Paper No. _____

UNITED STATES PATENT AND TRADEMARK OFFICE

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BEFORE THE PATENT TRIAL AND APPEAL BOARD

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OMRON OILFIELD & MARINE, INC.
Petitioner

v.

MD/TOTCO, A DIVISION OF VARCO, L.P.
Patent Owner

Patent No. 5,474,142
Issue Date: December 12, 1995
Title: AUTOMATIC DRILLING SYSTEM

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Inter Partes Review No. Unassigned

DECLARATION OF MITCHELL PINCKARD

I. INTRODUCTION

1. I have been retained as an expert in oil drilling systems by Foley & Lardner LLP, which represents Omron Oilfied & Marine, Inc. ("Omron") in this matter.

2. The documents that I have considered in developing my opinions set forth in this declaration are referenced in this declaration.

3. My curriculum vitae is attached hereto. My compensation for working on issues in this matter is based on a rate of $300 per hour for my time spent working on issues in this case. My compensation does not depend upon the outcome of this matter or the related litigation, the opinions I express, or my testimony.

4. Additional information may become available that would further support or modify the conclusions that I have reached to date. Accordingly, I reserve the right to modify and/or change my opinions and the bases thereof upon consideration of any further discovery, testimony, or other evidence, including any issues raised by any expert or witness of the Patent Owner, or based upon interpretations of any claim term by the Patent Office different than those assumed in this declaration.

II. QUALIFICATIONS

5. I have over 30 years of experience working in the oil drilling industry.

I began my career as an equipment mechanic in 1967. I started working on oil drilling in 1979 for Odeco, performing maintenance of offshore mobile drilling rigs. I was a drilling rig engineer for Western Oceanics from 1980 to 1993.

6. In 1993, Western Oceanics was acquired by Noble Corporation. After the acquisition, I became the Systems Manager for drilling rigs for Noble, and held that position from 1993 to 1997. In 1997, I became the Manager of Integrated Technology for Noble. In that role, I lead a research and development group working on drilling optimization technology.

7. I retired from Noble in 2004 and formed my own company, VeriDAQ LLC. Since then, I have been working as a consultant for various companies in the oilwell drilling industry. In 2011, I also assumed the role as the Business Development Manager for Fugro Drilling & Well Services Inc.

8. I am named as an inventor on over 10 patents pertaining to optimization of drilling. Many of those patents resulted in successful commercial embodiments for Noble.

9. I studied Mechanical Engineering with an Aerospace option for 2.5 years at Louisiana Mechanical Engineering. I have also taken various short courses on drilling operations, engineering, economics, quality (iso 9001, etc.), supervision and management.

III. SCOPE OF ASSIGNMENT

10. I have been retained to opine on the validity of U.S. Patent No. 5,474,142 ("the '142 patent") (Ex. 1001).

11. I have been asked to consider whether the invention(s) recited in claims 1, 11 and 14 of the '142 patent are invalid over certain prior art references.

12. This declaration sets forth my opinions on this topic.

IV. SUMMARY OF OPINIONS

13. Based upon my review and analysis, and for the reasons set forth below, it is my opinion that claims 1, 11 and 14 are anticipated by certain prior art references discussed in detail below. Alternatively, claims 1, 11 and 14 are obvious in view of the prior art discussed below.

V. LEGAL PRINCIPLES USED IN ANALYSIS

14. In rendering the opinions set forth in this declaration, I was asked to consider the patent claims through the eyes of "one of ordinary skill in the art." I was told by counsel for Omron to consider factors such as the educational level and years of experience, not only of the person or persons who have developed the invention(s) that is the subject of the case, but also of others working in the pertinent art; the types of problems encountered in the art; the teachings of the prior art; patents and publications of other persons or companies; and the sophistication of the technology. I understand that a person of ordinary skill in the art is not a specific real individual, but rather a hypothetical individual having the

qualities reflected by the factors discussed above.

15. In my opinion, based on my experience in oil drilling and development of drilling systems, a person of ordinary skill in the art of oil drilling systems as of the filing date of the ’142 patent (April 19, 1993) would have had at least 5-10 years experience in oil drilling operations, as well as some experience developing drilling systems.

VI. CLAIM CONSTRUCTION OF THE ASSERTED CLAIMS

16. For purposes of my opinions and declaration, I have considered the terms in the claims to have meanings consistent the constructions proposed in Omron’s Petition for *Inter Partes* Review.

VII. INVALIDITY OF CLAIMS 1, 11 AND 14 OF THE ’142 PATENT

A. Invalidity Based On Lindstad

17. In my opinion, all of the elements of claims 1, 11 and 14 are disclosed by Lindstad (Ex. 1013). The disclosures of Lindstad relevant to the elements of the claims are described in detail below.

18. Lindstad discloses a blasthole drilling system that automatically regulates the release of the drill string in response to changes in drilling fluid pressure. (Lindstad, Ex. 1013, 2:6-35; 2:55-65; 4:5-5:8; claims 4-5.) Lindstad discloses that the drill string is controlled by a downfeed control that was disclosed in a then co-pending application filed by the same assignee (with a common inventor), 854,871, which issued as U.S. Patent No. 3,581,830 to Stoner (“Stoner”)

(Ex. 1014). (Lindstad, Ex. 1013, 3:45-53.) Lindstad incorporates the disclosure of Stoner by reference. (*Id.*; *see also* Abstract.) Stoner discloses a blasthole drilling system that automatically regulates the release of the drill string in response to changes in the amount of force on the drill bit (i.e., the "bit weight"). (Stoner, Ex. 1014, 9:42-49.)

The Disclosures of Lindstad

19. Lindstad discloses an automatic blasthole drilling rig with a drill 8 (the "drill string") and drill bit 9. (Lindstad, Ex. 1013, 3:23-44; Fig. 1.) The drill 8 is driven into the earth by a downfeed drive motor 10. (*Id.*) The downfeed drive motor 10 is controlled by the downfeed control disclosed in Stoner. (*Id.* 3:45-67.)

20. Lindstad discloses that drilling fluid in the form of compressed air is forced through the hollow drill 8 and out holes in the drill bit 9: "During drilling the drill cuttings must be removed from the hole. This is presently accomplished by pumping compressed air through the hollow drill stem and out of holes in the bit, so that the resulting airblast blows the cuttings out of the hole." (*Id.* 1:27-40; 3:69-4:4.)

