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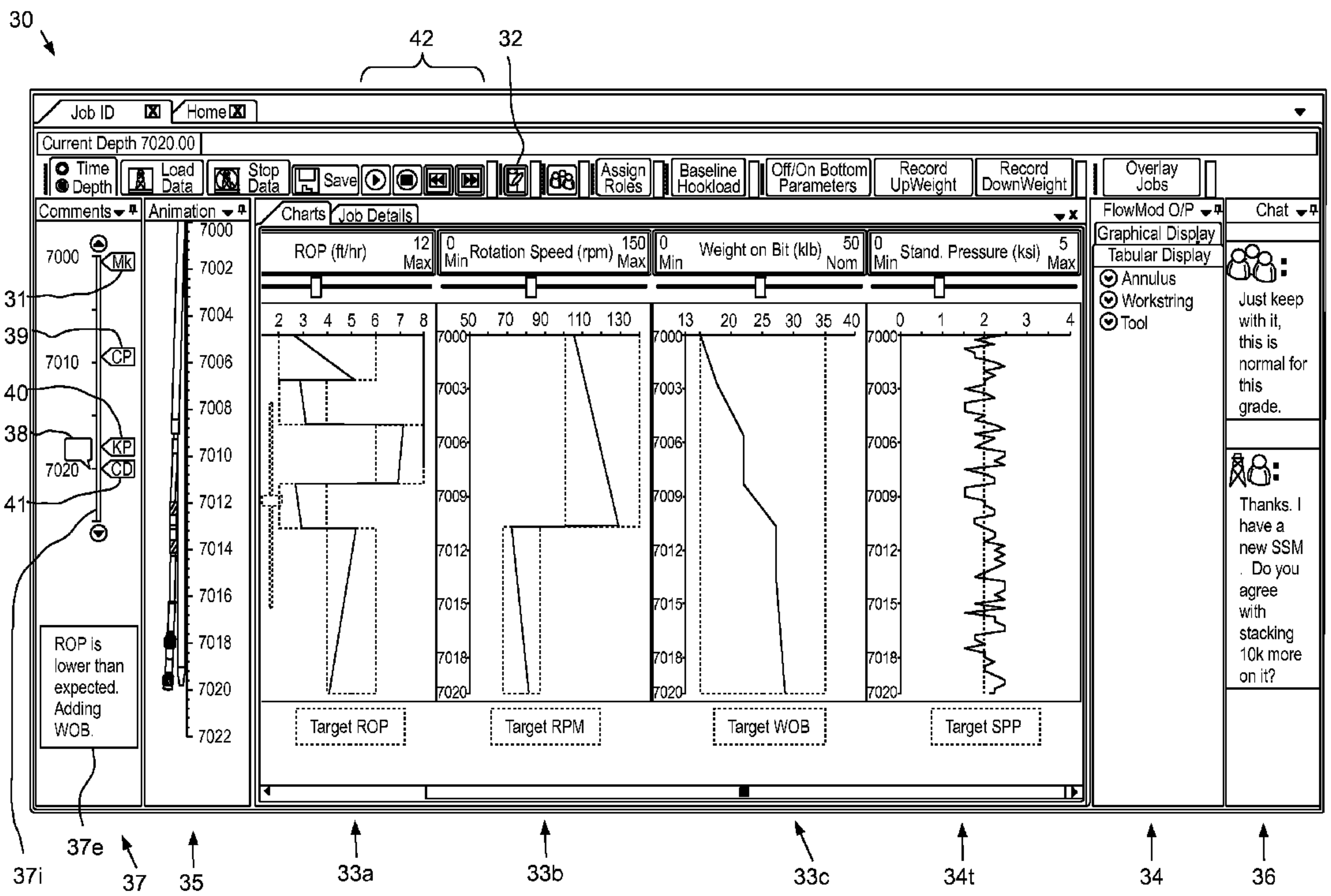

(57) Abrégé/Abstract:
A method of controlling a downhole operation includes: deploying a work string into a wellbore, the work string comprising a deployment string and a bottomhole assembly (BHA); digitally marking a depth of the BHA; and using the digital mark to perform the downhole operation.

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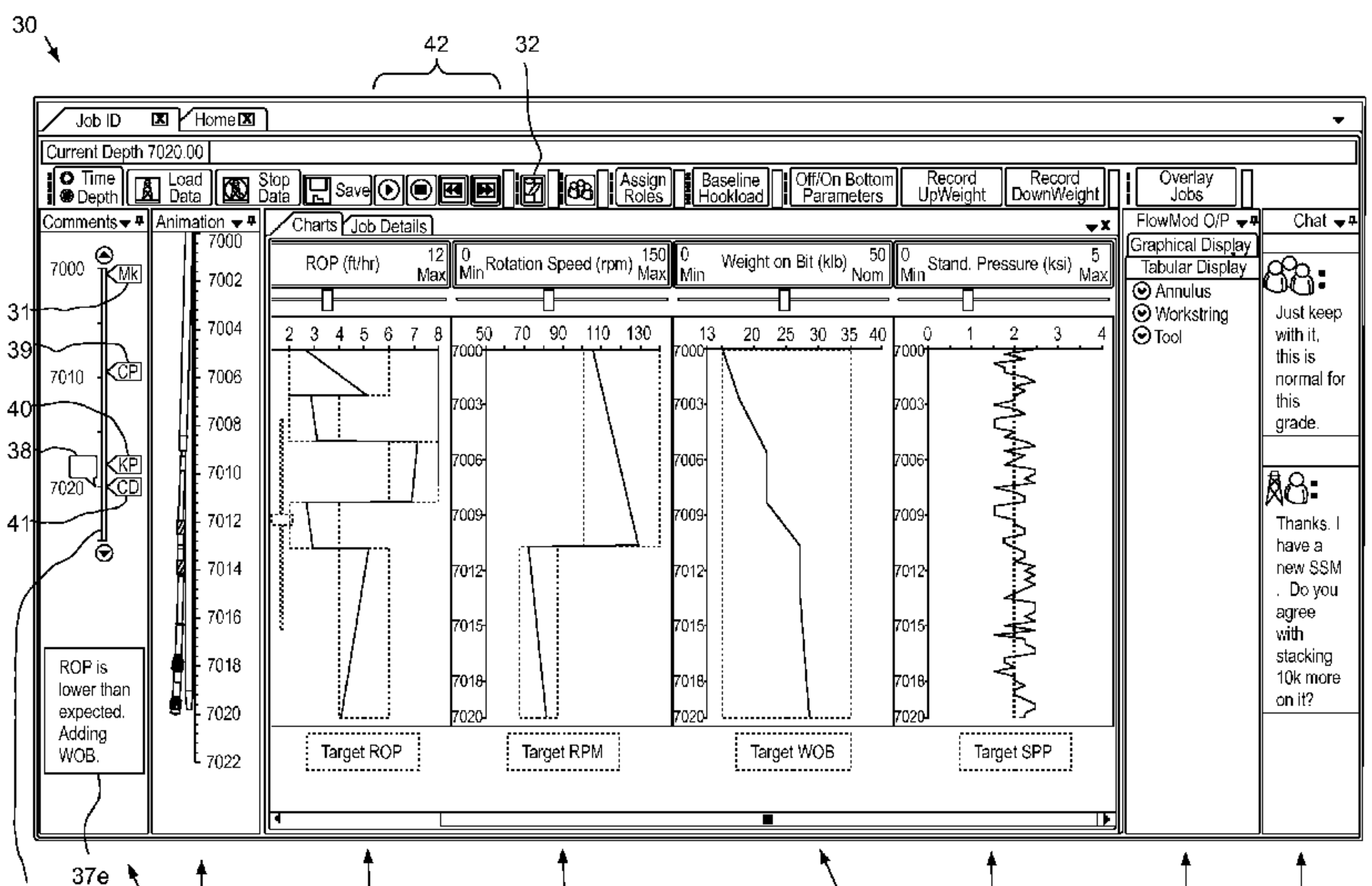

