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DRAWINGS ATTACHED

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(54) WELL DRILLING APPARATUS AND METHOD

(71) I, JAMES CLAY STORM, a citizen of the United States of America, of 823 S.Water Street, Apt.2A, Corpus Christi, State of Texas, United States of America, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This application is a divisional of British patent application No. 260/68 (Serial No. 1223431), filed January 2, 1968, and relates to a method and apparatus adapted for the directional drilling of boreholes in the earth, land site or marine locations, for exploratory or producing operations.

In U. S. Patent No. 1,829,304 (1931) to Schroeder there is shown a barge-mounted tilt-table dernick for drilling pile holes over the end of the barge. The dernick is tilted out beyond the end of the barge, and the draw works is in front of, and clear of the tilted dernick. No pipe rack is shown, nor is there any disclosure of a pipe handling device between a pipe rack and the dernick. Due to the position of the draw works, it is clear that a pipe handling device could not be placed in front of, and clear of, the tilted dernick. This disclosed arrangement is quite impractical and unsuited for fast and economic handling of large quantities of pipe between a pipe rack and the dernick, and for minimal size of operating area when a plurality of slant wells are to be drilled.

In U. S. Patent No. 2,792,198 (1957) to Braun there is shown a truck or barge-mounted dernick which can be tilted from one angular position to another through the vertical. A pipe rack is shown, but there is no disclosure of a pipe handling device between the pipe rack and the dernick. Due to the peculiar mounting of the dernick, a pipe handling device could not be placed in front of, and aligned with the plane of tilting of the dernick. This disclosed arrangement likewise is quite impractical and unsuited for fast and economic handling of large quantities of pipe between the pipe rack and the dernick, and for minimal size of operating area when a plurality of slant wells are to be drilled.

In the aforesaid British Patent application (Serial No. 1223431) No. 260/68 there is claimed an apparatus for drilling at a marine or land site a plurality of slanting wells comprising a platform, a dernick structure pivotally mounted on said platform for pivotal movement in a vertical plane about a horizontal axis, pivotal means to pivot said dernick structure about said horizontal axis selectively to an inclined position whereby said dernick structure when in said inclined position drills said slanting wells, a rotary table, and means pivotally mounting said rotary table to said platform for rotation in a vertical plane about the same horizontal axis as the dernick structure, the rotary table having an operating aperture therethrough, the said horizontal axis intersecting the longitudinal axis of the operating aperture, the drilling axis of the dernick structure being in alignment with the longitudinal axis of the operating aperture of the rotary table when the drilling axis and the longitudinal axis are parallel.

In British application (serial No. 1223432) No. 48255/69 which is another divisional application to the aforesaid British patent application (Serial No. 1223431) No. 260/68, there is claimed a method of drilling wells from a plurality of drilling stations spaced around the perimeter of an operating platform comprising, positioning a dernick structure on the operating platform at one of the drilling stations, positioning a draw works at the drilling station outboard of the dernick structure, positioning a pipe rack in the central portion of the operating platform inboard of the dernick structure, drilling a well at the drilling station, shifting the dernick structure, sequentially to each of the drilling stations, shifting the draw works to the next sequential drilling station and positioning the draw works outboard of the dernick structure, reorienting the pipe rack relative to the dernick structure while maintaining the pipe rack in the central portion of the operat-

ing platform and drilling a well at each of the drilling stations.

In the aforesaid divisional application no. (Serial No. 1223432) 48255/69 there is also claimed an apparatus for carrying out the method of drilling wells from a plurality of drilling stations comprising an operating platform, a plurality of openings in the operating platform, each opening constituting a drilling station, the openings being spaced around the perimeter of the operating platform, a derrick structure movably mounted on the operating platform and adapted to be shifted from one drilling station to another drilling station to drill through the openings in sequence, a pipe rack associated with the derrick structure and mounted in the central portion of the operating platform, inboard of the derrick structure when the derrick structure is drilling through any of the openings and a draw works for operating the derrick structure, the draw works being movably mounted on the operating platform and adapted to be shifted from one drilling station to another drilling station, the draw works being located outboard of the derrick structure when the derrick structure is drilling through any of the openings.

According to the present invention there is provided a method of drilling at a marine or land site a plurality of slanting wells having a predetermined inclination to the horizontal and having a predetermined orientation with respect to each other, comprising fabricating a platform with a plurality of guide tubes, each guide tube corresponding in inclination to the horizontal and orientation with one of the wells to be drilled, transporting the platform to the site, orienting and establishing the platform at the site so that the axis of each guide tube registers with the axis of one of the wells to be drilled, driving conductor casings through the guide tubes into the site floor and drilling the wells through the conductor casings.

