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(54) DIVERTED CONDUCTOR DRIVING SYSTEMS FOR THE DRILLING OF WELLS

(71) We, GURTLER, HERBERT AND CO. INC., a Corporation organised under the laws of the State of Louisiana, United States of America, of P.O Box 13807, New Orleans, State of Louisiana, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to the drilling of wells, and is particularly concerned with a method and apparatus for the emplacement of a conductor casing at a desired angle or curve and orientation from an offshore platform in order to facilitate directional drilling of a well in the substratum of an offshore well site.

The reasons for directional drilling of a hydrocarbon producing well are well-known For instance, in connection with offshore production, it is the usual practice to place a stationary platform in a desired location for the optimum production of substrate hydrocarbons. From this stationary platform a number of wells are drilled.

Obviously, because of the size und location of the hydrocarbon deposits, it is necessary to penetrate the substrata at various locations according to the geological formations available for production. In order to obtain maximum production from a given platform with a number of well locations, it is necessary to drill into the substrate at various predetermined depths and orientations.

However, the initial step in the drilling process includes the installation of a surface casing which is normally a steel pipe of relatively large diameter. In the case of offshore drilling, this surface casing is commonly called the "conductor pipe". This portion of the casing system through which the well is drilled provides the so-called "hole in the water through which the remaining smaller casing and the drill string can be installed. The primary function of this conductor pipe is to provide the "hole in the water" as mentioned as well as a seal below the surface of the seabed or "mudline" to a predetermined depth according to the requirements of the conditions encountered.

Normally, the conductor pipe is installed to a depth of from 100' to 300' below the mudline or sea bottom. After the installation of the conductor pipe the remaining smaller casings are placed through this pipe to the desired depth and the well is drilled by means of a drill string through the series of casings.

In order to achieve a specific direction or orientation of the drill string, a number of techniques have been developed for diverting or orienting the drill string. In the usual pipe conductor, the conductor is installed in a more or less true vertical position due to the standard techniques of installation of such conductors. All directional drilling or diverted work is done below the bottom of the pipe conductor.

However, it has recently been determined that there are certain advantages to orienting the conductor pipe in a given direction by means of curving or bending the conductor below the mudline in such a manner as to orient the drilling operation towards a given location as it leaves the end of the conductor. By this means a number of advantages are gained. It is possible to reach shallower hydrocarbon formations than can be reached by diverting the drilling operation after leaving a straight vertical conductor pipe and greater dispersion of drilling operations can be achieved from a central signal platform location. This method can also be used to avoid conflicts with previously installed conductor pipes or operating wells on an existing platform.

According to the invention, there is provided a method of providing a diverted conductor system at a site in an offshore body of water for enabling directional drilling of a well, said method comprising

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providing an open ended conductor casing, securing an open ended section of casing to the distal end of the conductor casing, the axis of said open ended section being inclined with respect to the axis of the adjacent part of said casing to produce an angularly offset portion of said casing extending laterally beyond one side of the outer circumference of the adjoining portion of the conductor casing; setting said conductor down through vertically aligned guides until the mudline is reached, while maintaining or positioning the angularly offset position of the casing in a preselected directional orientation; successively adding further portions of said conductor casing to the upper end thereof; driving said conductor with said open ended angularly offset portion through the substratum causing the conductor casing to be laterally diverted due to the interaction of the substratum against the side surfaces of said angularly offset portion of the casing from its point of entry into the substratum to its final position.

The invention also provides a deviated conductor system for a marine structure anchored at a site in an offshore body of water and adapted for the directional drilling of a well which comprises an conductor casing guide means carried on said structure being adapted to receive and guide a conductor passed downwardly therethrough, said conductor guide means including discrete guide units spaced vertically apart in substantially vertical alignment; and an elongated open ended conductor casing passing vertically downwardly and registered in said discrete guide units of said conductor casing guide means and penetrating into the substratum of said body of water, and diverted laterally into the substratum by a predetermined distance away from the vertical axis defined by said guide means, said conductor casing having an open ended, angularly offset portion at its distal end which is inclined with respect to the longitudinal axis of said guide means, which open ended, angularly off set portion extends laterally beyond one side of the outer circumference of the adjoining portion of the conductor casing.