21. The air pressure is measured using an air pressure sensor 22: "An air pressure sensor 22 is connected to the air conduit 16 and its output terminals 23 and 26 are respectively connected to a pair of input terminals 24 and 27 of the air pressure monitor 25, which is also located inside the machinery housing 4." (*Id.*

4:5-17; *see also id.* 2:5-34; 2:54-75; claims 4-5; Figs. 1-2.)

22. The air pressure sensor 22 is coupled to an air pressure monitor 25, which is a "drilling fluid pressure regulator." (*Id.* 4:5-17 & Fig. 2; claims 4-5.) The air pressure monitor 25 is depicted in Figure 2: "An air pressure sensor 22 is connected to the air conduit 16 and its output terminals 23 and 26 are respectively connected to a pair of input terminals 24 and 27 of the air pressure monitor 25, which is also located inside the machinery housing 4." (*Id.*)

23. During normal drilling conditions, the air pressure monitor 25 will generate a signal in the form of positive voltage. (*Id.* 4:48-5:8.) A blocking diode 54 within the air pressure monitor 25 blocks the positive voltage, resulting in no current flow to the downfeed speed control 12 and, thus, no change in the release of the drill string. (*Id.*)

24. As the air pressure increases, a proportionately increasing negative current is generated by the air pressure monitor 25. (*Id.*) Thus, the signal represents changes in drilling fluid pressure in the form of negative current such that the amount of change is indicated by the amount of negative current. (*Id.* 4:5-5:8.)

25. Lindstad discloses that the signal representing changes in drilling fluid pressure is transmitted to the speed control 12 via a coupling resistor 55, which is a "relay" (as recited in claim 1). (*Id.* 4:59-5:8; Fig. 2.) The coupling resistor 55 is

coupled to the air pressure monitor 25 (the "drilling fluid pressure regulator"). (*Id.* Fig. 2.) The signal is a "drill string control signal" (as recited in claim 1) because it controls the downfeed drive motor 10 that regulates the release of the drill string. (*Id.* 4:63-5:4; *see also* claims 4-5.)

26. The blocking diode 54 conducts the negative current to the downfeed speed control 12. (*Id.*) The negative current is subtracted from the positive reference current in the downfeed speed control, thus slowing the downfeed drive motor 10 (or reversing it). (*Id.*) When the air pressure returns to a safe level, the normal drilling speed of the downfeed motor 10 resumes: "When the pressure drops to a safe level, the normal drilling and water injection is automatically resumed." (*Id.* 2:55-75.)

27. The control process of Lindstad is explained in the following passage: "When a negative voltage appears at the output terminal 48 of the air pressure feedback amplifier 47, the blocking diode 54 conducts and the current subtracts from the preset positive reference current in the downfeed speed control 12 thus slowing the downfeed drive motor 10, or reversing it, if the output 48 swings sufficiently negative. During normal drilling, the positive bias current on noninverting input terminal 45 of the air pressure feedback amplifier 47 will produce a positive signal at the output terminal 48, which is blocked by the blocking diode 54, resulting in no current flow to the linear speed control 12. As

the air pressure in the airline increases, a proportionately increasing negative current is transmitted from the output terminal 33 of the air pressure sensor amplifier 30 to the noninverting input terminal 45 of the air pressure feedback amplifier 47. When this negative current equals the positive bias current, the output terminal 48 will swing negative and the downfeed rate will begin to decelerate." (*Id.* 4:63-5:4; *see also* claims 4-5.)

28. The regulation of the release of the drill string of Lindstad has a direct effect at the drill bit because the drill bit is attached to the bottom of the drill string and moves with the drill string. (*Id.* Fig. 1.)

The Disclosures of Stoner

29. Stoner discloses that the "downfeed control" incorporated into Lindstad also automatically regulates the release of the drill string in response to changes in the force on the drill bit (the "bit weight"). (Stoner, Ex. 1014, 9:42-49.) As in Lindstad, Stoner discloses that the drill stem 5 (the "drill string") is driven into the earth by a motor 11. (*Id.* 3:9-13.) The drilling rig has a drill bit in association therewith. (*Id.* 2:64-67.)

30. The motor 11 "is powered by a pump 12 that is driven by another AC motor 13 that is also connected across an AC source." (*Id.*) Together, this "downfeed drive means" exerts downfeed pressure on the drill stem (also called the tool 5) including "100 to 200 p.s.i. from the dead weight of the tool 5 plus 0 to

1,000 p.s.i. applied by the downfeed drive means." (*Id.* 3:1-4.)

31. The amount and direction of force (the "bit weight") applied by the downfeed drive means on the drill stem 5 is measured by pressure sensors 22 and 23 on the motor 11. (*Id.* 5:8-21.) Each pressure sensor has an electrical bridge that generates signals representing the direction and magnitude of the linear force: "Each of the pressure sensors 22 and 23 contains a diaphragm (not shown) exposed to fluid pressure in the conduits on respective sides of the linear motor 11 between the linear motor 11 and the valve 18. Each of the pressure sensors 22 and 23 also contains an electrical bridge (not shown), at least one leg of which includes a strain gauge (not shown) mounted on the diaphragm. Hence, the bridges will originate a DC signal proportional to the deflections of the diaphragms and thus proportional to the pressure of the hydraulic fluid in the conduits at the ports 24 and 25 of the motor 11. Since feedback signals are taken from both sides of the motor 11, the feedback signals will represent by polarity the direction of linear force, and by signal magnitude the amount of that pressure or force of that feed." (*Id.* 5:8-21; 3:1-23; Fig. 1.)

32. The feedback signals are used to generate output signals indicating the changes in the downward force (the "bit weight"): "When there is no pressure drop across the hydraulic motor 11, the output signals from the pressure sensors 22 and 23 will chancel each other so that no feedback signal is seen by the linear force

feedback amplifier 75. As a pressure drop builds up across the motor 11 during downfeed of the tool 5, a feedback signal is transmitted to the inverting input terminal 79 and noninverting input terminal 80 of the linear force feedback amplifier 75, resulting in a negative linear force feedback signal on the output terminal 74 of the linear force feedback amplifier 75, which feedback signal will be passed by the blocking diode 73 and transmitted to the inverting input terminal 59 of the comparator amplifier 57. If the tool 5 is withdrawn, a negative feedback signal will appear on the inverting input terminal 79 of the linear force feedback amplifier 75 resulting in a positive output signal on the output terminal 74, which positive signal will be blocked by the blocking diode 73." (*Id.* 5:27-40.) The linear force feedback signals are proportional to the force exerted by the linear drive motor 10 on the drill string. (*Id.* 1:75-2:1.) Thus, the amount of negative voltage indicates the changes in the downward force on the drill bit (the "bit weight"). (*Id.*; 5:27-40.)

