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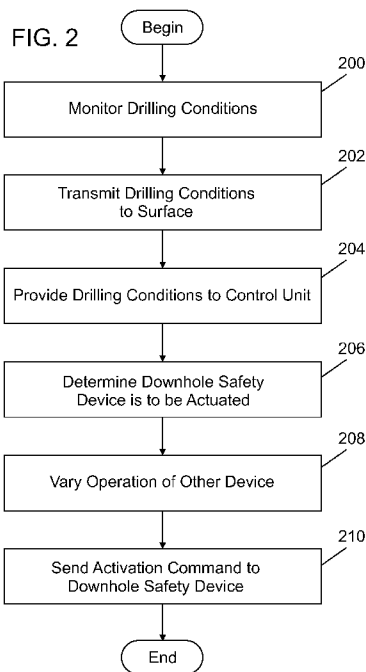
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Declarations under Rule 4.17:

- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))
- as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))

[Continued on next page]

(54) Title: CONTROL OF DOWNHOLE SAFETY DEVICES



(57) Abstract: A drilling system for drilling a borehole includes a drill string including a bottom hole assembly and a telemetry system coupled together and a communication device coupled to the drillstring configured to transmit sensor data to and receive control data from a control unit located at a surface location through the telemetry system. The system also includes a sensor coupled to the drillstring, the sensor providing the sensor data to the communication device and a downhole safety device coupled to the drill string and in operable communication with the communication device, the downhole safety device configured to actuate after receiving an activation signal initiated by the control unit.



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CONTROL OF DOWNHOLE SAFETY DEVICES

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Application No. 13/170954, filed on June 28, 2011, which is incorporated herein by reference in its entirety.

BACKGROUND

1. Field of the Invention

[0002] The present invention generally relates drilling and, in particular, to activation of downhole safety devices.

2. Description of the Related Art

[0003] Boreholes are drilled deep into the earth for many applications such as carbon sequestration, geothermal production, and hydrocarbon exploration and production. In all of the applications, the boreholes are drilled such that pass through or can allow for access to a material (e.g., a gas or fluid) contained in a formation located below the earth's surface. Many different types of tools and instruments may be disposed in the boreholes to perform various tasks and some of these can be utilized to take measurements of various values while the borehole is being drilled.

[0004] One disadvantageous phenomenon that can arise while drilling is referred to as "drilling kick" or simply "kick." Kick generally refers to the condition where a formation fluid or formation gas flows from the formation into the borehole while drilling. Kick can occur when formation pressure exceeds the hydrostatic pressure exerted on the formation by drilling mud utilized in drilling the borehole. This type of kick is generally referred to as "underbalanced kick." Another type of kick referred to as "induced kick" can occur when movement of the drill sting or casing causes the pressure in the borehole to fluctuate.

[0005] Regardless of the cause, the kick can, in extreme cases, result in an uncontrolled flow of formation fluid or gases into the atmosphere at the surface in a phenomenon referred to as "blowout." To prevent blowout, a blowout preventer is typically installed in the space between the drill pipe and the casing at the surface. The blowout preventer is activated when a kick is detected and seals off the annulus between the drill pipe and the casing to prevent the fluid or gasses from escaping. Early detection of a kick is required to effectively operate the blowout preventer and typically includes visual observation of bubbles in the drilling mud at the surface.

BRIEF SUMMARY

[0006] Disclosed is a drilling system for drilling a borehole that includes a drill string including a bottom hole assembly and a telemetry system coupled together. The system also includes a communication device coupled to the drillstring configured to transmit sensor data to and receive control data from a control unit located at a surface location through the telemetry system and a sensor coupled to the drillstring, the sensor providing the sensor data to the communication device. The system also includes a downhole safety device coupled to the drill string and in operable communication with the communication device, the downhole safety device configured to actuate after receiving an activation signal initiated by the control unit.