Also according to the present invention there is provided an apparatus for carrying out the method of drilling at a marine or land site a plurality of slanting wells comprising a platform adapted to be transported to and established at the site, a plurality of guide tubes mounted to the platform, each guide tube being adapted to correspond in inclination to the horizontal and orientation with one of the wells to be drilled, a conductor casing for each of the guide tubes and adapted to be driven through the guide tube into the site floor, and a derrick structure mounted on the platform and adapted to drill through each of the conductor casings into the site floor.

In order that the disclosure will be more fully understood and readily carried into effect, the following detailed description is given with reference to the accompanying drawings in which:

Figure 1 represents a view in elevation of the drilling derrick operating in tilted position on a platform in a marine location through one of several conductor casings, the phantom lines showing the derrick in vertical position;

Figure 2 represents a view in elevation taken at right angles to Figure 1 with the pipe handling device omitted;

Figure 3 represents a series of diagrammatic views in plan of the operating deck of the platform of Figures 1 and 2, showing a sequence of positions of the drilling derrick and the pipe handling device and pipe rack, for drilling a number of wells from the platform; specifically, a vertical well and eight slanting or directional wells;

Figure 4 represents a view in front elevation of the derrick in vertical position, showing the swivel hooked to the traveling block;

Figure 5 represents a view in side elevation of the derrick, taken from the left of Figure 4, the traveling block and swivel being omitted for purposes of clarity;

Figure 6 represents a section in elevation of the derrick, taken along the line 6—6 of Figure 4;

Figure 7 represents a section in plan taken along the line 7—7 of Figure 4;

Figure 8 represents a view in side elevation, partially in section, of the derrick in tilted position and the pipe handling device with a length of pipe being lowered onto the pipe handling device;

Figure 9 represents a view in side elevation of the lower portion of the derrick showing a pipe supporting arm in operative position to support a length of pipe which is free at its lower end, the phantom lines indicating the position of the pipe supporting arm when in inoperative position;

Figure 10 represents a view in front elevation of the pipe supporting arm;

Figure 11 represents a partial view in front elevation of the derrick, generally similar to Figure 4, showing the pipe elevator hooked to the traveling block;

Figure 12 represents a view in side elevation of the pipe handling device in fully extended position;

Figure 13 represents a view in side elevation of the pipe handling device in fully collapsed position; and

Figure 14 represents a view in end elevation of the pipe handling device in extended position.

The preferred embodiment of the invention is shown in the accompanying drawings in a marine environment (although it will be understood that the invention is also contemplated as being applicable to non-marine environments.)

Platform 1 for supporting the drilling equipment is seen as comprising tubular legs 2 receiving piles 3 driven into marine floor 4, with suitable cross-bracing 5, some of which is shown.

Vertical members 6 are secured to legs 2

and extend upwardly therefrom to support upper deck 7. Below upper deck 7 are mounted second deck 8 and third deck 9, all above the surface of the water 10.

Guide tubes 11 are suitably mounted to platform 1, each of said guide tubes 11 corresponding in angle and direction to one of the boreholes or wells to be drilled in marine floor 4. Not all of the bracing 5 may be shown in the drawings, to avoid confusion.

Extending through the guide tubes 11 and driven into the marine floor 4, are a number of conductor casings 11a. Each conductor casing 11a stands therefore at the desired angle and direction in which one borehole or well is to be drilled. This is a departure from the conventional practice of drilling vertically and then "shipstocking" to secure the desired directional borehole. In the arrangement herein disclosed, as seen in Figure 3, there would be eight slanted conductor casings 11a and one vertical conductor casing 11a whereby nine wells can be drilled from this equipment. Only a few of these conductor casings 11a and their respective guide tubes 11 have been shown in the drawings, to avoid confusion.

Skid unit 12 is movably mounted to upper deck 7, and can be shifted from one station to another on the said upper deck 7. Skid unit 12 supports derrick 13, rotary table 14 and draw works 15. Pipe handling device 16 associated therewith can be supported partially on skid unit 12 and partially on a stand 16a of the same height above upper deck 7 as skid unit 12, in front of derrick 13 and with one end thereof close to rotary table 14 as shown, or can be supported completely in front of skid unit 12 and flat on upper deck 7.

Referring now to the derrick 13, it will be seen that the same comprises forward and rear main structural elements 17 and 18, respectively, with bracing elements 19 extending between and secured to the rear main structural elements 18, and with bracing elements 20 extending between and secured to the forward and rear main structural elements 17 and 18. The front face 21 of derrick 13 has, between forward main structural elements 17, a longitudinally extending guideway 22 bounded by inwardly facing parallel channels 23 providing trackways as will hereinafter be described, the said channels 23 being secured to their respective forward main structural elements 17 by means of braces 24, and to the bracing elements 19 rearwardly thereof by means of braces 25.