FIG. 5

(57) **Abstract**: A method of controlling a downhole operation includes: deploying a work string into a wellbore, the work string comprising a deployment string and a bottomhole assembly (BHA); digitally marking a depth of the BHA; and using the digital mark to perform the downhole operation.

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CONTROL SYSTEM FOR DOWNHOLE OPERATIONS

[0001]

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] Embodiments of the present invention generally relate to a control system for downhole operations.

Description of the Related Art

[0003] In well construction and completion operations, a wellbore is formed to access hydrocarbon-bearing formations (e.g., crude oil and/or natural gas) by the use of drilling. Drilling is accomplished by utilizing a drill bit that is mounted on the end of a drill string. To drill within the wellbore to a predetermined depth, the drill string is often rotated by a top drive or rotary table on a surface platform or rig, and/or by a downhole motor mounted towards the lower end of the drill string. After drilling to a predetermined depth, the drill string and drill bit are removed and a section of casing is lowered into the wellbore. An annulus is thus formed between the string of casing and the formation. A cementing operation is then conducted in order to fill the annulus with cement. The casing string is cemented into the wellbore by circulating cement into the annulus defined between the outer wall of the casing and the borehole. The combination of cement and casing strengthens the wellbore and facilitates the isolation of certain areas of the formation behind the casing for the production of hydrocarbons.

[0004] Sidetrack drilling is a process which allows an operator to drill a primary wellbore, and then drill an angled lateral wellbore off of the primary wellbore at a chosen depth. Generally, the primary wellbore is first cased with a string of casing and cemented. Then a tool known as a whipstock is positioned in the casing at the depth where deflection is desired. The whipstock is specially configured to divert milling bits and then a drill bit in a desired direction for forming a lateral borehole.

SUMMARY OF THE INVENTION

[0005] Embodiments of the present invention generally relate to a control system for downhole operations. In one embodiment, a method of controlling a downhole operation includes: deploying a work string into a wellbore, the work string comprising a deployment string and a bottomhole assembly (BHA); digitally marking a depth of the BHA; and using the digital mark to perform the downhole operation.

[0006] In another embodiment, a method of performing a downhole operation in a wellbore includes monitoring operational parameters associated with the downhole operation; marking a reference point in a monitoring system; in response to the marking of a reference point, using the monitoring system to provide target values for selected operational parameters for execution of the downhole operation; and controlling the execution of the downhole operation according to the target values.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] So that the manner in which the above recited features of the present invention can be understood in detail, a more particular description of the invention, briefly summarized above, may be had by reference to embodiments, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only typical embodiments of this invention and are therefore not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

[0008] Figure 1 is a diagram of a control system, according to one embodiment of the present invention.

[0009] Figures 2A-2C illustrate a sidetrack milling operation conducted using the control system, according to another embodiment of the present invention. Figure 2A illustrates a pilot bit engaging a top of the whipstock. Figure 2B illustrates the milling operation near the start of the core point. Figure 2C illustrates the milling operation near completion.

[0010] Figure 3 illustrates a hardware configuration for implementing the control system, according to another embodiment of the present invention.

[0011] Figure 4 illustrates a reference database of the control system, according to another embodiment of the present invention.

[0012] Figure 5 is a screen shot of an operator interface of the control system.

DETAILED DESCRIPTION

[0013] Figure 1 is a diagram of a control system 1, according to one embodiment of the present invention. The control system may be part of a milling system. A primary wellbore 3p has been drilled using a drilling rig 2. A casing string 4 has been installed in the primary wellbore 3p by being hung from a wellhead 15 and cemented (not shown, see Figure 2A) in place. Once the casing string 4 has been deployed and cemented, a mill string 5b,d may be deployed into the primary wellbore 3p for a sidetrack milling operation.

[0014] The drilling rig 2 may be deployed on land or offshore. If the primary wellbore 3p is subsea, then the drilling rig may be a mobile offshore drilling unit, such as a drillship or semisubmersible. The drilling rig 2 may include a derrick 6. The drilling rig 2 may further include drawworks 7 for supporting a top drive 8. The top drive 8 may in turn support and rotate the mill string 5b,d. Alternatively, a Kelly and rotary table (not shown) may be used to rotate the mill string 5b,d instead of the top drive. The drilling rig 2 may further include a mud pump 9 operable to pump milling fluid 10 from of a pit or tank (not shown), through a standpipe and Kelly hose to the top drive 8. The milling fluid 10 may include a base liquid. The base liquid may be refined oil, water, brine, or a water/oil emulsion. The milling fluid 10 may further include solids dissolved or suspended in the base liquid, such as organophilic clay, lignite, and/or asphalt, thereby forming a mud.

[0015] The drilling rig 2 may further include a control room (aka dog house) (not shown) having a rig controller 11, such as a server 11s (Figure 3), in communication with an array 12 of sensors for monitoring the milling operation. The array 12 may include one or more of: a mud pump stroke counter (Pump Strokes), a hook load cell (Hook Ld), a hook (and/or drawworks) position sensor (Hook Pos), a standpipe pressure (SPP) sensor, a wellhead pressure (WHP) sensor, a torque sub/cell (Torque), a turns (top drive or rotary table) counter (Turns), and a pipe tally (Tally). From the sensor measurements and values input by an operator, the rig controller 11 may calculate additional operational parameters, such as bit (or BHA) depth (measured and vertical), flow rate, rate of penetration (ROP), rotational speed (RPM) of the deployment string 5b,d, and weight-on-bit (WOB). Alternatively, one or more of these additional parameters may be measured directly as the other parameters in the array 12 or calculated by any other device or process. The rig controller 11 may also have one or more wellbore parameters stored, such as bottomhole depth (measured and vertical).