[0007] Also disclosed is a method of actuating a downhole safety device in a drilling system that includes collecting information indicative of borehole conditions at a downhole location; transmitting the information to a surface control unit; determining that the downhole safety device should be actuated; sending an actuation signal through a telemetry system to the downhole safety device; actuating the downhole safety device using the actuation signal.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The following descriptions should not be considered limiting in any way. With reference to the accompanying drawings, like elements are numbered alike:

[0009] FIG. 1 illustrates a drilling system in which embodiments of the present invention may be implemented; and

[0010] FIG. 2 is flow chart illustrating a method according to one embodiment of the present invention.

DETAILED DESCRIPTION

[0011] A detailed description of one or more embodiments of the disclosed apparatus and method presented herein is by way of exemplification and not limitation with reference to the Figures.

[0012] FIG. 1 illustrates FIG. 1 is a schematic diagram of an exemplary drilling system 100 that includes a drill string having a drilling assembly attached to its bottom end that can be operated according to the exemplary methods apparatus disclosed herein. FIG. 1 shows a drill string 120 that includes a drilling assembly or bottomhole assembly (“BHA”)

190 conveyed in a borehole 126. The drilling system 100 includes a conventional derrick 111 erected on a platform or floor 112 which supports a rotary table 114 that is rotated by a prime mover, such as an electric motor (not shown), at a desired rotational speed. A tubing (such as drill pipe) 122 having the drilling assembly 190 attached at its bottom end extends from the surface to the bottom 151 of the wellbore 126. The tubing 122 is so-called wired pipe in one embodiment and allows for high-speed bi-directional communication through it.

[0013] A drill bit 150, attached to drilling assembly 190, disintegrates the geological formations when it is rotated to drill the borehole 126. The drill string 120 is coupled to a drawworks 130 via a Kelly joint 121, swivel 128 and line 129 through a pulley. Drawworks 130 is operated to control the weight on bit (“WOB”). The drill string 120 can be rotated by a top drive (not shown) instead of by the prime mover and the rotary table 114. The prime mover/rotary table 114 combination or a top drive or any other means of turning drill string 120 shall be referred to as drill string actuator herein. The operation of the drawworks 130 is known in the art and is thus not described in detail herein.

[0014] A suitable drilling fluid 131 (also referred to as “mud”) from a source 132 thereof, such as a mud pit, is circulated under pressure through the drill string 120 by a mud pump 134. The drilling fluid 131 passes from the mud pump 134 into the drill string 120 via a de-surger 136 and the fluid line 138. The drilling fluid 131 discharges at the borehole bottom 151 through openings in the drill bit 150. The returning drilling fluid 131b circulates uphole through the annular space 127 between the drill string 120 and the borehole 126 and returns to the mud pit 132 via a return line 35 and drill cutting screen 185 that removes the drill cuttings 186 from the returning drilling fluid 131b.

[0015] In some applications, the drill bit 150 is rotated by rotating the drill pipe 122. However, in other applications, a downhole motor 155 (mud motor) disposed in the drilling assembly 190 also rotates the drill bit 150. The rate of penetration (“ROP”) for a given drill bit and BHA largely depends on the WOB or the thrust force on the drill bit 150 and its rotational speed.

[0016] A surface control unit or controller 140 receives signals from downhole sensors and devices and processes such signals according to programmed instructions provided from a program to the surface control unit 140. The surface control unit 140 displays desired drilling parameters and other information on a display/monitor 141 that is utilized by a human operator to control the drilling operations. The surface control unit 140 can be a computer-based unit that can include a processor 142 (such as a microprocessor), a

storage device 144, such as a solid-state memory, tape or hard disc, and one or more computer programs 146 in the storage device 144 that are accessible to the processor 142 for executing instructions contained in such programs to perform the methods disclosed herein. The surface control unit 140 can process data relating to the drilling operations, data from the sensors and devices on the surface, and data received from downhole and can control one or more operations of the downhole and surface devices.

