. This data may be used to build an ongoing survey of the borehole for determining its path when combined with a measurement or estimate of the hole depth. This may be determined by simply counting the number of rods in the core drill at each core run.

[0049] As the gyroscope 34 will only need to track changes in the orientation of the tool 10 after drilling has stopped, the need to track changes during the descent of the tool down the hole and during drilling is avoided. This substantially reduces the running time of the gyroscope therefore reducing the drift that may occur. It also obviates the need for the gyroscope to track changes in high vibration periods during drilling thus avoiding a significant loss of accuracy.

[0050] In the above embodiment, the tool 10 is used as a stand alone tool to obtain orientation data. In order

to extract the data and relate the data to a core sample held within the core tube 12, the tool 10 may be used in conjunction with a core orientation system of the type described in Applicant's International application No. WO 2007/137356. In brief, the core orientation system in the abovereferenced publication comprises a combination of:

an electronic orientation device which may have some features common to the current device 10;

a core position indicator adapted for engagement with the core tube 12 when on the ground; and,

a remote unit such as a hand-held computer that communicates between the tool 10 and the core position indicator.

[0051] In short, the transceiver 28 in the tool 10 communicates via wireless communication with the hand-held computer which in turn transfers data to the core position indicator. More particularly, the tool 10 logs orientation data of a reference point on the core tube 12 relative to a first datum at the time the particular downhole event has occurred, ie, at or shortly before a core break. The reference point on the core tube need not be a physical marking. Once the core tube 12 is retrieved and placed in a stable position say on a core tray, the tool 10 is again operated to log orientation data of the same reference point on the core tube to a second datum. A rotational displacement σ from the first datum to the second datum is calculated by the hand-held computer and wirelessly communicated to the core position indicator. The core position indicator is then rotated about the core tube 12. When the core position indicator is moved to a position where it is rotated by the appropriate rotational displacement σ from the second datum, it emits a signal to indicate the position of the first datum.

[0052] The core position indicator also includes a guide in the form of a slat having an elongated slot for receiving a scribing or marking device such as a pencil. The forward most end of the slat extends over the front of a core lifter case 36 and a portion of the core extending from the core lifter case. The marker is then used to mark the core lifter case and/or core to signify the location of the core relative to the particular datum.

[0053] The core position indicator may be modified over and above that described in the above referenced application by the inclusion of a sensor to sense when a marker has been run along the slot to signify that a marking has been made on the core lifter case and/or core. The core position indicator and the hand-held computer can record how accurately an operator marks the core by comparing its position when marked to its required position. This accuracy of marking information can then be transferred back to the hand-held computer and integrated with the original orientation information. The information contained in the hand-held computer is trans-

ferable to a removal medium so that all the information can be provided to the recipient of the core.

[0054] Alternately, the core position indicator may be arranged so as to prevent a user from marking the core until the core position indicator is correctly orientated. This may be achieved for example by having a moveable gate that slides across the slot to block the slot when the core position orientator is not in the correct orientation.

[0055] In one variation the trigger system may be modified to provide trigger signals on based on one or both of (a) one or more downhole events, and (b) effluxion of time.

[0056] The time triggers may comprise one or a combination of:

(a) a single trigger at a specified delay time relative to a time the device was initialized by an operator or triggered by a physical event;

(b) multiple continuous triggers at preset intervals commencing at a specified delay time relative to a time the device was initialized by an operator or triggered by a physical event and from which one or more data sets are selected.

[0057] The trigger system 24 may trigger the sensors in the module 26 to record one, or a combination of readings of orientation at a point/points in time:

(a) exactly when the trigger occurs;

(b) after some time delay;

(c) prior to the trigger by selecting a pre recorded reading where multiple readings are taken at predetermined intervals.

[0058] The trigger system 24 may cyclically provide trigger signals for a prescribe period of time after the first trigger is provided. For example trigger signals may be provided every 10 seconds for a two minute period. Alternately, the electronic orientation device 20 may be arranged so that upon receiving a trigger signal, it logs the one or more first directional characteristics cyclically for a prescribed period of time, for example every 10 seconds for a 2 minute period.

[0059] Figures 3-6 illustrate various core orientation apparatuses 100 which comprise a combination of the core orientation tool 10 together with one or more secondary orientation devices. As described in greater detail below, one of the secondary orientation devices may be a core face orientation device which records the *in situ* orientation of the face of the core. Another secondary orientation device that may be incorporated into the apparatuses 100 is a bottom orientator which records the location of a zero gravity vector at the toe of the hole provided that the hole is inclined to the vertical. The secondary orientation devices may be mechanical or electronic.

[0060] In the embodiment of the apparatus 100 shown in Figure 3, the trigger system 26 is depicted as being

contained in the common housing 22 with the remainder of the electronic system 20. However this need not be the case and the trigger system 26 may be physically separate from the tool 100 but in communication remainder of the electronic system 20 (for example by radio communication) to allow delivery of the trigger signals.

[0061] The trigger system 24 may provide trigger signals based on the same downhole events described in relation to the first embodiment.

[0062] This embodiment of the apparatus 100 comprises: a secondary orientation device which provides core face orientation and is in the form of a profile device 120; and, body 122 having a downhole end 124 and an uphole end 126. The body 122 comprises a lock body 127, a latch body 128 and an anchor 130, which are described in detail hereinafter with reference to the embodiment shown in Figures 5 and 6. In the embodiment of Figure 3, the electronic orientation device 20 is located downhole of the body 122.

[0063] The device 120 may take the form of the face orientator as described in Applicant's above referenced International publication No. WO 07/109848. The device 120 comprises a substantially cylindrical body 132 having a plurality of internal axially extending holes 134 for seating respective pins 136. The pins 136 are held within the holes 134 with a degree of resilience so that if an axial force is placed on the pins 136 in the uphole direction, the pins 136 can slide within the body 132, but when the force is removed, the pins 136 maintain their relative position in their holes 134. The body 132 is also provided with a bearing scale 138 marked on its outer circumferential surface 140. The scale provides markings in five degree increments from 0° to 360°. The 0° mark is aligned with a positional reference mark 142 provided at a downhole end of a shaft 144 that extends into the electronic orientation device 20.

[0064] The mark 142 also provides a zero reference for the electronic orientation device 20 so that by coupling of the device 120 to the electronic device 20 both are keyed to the same zero reference.

The face orientator 120 provides a profile recording of a toe of the hole from which a core 112 is cut. It will be understood by those skilled in the art that the toe of the hole becomes an uphole face of the core 112. Typically the device 120 is constructed as a single use device that, upon extraction of the core, is removed from the apparatus 100 and is stored with the core 112. Prior to this occurring, the scale 138 is marked with an angle denoting the orientation of the core relative to the zero degree mark on the scale 138. This marking may be obtained by transferring data from the electronic device 20 to the device 120 by an intervening hand held telemetry device (hand held computer) that interrogates the device 20 to obtain for example the tool face orientation data at the time the trigger signal is provided by the triggering system 26. This will provide for example a bearing in degrees referenced to the reference mark 142. This bearing can then be physically marked on the scale 138. For example

if the tool face orientation was 35° relative to the marking 142, then an indelible mark can then be made on the 35° position on the scale 138.