[0016] The milling fluid 10 may flow from the standpipe and into the mill string 5b,d via a swivel. The milling fluid 10 may be pumped down through the mill string 5b,d and exit a lead mill 13m,p, where the fluid may circulate the cuttings away from the mill and return the cuttings up an annulus formed between an inner surface of the casing 4 and an outer surface of the mill string 5d,b. The milling fluid 10 and cuttings (collectively, returns) may flow through the annulus to the wellhead 15 and be discharged to a primary returns line (not shown). Alternatively, a variable choke and rotating control head may be used to exert backpressure on the annulus during the milling operation. The returns may then be processed by a shale shaker 16 to separate the cuttings from the milling fluid 10. One or more blowout preventers (BOP) 17 may also be fastened to the wellhead 15. The mill string 5b,d may include a deployment string 5d, such as joints of drill pipe screwed together, and a bottom hole assembly (BHA) 5b. Alternatively, the deployment string may be coiled tubing instead of the drill pipe.

[0017] Figures 2A-2C illustrate a sidetrack milling operation conducted using the control system 1, according to another embodiment of the present invention. Figure 2A illustrates a pilot bit 13p engaging 27 a top of the whipstock 18w. Figure 2B illustrates the milling operation near a start of a core point 24. Figure 2C illustrates the milling operation near completion. The BHA 5b may include the lead mill 13m,p, drill collars, a trail (i.e., secondary or flex) mill 14, measurement while drilling (MWD) sensors (not shown), logging while drilling (LWD) sensors (not shown), and a float valve (to prevent backflow of fluid from the annulus). The deployment string 5d may also include one or more centralizers (not shown) spaced therealong at regular intervals and/or the BHA 5b may include one or more stabilizers. The mills 13m,p, 14 may be rotated from the surface by the rotary table or top drive 8 and/or downhole by a drilling motor (not shown). Alternatively, the BHA may include an orienter.

[0018] The lead mill 13m,p may include a mill bit 13m and a pilot bit 13p. The trail mill 14 may include a mill bit. Each bit 13m,p 14 may include a tubular housing connected to other components of the BHA 5b or to the deployment string 5d, such as by a threaded connection. Each bit 13m,p 14 may further include or more blades formed or disposed around an outer surface of the housing. Cutters may be disposed along each of the blades, such as by pressing, bonding, or threading. The cutters may be made from a hard material, such as ceramic or cermet (i.e., tungsten carbide) or any other material(s) suitable for milling a window.

[0019] The milling system may further include a deflector 18w,a. The deflector 18w,a may include a whipstock 18w and an anchor 18a. The anchor 18a may or may not include a packer for sealing. The deflector 18w,a may be releasably connected (i.e., by one or more shearable fasteners) to the BHA 5b for deployment so that the milling operation may be performed in one trip. The anchor 18a may be mechanically and/or hydraulically actuated to engage the casing 4. The whipstock 18w may be releasably connected to the anchor 18a such that the whipstock may be retrieved, an extension (not shown) added, and reconnected to the anchor for milling a second window (not shown). Alternatively, the anchor and/or the deflector may be set in a separate trip.

[0020] Figure 3 illustrates a hardware configuration for implementing the control system 1, according to another embodiment of the present invention. The control system 1 may include a programmable logic controller (PLC) 20 implemented as software on one or more computers 21, 22, such as a server 21, laptop 22, tablet, and/or personal digital assistant (PDA). The software may be loaded on to the computers from a computer readable medium, such as a compact disc or a solid state drive. The computers 21, 22 may each include a central processing unit, memory, an operator interface, such as a keyboard, monitor, and a pointing device, such as mouse or trackpad. Alternatively or additionally, the monitor may be a touchscreen. Each computer 21, 22 may interface with the rig controller via a router 23 and each computer may be connected to the router, such as by a universal serial bus (USB), Ethernet, or wireless connection. The interface may allow the PLC 20 to receive one or more of the rig sensor measurements, the operational parameters, and the wellbore parameters from the rig controller 11. Each computer 21, 22 may also interface with the Internet or Intranet via the rig controller 11 or have its own connection. Alternatively, the PLC software may be loaded onto the rig controller instead of the computers.

[0021] Figure 4 illustrates a reference database 25 of the control system 1, according to another embodiment of the present invention. The control system 1 may further include the window milling reference database 25. The database 25 may be loaded locally 25c on the milling server 21 and/or accessed (or updated) from a master version 25m possibly via the Internet and/or Intranet. The database 25 may include locations of known or expected events during a window milling operation, such as one or more of: beginning of cutting for each mill, beginning of cutout for each mill, maximum deflection, start and end of whipstock retrieval slot 19 (Figure 2B) (may also include end of retrieval lug), start, middle, and end of the core point 24, and kickoff point 26. The locations may be a distance from a known reference point, such as a top 27 of the whipstock. The events may be used to divide the window milling operation into two or more regions, such as a cutout region, a maximum deflection region, a retrieval slot region, a core point region, and a kickoff region. The database 25 may include a set of locations for each of various casing sizes and/or weights (two different sets shown).

[0022] The database 25 may also include minimum and maximum target values of one or more milling parameters, such as ROP, RPM, and/or WOB, for each region or each event. For example, the database 25 may include a first minimum and maximum ROP for the cutout region, a second minimum and maximum ROP for the maximum deflection region, a third minimum and maximum ROP for the core point region, and a fourth minimum and maximum ROP for the kickoff region. The target values of one or more the milling parameters may be predetermined or may vary depending on values measured during the milling process. The target values of one or more the milling parameters may be constant or may vary based on a particular casing size or weight (only one set of target values shown for each parameter). If the target values of a particular milling parameter vary with casing size and/or weight, then the database may include a set of target values for the parameter for each casing size and/or weight. The database 25 may also include predetermined comments based on previous experience for one or more particular regions or events. Alternatively, the database 25 may only include a target value for one or more of the milling parameters instead of a minimum and maximum.

[0023] Figure 5 is a screen shot of an operator interface 30 of the control system 1. In operation, the operator 28 may enter (and/or the PLC 20 may receive from the rig controller) known parameters into the PLC 20, such as casing parameters (i.e., size and weight), BHA parameters (mill sizes, types, and spacing), and deflector parameters. The mill string 5b,d may be run into the primary wellbore 3p to a desired depth of the window 3w. The whipstock 18w may be oriented by rotation of the deployment string 5d using the MWD sensors in communication with the rig controller via wireless telemetry, such as mud pulse, acoustic, or electromagnetic (EM). Alternatively, the mill string may be wired or include a pair of conductive paths for transverse EM. The PLC may record the orientation. The anchor 18a may be set with the whipstock 18w at the desired orientation. The deflector 18a,w may be released from the BHA 5b.

[0024] The BHA 5b may then be rotated by rotating the deployment string 5d (and/or operating the drilling motor) and milling fluid 10 may be pumped to the BHA 5b via the deployment string 5d. The mill string 5b,d may then be lowered toward the whipstock 18w. The PLC 20 may monitor the torque and may calculate and monitor a torque differential with respect to time or depth. The BHA 5b may be lowered until the lead mill 13p,m (i.e., pilot bit 13p) engages 27 the whipstock 18w (Figure 2A). The PLC 20 may detect engagement by comparing the torque differential to a predetermined threshold (from the reference database 25). The PLC 20 may then alert the operator 28 when engagement is detected and the operator may digitally mark 31 the pipe by clicking on an appropriate icon 32. The digital mark 31 may represent a reference point for the PLC 20 to monitor and control the downhole operation. Alternatively, the PLC may automatically mark the pipe. Alternatively, the operator may disregard the PLC's suggestion and mark the pipe based on experience.