[0017] The drilling assembly 190 also contains formation evaluation sensors or devices (also referred to as measurement-while-drilling, "MWD," or logging-while-drilling, "LWD," sensors) determining borehole pressure, formation pressure, resistivity, density, porosity, permeability, acoustic properties, nuclear-magnetic resonance properties, corrosive properties of the fluids or formation downhole, salt or saline content, and other selected properties of the formation 195 surrounding the drilling assembly 190. Such sensors are generally known in the art and for convenience are generally denoted herein by numeral 165 and can include, for example, resistivity sensors, density sensors, porosity sensors, permeability sensors, temperature sensors, pressure sensors, vibration sensors, bending moment sensors, rotation sensors, orientation sensors and shear sensors. The drilling assembly 190 can further include a variety of other sensors and communication devices 159 for controlling and/or determining one or more functions and properties of the drilling assembly (such as velocity, vibration, bending moment, acceleration, oscillations, whirl, stick-slip, etc.) and drilling operating parameters, such as weight-on-bit, fluid flow rate, pressure, temperature, rate of penetration, azimuth, tool face, drill bit rotation, etc.

[0018] A suitable telemetry sub (communication device) 180 using, for example, two-way telemetry, is also provided as illustrated in the drilling assembly 190 and provides information from the various sensors to the surface control unit 140 through the wired pipe 122. The telemetry sub 180 can also provide control or activation data received from the control unit 140 to the sensors or other devices located at or near the BHA 190. In one embodiment, the telemetry sub 180 provides activation signals to downhole safety devices 167.

[0019] Still referring to FIG. 1, the drill string 120 further includes an energy conversion device 160. In an aspect, the energy conversion device 160 is located in the BHA 190 to provide an electrical power or energy, such as current, to sensors 165 and/or communication devices 159. Energy conversion device 160 can include a battery or an energy conversion device that can for example convert or harvest energy from pressure

waves of drilling mud which are received by and flow through the drill string 120 and BHA 190. Alternately, a power source at the surface can be used to power the various equipment downhole.

[0020] The drill string 120 further includes one or more downhole safety devices 167. These safety devices 167 can include, for example, blowout preventers (BOPs). The BOPs, as is known in the art, are operated to seal incoming fluid from the formation 169 from traversing up the annulus between the drill pipe 122 and the borehole 126. It shall be understood that the safety devices 167 can receive an activation signal from the control unit 140 through the telemetry sub 180. In some cases, a surface BOP can also be provided that seals fluid from escaping into the atmosphere.

[0021] According to one embodiment of the present invention, the sensors 165 can sense one or more of formation pressure, flow rate of the drilling mud and composition of the drilling mud. Information collected by the sensors 165 is provided to the controller 140 through wired pipe 122. At the controller 140 it is determined if a kick is about to or has occurred. The determination can be automatic or based on analysis of the data by an operator. If kick has or is about to occur, the controller 140 can transmit a signal through the wired pipe 122 to safety devices 167 that cause them to activate.

[0022] In prior art applications, after detection of a kick at the surface, an activation of the safety devices 167 has heretofore been initiated manually with significant time delay from surface by dropping a ball or the like or sending a downlink. In either case, the safety devices 167 are actuated independent of the other portions of the drilling system 100. Such activation, while suitable for reducing or eliminating the effects of kick, is not very effective due to the time delay and can create additional problems. For instance, if the safety device 167 is activated before the rotary table 114 is stopped, the drill string 120 could be damaged. In some cases a blow-out will not be even recognized (underground blow-out) at surface.

[0023] By making the determination of a kick condition based on downhole information at the surface, other related systems can be stopped or altered in the correct order. For instances, if the sensors detect conditions indicative of kick, the rotary table 114 could be stopped, a surface BOP (not shown) activated, and then the controller 140 could then transmit the signal to cause the safety devices 167 to actuate. In short, due to the high speed communication capabilities of e.g. wired pipe, the correct sequencing of a kick related shut-down can be controlled from the surface in real-time.

[0024] Such safety device can also be used in case of mud losses to shut-in the annulus and prevent an underbalanced condition causing borehole instability or a kick initiation.