33. By incorporating the downfeed control of Stoner by reference, Lindstad teaches a drilling system with a downfeed control that automatically regulates the release of the drill string in response to changes in both bit weight and drilling fluid pressure. When measuring the changes in these parameters in parallel, the downfeed control would necessarily "select" the drilling fluid pressure signal, the bit weight signal, or both to control the release of the drill string (as

recited in claim 14).

34. Stoner discloses relaying the bit weight signal to the drill string controller and regulating the release of the drill string in response to the signal. (*Id*. 9:37-49.) Specifically, Stoner discloses that when the linear force (the "bit weight") becomes excessive, a feedback signal (in the form of negative voltage) causes the downward movement of the drill string to be reduced or reversed: "A Zener diode 117 and a blocking diode 118, which are connected in series between the output terminal 74 of the linear force feedback amplifier 75 and the input terminal 50 of the servo valve amplifier 51, serve as a pressure limiter by providing a safety feedback signal when the load on the hydraulic motor 11 becomes excessive. Excessive loading on the linear drive will cause the output terminal 74 of the linear force feedback amplifier 75 to go negative and the Zener diode 117 to conduct driving the input terminal 50 of the servo valve amplifier 51 negative. This reduces or reverses the feed until the condition causing the excessive load on the linear drive is corrected or the feedrate is reduced by the operator." (*Id.*)

35. As the above passage indicates, the signal representing changes in bit weight is transmitted to the servo amplifier 51. (*Id.*) The servo amplifier 51 controls the linear drive motor 11, which controls the direction and rate of linear drive of the drill 5: "The servo valve amplifier 51 originates a control signal proportional to the error signal at its output terminal 53 which is connected to an

electrical control 54 of the electrically controlled directional and flow control hydraulic valve 18 to actuate the valve 18 which controls the direction and rate of fluid flow to the linear drive motor 11 to control the direction and rate of linear drive of the tool 5." (*Id.* 4:13-21.)

B. Invalidity Based on Lindstad and Crake

36. Alternatively, claims 1, 11, and 14 are obvious in view of Lindstad and Crake. The disclosures of Lindstad relevant to the elements of the claims have already been described in detail above. The disclosures of Crake relevant to the elements of the claims are described in detail below.

37. Crake discloses an oilwell drilling system that automatically regulates the release of the drill string in response to changes in two drilling parameters: bit weight and the rate of penetration of the drill bit. (Crake, Ex. 1015, 1:1-6.) A combination of Lindstad and Crake would result in an oilwell drilling system that measures both bit weight and drilling fluid pressure, and automatically regulates the release of the drill string based on changes in these parameters.

38. A person of ordinary skill in the art at the time of the '142 patent invention would have been motivated to combine the teachings of Lindstad and Crake. Crake teaches the automatic regulation of the drill string based on changes in bit weight. (Crake, Ex. 1015, 1:1-6.) But as acknowledged by the specification of the '142 patent, automatic drillers that use bit weight as the drilling parameter

cease to operate properly for directional and horizontal drilling because the bit weight measurements are inaccurate when the drill string deviates from vertical. (’142 patent, Ex. 1001, 1:36-50.) The teachings of Lindstad overcome this problem because measuring drilling fluid pressure can indicate when the drill bit is “off bottom” regardless of whether the drill is vertical, directional, or horizontal. Accordingly, a person of ordinary skill would have been motivated to combine the teachings of a bit weight automatic driller (such as Crake) with the teachings of automatic driller that is effective for directional and horizontal drilling (such as Lindstad).

The Disclosures of Crake

39. Crake discloses a drilling system that automatically regulates the release of the drill string in response to changes in two drilling parameters: bit weight and the rate of penetration of the drill bit. (Crake, Ex. 1015, 1:1-6.) The drilling rig disclosed in Crake has a drill bit in association therewith. (*Id.* 2:42-45; Fig. 1.)

40. Crake discloses the use of a weight controller 31 and a speed controller 32 similar to the regulators of the ’142 patent. (*Id.* Figs. 1-3; 3:22-75.) The two controllers are used cooperatively to maintain the bit weight and penetration rate at desired limits. (*Id.* 6:27-39.)

41. The weight controller 31 measures bit weight using a weight-

indicating device 36. (*Id.* 3:36-51; Fig. 2.) Crake discloses that a signal is generated in response to changes in bit weight and that the signal represents changes in bit weight: "Upon the drill bit encountering thereafter a hard layer where the penetration rate is in excess of the penetration rate, resulting immediately in a slack in the cable and a corresponding increase of the weight on the bit to a value in excess of 10,000 lbs., thus causing an undesirable condition. The slack on the cable, however, results in a contraction of the Bourdon tube of the weight controller, which permits the pressure fluid to escape through channel 55, thereby relieving the pressure on the diaphragm 21 of fluid motor 28, and applying the brake 19 to slow down the bit feed rate . . . ." (*Id.* 5:66-6:9.)

42. As explained in the above passage, if the bit weight gets too high, the weight controller causes fluid motor 28 to apply brake 19 to slow down the release of the drill string. (*Id.* 5:62-6:9.) If the bit weight gets too low, the reverse happens: "If, after passing through the hard layer, the bit encounters an extremely soft formation, or even a cavity in the ground, all weight is momentarily removed from the bit and is carried in the cable. The weight controller acts in this case to disengage the brake 19, and the drum 8, under the effect of the heavy weight of the drill string, has a tendency to unwind at a very high rate, thus dropping the drill string to the bottom." (*Id.* 6:10-18.) The speed controller 32 controls brake 119 in a similar fashion. (*Id.* 6:19-26.)

43. The release of the drill string of Crake has a direct effect at the drill bit because the drill bit is attached to the bottom of the drill string and moves with the drill string. (*Id.* Fig. 1.)