[0065] Figure 4 illustrates a further embodiment of the apparatus 100. In this figure the features which are identical to those described with reference to Figure 3 are denoted by the same reference numbers. The substantive difference between the apparatus 100 shown in Figure 4 and that shown in Figure 3 is that the tool 10 in Figure 4 is located at the uphole end 126 of the body 122 and, an additional secondary orientation device in the form of a mechanical bottom orientator 146 is coupled between the downhole end 124 of the body 122 and the core face profile device 120. The bottom orientator 146 is provided with three balls 148a, 148b and 148c (hereinafter referred to in general as "balls 148") disposed within respective races 150a, 150b, and 150c (hereinafter referred to in general as "races 150"). Prior to the bottom orientator 146 being activated the balls 148 are free to roll within their respective races 150. Accordingly, by action of gravity, provided that the apparatus 100 is disposed in a borehole that is not absolutely vertical, the balls 148 will roll to the lowest point within their respective races. When the bottom orientator 146 is activated, the width of the races 150 is reduced so that the balls 148 are clamped in their races. This prevents any further rolling of the balls and thus maintains the indication of the bottom of the hole.

[0066] The bottom orientator 146 is operated by the apparatus 100, and in particular the core face profile device 120, tagging the bottom of the borehole. The operation of the bottom orientator 146, the latch body 128 and the anchor 130 are described in detail in Applicant's above referenced applications WO 03/038232 and WO 2005/078232. Nevertheless a brief description of the operation of these components is provided below with particular reference to Figures 4 and 5.

[0067] A shaft 152, which is provided with the key mark 142, extends axially through the races 150 and up into the lock housing 127 and latch body 128. The device 120 is coupled to a downhole end of the shaft 152. The lock housing 127 includes a tubular extension 156 which has seats 157 on its outer surface for respective latches 158 that are pivotally coupled to the latch body 128 and can extend through windows 160 formed in the latch body 128. A shroud 159 is attached to a downhole end of the lock housing 127 and covers the bottom orientator 146. A recess 161 is also formed in the lock housing 127 between the seats 157 and the shroud 159. A pretensioned spring 162 is disposed about an upper end of the shaft 152 within the extension 156 and biases the shaft to in an uphole direction. A further spring 164 is held in a cavity between the latch body 128 and the extension 156 and acts to bias the extension 156 and thus the lock housing 127 in a downhole direction.

[0068] Another spring 166 acts between the latch body 128 and an anchor sleeve 168 of the anchor 130 biasing the sleeve 168 toward a shoulder 170 formed about an

anchor body 172 of the anchor 130. A plurality of anchor balls 174 are retained within the anchor sleeve 168. The anchor balls 174 roll along an outer surface 176 of the anchor body 172. When the anchor sleeve 168 is butted against the shoulder 170 by the spring 166, the balls 174 extend radially beyond the anchor sleeve 168. In this position, the anchor balls 168 are held on a constant outer diameter portion 178 of the anchor body 172.

[0069] Moving in a downhole direction from the portion 176 the outer circumference of the outer body 172 is formed with a tapered portion 180 that leads to a circumferential recess 182. The anchor body 172 also has, at its downhole end, a portion 184 of a first constant inner diameter, then a contiguous tapered portion 186 that has an increasing inner diameter, and which then leads to a further portion 188 having a constant inner diameter greater than the inner diameter of the portion 184.

[0070] A trigger seat 190 is attached to a uphole end of the shaft 152 and a plurality of trigger balls 192 are each seated partially in a circumferential groove 194 formed in the trigger seat 190 and in holes 196 formed in an uphole end of the extension 156.

[0071] The apparatus 100 is loaded into a downhole end of a core tube 12 by first inserting the end provided with the tool 10. Eventually the latch dogs 158 abut a downhole end of the core tube 12 preventing further insertion of a tool 100. During the insertion, the anchor body 168 slides axially away from the shoulder 170 so that the anchor balls 174 roll along the tapered portion 180 and thus move radially inward. Once insertion of the apparatus 100 has been ceased by abutment of the latches 158 with the downhole end of the core tube, the spring 166 pushes the sleeve 168 in a uphole direction causing the anchor balls 174 to commence to ride up the tapered length 180 to a position where they extend radially outward from the sleeve 168 to an extent where they bear against an inner surface of the core tube 12. This effectively locks the apparatus 100 to the core tube 12 preventing it from falling out. The core tube 12 is then lowered into a core drill 193 via a conventional backend and wire line or other insertion method, with the core drill being suspended above the toe of the borehole. With the core tube correctly seated within the core drill, the core face profile device 120 extends from the shroud 159 and a drill bit 195 coupled to a downhole end of the core drill 193. During this time, the orientation balls 148 are free to roll within their races 150.

[0072] The core drill is then lowered onto the toe of the hole resulting in the pins 136 sliding axially within the cylindrical body 132 to provide a profile of the toe of the hole.

[0073] As the core drill is further lowered, prior to the commencement of drilling, an end of the shroud 59 will eventually be brought into contact with the toe of the hole. Now, further lowering of the core drill results in the extension 156 sliding axially inward relative to the latch body 128 in a uphole direction compressing the spring 164.

Eventually, the trigger balls 192 will roll outwardly along the tapered portion 186 to the portion 188 of the anchor body 172. When this occurs, the trigger balls 192 are able to move outwards in a radial direction and disengage from the groove 194 in the trigger seat 190. This releases the spring 162 allowing it to push the trigger seat 190 and thus the shaft 152 in an uphole direction relative to the extension 156. This results in a clamping of the orientation balls 148 within their races 150.

[0074] Continued lowering of the core drill onto the toe of the hole results in the seats 157 sliding from under the latches 158 so that the recess 161 underlies the latches 58. The latches 158 are now free to rotate inwardly thereby disengaging the apparatus 100 from the downhole end of the core tube 12.

[0075] The axial motion of the shaft 152 may be used to activate a switch such as, but not limited to, a micro-switch, a Hall Effect switch, an optical switch or a pressure switch, which may be considered as forming part of the trigger system, to provide a trigger signal for the electronic orientation device 20. The electronic orientation device 20 can then log data relating to the orientation of a tool 10, the borehole in which it resides, and/or the core 112. The logging of information by the electronic device 20 may occur at a predetermined frequency for a predetermined period of time. For example the electronic orientation device/system 20 may log orientation data every 10 seconds for a two minute period after receipt of the initial trigger signal.

[0076] The electronic orientation device 20 may be arranged so that the logging of indications of orientation occur only when trigger signals are received from both motion of shaft 152 and at least one other sensor or transducer of the trigger system 24.

[0077] The indication of orientation provided by the core face profile device 120 and bottom orientator 146 can be transferred to the core 112 in a manner described in Applicant's above referenced Australian patent application no. 2006901550 using template 198 as depicted in Figure 7. Template 198 comprises a pair of parallel lines 200 for location on opposites sides of the orientation balls 148, and a pointer line 202 that extends parallel with an centrally between the tram lines 200. An elongated slot 204 is cut in the template 198 and has one edge 206 in alignment with the pointer line 202. The slot 204 extends over the scale 138 on the body 132 as well as over a portion of the core sample 112. An operator can use a marker such as a pen or pencil to draw line segments 208a along the edge 206 from the body 132 across the scale 138 and 208b along the core 112. Indication of orientation logged by the electronic orientation device 20 may be obtained and marked on the core 112 in the same manner as described in Applicant's above referenced Australian application no. 2006902873.