Rear main structural elements 18 are, for the major portion of their lengths, generally parallel to forward main structural elements 17. The topmost and bottommost portions of rear main structural elements 18 are inclined toward forward main structural elements 17 as best shown in Figures 5 and 6.

At the bottom of derrick 13, at the junctures of forward and rear main structural elements 17 and 18, are bearings 26 receiving axles or pivot pins 27, the said axles or pivot pins 27 being rotatably supported in brackets 28 secured to skid unit 12. In this manner, derrick 13 is tiltably mounted to skid unit 12 and is capable of assuming a vertical position or a slanting position at an angle to the vertical.

On each side of skid unit 12, a hydraulic ram 29 is pivotally supported on a leg 30 secured to the skid unit 12, and the top of the hydraulic ram 29 is pivotally connected to one of the rear main structural elements of derrick 13. It will be apparent that when the hydraulic rams 29 are operated, by conventional hydraulic systems (not shown), the angle of the derrick 13 may be adjusted as desired. Various stiff legs or braces 31, 32 and 33, adjustable or non-adjustable depending upon whether the derrick 13 is to be operated at one or several inclinations at a particular location, may be secured to the skid unit 12 and derrick 13 after the derrick 13 has been set at the desired inclination, to permit the hydraulic rams 29 to be relieved of pressure therein if desired. One of these braces 31 is shown in Figure 5, in which figure the derrick 13 has been indicated for convenience as vertical, and Figure 8 shows the three sets of braces 31, 32 and 33 employed with the derrick 13 when in inclined position. Guy lines 34 extending between skid unit 12 and the top of derrick 13 are also used to brace the derrick 13 when in vertical or inclined position.

Crown block 35 is mounted to the top of derrick 13. Traveling block 36 is provided with wheels 37 riding in channels 23, whereby motion of said traveling block 36 is constrained to longitudinal movement relative to derrick 13 within longitudinal guideway 22 regardless of the inclination of said derrick 13. Movement of traveling block 36 within longitudinal guideway 22 is controlled by means of lines 38 passing over crown block 35 and connected to a drum on draw works 15. Pivotally secured to the bottom of traveling block 36 are hook eyes 39 for a purpose which will hereinafter be described. The conventional swivel 40 employed in rotary drilling operations is provided with wheels 41 adapted to ride in channels 23, whereby motion of said swivel 40 is constrained to longitudinal movement relative to derrick 13 within longitudinal guideway 22 regardless of the inclination of said derrick 13. Swivel 40 is provided with hooks 42 adapted to be removably engaged in hook eyes 39 of traveling block 36. The conventional mud line 43 communicates between a mud tank (not shown) and the swivel 40 in the well-known manner. Kelly 44 is connected to swivel 40 and is adapted to extend through drive bushings 45 in rotary table 14.

It will be noted that portions of the front flanges of channels 23 have been removed to provide openings 100 in the said channels 23. These openings 100 are of length somewhat

greater than the diameters of wheels 41, and are at an elevation such that, when swivel 40 has been raised to place wheels 41 adjacent said openings 100, the bottom of kelly 44 will clear the operating area on the skid unit 12. Along one side of longitudinally extending guideway 22, a pair of lugs 101 is secured to braces 24, and these lugs 101 are perforated to receive a tubular element 102, the said tubular element 102 being fixed to the said lugs 101. Tubular collar 103 is loosely mounted concentrically about tubular element 102, between lugs 101, and is therefore free to rotate but is fixed longitudinally. Arm 104 is rigidly secured to tubular collar 103, and is braced thereto by means of brace 105. The end of arm 104 has an upstanding pin element 106. Bracket 107, secured to swivel 40, is provided with one or more perforations 108 adapted to receive pin element 106. The elevation of arm 104 and pin element 106, the elevation of openings 100, the length of openings 100, and the length of arm 104 are so related that, when wheels 41 have been raised adjacent the upper portions of openings 100, arm 104 can be rotated from inoperative position (as shown in Figure 4) to a position just under bracket 107 with pin element 106 below a perforation 108, and when swivel 40 has been lowered to seat perforation 108 around pin element 106 and rest bracket 107 on arm 104, wheels 41 will clear the bottoms of openings 100.