44. In the event the Board adopts a narrow claim construction of the term "release" to exclude a drill with a motor that exerts a downward force on the drill string as in Lindstad, claims 1, 11 and 14 would nonetheless be invalid over Lindstad and Crake. Crake discloses a drilling system that automatically regulates the release of the drill string in response to changes in bit weight and rate of penetration. (*Id.* 1:1-6.) Crake discloses a drill for oilwell drilling. (*Id.*) There is no motor that exerts a downward force on the drill string. (*See generally* Crake, Ex. 1015.) Instead, the only force applied to the drill string is the weight of the drill string itself, similar to the '142 patent. (*Id.* 2:46-55.) It would have been obvious to one of ordinary skill in the art at the time of the '142 invention to include a drilling fluid pressure controller to the control system of Crake based on the teachings of Lindstad. Based on the teachings of Lindstad, a drilling fluid pressure controller added to Crake would generate a drill string control signal wherein a decrease in drilling fluid pressure would cause an increase in the rate of release of the drill string and an increase in drilling fluid pressure would cause a decrease in the rate of release of the drill string. (*See* Lindstad, Ex. 1013, 4:63-5:8; 2:6-35; 2:55-75; claims 4-5.) The weight controller and speed controllers of Crake

operate in the same manner. (Crake, Ex. 1015, 5:66-6:26.)

45. Crake discloses "selecting" (as recited in claim 14) a signal representing changes in bit weight, a signal representing changes in rate of penetration, or both signals. (*Id.* 5:66-6:26.) It would have been obvious to one of ordinary skill in the art at the time of the '142 invention to include a drilling fluid pressure controller to the control system of Crake based on the teachings of Lindstad. Upon addition of a drilling fluid pressure controller to the drilling control system of Crake, the system would "select" the signal generated by the weight controller, the drilling fluid pressure controller, or both in the same manner that Crake already discloses selecting between the signals generated by the weight controller and the speed controller. (*Id.* 5:66-6:26.)

C. Invalidity Based On Lindstad and Brooks

46. Alternatively, claims 1, 11, and 14 are obvious in view of Lindstad and Brooks. The disclosures of Lindstad relevant to the elements of the claims have already been described in detail above. The disclosures of Brooks relevant to the elements of the claims are described in detail below.

47. Brooks discloses a drilling rig with a drilling information gathering system for detecting various drilling parameters, including weight on bit and drilling fluid pressure. (Brooks, Ex. 1017, 3:23-41.) In addition, Brooks discloses that the release of the drill string can be automatically regulated in response to

changes in bit weight. (*Id.* 9:68-10:6.)

48. A combination of Lindstad and Brooks would result in an oilwell drilling system that measures both bit weight and drilling fluid pressure, and automatically regulates the release of the drill string based on changes in these parameters.

49. A person of ordinary skill in the art at the time of the ’142 patent invention would have been motivated to combine the teachings of Lindstad and Brooks for the same reason discussed above (i.e., because the automatic bit weight driller disclosed in Brooks would not operate properly for directional and horizontal drilling).

50. In addition, Brooks provides motivation because it teaches the importance of measure at least six drilling parameters, including both bit weight and drilling fluid pressure: “To get a complete picture of the efficiency of a drilling operation, it is necessary to know the value of at least six variables: (1) drilling rate or penetration with respect to time; (2) weight on the bit; (3) rate of rotation of the drill string; (4) torque imparted to the drill string, often referred to simply as torque; (5) pressure of the drilling fluid; and (6) flow, or circulation rate, of the drilling fluid.” (Brooks, Ex. 1017, 1:49-56.) Brooks teaches the benefit of monitoring various drilling parameters as drilling operations become more automated: “Further inquiry into the complex and interrelated variables of the

drilling operation reinforces the conclusion that only a drilling information gathering system will suffice. This becomes especially true in the forthcoming automation of the drilling operation." (*Id.* 3:49-53.) Brooks also teaches the importance of monitoring drilling fluid pressure to both optimize the drilling rate and avoid adverse events. (*Id.* 5:40-75.) Accordingly, one of ordinary skill in the art would have been motivated to combine the teachings of Brooks with a prior art system that teaches automatically regulating the release of the drill string in response to changes in drilling fluid pressure (such as Lindstad).

The Disclosures of Brooks

51. Brooks discloses a drilling system with a drill string 4 with a drill bit 1 in association therewith. (Brooks, Ex. 1017, 6:50-52; Fig. 1.)

52. Brooks discloses a drilling fluid pressure sensor that measures drilling fluid pressure: "[T]he pressure on the drilling fluid being circulated is monitored on the discharge manifold 60 of the fluid pump 19. A standard BLH pressure cell which is available from Waltham, Massachusetts is used for this purpose." (*Id.* 11:65-70.)

53. Brooks discloses outputting a signal representing changes in drilling fluid pressure: "The means for generating a function output representing fluid pressure, designated by a block 311, is connected, as shown in the block diagram of FIGURE 3, through the control equipment 38 to the recorder 39. . . ." (*Id.*

11:64-12:19.) The signal is in the form of voltage such that the amount of change is indicated by the amount of voltage. (*Id.*; Fig. 4.)

54. Brooks discloses measuring bit weight using a pressure transducer attached to the deadline diaphragm unit for the cable that controls the drill stem: "As a means for generating a second function representative of hook load, or modified to represent weight on the bit, we use the following instrumentation. To measure the weight on the bit, we connect a deadline diaphragm unit 40 (FIGURE 1) a strain gauge type pressure transducer 41." (*Id.* 8:30-35; Fig. 1.) In an alternative embodiment, Brooks teaches that the hook load (which can be modified to represent bit weight) can be measured using strain gauges on the bail of a swivel of the draw works: "An alternative embodiment can be seen in FIGURE 6. . . . That is, strain gauges 601 and temperature compensating strain gauges 603 are installed on the bail 605 of a swivel 21. . . . This method affords an excellent, stable, sensitive way to monitor indirectly the weight on the bit by monitoring the hook load. As taught above, control equipment 38 can be manipulated to generate a function representative of weight on the bit." (*Id.* 9:31-50.)

55. Brooks discloses that the bit weight measurements are recorded over time to monitor changes: "The output from either of these instruments [the pressure transducer or strain gauges], measuring the hook load, goes to the control equipment 38, where it is corrected to measure weight on the bit. This is then sent

to recorder 39 where it is recorded on the record which is being advanced with advancing time." (*Id.* 9:69-73.)

56. Brooks discloses that changes in bit weight can be used as a control signal to automatically control the release of the drill string: "Thus, the value of the weight on the bit which produced the particular penetration, plotted on the same advancing record as the penetration, can be observed and used in subsequent comparative tests. It can thus be used to control, manually or automatically, the lowering of the travelling block to achieve and maintain any desired weight on the bit." (*Id.* 9:75-10:6.) The signal is in the form of voltage such that the amount of change is indicated by the amount of voltage. (*Id.* 8:50-75; 9:42-44.)