[0025] Once the pipe is digitally marked 31, the PLC 20 may correlate the target values from the database 25 with BHA/bit depth by calculating the depths of the events/regions from the database 25 using the digital mark. The PLC 20 may then display a default set of target windows 33a-c for one or more of the operational parameters, such as ROP 33a, RPM 33b, and WOB 33c. If the target values for a particular operational parameter are predetermined, the PLC 20 may display the particular target window for the entire milling operation. If the target values for the particular operational parameter depend on actual measurements of the parameter or other parameters, the PLC 20 may calculate the particular target based on the actual parameter, other actual parameters, or differentials thereof, and criteria from the database 25. The criteria may vary based on the current event or region of the milling operation. The PLC 20 may then illustrate the calculated window for the current depth 41. The PLC 20 may also monitor actual values for the operational parameters (from the rig controller 11) and display plots of the various parameters for comparison against the respective target windows. The PLC 20 may receive and plot the actual values in real time. The PLC 20 may display the parameters (target and actual) plotted against time or depth (selectable by the operator). The PLC 20 may also monitor actual BHA/bit depth 41.

[0026] The PLC 20 may also interface with a flow model 34. The flow model 34 may be executed during the milling operation by the rig controller 11, the milling server 21, or an additional computer (not shown). The flow model 34 may calculate a target SPP 34t based on sensor measurements received from the rig controller 11. The PLC 20 may also display a target plot 34t for the received target SPP and plot the actual SPP (from the rig controller) for a graphical comparison. Additionally, the flow model 34 may calculate a cuttings removal rate and calculate a flow rate of the milling fluid 10 necessary to remove the cuttings. The flow model 34 may monitor the milling fluid flow rate and compare the actual flow rate to the calculated flow rate and alert the operator if the actual flow rate is less than the calculated flow rate needed for cuttings removal. The PLC 20 may also calculate a maximum flow rate based on a maximum allowable SPP, formation fracture pressure, or equivalent circulation density (ECD) limits and compare the actual flow rate to the maximum.

[0027] Alternatively, an operator may change the default target plots to illustrate target plots for one or more additional parameters, such as rathole depth.

[0028] The PLC 20 may also generate an animation 35 of the BHA 5b, whipstock 18w, and casing 4 to scale (or not to scale) and update the animation based on actual BHA/bit depth 41. The animation 35 may allow an operator 28 to view engagement of the mills 13p,m, 14 with the casing 4. The PLC 20 may also offset or adjust the animation 35 based on actual parameters, such as torque and/or drag. The animation 35 may also illustrate rotational speed (or velocity) of the mill string 5b,d.

[0029] The operator 28 may monitor the parameters displayed by the PLC 20 and make adjustments, such as altering RPM and/or WOB, as necessary to keep the operational parameters within the respective target windows. Alternatively, the rig controller may be capable of autonomous or semi-autonomous control of rig functions and the PLC may make adjustments to keep the operational parameters within the respective target windows. The operator 28 may then only monitor, subject to override of the autonomous control. The PLC 20 may also compare the actual parameters to the target windows and alert the operator 28 if any of the parameters depart from the respective target windows. The PLC 20 may also warn the operator 28 if the actual parameters approach margins of the respective windows. For the calculated windows, the PLC 20 may forecast a portion of the window and display the forecast portion to facilitate control by the operator 28. This predictive feature may allow the operator to make corrections to the operational parameters in anticipation of the forecasted changes. The PLC 20 may then correct the forecast on the next iteration. The PLC 20 may also warn the operator 28 if a differential of a particular parameter indicates that the parameter will quickly depart from the target window.

[0030] The PLC 20 may iterate in real time during the milling operation. Once the milling operation is complete (including the milling of any required rathole), the mill string 5b,d may be removed and the milling BHA 5b replaced by a drilling BHA. The drill string may be deployed and the lateral wellbore drilled through the casing window 3w. Alternatively, the milling BHA may be used to drill the lateral wellbore. Once drilled, the lateral wellbore may be completed, such as by expandable liner or expandable sand screen.

[0031] The PLC 20 may continue to track the digital mark 31 during the drilling and completion operations so the mark may be reused to retrieve the whipstock 14w or assist in passing of future completion BHA(s) through the window 3w. As discussed above, an extension may be added to the whipstock 14w for use in milling a second window. Additionally, the PLC 20 may allow the operator to make a plurality of digital marks and track the marks for future reference.

[0032] Additionally, the PLC 20 may include a chat (aka instant messaging) feature 36 allowing communication of the operator 28 with one or more remote users, such as engineers 29, located at a remote support center. The PLC 20 may also communicate with the remote support center such that the engineers 29 may view a display similar to that of the operator 28.

[0033] Additionally the PLC 20 may include a digital tally book 37. The digital tally book 37 may include a progress indicator 37i and a comments section. The comments section may allow the operator 28 to enter comments 37e during the milling operation. The comment entries 37e may be time and depth stamped for later evaluation and be represented by an icon 38 on the progress indicator 37i. The progress indicator 37i may be a depth-line when the depth selector is chosen and a timeline when the time selection is chosen. The digital mark 31 may be illustrated on the progress indicator 37i. The PLC may also illustrate one or more events using pointers, such as core point (CP) 39, kickoff point (KP) 40, and current depth 41. The comments from the database 25 may also be illustrated as icons (not shown) on the progress indicator.

[0034] The PLC 20 may save the operational data such and include a playback feature 42 such that the operation may be later evaluated. The operational data may be encoded with time and depth stamps for accurate playback.

[0035] Alternatively, the PLC may monitor actual values and display target values for setting the anchor and orienting the whipstock. The deflection angle of the whipstock may be input by the operator. The values may include azimuth, inclination, and/or tool face angle. The PLC may display the actual and target values to ensure that the correct orientation is obtained. This display may allow the operator to make adjustments based on actual data from the MWD sub to account for wellbore deviation. The PLC or the operator may digitally mark the pipe before, during, and/or after setting anchor and orienting the whipstock.

[0036] Alternatively, the PLC may include a simulator so that the milling operation may be simulated before actual performance. Alternatively, the reference database may be a historical database including the operational parameters for similar previously milled wellbores and the historical operational plots may be used instead of target windows.

[0037] Alternatively, the control system may be used with other downhole operations, such as a fishing operation for freeing and retrieving a stuck portion of a drill string. The digital pipe mark may be made when a fishing tool, such as a spear or overshot, engages the stuck portion of the drill string. The pipe mark may be tracked and reused if the stuck portion must be milled due to failure of the fishing operation. The control system may also be used for drilling out casing shoes, packers, and/or bridge plugs. The control system may also be used for setting liner hangers or packers. The control system may also be used for milling reentry of the parent wellbore (milling through a wall of the liner at the junction of the parent and lateral wellbore) as discussed and illustrated in U.S. Pat. No. 7,487,835.