Thus, when it is desired to remove swivel 40 and kelly 44 from derrick 13, traveling block 36 is raised to bring wheels 41 adjacent the upper portions of openings 100. Arm 104 is swung from inoperative position to a position beneath bracket 107, with pin element 106 registering with a perforation 108, and traveling block 36 is lowered so that bracket 107 rests on arm 104 with pin element 106 in perforation 108. The weight of the swivel 40 and kelly 44 now being supported on arm 104, hooks 42 are then disengaged from hook eyes 39. Arm 104 is swung away from longitudinally extending guideway 22, carrying with it swivel 40 and kelly 44 to one side of the derrick 13 where the same may be stored until again needed.

When it is desired to reintroduce swivel 40 and kelly 44, the operations above described are reversed.

Any means may be employed to rotate arm 104 and tubular collar 103 about tubular element 102. In the preferred embodiment, a hydraulic cylinder is employed. This hydraulic cylinder has been omitted from the drawings to avoid excessive and unnecessary detail which would obfuscate the said drawings.

A pipe elevator 46 with bowl 47 adapted to receive drill pipe 48 and containing conventional slips (not shown) to support the drill pipe 48 from the said pipe elevator 46, is provided with wheels 49 adapted to ride in channels 23, whereby motion of said pipe elevator 46 is constrained to longitudinal movement relative to derrick 13 within longitudinal guideway 22 regardless of the inclination of said derrick 13. Pipe elevator 46 is provided with hooks 50 adapted to be removably engaged in hook eyes 39 of traveling block 36.

Rotary table 14, indicated diagrammatically only in the several figures, is mounted for support in a base 14a. Base 14a, also indicated only diagrammatically, is pivotally mounted in brackets 51 secured to skid unit 12. It is to be particularly noted that the axis 52 about which the base 14a (and therefore rotary table 14) is mounted is the same axis about which derrick 13 is mounted to skid unit 12, and that axis 52 intersects the longitudinal (i.e., vertical) axis of the opening or operating aperture of rotary table 14. Because of this geometrical relationship, the angular relationship of the derrick 13 with skid unit 12 can be duplicated by the angular relationship of rotary table 14 with skid unit 12, and the opening in the said rotary table 14 can therefore always register with the drilling axis of the derrick 13, and thus be in proper alignment to receive kelly 44 or drill pipe 48. Rotary table 14 is driven from a power takeoff of draw works 15 in a conventional manner. It will be understood that skid unit 12 is provided with opening 53 between brackets 51 sufficiently large to permit the desired tilting of the base 14a. As shown in some of the figures, a guard 54 is mounted to skid unit 12 between the rotary table 14 and pipe handling device 16 for reasons of safety.

A baffle 55 is secured to bracing elements 19 of derrick 13, as shown particularly in Figures 4 and 7, to prevent damage to draw works 15 by falling tools when derrick 13 is inclined over the said draw works 15.

It will be recognized that there are times, when derrick 13 is tilted, that sections of drill pipe 48, or even kelly 44, will be supported at their upper ends only. Due to the action of gravity, the said sections of drill pipe 48 or the kelly 44 will tend to assume a vertical position and, in so doing, may damage, or be damaged by, portions of the derrick structure, or might otherwise interfere with operations. To maintain these sections of drill pipe 48 or the kelly 44 in alignment with derrick 13, regardless of the degree of tilt, supporting arm 56 is provided. As shown in Figures 9 and 10, one end of supporting arm 56 is pivotally mounted by means of pin 57 passing therethrough and through brackets 58, to strap 59 fastened across the rear of derrick 13 at a suitable elevation adjacent the lower end thereof. The free end of supporting arm 56 is provided with a fork 60 adapted to cradle drill pipe 48 or kelly 44. A hydraulic ram 61 is pivotally mounted at one end to the rear of the derrick structure below brackets 58, as shown in Figure 9, and the other end is pivotally mount-

ed to supporting arm 56, immediately behind fork 60. It will be seen that supporting arm 56 can be raised from the inoperative position shown in phantom in Figure 9 to the operative position therein shown in solid lines by pressurizing the hydraulic ram 61.

Derrick 13 is provided with a folding walkway 62 pivotally mounted to forward main structural elements 17 and maintained in position by guy wires 63 fastened between the unhinged end of folding walkway 62 and the top of derrick 13.