57. The release of the drill string of Brooks has a direct effect at the drill bit because the drill bit is attached to the bottom of the drill string and moves with the drill string. (*Id.* Fig. 1.)

58. In the event the Board adopts a narrow construction of the term "release" to exclude a drill with a motor that exerts a downward force on the drill string as in Lindstad, claims 1, 11 and 14 would nonetheless be obvious over Lindstad and Brooks. Brooks discloses a drill for oilwell drilling. (Brooks 1:21-22.) There is no motor that exerts a downward force on the drill string. (*See generally* Brooks, Ex. 1017; 6:50-58.) Instead, the only force applied to the drill string is the weight of the drill string itself, similar to the '142 patent. (*Id.* 6:50-

58.) Brooks also discloses a drill that automatically regulates the release of the drill string in response to changes in bit weight. (*Id.* 9:69-10:6.) Brooks also discloses measuring drilling fluid pressure. (*Id.* 11:65-70.) It would have been obvious to one of ordinary skill in the art at the time of the '142 invention to use the drilling fluid measurements taught by Brooks to control the release of the drill string based on the teachings of Lindstad. The system of Brooks would regulate the release of the drill string in response to changes in drilling fluid pressure in the same manner in which it already regulates the release of the drill string in response to changes in bit weight. (*See id.* 9:69-10:6.)

59. The combined system would "select" the signal representing changes in drilling fluid pressure, the signal representing changes in bit weight, or both to control the release of the drill string (as recited in claim 14).

D. Invalidity Based on Warren

60. In my opinion, all of the elements of claims 1, 11 and 14 are disclosed by Warren. The disclosures of Warren relevant to the elements of the claims are described in detail below.

The Disclosures of Warren

61. Warren discloses a system for directional drilling. (*See generally* Warren, Ex. 1018.) The system has a drill string 14 and a drill bit 26 in association therewith. (*Id.* 3:34-56.) The system automatically regulates the release of the

drill string in response to changes in various drilling parameters, including drilling fluid pressure and weight on bit. (*Id.* 3:1-16; 4:13-38.)

62. Warren discloses that various drilling parameters, including fluid pressure and weight on bit, can be measured by a measurement-while-drilling (MWD) tool 20: "The downhole data collection and transmission device can be any commercially available downhole measurement-while drilling (MWD) tool that transmits data to the surface either by mud pulse or electromagnetic energy . . . . Regardless of what type of device is used, at a minimum the device needs to transmit an accurate measurement of wellbore inclination, azimuthal direction (from True North, for example) and drillstring orientation. Any other transmitted data, referred to as drilling associated parameters, such as drill bit torque, RPM, WOB, downhole temperature, downhole pressure and the like, can be used if available." (*Id.* 3:1-16.) The phrase "downhole pressure" in this passage refers to "drilling fluid pressure." The MWD tool is connected to a lower end of the drillstring: "A downhole telemetry measurement and transmission device 20, commonly referred to as a measurement-while-drilling (MWD) tool is connected to a lower end of the drillstring 14 and transmits drilling associated parameters to the surface by mud pulse or electromagnetic transmission." (*Id.* 3:41-46.)

63. Warren discloses a "drilling fluid pressure regulator" in the form of a data reception device connected to a computer. Warren discloses that the MWD

tool sends signals regarding the drilling parameters to the data reception device: "The [drilling associated parameter] signals are received at the surface by a data receiving device 22, which is commercially available and necessary with use of an MWD tool." (*Id.* 3:41-49.)

64. The data reception device stores the signals in the memory of a programmable digital computer: "The downhole signals received by the data reception device 22 are provided by direct electrical or indirect cable, fiberoptic or radio link to a memory associated with a programmable digital computer 28." (*Id.* 3:57-60; Fig. 1.)

65. The computer compares the signals received from the MWD to the desired limits for the parameters previously stored in the memory of the computer: "[D]esired limits of the drilling associated parameters to be monitored are inputted into the memory associated with the programmable digital computer 28. . . . Drilling is commenced and the MWD signals are sent to the computer 28 and display device 30. Computer logic within the programmable digital computer compares and correlates the desired limits for the drilling associated parameters." (*Id.* 4:13-29.) In this way, the computer "selects" the signal representing changes in drilling fluid pressure, the signal representing changes in bit weight, or both signals to regulate the release of the drill string (as recited in claim 14).

66. The computer is operatively connected to the controls for draw works

of the drill string: "The programmable digital computer 28 is operatively connected to controls of the draw works 17 to control WOB, ..." (*Id.* 4:3-5; Figs. 1-2.)

67. The computer sends signals (which are "drill string control signals") via a "relay" (the connection between the computer and the controls of the draw works) to the controls of the draw works representing undesirable changes in the parameters: "If any one of the [drilling parameter] values is outside the desired limits then the programmable digital computer's logic causes an alarm to be activated so corrective action can be taken. Preferably, the logic causes the draw works 17, top drive or power swivel 12, rotary table 18 and/or mud pumps to be adjusted by a preselected amount or increment. Most preferably, the logic calculates the optimum adjustments necessary to the devices so that the parameter values are brought back to within the desired limits." (*Id.* 4:29-38; Fig. 2.) With respect to fluid pressure, Warren necessarily teaches that an increase in the fluid pressure above the preselected limit would cause the draw works to decrease the rate of release of the drill string and vice versa.

68. This causes a direct effect at the drill bit because the drill bit is attached to the bottom of the drill string and moves with the drill string. (*Id.*; Fig. 1.)

E. Invalidity Based On Warren and Brooks

69. Alternatively, claims 1, 11, and 14 are obvious in view of Warren and Brooks. The disclosures of Warren and Brooks relevant to the elements of the claims have already been described in detail above.

70. If the Board finds that Warren does not disclose each and every element of claims 1, 11 and 14 because Warren utilizes a downhole MWD device rather than conventional sensors at the surface (as in the ’142 patent), the claims would nonetheless be obvious over Warren in combination with Brooks.

71. The use of surface sensors versus downhole sensors is a matter of mere preference and both were well known in the art at the time of the ’142 patent.

F. Invalidity Based On Miller and Crake

72. In my opinion, all of the elements of claims 1 and 11 are disclosed by Miller. Claim 14 is obvious in view of Miller and Crake. The disclosures of Miller relevant to the elements of the claims are described in detail below. The disclosures of Crake relevant to the elements of the claims have already been described in detail above.