[0038] Additionally, the PLC may include additional threshold parameters for detecting actuation of the deflector. For example, WOB and/or torque differentials may be monitored and compared to thresholds to confirm actuation of the anchor and/or release of the whipstock and anchor from the BHA. Alternatively, the threshold parameters may be used to confirm other operations, such as engagement of a drill bit with a casing shoe, engagement of a liner hanger with a casing; engagement of the fishing tool with the stuck portion; or the engagement of a drill or mill bit with a bridge plug or packer.

[0039] While the foregoing is directed to embodiments of the present invention, other and further embodiments of the invention may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

Claims:

1. A method of controlling a downhole operation, comprising:

deploying a work string into a wellbore, the work string comprising a deployment string and a bottomhole assembly (BHA);

generating a digital mark in a controller according to a depth or a time of the BHA when an operational parameter reaches a threshold value; and

using the digital mark as a reference point to generate target values for operational parameters of the downhole operation.

2. The method of claim 1, further comprising engaging the BHA with an object in the wellbore and detecting the engagement by monitoring whether the operational parameter reaches the threshold value,

wherein the deployment string is digitally marked in response to detection of the engagement.

3. The method of claim 2, wherein the engagement is one of the BHA engaging with a whipstock anchored in the wellbore, an anchor on the BHA engaging with a casing, a deflector on the BHA engaging with the wellbore, a liner hanger on the BHA engaging with a casing, a drill bit on the BHA engaging with a casing, a fishing tool on the BHA engaging with a stuck portion in the wellbore, and a drill bit or mill bit on the BHA engaging with a bridge plug or a packer in the wellbore.

4. The method of claim 1, further comprising:

correlating a first set of minimum and maximum first target values to the digital mark; and

while performing the downhole operation:

monitoring a first operational parameter of the downhole operation; and

comparing the first monitored parameter to the first set of the first target values.

5. The method of claim 4, wherein:

the first set of the first target values is correlated to a first event or region of the downhole operation, and

the method further comprises:

correlating a second set of minimum and maximum first target values to a second event or region of the downhole operation; and

comparing the first monitored parameter to the second set of the first target values while performing the downhole operation.

6. The method of claim 4, further comprising:

correlating a first set of minimum and maximum second target values to the digital mark; and

while performing the downhole operation:

monitoring a second operational parameter of the downhole operation; and

comparing the second monitored parameter to the first set of the second target values.

7. The method of claim 6, wherein:

the first sets of the target values are correlated to a first event or region of the downhole operation, and

the method further comprises:

correlating second sets of minimum and maximum first and second target values to a second event or region of the downhole operation; and

comparing the first and second monitored parameters to the second sets of the respective target values while performing the downhole operation.

8. The method of claim 6, further comprising controlling the second operational parameter by adjusting the first operational parameter while performing the downhole operation.

9. The method of claim 6, further comprising, while performing the downhole operation:

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displaying the target values as windows on respective graphs; and

plotting the operational parameters on respective graphs.

10. The method of claim 9, further comprising displaying an animation of the downhole operation while performing the downhole operation.

11. The method of claim 6, further comprising:

correlating a set of minimum and maximum third target values to the digital mark; and

while performing the downhole operation:

monitoring a third operational parameter of the downhole operation; and

comparing the third monitored parameter to the set of the third target values,

wherein:

the first operational parameter is rate of penetration,

the second operational parameter is rotational speed of the BHA and

the third operational parameter is weight exerted on a bit of the BHA.

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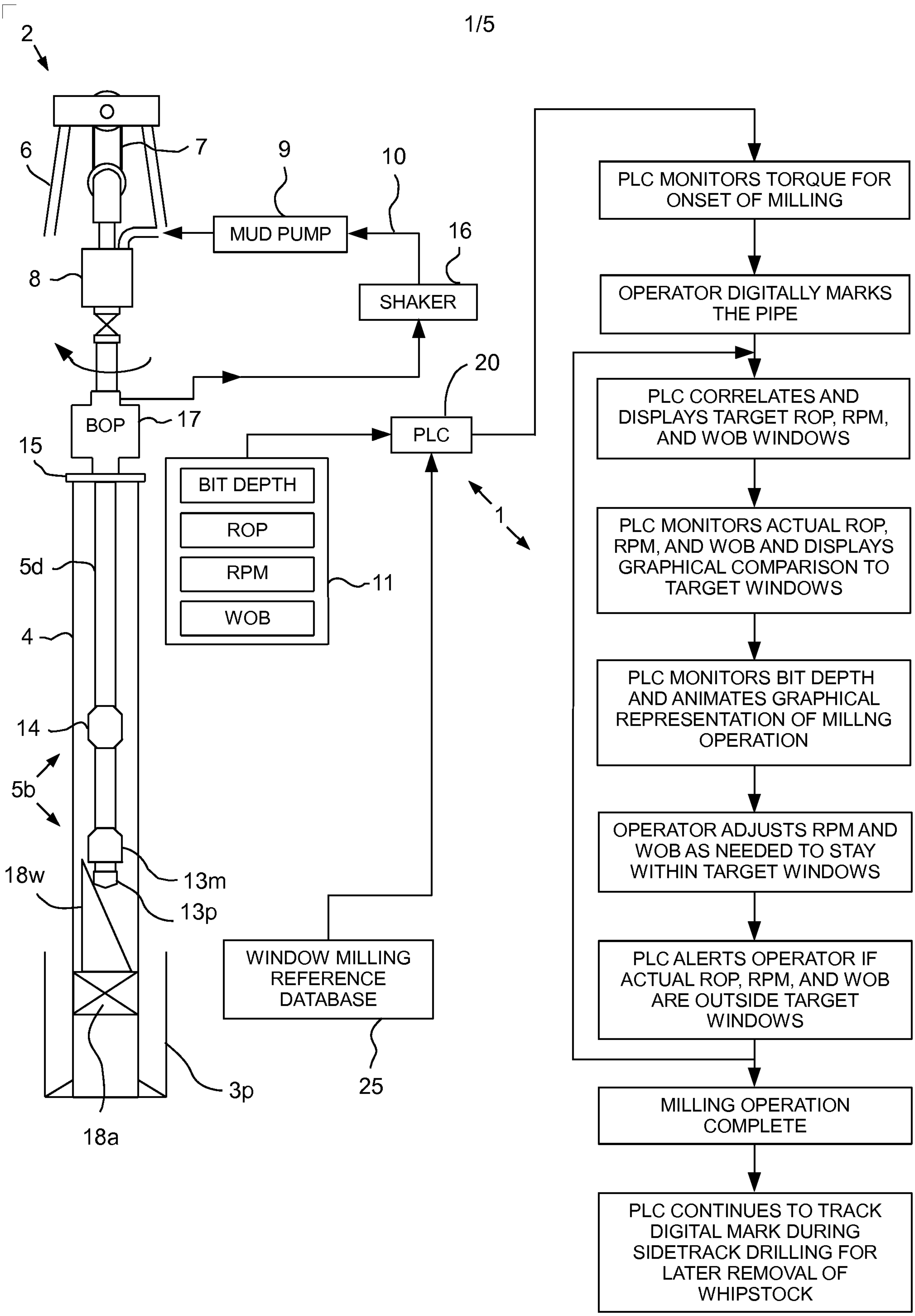