[0078] The provision of both the tool 10 and the mechanical orientation device 146, as depicted in Fig.4, also enables auditing of the apparatus 100 to provide a degree of confidence in the orientation data obtained therefrom.

This arises because embodiments where there is both the electronic orientation device 20 and one or more mechanical orientation devices 146, a comparison can be made between the same indications of orientation obtained from each of the devices. For example if bottom of hole indications provided by the separate devices are within an acceptable tolerance range (e.g. up to 5°) a high degree of confidence is provided that each of the devices 20 and 146 is providing reliable indications of orientation. However, if the devices give indications that differ more than an acceptable range, potential errors can be flagged on site to enable corrective action.

[0079] The combination of the core tube 12 and the core orientation tool 10 forming the apparatuses shown in Figures 3-6 comprise what is believed to be a unique core retrieval system in that the electronic orientation device 20 is, at least at the time of deployment, located at a downhole or front end of the core tube 12. More particularly, as will be appreciated from the above description, the apparatus 100 being at the front or down hole end of the core tube 12 is physically close to the core sample 112 at the time, or one of the times, at which the electronic orientation device 14 logs orientation data of the tool 100. It is believed that this may give rise to higher accuracy in the orientation data recorded than other systems in which electronic orientation devices are located at a backend of the inner core tube, i.e. between an up-hole end of the inner core tube and an overshot. In this regard, inner core tubes typically come in lengths of three or six metres.

[0080] It is envisaged that various embodiments of the tool 10 may perform self checks and provide users with information regarding the status of the tool 10. Status messages may include one or a combination of low battery power, communications error, system faults. The tool 10 may also collect and process data so as to provide users with a measure of the accuracy and reliability of the recorded orientation data. The data collected by the tool 10 to provide orientation information may be analysed using statistical measures of its accuracy. Log data may be analysed to identify the presence of any movement during the logging of orientation data. The direction of motion may also be determined and provided to a user. These self checks may be beneficial to identify surface requirements. In particular the indication of movement during logging may be beneficial in identifying improper operation of the tool 10 and thus flag the need for training or retraining of operators.

[0081] For example one can analyze data from the sensors to determine whether the core drill was rotating and/subject to excessive vibration at the time of a core break. Such events, particularly the rotation, will decrease the reliability of the orientation data. The tool 10 would typically comprise three accelerometers to provide acceleration data about the X, Y and Z axes respectively. Rotation of the core drill at the time of the core break would be indicated by readings from these accelerometers. More particularly the tool 10 may provide the operator

with information regarding the proper operation of its components parts and systems. If a component or system fails the tool 10 could report the failure to the operator via the handheld control unit. If the failure occurs or is detected while the tool 10 is down a bore hole it can be reported to the operator via the handheld control unit once the tool has been recovered to the surface.

[0082] Further to the above operation the tool 10 could also be capable of performing a complete self check that verifies the correct operation of the entire system. This self diagnostics could be run on demand by an operator or automatically when the operator is preparing the tool for a core run (being run down a bore-hole to perform its function). In this way a faulty tool would not be used for a core run and result in a failed orientation.

The tool 10 may also be able to provide information to the operator regarding the certainty of a provided orientation measure. The certainty of an orientation measure can be determined by analysing the tools sensor input before during and after the orientation measure is made. When analysed the sensor data may reveal that there was an unwanted environmental condition present when the orientation measure was made. The unwanted environmental condition could be motion in the form of a linear movement, rotation or vibration. It could also be some other environmental condition such as a high or low temperature. The results of the analyses could be reported to the operator in one or a combination of the following ways:

1. By providing an indication of the source of unwanted environmental condition.
2. By associating the unwanted environmental condition to a known down-hole event that should not have occurred and providing the event to the operator.
3. By providing a calculated measure of the orientations certainty from the analysed sensor data. For example a scale of 1 to 5 could be employed where 1 is a certain orientation and 5 is a very uncertain orientation (failed). The certainty of orientations could then be provided using this scale.

[0083] The information provided by the tool in the above ways will be useful in identifying procedural errors made by the operators of the tool. For example if the core drill was spinning when the orientation was measured the tool 10 would report that the orientation is uncertain because rotation was detected during the orientation. It could also report that the likely cause of the rotation was that the core drill was spinning. In future the operator will know to ensure that the core drill is not spinning when the orientation is being measured. Similarly if the core drill was being raised or lowered when the orientation was measured the tool 10 could provide a relevant report to the operator.

[0084] By providing feedback regarding device faults and the certainty of the orientations when something goes wrong the operator will be fully informed as to the cause. Thus operator error can be discerned from tool failure/error. These reports can also be made available to supervisors or managers via the hand held control device or when the data is exported to an external memory device or laptop to assist them in maintaining equipment or attending to training issues.

Now that various embodiments of the present invention have been described in detail it will be apparent to those skilled in the relevant arts that numerous modifications and variations may be made without departing from the basic inventive concepts. For example, a mechanical orientation device 146 is described which utilises three orientation balls 148. However in an alternate variation, this orientation device may comprise only a single orientation ball. In addition or alternately, the mechanical orientation device may include a washer that is indented with a mark representative of the location of the bottom of the hole such as described in Applicant's international publication no. WO 03/038232. Embodiments of the invention may also include in addition or as an alternate to the mechanical orientator 146 a mechanical inclinometer an example of which is described in Applicant's above referenced international publication no. WO 03/038232.

[0085] As an alternative to the Van Ruth (ie pin type) face orientator 120, core face orientation may be obtained by other devices including, marker pencils and scribes, optical or electromagnetic imaging and distance measuring devices. The logging of azimuth can be achieved using any known electronic system when measured by the electronic orientation device 20, or any known mechanical system when measured by a mechanical orientation device 146. These include for example the use of magnetometers to sense magnetic direction when used in conjunction with nonmagnetic drilling equipment or if attached in a position outside the drill string to avoid magnetic interference. Azimuth may also be recorded using gyroscope type sensors to measure inertial change in position from a known reference point; or by use of a gyrocompass or north seeking gyroscope type sensor.

[0086] All such modifications and variations together with others that would be obvious to a person of ordinary skill in the art are deemed to be within the scope of the present invention the nature of which is to be determined from the above description, and the appended claims.

ASPECTS OF THE PRESENT INVENTION

[0087] There will be described aspects of the present invention that are disclosed in the present application.

[0088] According to a first aspect, a core orientation tool for providing an indication of *in situ* orientation of a core sample extracted from a borehole by a core drill is disclosed, the tool comprising:

an electronic orientation system coupled with the core drill, the electronic orientation system configured, upon receiving a trigger signal, to log one or more first indications of orientation of the tool; and, a trigger system that provides the trigger signal upon detecting one or more downhole events associated with operation of the core drill.