[0025] FIG. 2 is a flow chart showing a method according to one embodiment. At process 200 current drilling conditions are monitored by sensors located on or near the BHA of a drill string. The conditions can include, for example, the flow rate or composition of the drilling mud and hydrostatic pressure of the formation to name but a few. At process 202 the drilling conditions are transmitted to the surface. At the surface, the drilling conditions are provided to a control unit as indicated at process 204. It shall be understood that the control unit can be located at the same location as or remote from the location where the drilling is being conducted. That is, the control unit could be remote from the drilling rig in one embodiment.

[0026] Regardless of where the control unit is located, at block 206 a determination is made that a downhole safety device located along the drill string needs to be actuated. This determination can be made either by an operator, fully automatically by the control unit using an expert system approach, or combinations of operator determined and automatic control. At process 208 at least one other portion of the drilling system (e.g., the rotary table) is provided a command to cause it vary its operation (e.g., stop). After process 208 is completed, at process 210, an activation command is sent to from the control unit to the downhole safety device. In some instances, downhole conditions are further monitored to determine is the activation command achieved the desired result or if further safety devices need to be actuated or other actions taken.

[0027] Elements of the embodiments have been introduced with either the articles “a” or “an.” The articles are intended to mean that there are one or more of the elements. The terms “including” and “having” are intended to be inclusive such that there may be additional elements other than the elements listed. The conjunction “or” when used with a list of at least two terms is intended to mean any term or combination of terms. The terms “first,” “second,” and “third” are used to distinguish elements and are not used to denote a particular order.

[0028] It will be recognized that the various components or technologies may provide certain necessary or beneficial functionality or features. Accordingly, these functions and features as may be needed in support of the appended claims and variations thereof, are

recognized as being inherently included as a part of the teachings herein and a part of the invention disclosed.

[0029] While the invention has been described with reference to exemplary embodiments, it will be understood that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications will be appreciated to adapt a particular instrument, situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the appended claims.

CLAIMS

What is claimed is:

1. A drilling system for drilling a borehole comprising:
a drill string including a bottom hole assembly and a telemetry system coupled together;
a communication device coupled to the drillstring configured to transmit sensor data to and receive control data from a control unit located at a surface location through the telemetry system;
a sensor coupled to the drillstring, the sensor providing the sensor data to the communication device; and
a downhole safety device coupled to the drill string and in operable communication with the communication device, the downhole safety device configured to actuate after receiving an activation signal initiated by the control unit.
2. The drilling system of claim 1, wherein the sensor senses one of: formation pressure of a formation surrounding the borehole, mud flow, and mud composition, or combinations thereof.
3. The drilling system of claim 1, wherein the downhole safety device includes a blowout preventer.
4. The drilling system of claim 1, wherein the activation signal is automatically initiated.
5. The drilling system of claim 1, wherein the activation signal is initiated relative to a second signal that causes another portion of the drilling system to vary its operation, wherein the activation signal is created based on the sensor data.
6. The drilling system of claim 5, wherein the activation signal and the second signal are initiated in a predetermined coordinated way.
7. The drilling system of claim 5, wherein the other portion is a drill string actuator.
8. The drilling system of claim 5, wherein the other portion is a surface blowout preventer.
9. A method of actuating a downhole safety device in a drilling system, the method comprising:
collecting information indicative of borehole conditions at a downhole location;
transmitting the information to a surface control unit;

determining that the downhole safety device should be actuated;
sending an actuation signal through a telemetry system to the downhole safety device;
and
actuating the downhole safety device using the actuation signal.

10. The method of claim 9, wherein the downhole safety device is a blowout preventer.

11. The method of claim 9, further comprising:
sending a variation signal to another portion of the drilling system that causes the other portion to vary its operation, the variation signal being sent relative to the actuation signal.