Pipe handling device 16 comprises a base 64 wide enough for stability and resting partially on skid unit 12 with one end close to guard 54, and partially on stand 16a having a top surface even with the top surface of skid unit 12, with V-shaped cradle 65, and parallel links 66 on each side of base 64 and cradle 65 pivotally mounted to the said base 64 by means of pins 67, and to the said cradle 65 by means of pins 68. It will be seen that cradle 65 is capable of being raised upwardly and simultaneously shifted laterally towards rotary table 14, and vice versa, as shown by the arrows in Figures 12 and 13. Approximately in the center of pipe handling device 16, a hydraulic ram 69 is interposed between base 64 and cradle 65. The hydraulic cylinder 70 of ram 69 is pivotally mounted to base 64 by means of pin 71 passing through brackets 72 secured to base 64 and passing through ear 73 on the cylinder 70. The piston rod 74 of ram 69 is pivotally mounted to cradle 65 by means of pin 75 passing through an aperture in the piston rod 74 and through brackets 76 secured to the cradle 65. The longitudinal axis of ram 69, when pipe handling device 16 is fully collapsed as shown in Figure 13, is preferably at a slight angle to the horizontal, to minimize the force initially required to open and extend the pipe handling device. Pipe supports 77 are mounted in cradle 65 on rollers 78, whereby the said pipe supports 77 are freely movable in said cradle 65 longitudinally of the pipe handling device 16. It will be particularly noted that the longitudinal axis of pipe handling device 16 (viz., the center of cradle 65) is in line with the plane in which the longitudinal centerline of derrick 13 is rotated as the said derrick is tilted from the vertical. Therefore, regardless of the angle at which derrick 13 is set for drilling, drill pipe 48 can always be removed from, or passed to the said derrick 13 in a straight line.

Hydraulic lines 79 and 80 communicate between both ends of hydraulic cylinder 70 and a remote source of pressurized hydraulic fluid (not shown) and are controlled by a remotely situated control valve (not shown) whereby the degree of extension of hydraulic ram 69, and hence the elevation of cradle 65, can be closely controlled and stopped at any desired point.

Means to rack pipe 48 may be positioned to either or both sides of pipe handling device. As shown in Figure 3, the pipe rack, indicated diagrammatically as 81, in the particular arrangement herein disclosed, is located to one side only of the pipe handling device.

The operation of the preferred embodiment of the invention will now be described.

It will be assumed that one vertical well and eight slanted or directional wells are to be drilled in a marine environment. (It will be understood, of course, that more than eight directional wells can be drilled). Platform 1, with guide tubes 11, is properly oriented and established on location.

It will be noted that the tops of guide tubes 11 terminate above third deck 9 and below second deck 8, and that there are flared mouths 82 on top of guide tubes 11 above third deck 9. Conductor casings 11a are now inserted into guide tubes 11, the flared mouths 82 facilitating entry thereof, and the conductor casings 11a are driven into marine floor 4 as shown. Second deck 8 is intended to support such equipment as mud pumps, mud tanks, water tanks and the like (not shown), and this equipment may now be placed on said second deck 8. The conventional "Christmas trees" (not shown) for well control are intended to be installed and maintained from the level of third deck 9 (or as desired by the operator) upon completion of wells.

Drilling equipment, comprising derrick 13, rotary table 14 and draw works 15 mounted on skid unit 12, pipe handling device 16, and crane 83 are now placed on upper deck 7. Other auxiliary equipment (not shown) such as bulk cement storage tanks, a logging unit, fuel tanks and the like are also placed on upper deck 7.

The actual drilling operations are now ready to take place. It will be noted that upper deck 7 has a number of openings therethrough, each aligned with the longitudinal axis of one of the conductor casings 11a. These openings are indicated diagrammatically by the letters "A", "B", "C", "D", "E", "F", "G", "H", and "I" in Figure 3. The plan of operation is to drill through the central opening A and the vertical conductor casing 11a first, as shown in Figure 3a, derrick 13 being vertical of course. Skid unit 12 is shifted to the proper position to align the opening in rotary table 14 over opening A, and pipe handling device 16 and stand 16a are set up in front of, and aligned with derrick 13. In Figure 3a, "84" represents the longitudinal center line of pipe handling device 16, and this line passes through the center of the opening in rotary table 14 and through the center of derrick 13 (i.e., through the drilling axis of derrick 13.) The numeral "85" represents an axis of the opening in rotary table 14 perpendicular to line 84. Pipe rack 81 is set up to one side of pipe handling device 16. The rectangle 86 represents diagrammatically the horizontal extent of skid unit 12, and the nu-

meral 87 represents diagrammatically the area required for operations with pipe handling device 16 and pipe rack 81. In the drilling operation, pipe 48 from pipe rack 81 is readily shifted to pipe supports 77 of pipe handling device 16 and rolled toward derrick 13 where it is added to the upper string when "making hole". Conversely, pipe 48 is readily moved from the derrick 13 to pipe supports 77 of pipe handling device 16 and rolled toward pipe rack 81, when "making a trip" (i.e., when removing and breaking down the drill pipe string to replace a drill bit.) The actual operations at the derrick will be described further on. After completion of drilling operations through opening A, the "Christmas tree" is installed from the level of third deck 9.