[0089] According to a second aspect, a core orientation tool for providing an indication of *in situ* orientation of a core sample extracted from a borehole by a core drill is disclosed, the tool comprising:

an electronic orientation system coupled with the core drill, the electronic orientation system configured, upon receiving a trigger signal, to log one or more first indications of orientation of the tool; and, a trigger system that provides the trigger signal upon one or both of (a) detecting one or more downhole events associated with operation of the core drill, and (b) effluxion of time.

[0090] According to a third aspect, a core orientation tool for providing an indication of *in situ* orientation of a core sample extracted from a borehole by a core drill is disclosed, the tool comprising:

an electronic orientation system coupled with the core drill, the electronic orientation system configured to log one or more first indications of orientation of the tool; and, a trigger system that provides a trigger signal upon detecting one or more downhole events associated with operation of the core drill; and, wherein tool is configured to associate the one or more first indications of orientation with the trigger signal.

[0091] According to a fourth aspect, in the core orientation tool according to any one of the first to third aspects, trigger signal is one of a plurality of trigger signals provided by the trigger system.

[0092] According to a fifth aspect, the core orientation tool according to the fourth aspect is configured to log different first indications of orientation upon receipt of different trigger signals.

[0093] According to a sixth aspect, in the core orientation tool according to any one of the first to fifth aspect, the one or more downhole events comprise respective physical events arising from motion of the tool or the drill in the borehole.

[0094] According to a seventh aspect, in the core orientation tool according to the sixth aspect, the motion comprise one or a combination of:

(a) motion in an uphole direction;

(b) a change in motion from motion having a linear

component in a downhole direction to motion having no linear component;

(c) a change in motion from motion in a downhole direction to motion in an uphole direction;

(d) a change in motion from no linear motion to motion in an uphole direction;

(e) a change in characteristics of vibration motion on the tool or drill arising from the cessation or commencement of drilling;

(f) a change in speed of linear motion of the tool;

(g) any change in velocity (speed and/or direction of movement); and,

(h) a change in the rate or direction of rotation around the tool's longitudinal, lateral or normal axis.

[0095] According to an eighth aspect, in the core orientation tool according to any one of the first to seventh aspects, the trigger system is configured to provide the trigger signal upon detecting a predetermined event or sequence of downhole events.

[0096] According to a ninth aspect, in the core orientation tool according to the eighth aspect, the sequence of downhole events comprise a cessation of drilling followed by motion of the tool in an uphole direction.

[0097] According to a tenth aspect, in the core orientation tool according to the ninth aspect, the sequence of downhole events further comprise commencement of drilling prior to the cessation of drilling.

[0098] According to an eleventh aspect, in the core orientation tool according to the tenth aspect, the sequence of downhole events further comprise one or more of:

(a) detecting contact of a backend assembly to which the tool is coupled hitting a landing ring in the core drill;

(b) detecting the backend assembly hitting a water table in a drilling operation where the drill is operated in the borehole below the water table;

(c) detecting release of the backend assembly from a wire line when initially inserting a core tube into the core drill;

(d) detecting the tool or core drill tagging a toe of the bore hole;

(e) an overshot hitting and latching onto the backend assembly;

(f) retrieval of the backend assembly from the drill hole; and,

(g) a change in the flow of fluid through or around the backend assembly.

[0099] According to a twelfth aspect, in the core orientation tool according to any one of the first to eleventh aspects, the electronic orientation system further comprises an electronic azimuth measuring device, wherein the electronic azimuth measuring device operates to log azimuth upon receiving the trigger signal.

[0100] According to a thirteenth aspect, in the core orientation tool according to the twelfth aspect, the electronic azimuth measuring device is configured to operate in an idle state prior to receipt of the trigger signal.

[0101] According to a fourteenth aspect, in the core orientation tool according to the thirteenth aspect, the electronic azimuth measuring device comprises an electronic gyroscope.

[0102] According to a fifteenth aspect, a core retrieval system for a core drill is disclosed, said core retrieval system comprising:

a core tube having an uphole end and a downhole end, the downhole end provided with an opening for receiving a core sample cut by the core drill; and,

a core orientation tool in accordance with any one of the first to fourteenth aspects, wherein the core orientation tool is coupled to the core tube at a location uphole of the downhole end of the core tube.

[0103] According to a sixteenth aspect, the core retrieval system according to the fifteenth aspect further comprises a backend assembly coupled to the uphole end of the core tube and wherein the core orientation tool is attached to the backend assembly uphole of the uphole end of the core tube.

[0104] According to a seventeenth aspect, a method of logging in situ orientation of a core sample extracted from the ground by a core drill is disclosed, the method comprising:

coupling an electronic core orientation device in a known spatial relationship to a core sample cut by the core drill;

configuring the electronic core orientation device to log one or more indications of orientation of the device upon receipt of a trigger signal; and,

providing the trigger signal upon detecting one or more downhole events associated with the operation of the core drill.

[0105] According to an eighteenth aspect, in the method according to the seventeenth aspect, the downhole events are indicative of a, or an imminent, core break.

[0106] According to a nineteenth aspect, in the method according to the seventeenth or eighteenth aspect, de-

tecting of the one or more downhole events comprises detecting an uphole motion of the device.

[0107] According to a twentieth aspect, in the method according to the nineteenth aspect, the detecting of the downhole event comprises detecting a cessation of drilling prior to detecting the uphole motion of the device.

[0108] According to a twenty-first aspect, in the method according to the twentieth aspect, the detecting further comprises detecting commencement of drilling prior to detecting cessation of drilling.

[0109] According to a twenty-second aspect, in the method according to the twenty-first aspect, the detecting comprises detecting a cessation of downhole movement of the device prior to detecting the commencement of drilling.

[0110] According to a twenty-third aspect, in the method according to any one of the seventeenth to twenty-second aspect, the configuring comprises configuring the electronic core orientation device to determine azimuth.

[0111] According to a twenty-fourth aspect, the method according to the twenty-third aspect further comprises withdrawing the tool after the trigger system provides the trigger system and operating the electronic core orientation device to track changes in orientation until the tool reaches a collar of the borehole.

[0112] According to a twenty-fifth aspect, a core orientation apparatus for providing an indication of orientation of a core sample extracted from a borehole by a core drill is disclosed, the apparatus comprising:

a core orientation tool according to any one of the first to fourteenth aspects and,
one or more secondary orientation devices which provide one or more second indications of orientation of the core or borehole, wherein the electronic orientation device is in a known rotational position relative to the one or more secondary orientation devices.

[0113] According to a twenty-sixth aspect, in the apparatus according to the twenty-fifth aspect, the secondary devices comprise one or both of (a) a core face orientation device which records orientation of an uphole face of a core sample; and (b) a bottom of hole recording device.

[0114] According to a twenty-seventh aspect, in the apparatus according to the twenty-fifth or twenty-sixth aspect, the tool comprises a body having a downhole end and an uphole end, wherein the one or more secondary orientation devices are located downhole of the body and the electronic orientation device is located between the secondary orientation devices and the downhole end of the body.