73. Miller discloses a drilling system that automatically regulates the release of the drill string in response to changes in drilling fluid pressure. (Miller, Ex. 1022, 1:25-27.) A combination of Crake and Miller would result in a drilling rig that measures both bit weight and drilling fluid pressure, and automatically regulates the release of the drill string based on changes in these parameters.

74. A person of ordinary skill in the art at the time of the ’142 patent invention would have been motivated to combine the teachings of Crake and Miller for the same reason discussed above (i.e., because the automatic bit weight driller disclosed in Crake would not operate properly for directional and horizontal drilling). A person of ordinary skill using the Crake system would have been motivated to add the features of the Miller system for use during directional and horizontal drilling to assess when the drill bit is “off bottom.” As indicated in the ’142 patent, automatic bit weight drillers (as taught by Crake) do not operate properly for directional and horizontal drilling. (’142 patent, Ex. 1001, 1:36-50.) It would have been obvious to add the features of Miller to the Crake system to determine when the drill bit is “off bottom” during directional and horizontal drilling.

75. In addition, Miller discloses a motivation to combine its teachings with the teachings of Crake. Miller discloses the importance of maintaining proper weight on bit. (Miller, Ex. 1022, 2:20-23; 6:71-75.) Although Miller states that “*some* percussion bits usually work best with substantially zero or very little weight on bit” and that the disclosed telescoping joint can be used to ensure that no weight is imposed on the bit (*id.*, 6:71-7:6 (emphasis added)), one of ordinary skill in the art would have been motivated to combine the teachings of Miller with Crake in drilling operations where a greater amount of weight on bit is desired.

One could use the telescopic joint of Miller to determine when the drill bit is "off bottom." The system could be calibrated such that the brake would continue to allow the drill string to release until the desired bit weight is achieved (as measured by the bit weight sensor of Crake).

The Disclosures of Miller

76. Miller discloses a drilling system that automatically regulates the release of the drill string in response to changes in drilling fluid pressure. (Miller, Ex. 1022, 1:25-27.) Miller discloses a drilling rig with a drill string 205 and a drill bit 208. (*Id.* 6:40-55; Fig. 5.) The raising and lowering of the drill string is controlled by a motor 218. (*Id.* 7:15-35; Fig. 5.)

77. The lower end of the drill string of Miller includes a telescopic joint 206. (*Id.* 6:40-55.) The telescopic joint is used to automatically regulate the release of the drill string based on changes in drilling fluid pressure. (*Id.* 10:62-12:50.) The telescopic joint includes "a vent opened when the joint is near full extended to signal the surface by a drop in pressure and a choke that is actuated to raise the pressure when the joint is near full contraction." (*Id.* 10:62-75.) When the telescopic joint extends and the air pressure drops, this signals the motor 218 to lower the drill string. (*Id.* 12:14-29.) As the drill string lowers and the telescopic joint contracts, the vent closes causing the fluid pressure to rise, which deactivates the lowering of the drill string. (*Id.* 12:37-50.)

78. Miller discloses the use of air, gas, oil, or mud as the drilling fluid: "This invention relates to earth drilling and more particularly to apparatus for automatically lowering a drill string as the drill bit progresses down the earth bore. Although especially suited for use in drilling apparatus employing air or other gas as a medium to cool the bit and bring the cuttings to the surface, it may also be used in connection with other drilling apparatus, e.g. a system employing circulating mud to cool the bit and bring the cuttings to the surface." (*Id.* 1:25-36, 13:65-68.) All of the embodiments use air as the drilling fluid. (*See generally* Miller, Ex. 1022.)

79. Miller discloses a drilling fluid pressure sensor in the form of a spring loaded relief valve disposed between the air pipes carrying the drilling fluid. (*Id.* 12:4-50; Figs. 15-16.)

80. Miller discloses a drilling fluid pressure regulator in the form of surfaces control means in Figures 15-16 that sense changes in drilling fluid pressure and output a signal representing those changes. (*Id.* 12:4-50; Figs. 15-16.)

81. Miller discloses a relay coupled to the drilling fluid pressure regulator. The relay is a series of pipes and valves depicted in Figures 5 and 15-16. The relay responds to the output signal of the drilling fluid pressure regulator to supply a drill string control signal at an output thereof. (*Id.* 12:4-50.)

82. Miller discloses a drill string controller in the form of top head drive

motor that controls the release of the drill string: "As the motor 218 drives the cable 220, the rotary drive means 209 is moved up or down raising or lowering the drill string. There is thus provided a vertical positioning means for the drill string." (*Id.* 7:33-36.)

83. Miller discloses that in one embodiment, a decrease in drilling fluid pressure results in an increase in the rate of release of the drill string (with a direct effect at the associated bit): "When the pressure in pipe 450 drops, e.g., a few p.s.i., spring 451 overcomes the pressure acting on piston 452 and the latter moves to the left. As piston 452 moves to the left, piston rod 453 pushes stem 454 of spool valve 455 to the left. This opens port 456 to atmosphere and communicative port 457 with the interior of the body 457' of the spool valve. As a result, fluid from the pipe 458 passes through spool valve 455 to the left side of piston 459 forcing piston rod 460 to the right. Rod 460 is connected to stem 461 (FIGURE 16) of gate valve 462, which is thereby opened. When valve 462 opens, air feeding from pipe 215 through pipe 463 is supplied to valve 464 which is similar to valve 340 shown in FIGURE 11. When valve 464 opens, air is fed through pipe 465 to top head drive motor 218 (FIGURE 5). This lowers the drill string." (*Id.* 12:14-29; Fig. 15.)

84. Conversely, an increase in drilling fluid pressure causes a decrease in the rate of release of the drill string: "When the drill string is lowered enough so

that the telescopic joint approaches fully contraction, the flow constriction means of the joint becomes active and causes a rise in pressure of the drilling fluid. When the line pressure thus rises, e.g., a few p.s.i., the pressure at the left piston 470, fed through pipe 470' overcomes compression spring 471 and moves piston rod 472 to the right. This moves spool valve stem 454 to the right, as shown, opening port 457 to atmosphere and communicating port 456 with line pressure. Piston 459 is thus caused to move to the left, carrying with it stem 461 of gate valve 467, thereby closing valve 462. When pilot valve 462 closes, valve 464 closes and deactivated the vertical positioning means." (*Id.* 12:37-50.)