The next well to be drilled in sequence is that through conductor casing 11a registering with opening B. Skid unit 12 is shifted to the position shown in Figure 3b, with centerlines 84 and 85 aligned with the center of opening B. Derrick 13 and base 14a supporting rotary table 14 are tilted to the proper angle to align the drilling axis of derrick 13 and the longitudinal axis of the operating aperture of rotary 14 with the longitudinal axis of the corresponding conductor casing 11a, it being noted that the draw works 15 is adjacent the edge of upper deck 7 and that derrick 13 is inclined backwardly and away from the center of upper deck 7. It will also be noted that pipe rack 81 is approximately in the center of upper deck 7. After pipe handling device 16 and 16a have been placed in front of derrick 13, and pipe 48 stored on pipe rack 81, the drilling operation proceeds, the string of drill pipe 48 being made up and broken down as required. Upon completion of the well, and installation of the "Christmas tree" at the level of third deck 9, the skid unit 12 is positioned over opening C as shown in Figure 3c, and the operations described in connection with Figure 3b are repeated. The sequence of drilling proceed clockwise through the remainder of the openings D through I, as shown in Figures 3d through 3i. It will be particularly noted that in drilling the slanted or directional wells through openings B through I, as shown in Figures 3b through 3i, the pipe rack 81 is always approximately in the center of upper deck 7, and that in setting up the drill pipe 48 after completion of one slanted well and prior to drilling the next slanted well, substantially only the alignment of the pipe 48 must be changed, with a slight shifting or translation of the pipe 48. When it is realized that thousands of feet of pipe 48 are ordinarily used in drilling a well, and that all of this pipe 48 may be on pipe rack 81 after completion of one well and prior to starting drilling of the next well, it should be appreciated that this minimal handling of pipe between drilling stations affords a very considerable saving in the drilling operation. It should also be apparent from an inspection of Figures 3a through 3i that the particular arrangement of drilling equipment, with draw works 15 outboard derrick 13, with derrick 13 slanted backwardly and away from the center of upper deck 7, and with the pipe rack 81 always approximately in the center of upper deck 7 (except when drilling through opening A), the area required for upper deck 7 is minimal. This, of course, affords a considerable saving in construction costs of platform 1.

In the actual drilling operating at a particular drilling station on upper deck 7, swivel 40 is hooked to traveling block 36, and drilling proceeds in the customary manner.

Let it now be assumed that it becomes necessary to replace the drill bit at the bottom of the drill string in the course of drilling a directional or slanted well. This means that all of the drill pipe 48 must be removed from the hole. The traveling block 36 is raised to bring wheels 41 of swivel 40 adjacent the upper portion of openings 100, and arm 104 is swung under bracket 107 to register pin element 106 with a perforation 108. Traveling block 36 is lowered slightly to transfer the weight of the swivel 40 and kelly 44 to arm 104, swivel 40 is unhooked from traveling block 36, and arm 104 is swung to the side of the derrick 13, carrying swivel 40 and kelly 44 away, all as hereinbefore described. Traveling block 36 is then lowered, and pipe elevator 45 hooked thereto, the wheels 49 being introduced into channels 23 from the bottoms thereof. In this connection, it will be observed that channels 23 are flared at their bottoms to facilitate entry. Pipe elevator 45, now being connected to traveling block 36, is placed over the top of the drill string in the well, slips in the pipe elevator 45 are set and the pipe elevator 45 is raised to withdraw a portion of the drill string. Usually, several sections of connected pipe 48 are thus raised above rotary table 14, and the bottom end thereof unscrewed from the remaining drill string which is held suspended by means of slips in the customary manner. In this regard, it should be noted that the top of the drill string must be centered in the rotary opening in order that the slips can be properly set. In slant or directional drilling, the top of the drill string will not be centered but will be adjacent the low side of the rotary opening, and must therefore be pushed to the center of the rotary opening. This can be done by means of a hydraulic cylinder mounted in the skid unit 12 below the rotary table 14, the end of the piston rod having a roller adapted to contact and push the top of the drill string to a central position in the rotary opening when the hydraulic cylinder is pressurized. Prior to the operation of disconnecting the sections of pipe 48 from the remaining drill string, supporting arm 56 is extended so that fork 60 engages the lower