[0115] According to a twenty-eighth aspect, in the apparatus according to the twenty-fifth or twenty-sixth aspect, the tool comprises a body having a downhole end and an uphole end, wherein the one or more secondary orientation devices are located downhole of the body and

the electronic orientation device is located uphole of the body.

[0116] According to a twenty-ninth aspect, in the apparatus according to the twenty-seventh or twenty-eighth aspect, the body is provided with a positional reference for the first and second indications of orientation, and one or more keys for keying the electronic orientation device and the one or more secondary orientation devices to the position reference.

[0117] According to a thirtieth aspect, a core retrieval system for a core drill is disclosed, which core retrieval system comprises:

an inner core tube having an uphole end and an opposite downhole end provided with an opening for receiving a core cut by the core drill; and,
a core orientation tool coupled to the inner core barrel and movable inside the inner core tube in an uphole direction by abutment with the core, wherein the core orientation tool accords with any one of the first to fourteenth aspects.

[0118] According to a thirty-first aspect, the core orientation tool according to any one of the first to fourteenth aspects is configured to analyse outputs from sensors and transducers in the trigger system that detect the downhole events, to verify correct operation of the tool.

[0119] According to a thirty-second aspect, the core orientation tool according to the thirty-first aspect is configured to analyse outputs from sensors and transducers in the trigger system that detect the downhole events to verify that the core drill was stationary when a core break operation was performed.

[0120] According to a thirty-third aspect, the method according to any one of the seventeenth to twenty-fourth aspects comprises analyzing outputs from sensors and transducers in the trigger system that detect the downhole events, to verify correct operation of the tool.

[0121] According to a thirty-fourth aspect, in the method according to the thirty-third aspect, the analyzing comprises analyzing the outputs to verify the core drill was stationary at when a core break operation occurred.

Claims

1. A core orientation tool (10) for providing an indication of *in situ* orientation of a core sample (112) extracted from a borehole by a core drill the tool comprising:

an electronic orientation system (20) coupled with the core drill, the electronic orientation system (20) configured to log one or more first indications of orientation of the tool; and,
a trigger system (24) that provides the trigger signal upon detecting one or more downhole events associated with operation of the core drill; and

- wherein tool (10) is configured to associate the one or more first indications of orientation with the trigger signal.
2. The core orientation tool (10) according to claim 1 wherein trigger signal is one of a plurality of trigger signals provided by the trigger system (24).
 3. The core orientation tool (10) according to claim 2 wherein the tool is configured to log different first indications of orientation upon receipt of different trigger signals.
 4. The tool (10) according to any one of claims 1-3 wherein the one or more downhole events comprise respective physical events arising from motion of the tool (10) or the drill in the borehole.
 5. The tool according to claim 4 wherein the down hole events comprise one or more of:
 - (a) motion in an uphole direction;
 - (b) a change in motion from motion having a linear component in a downhole direction to motion having no linear component;
 - (c) a change in motion from motion in a downhole direction to motion in an uphole direction;
 - (d) a change in motion from no linear motion to motion in an uphole direction;
 - (e) a change in characteristics of vibration motion on the tool (10) or drill;
 - (f) a change in speed of linear motion of the tool (10);
 - (g) any change in velocity (speed and/or direction of movement); and,
 - (h) a change in the rate or direction of rotation around the tool's longitudinal, lateral or normal axis;
 - (i) contact of a backend assembly (14) to which the tool is coupled with a landing ring in the core drill;
 - (j) the backend assembly (14) hitting a water table in a drilling operation where the drill is operated in the borehole below the water table;
 - (k) release of the backend assembly (14) from a wire line when initially inserting a core tube (12) into the core drill;
 - (l) the tool (10) or core drill tagging a toe of the bore hole;
 - (m) an overshot hitting and latching onto the backend assembly (14);
 - (n) retrieval of the backend assembly (14) from the drill hole; and,
 - (o) a change in the flow of fluid through or around the backend assembly (14).
 6. The tool (10) according to any one of claims 1-5 wherein the trigger system (24) is configured to provide the trigger signal upon detecting a predetermined event or sequence of downhole events.
 7. The tool (10) according to claim 6 wherein the sequence of downhole events comprise a cessation of drilling followed by motion of the tool (10) in an uphole direction.
 8. The tool (10) according to claim 7 wherein the sequence of downhole events further comprise commencement of drilling prior to the cessation of drilling.
 9. The tool according to any one of claims 1-8 wherein the electronic orientation system (20) further comprises an electronic azimuth measuring device, wherein the electronic azimuth measuring device operates to log azimuth upon receiving the trigger signal.
 10. The tool (10) according to claim 9 wherein the electronic azimuth measuring device is configured to operate in an idle state prior to receipt of the trigger signal.
 11. A core retrieval system for a core drill comprising:
 - a core tube having an uphole end and a downhole end, the downhole end provided with an opening for receiving a core sample cut by the core drill; and,
 - a core orientation tool in accordance with any one of claims 1-10, wherein the core orientation tool is coupled to the core tube at a location uphole of the downhole end of the core tube.
 12. The core retrieval system according to claim 11 further comprising a backend assembly coupled to the uphole end of the core tube and wherein the core orientation tool is attached to the backend assembly uphole of the uphole end of the core tube.