85. The regulation of the release of the drill string of Miller necessarily has a direct effect at the drill bit in certain situations. If the drill bit is completely "off bottom," both the drill string and the drill bit will lower until the drill bit comes into contact with the bottom of the borehole. Conversely, once the telescoping joint is fully contracted and the lowering of the drill string ceases, this will prevent further driving of the drill bit into the bottom of the borehole.

86. Crake discloses "selecting" (as recited in claim 14) a signal representing changes in bit weight, a signal representing changes in rate of penetration, or both signals. (Crake, Ex. 1015, 5:66-6:26.) It would have been obvious to one of ordinary skill in the art at the time of the '142 invention to include a drilling fluid pressure controller to the control system of Crake based on

the teachings of Miller. Upon addition of a drilling fluid pressure controller to the drill control system of Crake, the system would "select" between a signal generated by the weight controller, the drilling fluid pressure controller, or both in the same manner that Crake already discloses selecting between the signals generated by the weight controller and the speed controller. (*Id.* 5:66-6:26.)

87. Crake discloses that each of the controllers relays a signal to a drill string controller, which regulates the release of the drill string. (*Id.* 5:66-6:26.) Thus, the combined system of Crake and Miller discussed in the preceding paragraph would do the same.

G. Invalidity Based on Le Compte and Crake

88. In my opinion, claim 14 is obvious in view of Le Compte and Crake. The disclosures of Le Compte relevant to the elements of the claims are described in detail below. The disclosures of Crake relevant to the elements of the claims have already been described in detail above.

89. Le Compte discloses a drilling system that automatically regulates the release of the drill string in response to changes in drilling fluid pressure. (Le Compte, Ex. 1023, 1:19-63.) A combination of Crake and Le Compte would result in a drilling system that measures both bit weight and drilling fluid pressure, and automatically regulates the release of the drill string based on changes in these parameters.

90. A person of ordinary skill in the art at the time of the ’142 patent invention would have been motivated to combine the teachings of Crake and Le Compte for the same reason discussed above (i.e., because the automatic bit weight driller disclosed in Crake would not operate properly for directional and horizontal drilling). A person of ordinary skill using the Crake system would have been motivated to add the features of the Le Compte system for use during directional and horizontal drilling to assess when the drill bit is “off bottom.” As indicated in the ’142 patent, automatic bit weight drillers (as taught by Crake) do not operate properly for directional and horizontal drilling. (’142 patent, Ex. 1001, 1:36-50.) It would have been obvious to add the features of Le Compte to the Crake system to determine when the drill bit is “off bottom” during directional and horizontal drilling.

91. A person of ordinary skill would have been motivated to use both bit weight (as in Crake) and drilling fluid pressure (as in Le Compte) to regulate the release of the drill string because the Le Compte system alone does not allow the driller to change the desired amount of bit weight during the drilling process. In the Le Compte system, the only weight applied to the drill bit is the weight of the lower drill string (the portion below the telescopic joint). (Le Compte, Ex. 1023, 2:92-95.) As Le Compte teaches, this is desirable in deep well drilling and while drilling hard earth formations, such as granite. (*Id.* 1:3-18.) However, it would be

desirable to apply a greater weight on bit during the initial drilling process (before the drill progresses too deeply) and while drilling soft earth formations. Therefore, a person of ordinary skill using the Le Compte system would have been motivated to also measure changes in bit weight to regulate the release of the drill string (as taught by Crake) to provide flexibility in the amount of weight applied to the drill bit. A driller using the Le Compte system (without the features of Crake) would have to drill the entire borehole using the same amount of weight on bit (the weight of the lower drill string).

The Disclosures of Le Compte

92. Le Compte discloses a drilling system that automatically regulates the release of the drill string in response to changes in drilling fluid pressure. (Le Compte, Ex. 1023, 1:19-63.) Specifically, Le Compte discloses the use of a telescopic drill stem section that causes a buildup of fluid pressure (mud) as the telescopic section contracts, which causes the release of the drill string to automatically slow down. (*Id.*) As the telescopic section expands, the fluid pressure decreases, causing the release of the drill string to increase. (*Id.* 6:16-30.)

93. Le Compte discloses measuring drilling fluid pressure. The drilling fluid pressure is measured using a slidable valve 84 in contact with a branch of the mud fluid line 82. (*Id.* 5:51-112; 6:16-30; Fig. 15.) As the fluid pressure increases, the mud in the fluid line 82 causes the slidable valve 84 to open to a

greater degree (and vice versa). (*Id.*)

94. Le Compte discloses that the slidable valve 84 opens or closes in response to changes in drilling fluid pressure. (*Id.* 5:51-112; 6:16-30.) The slidable valve 84 dictates how much steam is allowed to pass to the brake controls, and thus the engagement of the brake. (*Id.*) Thus, the "changes" in drilling fluid pressure are indicated by the amount of steam that is allowed to pass to the brake controls. (*Id.*)

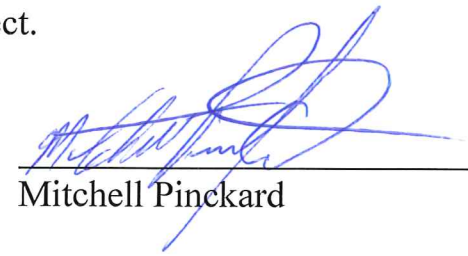
95. Crake discloses "selecting" (as recited in claim 14) a signal representing changes in bit weight, a signal representing changes in rate of penetration, or both signals. (Crake, Ex. 1015, 5:66-6:26.) It would have been obvious to one of ordinary skill in the art at the time of the '142 invention to include a drilling fluid pressure controller to the control system of Crake based on the teachings of Le Compte. Upon addition of a drilling fluid pressure controller to the drill control system of Crake, the system would "select" between a signal generated by the weight controller, the drilling fluid pressure controller, or both in the same manner that Crake already discloses selecting between the signals generated by the weight controller and the speed controller. (*Id.* 5:66-6:26.)

96. Crake discloses that each of the controllers relays a signal to a drill string controller, which regulates the release of the drill string. (*Id.* 5:66-6:26.) Thus, the combined system of Crake and Le Compte discussed in the preceding

paragraph would do the same.

I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct.