12. The method of claim 11, wherein the variation signal and the actuation signal are initiated in a predetermined coordinated way

13. The method of claim 11, wherein the other portion is a drill string actuator.

14. The method of claim 11, wherein the other portion is a surface blowout preventer.

15. The system of claim 1, wherein the telemetry system includes a plurality of joined wired pipe segments.

FIG. 1

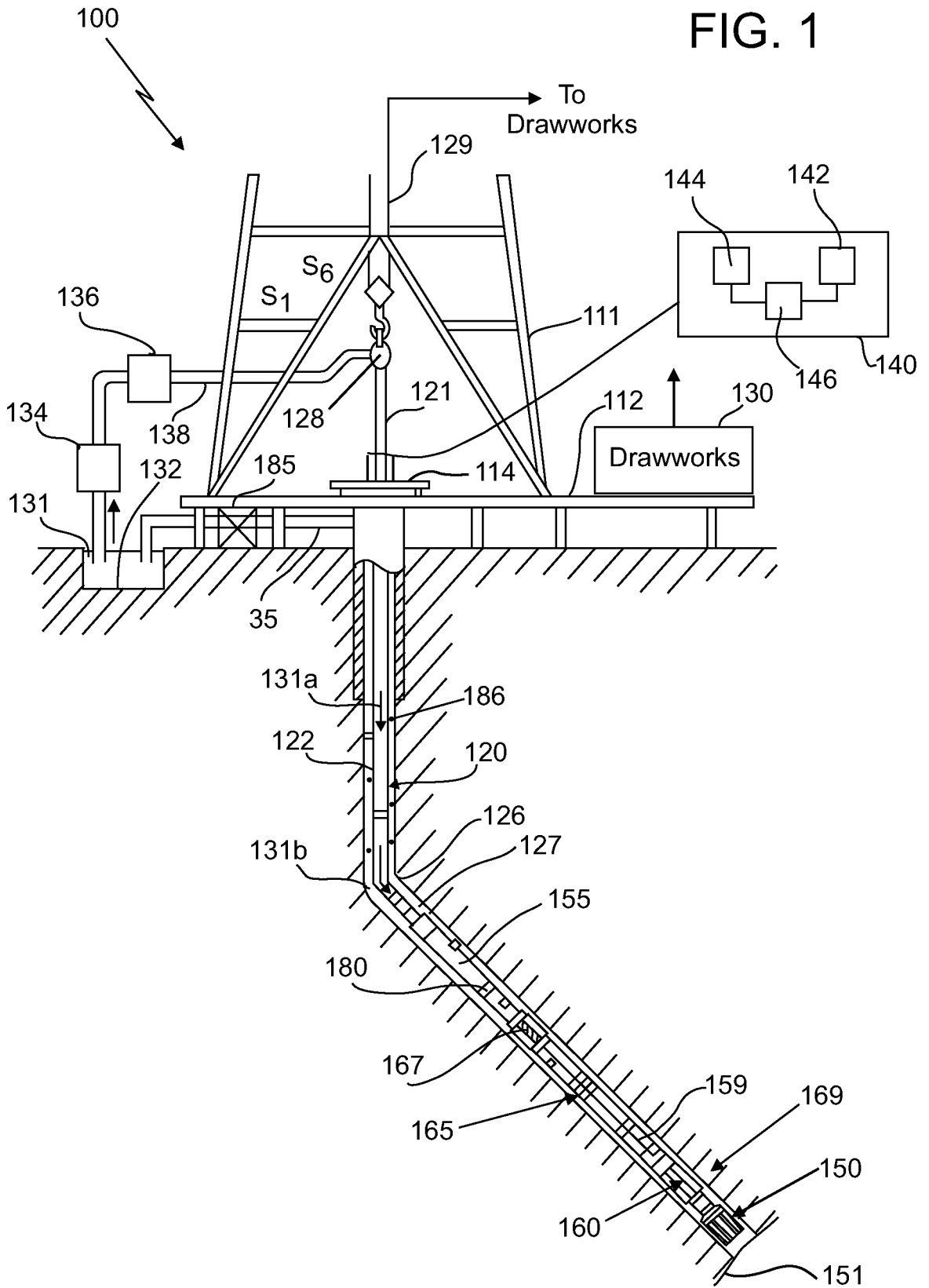


FIG. 2