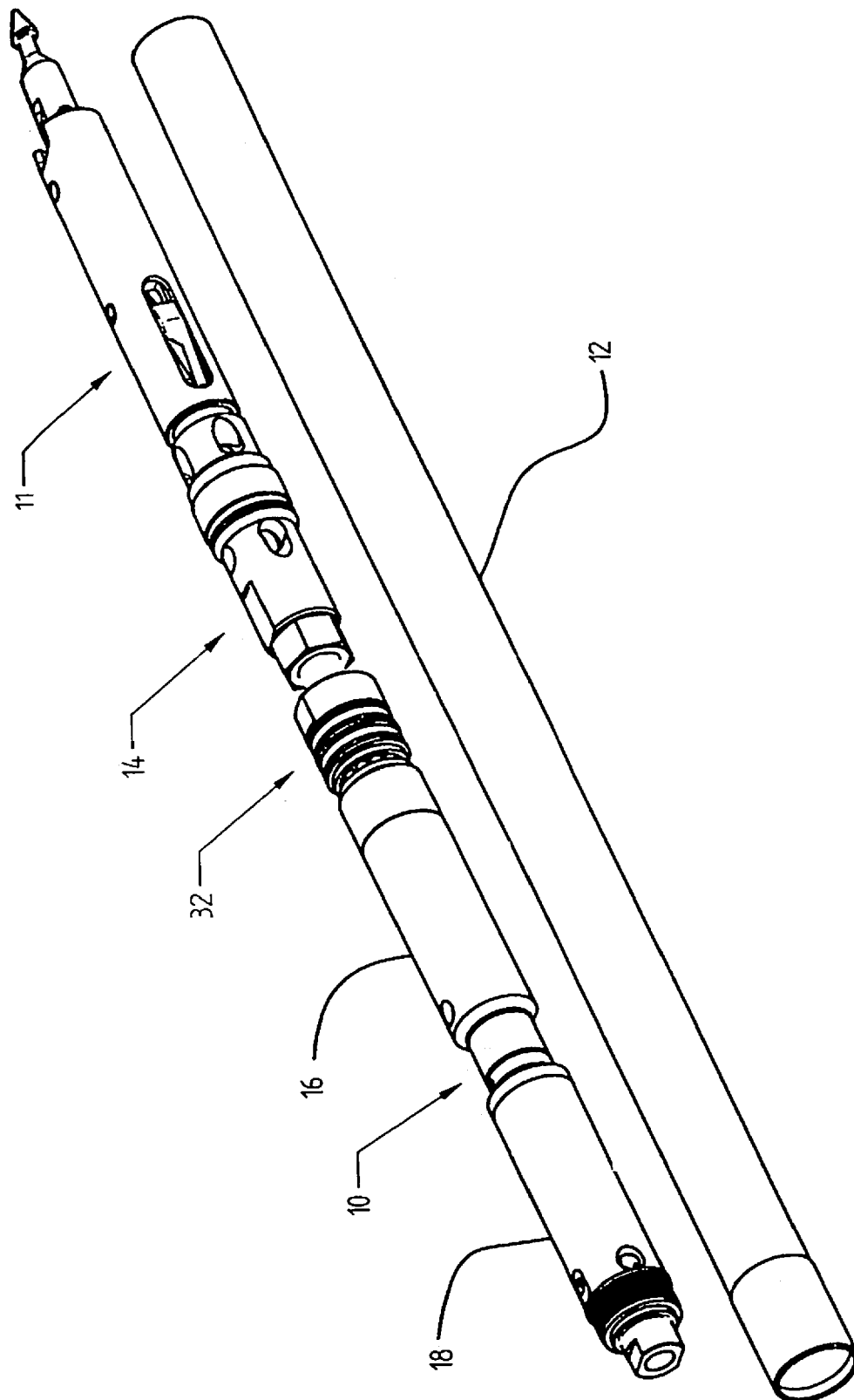


Figure 1.