2
6
7
9
10
MUD PUMP
16
8
SHAKER
20
BOP
17
15
PLC
BIT DEPTH
ROP
RPM
WOB
1
5d
11
4
14
5b
18w
13m
13p
WINDOW MILLING REFERENCE DATABASE
25
3p
18a
PLC MONITORS TORQUE FOR ONSET OF MILLING
OPERATOR DIGITALLY MARKS THE PIPE
PLC CORRELATES AND DISPLAYS TARGET ROP, RPM, AND WOB WINDOWS
PLC MONITORS ACTUAL ROP, RPM, AND WOB AND DISPLAYS GRAPHICAL COMPARISON TO TARGET WINDOWS
PLC MONITORS BIT DEPTH AND ANIMATES GRAPHICAL REPRESENTATION OF MILLNG OPERATION
OPERATOR ADJUSTS RPM AND WOB AS NEEDED TO STAY WITHIN TARGET WINDOWS
PLC ALERTS OPERATOR IF ACTUAL ROP, RPM, AND WOB ARE OUTSIDE TARGET WINDOWS
MILLING OPERATION COMPLETE
PLC CONTINUES TO TRACK DIGITAL MARK DURING SIDETRACK DRILLING FOR LATER REMOVAL OF WHIPSTOCK

FIG. 1

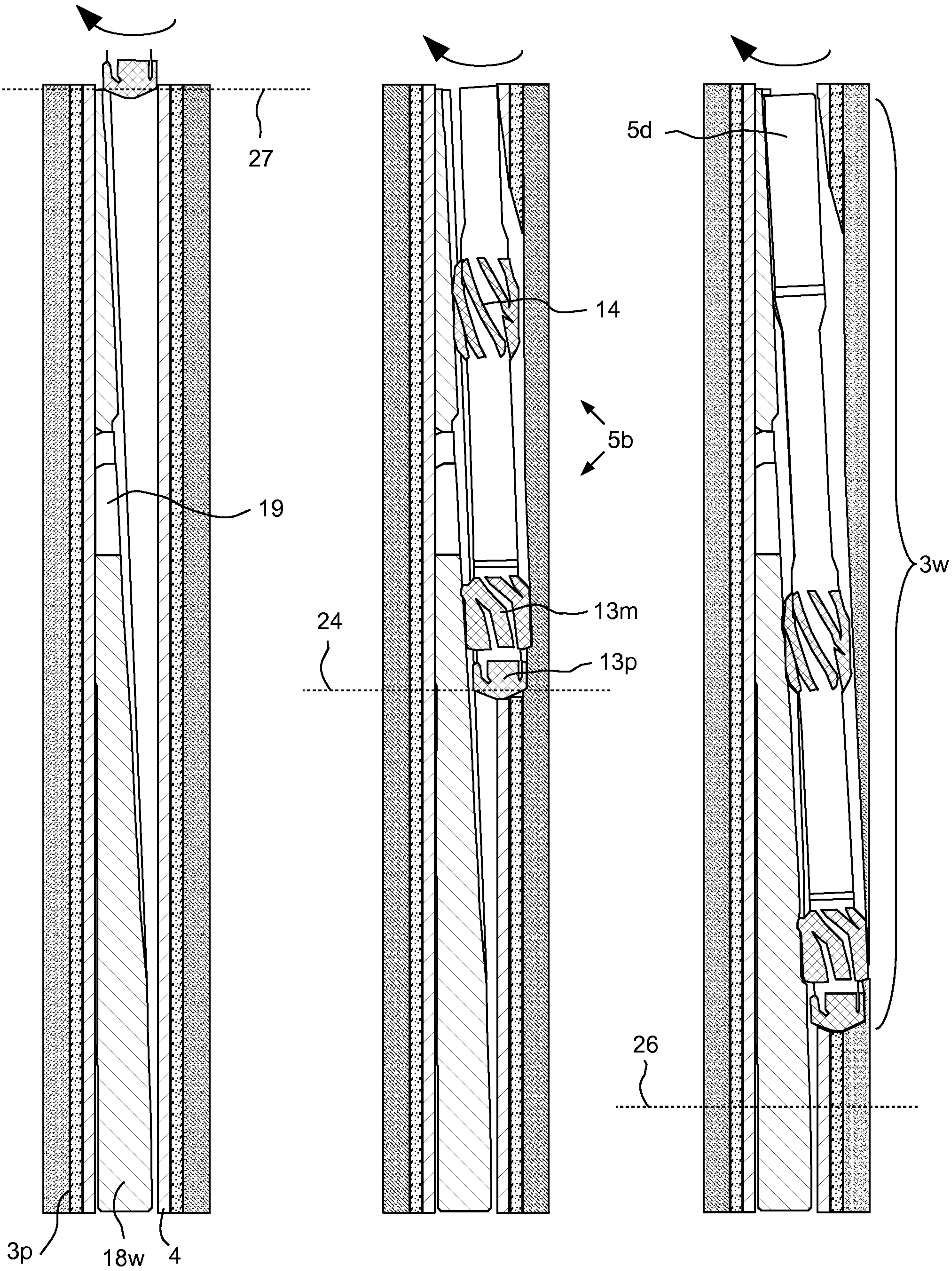


FIG. 2A FIG. 2B FIG. 2C

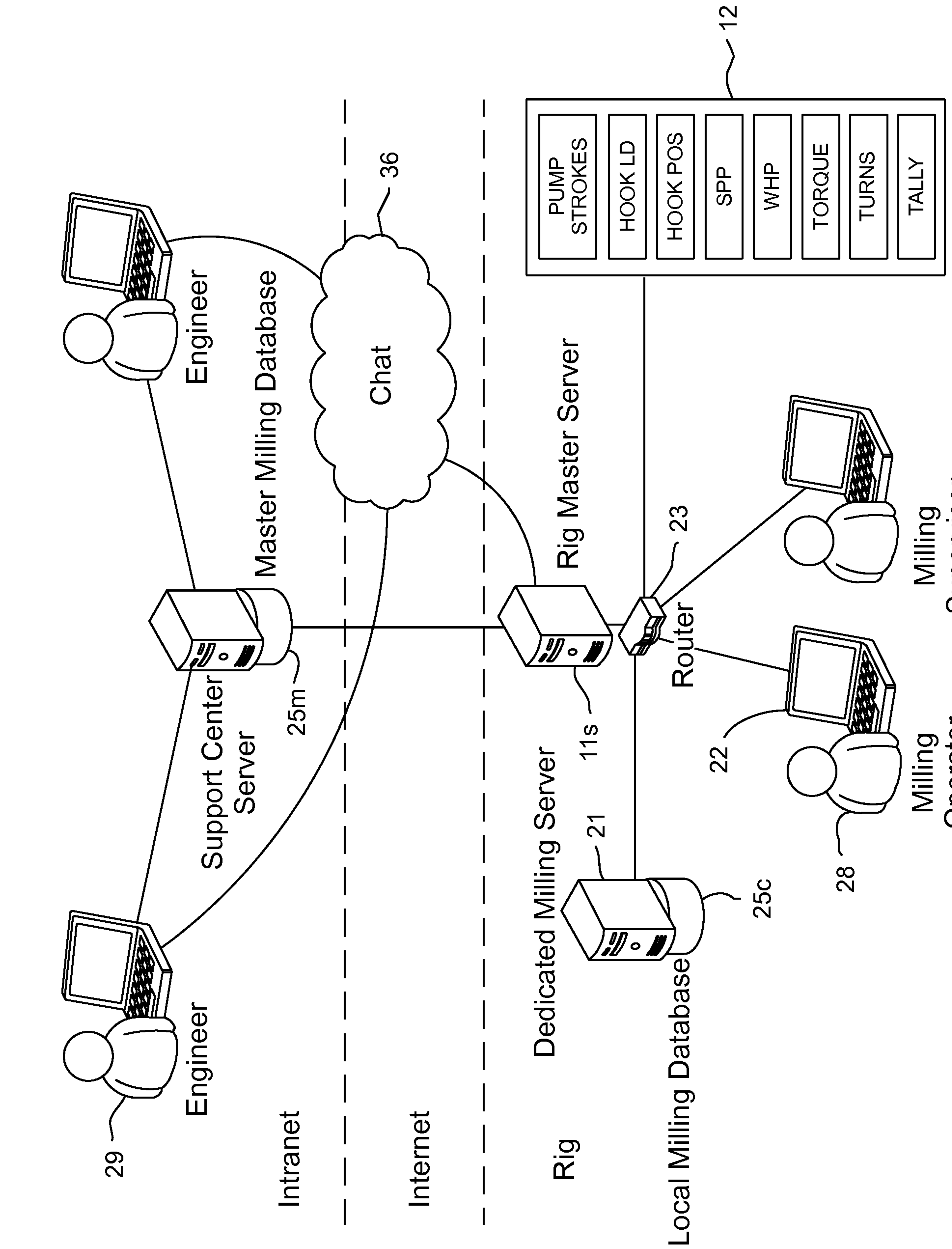

29
Engineer
Engineer
Intranet
Internet
Rig
Support Center
Server
25m
Master Milling Database
Chat
36
Rig Master Server
11s