portion of the sections of pipe 48, thus preventing the same from swinging to the vertical when disconnection is complete. In Figure 8, I show three connected sections of drill pipe 48 being handled as one piece (called a "thribble"). Pipe handling device 16 is in fully extended position, and pipe supports 77 are all adjacent rotary table 14. The bottom of the thribble is pushed away from derrick 13, if desired with the aid of a hydraulic cylinder (not shown) interposed between the derrick 13 and the bottom of the thribble, and is placed on that pipe support 77 furthest from rotary table 14, and pipe elevator 46 is lowered (see Figure 8). Derrick 13 being in tilted position, the bottom of the thribble will move to the right in Figure 8, supported on pipe support 77, and pipe elevator 46 is lowered further until the upper portion of the thribble rests on a pipe support 77. In this operation, it may be necessary to let pipe elevator 46 leave channels 23 temporarily to bed the upper portion of the thribble on the pipe support 77. The thribble, now being in horizontal position on pipe supports 77, is moved away from derrick 13 toward pipe rack 81 and, simultaneously, hydraulic ram 69 may be operated to collapse pipe handling device 16 to the extent that the thribble is on the approximate level of the said pipe rack 81. The thribble may now be lifted from pipe supports 77 and shifted laterally to the pipe rack 81. Pipe elevator 46 is again placed over the top of the drill string and this operation repeated until the entire drill string has been broken down into sections (thribbles, as herein disclosed) and racked on pipe rack 81.

Let it now be assumed that the drill bit has been replaced. It is now required to reinstall the string of drill pipe 48 in the well before further drilling operations are commenced. The procedure outlined in the preceding paragraph is reversed, the thribbles being shifted laterally from pipe rack 81 to pipe supports 77 on collapsed pipe handling device 16, and then moved toward derrick 13 while pipe handling device 16 is being extended. Pipe elevator 46 is lowered and connected to one end of the thribble (if necessary, being temporarily removed from channels 23) and raised, drawing the thribble of drill pipe 48 upwardly into the derrick 13. Supporting arm 56 is extended to hold the thribble on the drilling axis of the derrick 13 until the lower end of the thribble is connected to the drill string held suspended in the well. Pipe elevator 46 is lowered, lowering the thribble and connected drill string, and the same is resuspended in the conventional manner. Pipe elevator 46 is disengaged form the drill string, and this procedure is repeated until the drill string has been completely made up.

It will be understood that, when derrick 13 is in vertical position, drilling a vertical well, the drill pipe 48 is racked upright in a conventional manner, there being no necessity to lay the drill pipe 48 down as is required for slant or directional wells as hereinbefore described.

Drilling operations are now ready to be resumed. Traveling block 36 is lowered to permit the wheels 49 of pipe elevator 46 to clear the bottoms of channels 23. Pipe elevator 46 is then unhooked from traveling block 36 and stored in a convenient place. Traveling block 36 is then raised to a position above openings 100. Arm 104, carrying the swivel 40, kelly 44 and drive bushing 45, is swung toward the longitudinally extending guideway 22, and wheels 41 are introduced through openings 100. Hooks 42 are engaged in hook eyes 39, the elevation of traveling block 36 being suitably adjusted for this purpose. Traveling block 36 is then raised to support the weight of the swivel 40, kelly 44 and drive bushing 45 and to free bracket 107 from pin element 106. Arm 104 is then swung away to the side of the derrick 13. Connection of the kelly 44 to the drill pipe 48 is made and drilling operations can begin as hereinbefore described.

WHAT WE CLAIM IS:—

1. A method of drilling at a marine or land site a plurality of slanting wells, said wells having a predetermined inclination to the horizontal and having a predetermined orientation with respect to each other, comprising fabricating a platform with a plurality of guide tubes, each guide tube corresponding in inclination to the horizontal and orientation with one of said wells to be drilled, transporting said platform to the site, orienting and establishing said platform at the site so that the axis of each guide tube registers with the axis of one of said wells to be drilled, driving conductor casings through the guide tubes into the site floor and drilling said wells through said conductor casings.

2. The method of drilling at a marine or land site according to claim 1, further including mounting a derrick having a drilling axis on said platform, and tilting said derrick to align the drilling axis thereof with the axis of each of said conductor casings in sequence and drilling said wells through said conductor casings in sequence.