Executed on May 3, 2013



Mitchell Pinckard

Mitchell D. Pinckard

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Proven abilities with strong technical and a broad commercial background focused on drilling process optimization for well construction in the energy industry with a track record in new technology R&D, predictive maintenance and project management.
Provides leadership in

- Identifying technology, operational & practical barriers within a process for enterprise, regional and local levels
- Board of Directors, Senior Management, &Special Drilling committee Technical & Operations Advisor
- Developing strategic plan for optimization / Success at local & enterprise levels
- Delivering workable solutions for strategic plan implementation on global level.

Operational experience with all rig types in diverse areas including the North Sea, GOM, South America, Mexico, Spain, Canada, Alaska, Wyoming, Texas and Louisiana from ultra deepwater to mountain tops.

Project Management

Project management experience includes maintenance projects on all rig types from minor component replacement to major modifications for change in class (submersible to self propelled Semi). New concept design experience includes drilling units for rapid deployment, simultaneous operations and ultra deep water well service vessels.

Drilling project experience includes projects from typical well operations to experimental drilling with new technology (including 10,000 psi mud pumps, methane hydrate coring) onshore, offshore and the North Slope.

R&D

A unique perspective ability to breakdown the process and identify the issues has led to a successful career in producing commercially viable solutions with new and innovative technology. The primary focus of the new tools focused on optimizing the drilling process and controlling the risk of well control during operations.

Predictive Maintenance

Prior to focusing my energies on optimization of the drilling process my area of interest was in optimizing the day to day operation of the drilling asset. Developing the procedures required to minimize downtime and maximize the available resources. This included developing manual and computerized preventive maintenance and material acquisition programs.

Education & Training

La Tech in Ruston, La Mechanical Engineering with Aerospace option
Various Short Courses: Okla State University 1977 (Fleet Management); Personnel Supervision and Motivation; Offshore Installation / Drilling Courses.

Research Interests

Operation Process Optimization
Data Mining – High Density Drilling Data
Drilling Process Automation
Real time drilling Instrumentation Data

Professional History:

Fugro Drilling & Well Services Inc.

Business Development Mgr 02/2011 – Present Houston, TX
Developing Ultra Deepwater Well Construction and Intervention Business
Business segment is focused on industry introduction of top hole construction and Coiled Tubing intervention.

VeriDAQ LLC

Founder / CEO 07 / 2004 – Present Houston, TX
Consulting, Instrumentation and drilling automation systems
Designed and constructed on demand:
Mud Logging Units, Drilling Rig Instrumentation, Automatic Drillers
Consulting:
Operations Consultant to Board of Directors at Enterprise and Country Levels
Consultant for Law Firms in SEC and Post Mortem of Well Construction Operations
Optimization of Well Construction
Well Design Optimization and Review for SubSea Wells
Technical Solutions for Remote Area Well Construction Arctic and Sensitive Areas.

Noble Corp

Manager Integrated Technology – NED 1997 – 07 / 2004 Sugar Land, TX
- Directed Drilling Optimization Research
- New Technology & Software Development
- Initially focused on Turnkey Optimization (Triton Engineering)

Systems Manager – Gulf Coast Marine 1993 – 1997 Lafayette, La.
- Fleet Preventive Maintenance – Reduced Downtime from 1.5% to .25%
- Operations & Engineering Management
- Maintenance & Engineering Project Management On site & Shipyard

Western Oceanics

Rig Engineer Various Semi & Jackups 1980 – 1993 Houston, TX

Progressive Drilling
Maintenance Supt – Platform Drilling Units 1979 – 1980 Morgan City, La.

Pre-Energy Industry
Equipment Supt – Construction and Timber 1968 – 1979 Monroe, La

Professional Organizations

Society of Petroleum Engineers
International Society of Automation
Aircraft Owners and Pilots Association

Selected Accomplishments:

Drilling Process Optimization

- Visualized and developed software tools, procedures and process to increase ROP and reduce rotating hours by as much as 50% utilizing techniques to provide the driller with the missing skills.
- Conceived and developed best-of-practice procedures (customized and produced from the drilling plan for the desired rig type). (Published in patents, SPE and IADC articles and versions customized for Noble, Deutag, Gas de France, and Triton with identification of risk exposure to accident and equipment events resulting in lost time)
- Invented the procedure referred to by the industry as real time drill off technique to reduced rotating hours by 30% and published in SPE articles.
- Conceived, designed and developed an automated draw works feed off system for a 50% reduction in rotating hours with continuous feed of the bit at ROP rates of 1 meter / hour and less. (Automatic Driller)

Engineering & Technology

- Conceived, produced and implemented interactive program to optimize rate of penetration dynamically – DrillSmart® (Patented Noble Corp)
- Created Band Brake control system for constant feed of drill line at <1 m Hr Penetration Rates – OptiDrill® (Patented Noble Corp)
- Developed Graphical Tool for Drilling Trend Analysis – DrillGraph® (Patented Noble Corp)
- Conceptualized and Supervised the Development of Real Time Drilling Event Recognition System – (Patented Noble Corp)
- Developed and implemented system to improve operational efficiency in offshore well construction – Noble IDEAS® (Patented Noble Corp).
- Developed and implemented Process to Lower Downtime for Drilling Fleet – From 1.5% of time to <. 25% and increase uptime availability.
- Conceived & Developed Automation strategy for Direction Drilling – Slider® (patented SliderCorp Houston, TX)
- Conceived and prototyped Utility line mapping for trenchless systems (GRI 8405).
- Supervised and Performed High Pressure Drilling (>10,000 Psi Standpipe Pressure) at the Rocky Mountain Oilfield Testing Center.

Marketing & Business Development

- Developed Economic Models for Technology Growth for Noble Engineering & Development (NED – Noble Corp)
- Developed the core technology base for Noble Engineering and Development.
- Developed Real Time Optimization Software Tools to create market niche.
- Developed Real Time Well Control Software Tools to create market niche.
- Development 1Hz Drilling Data enterprise wide real time delivery system.
- Developed and Implemented Tools to Increase Profitability for Turnkey Well Construction – (Triton Engineering)

Granted Patents:

- Methods for optimizing rate of penetration in drilling operations – 6,293,356; 6,192,998; 6,155,357; 6,026,912, 6,382,331
- Method of and system for monitoring drilling parameters – 6,152,246
- Method of and system for increasing drilling efficiency – 6,233,498
- Instrumented cementing plug and system – 6,634,425
- Automated method and system for recognizing well control events – 6,820,702
- Automated method and system for determining the state of well operations and performing process evaluation – 6,892,812
- Method and apparatus for direction drilling – 6,802,378
- System & Method for automatic drilling – 7,044,239