Dedicated Milling Server
21
Local Milling Database
25c
Router
23
22
Milling
Operator
28
Milling
Supervisor
12
PUMP
STROKES
HOOK LD
HOOK POS
SPP
WHP
TORQUE
TURNS
TALLY

FIG. 3

25

CASING SIZE	XX	XX				
CASING WEIGHT	XX	XX		TARGETS		COMMENT
LIST OF EVENTS	DISTANCE FROM PIPE MARK		ROP	RPM	WOB	
MILL BIT STARTS CUT	X.X	X.X	X TO X	X TO X	X TO X	~~~~~~~~~
MILL BIT CUTS OUT	X.X	X.X	X TO X	X TO X	X TO X	~~~~~~~~~
PILOT BIT STARTS CUT	X.X	X.X	X TO X	X TO X	X TO X	~~~~~~~~~
TRAIL MILL STARTS CUT	X.X	X.X	X TO X	X TO X	X TO X	~~~~~~~~~
MAX DEFLECTION	X.X	X.X	X TO X	X TO X	X TO X	~~~~~~~~~
START OF RETRIVAL SLOT	X.X	X.X	X TO X	X TO X	X TO X	~~~~~~~~~
END OF LUG	X.X	X.X	X TO X	X TO X	X TO X	~~~~~~~~~
END OF RETRIEVAL SLOT	X.X	X.X	X TO X	X TO X	X TO X	~~~~~~~~~
CORE POINT START	X.X	X.X	X TO X	X TO X	X TO X	~~~~~~~~~
CORE POINT MID	X.X	X.X	X TO X	X TO X	X TO X	~~~~~~~~~
CORE POINT END	X.X	X.X	X TO X	X TO X	X TO X	~~~~~~~~~
KICK OFF POINT	X.X	X.X	X TO X	X TO X	X TO X	~~~~~~~~~