3. Apparatus for carrying out the method of drilling at a marine or land site according to claim 1 or 2, comprising, a platform adapted to be transported to and established at the site, a plurality of guide tubes mounted to the platform, each guide tube being adapted to correspond in inclination to the horizontal and orientation with one of said wells to be drilled, a conductor casing for each of said guide tubes and adapted to be driven through the guide tube into the site floor, and a derrick structure mounted on the platform and adapted to drill through each of said conductor casings into the site floor.

portion of the sections of pipe 48, thus preventing the same from swinging to the vertical when disconnection is complete. In Figure 8, I show three connected sections of drill pipe 48 being handled as one piece (called a "thribble"). Pipe handling device 16 is in fully extended position, and pipe supports 77 are all adjacent rotary table 14. The bottom of the thribble is pushed away from derrick 13, if desired with the aid of a hydraulic cylinder (not shown) interposed between the derrick 13 and the bottom of the thribble, and is placed on that pipe support 77 furthest from rotary table 14, and pipe elevator 46 is lowered (see Figure 8). Derrick 13 being in tilted position, the bottom of the thribble will move to the right in Figure 8, supported on pipe support 77, and pipe elevator 46 is lowered further until the upper portion of the thribble rests on a pipe support 77. In this operation, it may be necessary to let pipe elevator 46 leave channels 23 temporarily to bed the upper portion of the thribble on the pipe support 77. The thribble, now being in horizontal position on pipe supports 77, is moved away from derrick 13 toward pipe rack 81 and, simultaneously, hydraulic ram 69 may be operated to collapse pipe handling device 16 to the extent that the thribble is on the approximate level of the said pipe rack 81. The thribble may now be lifted from pipe supports 77 and shifted laterally to the pipe rack 81. Pipe elevator 46 is again placed over the top of the drill string and this operation repeated until the entire drill string has been broken down into sections (thribbles, as herein disclosed) and racked on pipe rack 81.

Let it now be assumed that the drill bit has been replaced. It is now required to reinstall the string of drill pipe 48 in the well before further drilling operations are commenced. The procedure outlined in the preceding paragraph is reversed, the thribbles being shifted laterally from pipe rack 81 to pipe supports 77 on collapsed pipe handling device 16, and then moved toward derrick 13 while pipe handling device 16 is being extended. Pipe elevator 46 is lowered and connected to one end of the thribble (if necessary, being temporarily removed from channels 23) and raised, drawing the thribble of drill pipe 48 upwardly into the derrick 13. Supporting arm 56 is extended to hold the thribble on the drilling axis of the derrick 13 until the lower end of the thribble is connected to the drill string held suspended in the well. Pipe elevator 46 is lowered, lowering the thribble and connected drill string, and the same is resuspended in the conventional manner. Pipe elevator 46 is disengaged form the drill string, and this procedure is repeated until the drill string has been completely made up.

It will be understood that, when derrick 13 is in vertical position, drilling a vertical well, the drill pipe 48 is racked upright in a conventional manner, there being no necessity to lay the drill pipe 48 down as is required for slant or directional wells as hereinbefore described.

Drilling operations are now ready to be resumed. Traveling block 36 is lowered to permit the wheels 49 of pipe elevator 46 to clear the bottoms of channels 23. Pipe elevator 46 is then unhooked from traveling block 36 and stored in a convenient place. Traveling block 36 is then raised to a position above openings 100. Arm 104, carrying the swivel 40, kelly 44 and drive bushing 45, is swung toward the longitudinally extending guideway 22, and wheels 41 are introduced through openings 100. Hooks 42 are engaged in hook eyes 39, the elevation of traveling block 36 being suitably adjusted for this purpose. Traveling block 36 is then raised to support the weight of the swivel 40, kelly 44 and drive bushing 45 and to free bracket 107 from pin element 106. Arm 104 is then swung away to the side of the derrick 13. Connection of the kelly 44 to the drill pipe 48 is made and drilling operations can begin as hereinbefore described.

WHAT WE CLAIM IS:—

1. A method of drilling at a marine or land site a plurality of slanting wells, said wells having a predetermined inclination to the horizontal and having a predetermined orientation with respect to each other, comprising fabricating a platform with a plurality of guide tubes, each guide tube corresponding in inclination to the horizontal and orientation with one of said wells to be drilled, transporting said platform to the site, orienting and establishing said platform at the site so that the axis of each guide tube registers with the axis of one of said wells to be drilled, driving conductor casings through the guide tubes into the site floor and drilling said wells through said conductor casings.

2. The method of drilling at a marine or land site according to claim 1, further including mounting a derrick having a drilling axis on said platform, and tilting said derrick to align the drilling axis thereof with the axis of each of said conductor casings in sequence and drilling said wells through said conductor casings in sequence.

3. Apparatus for carrying out the method of drilling at a marine or land site according to claim 1 or 2, comprising, a platform adapted to be transported to and established at the site, a plurality of guide tubes mounted to the platform, each guide tube being adapted to correspond in inclination to the horizontal and orientation with one of said wells to be drilled, a conductor casing for each of said guide tubes and adapted to be driven through the guide tube into the site floor, and a derrick structure mounted on the platform and adapted to drill through each of said conductor casings into the site floor.

4. The method of drilling at a marine or land site substantially as hereinbefore described.

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