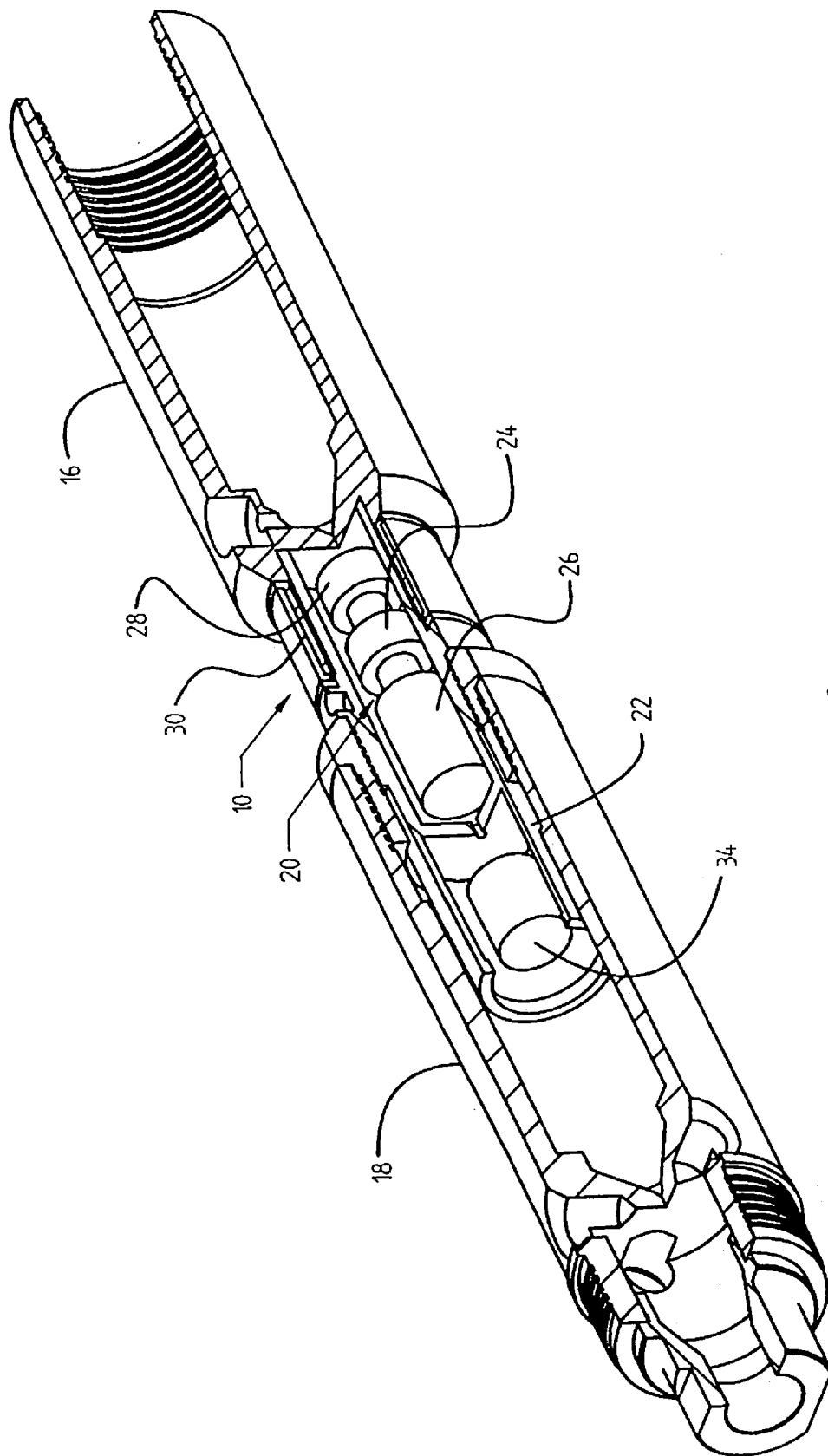


Figure 2

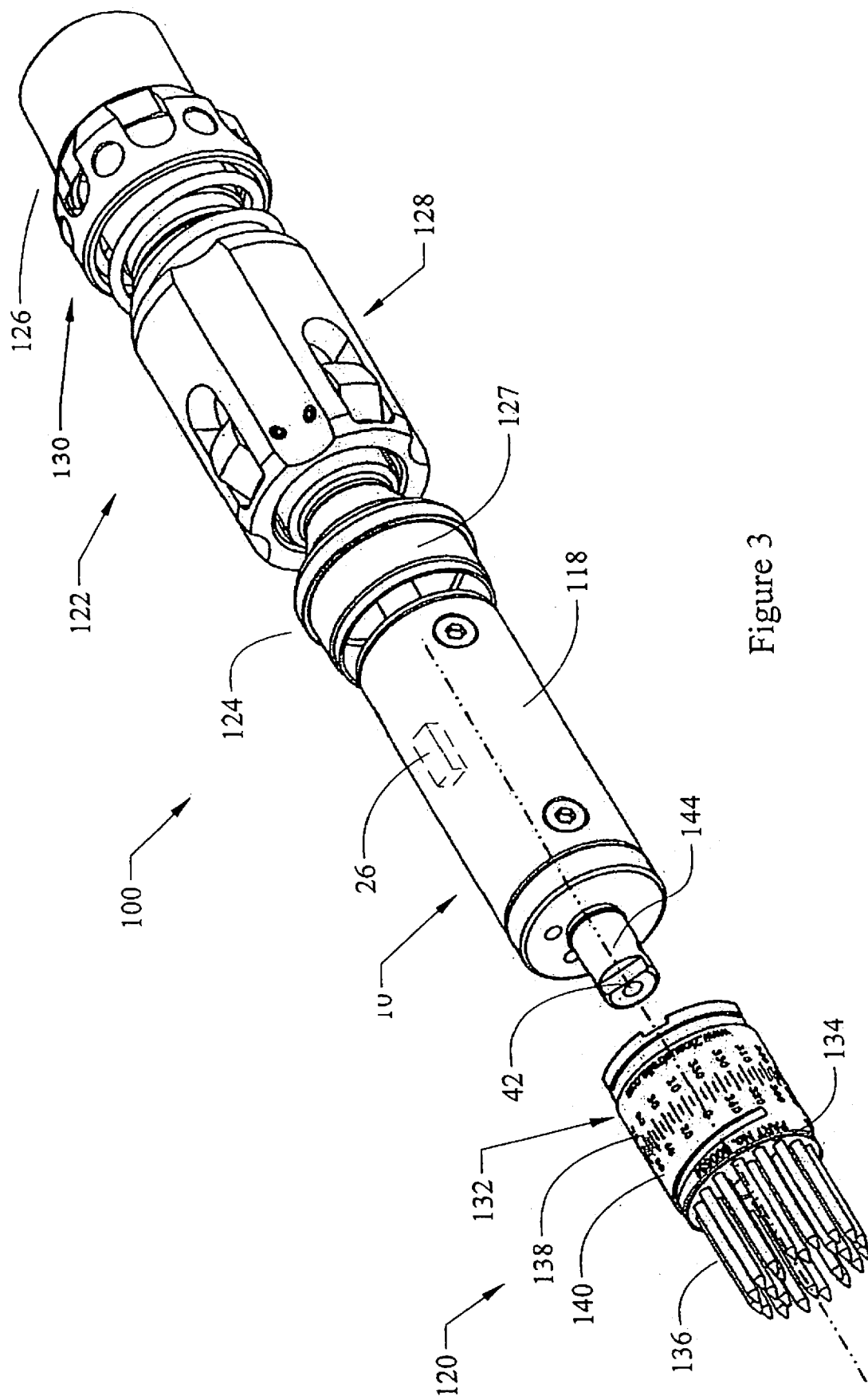


Figure 3

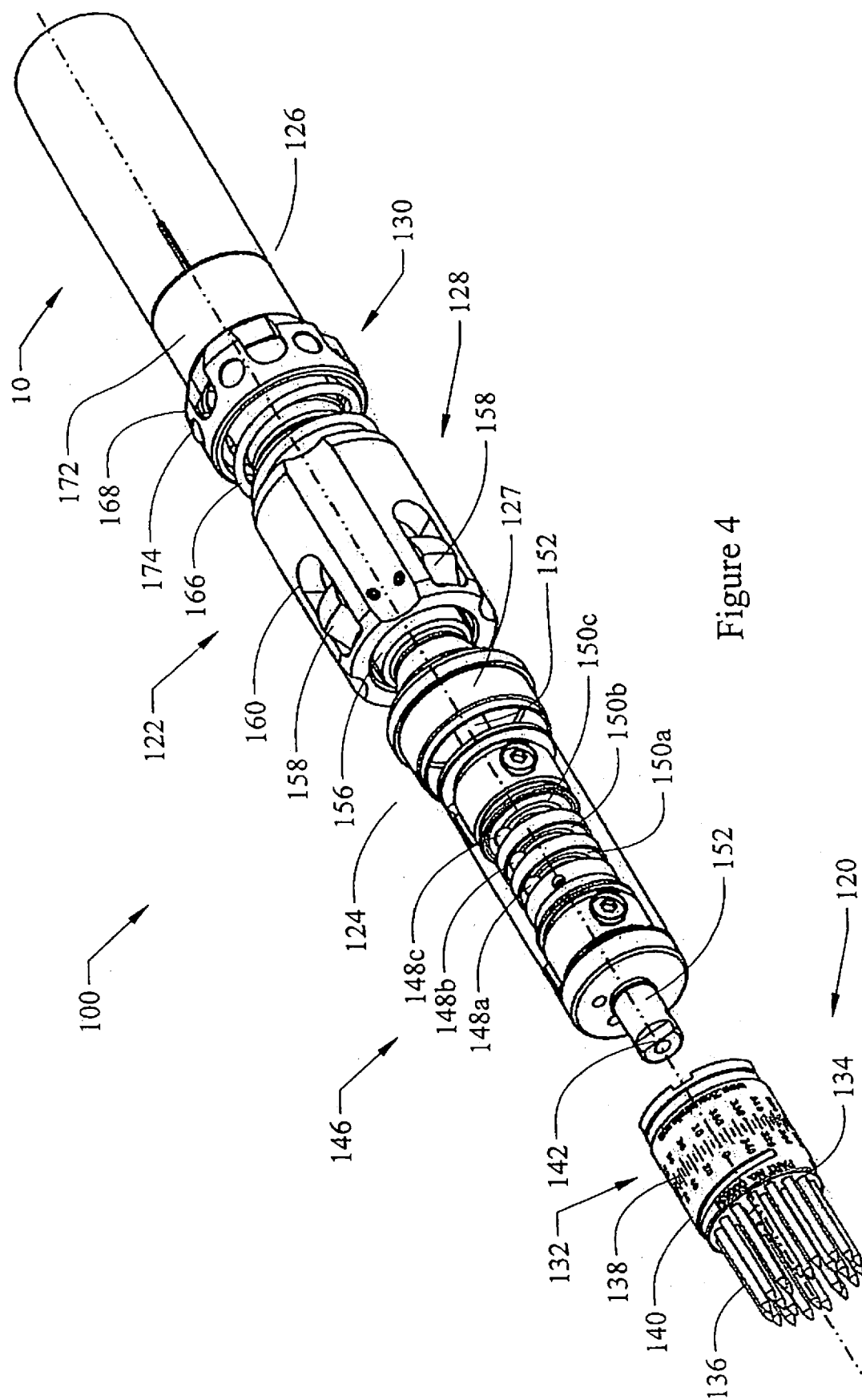


Figure 4

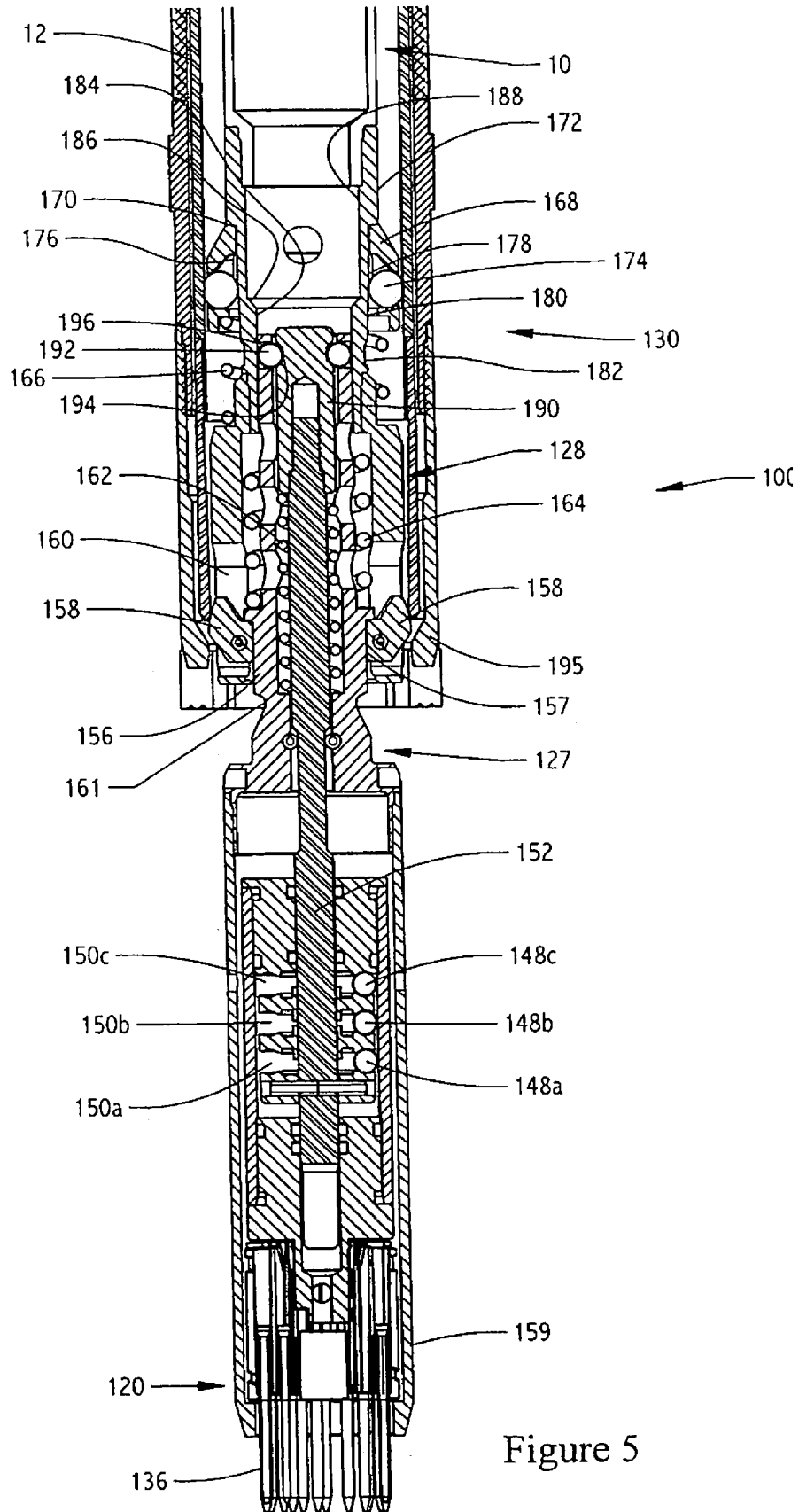


Figure 5

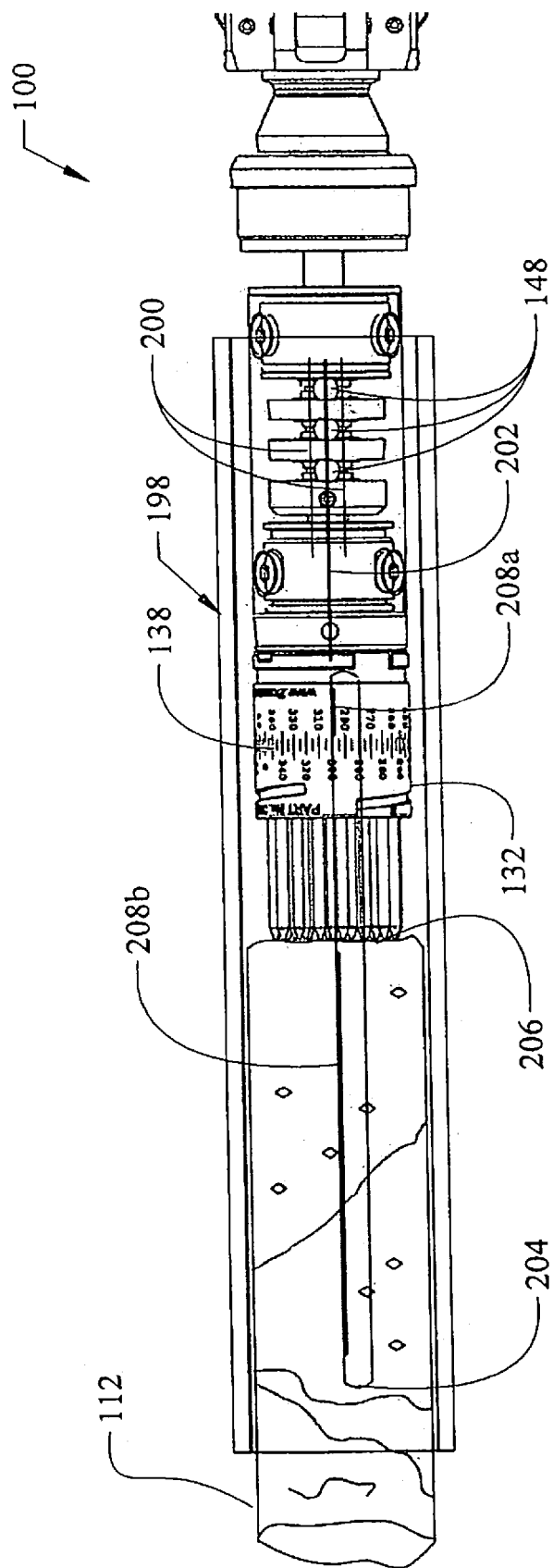


Figure 6



EUROPEAN SEARCH REPORT

Application Number
EP 17 18 1691

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	GB 2 318 372 A (BAKER HUGHES INC [US]) 22 April 1998 (1998-04-22) * abstract * * page 4, line 8 - line 20 * * page 6, line 20 - line 25 * * page 11, line 8 - line 16 * * page 16, line 20 - line 30 * * claims 10,19-21 *	1-12	INV. E21B25/16 E21B49/02
A	WO 2004/076799 A2 (CHARLES MACHINE WORKS [US]; COLE SCOTT B [US]; CAMPBELL MICHAEL R [US]) 10 September 2004 (2004-09-10) * claims 1,5 *	1,11	
A	RU 2 160 821 C2 (TIE PILOT; G NP PREDPRIJA) 20 December 2000 (2000-12-20) * abstract *	1	
			TECHNICAL FIELDS SEARCHED (IPC)
			E21B
The present search report has been drawn up for all claims			
Place of search Berlin		Date of completion of the search 13 September 2017	Examiner Schaeffler, C
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 17 18 1691

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