FIG. 4

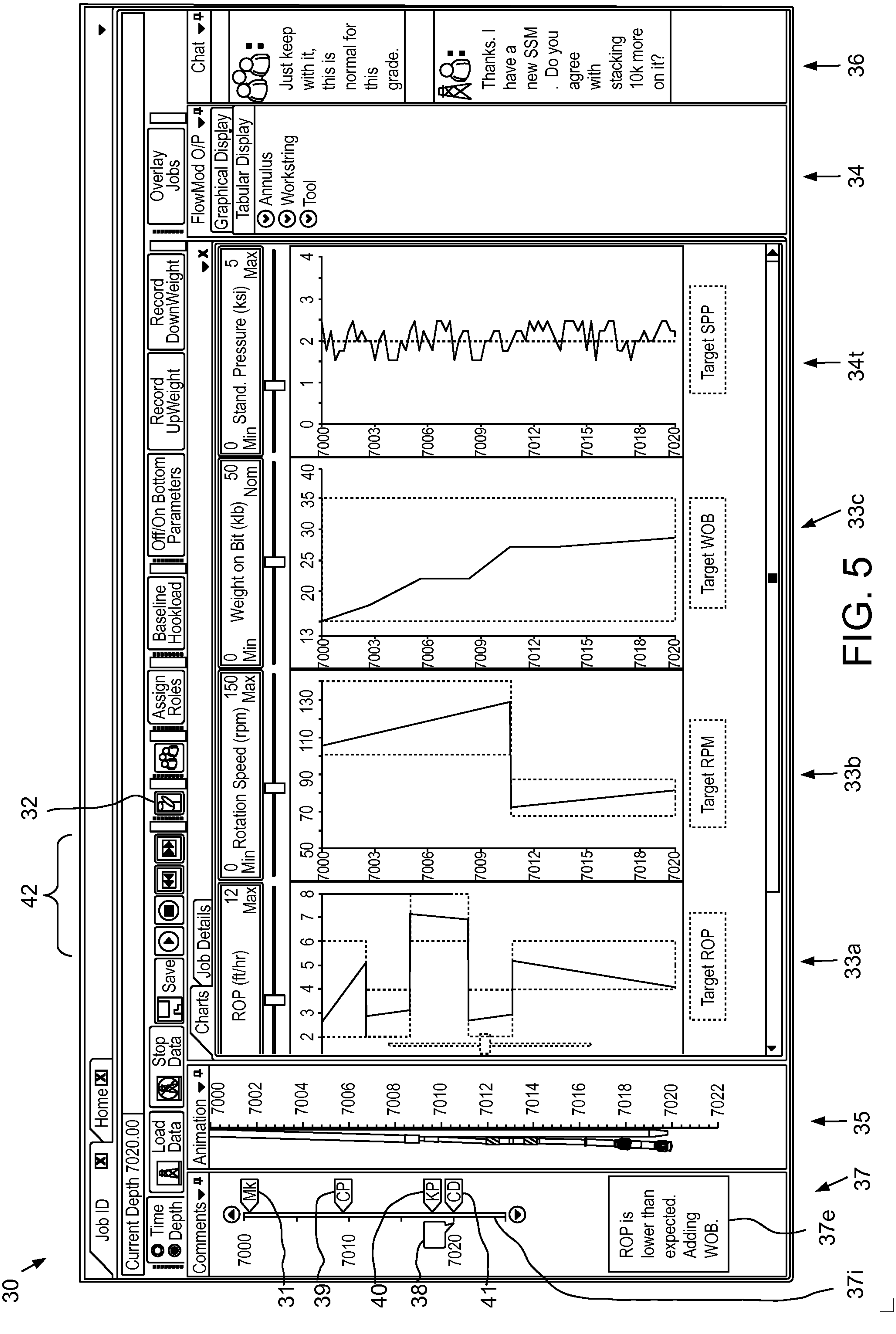
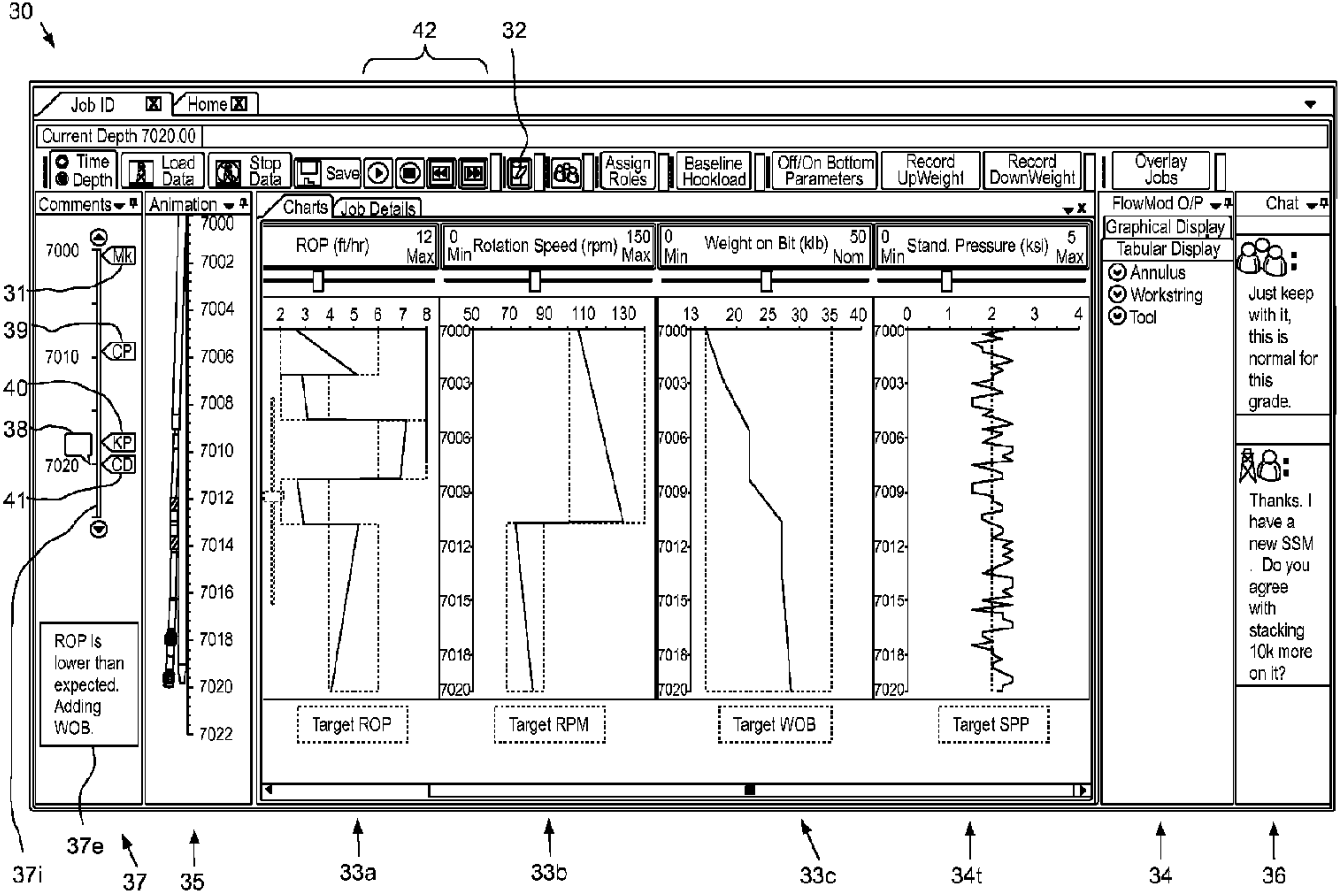

30
Job ID
Home
Current Depth 7020.00
Time
Depth
Load Data
Stop Data
Save
Assign Roles
Baseline Hookload
Off/On Bottom Parameters
Record UpWeight
Record DownWeight
Overlay Jobs
Comments
Mk
CP
KP
CD
7000
7010
7020
ROP is lower than expected. Adding WOB.
Animation
7000
7002
7004
7006
7008
7010
7012
7014
7016
7018
7020
7022
Charts
Job Details
ROP (ft/hr)
12 Max
Rotation Speed (rpm)
0 Min
150 Max
Weight on Bit (klb)
50 Nom
Stand. Pressure (ksi)
5 Max
Target ROP
Target RPM
Target WOB
Target SPP
FlowMod O/P
Graphical Display
Tabular Display
Annulus
Workstring
Tool
Chat
Just keep with it, this is normal for this grade.
Thanks. I have a new SSM. Do you agree with stacking 10k more on it?
31
39
40
38
41
37i
37e
37
35
33a
33b
33c
34t
34
36
32
42

FIG. 5


30
42
32
Job ID
Home
Current Depth 7020.00
Time
Depth
Load Data
Stop Data
Save
Assign Roles
Baseline Hookload
Off/On Bottom Parameters
Record UpWeight
Record DownWeight
Overlay Jobs
Comments
Animation
Charts
Job Details
FlowMod O/P
Chat
ROP (ft/hr) 12 Max
0 Min Rotation Speed (rpm) 150 Max
0 Min Weight on Bit (klb) 50 Nom
0 Min Stand. Pressure (ksi) 5 Max
Graphical Display
Tabular Display
Annulus
Workstring
Tool
MK
CP
KP
CD
Just keep with it, this is normal for this grade.
Thanks. I have a new SSM . Do you agree with stacking 10k more on it?
ROP Is lower than expected. Adding WOB.
Target ROP
Target RPM
Target WOB
Target SPP
31
39
40
38
41
37i
37e
37
35
33a
33b
33c
34t
34
36