Further, according to the invention there is provided a conductor casing for producing a diverted conductor system for a marine structure anchored at a site in an offshore body of water and adapted for directional drilling of a well which comprises an elongated open ended conductor casing made up of a plurality of individual conductor casing segments welded together; the distal end of said conductor casing comprising an open ended conductor casing segment secured to the end of the adjoining casing segment with its axis inclined to the axis of said adjoinging segment such that said distal end projects laterally beyond one side of the adjoining conductor casing, the conductor otherwise being made of axially aligned straight segments.

In order to achieve the deviation or curvature of pipe conductors there exist three basic patents involving methods significantly different from the method according to the present invention. U.S. Patents No. 3,670,507 and No. 3,687,204 both depend upon the use of a series of offset or staggered guides in the platform structures—spaced so as to either accommodate a continuously precurved conductor pipe or force a conductor pipe into a curved form by means of these guides.

In addition, U.S. Patent No. 3,610,340 contemplates the bending or deviation of the pipe conductor by forcing it into a predrilled hole in a very hard, consolidated stratum of soil. This latter method has obvious limitations to a specific type of soil. Also, it involves the necessity for predrilling in every case.

The first two methods mentioned involving the use of a series of guides require that the platform be specifically designed for curved conductors at the design stage. That is, a platform which has been built for the normal vertical conductor installation with vertically aligned guides cannot utilize either of these methods. Thus, because of the precurvature of the pipe, there are limited possibilities for deviations from the predetermined curvature in the field.

For other general, prior art background information, reference is also directed to U.S. Patent No. 3,451,493 as a typical example of what is known in the art as "slant drilling" wherein the entire drilling derrick is tilted to produce directional drilling. Other general interest prior art patents are U.S. Patents No. 3,610,346 and No. 3,685,300; the former using pre-drilled or pre-formed guide passages in the substratum and a backward drag shoe section (element 26) at the end of the casing, while the latter uses the basic support legs of the platform which have been pre-curved as guides for directional drilling.

General background reference may also be made to U.S. Patent No. 3,598,190 which uses deviated drilling in an off-shore "Salt Dome Drilling Method" and indicates that the course of the drilling string may be deflected through a formation by use of any of the well-known devices for this purpose, such as jetting, whipstocks or knuckle joints.

The presentt invention is applicable to the placement of diverted conductors from an offshore platform, particularly where there is included on the platform a series of standard conductor guides which are vertically aligned, that is, their openings define a straight line in at least a generally vertical direction.

The preferred method of the present invention comprises the method of diverting a conductor casing by means of welding a short section of the casing on the bottom of the conductor casing at a slight angle to the axis of the conductor adjoining segment of the casing. Before the conductor casing is inserted in the vertically aligned guides, a short section is cut off and rewelded at a slight angle to the axis of the adjoining straight portion, thus creating what is commonly known as a "dog-leg".

It has been found by experience that this angularly offset "dog-leg" is sufficient to divert the conductor casing in a given direction as the conductor casing is forced through the substratum soils by means of a pile-driving hammer. The present invention contemplates the installation of the "dog-leg", as noted, on the first incremental length only of the casing, before installation of the conductor casing through the vertically aligned platform guides, the conductor being otherwise straight.

The orientation of the "dog-leg" with respect to a given direction is maintained by means of providing a longitudinal line on each incremental segment of the conductor casing as it is added on. Thus, when the "dog-leg" bottom portion of the conductor casing reaches the mudline, the direction in which this "dog-leg" is pointing is predetermined. At this point normal driving operations can commence.

It has been found that the "dog-leg" will cause the conductor casing to be diverted in the direction of its orientation. Depending upon the type of soil encountered and based on experience and the amount of "dogleg" or angular offset, the conductor casing will be found to assume a smooth, curved shaped which permits the easy installation of smaller casings and eventually the drill string required for final completion of the well.

The manner of carrying the present invention into effect will now be described by way of example and with reference to the accompanying drawings, in which like parts are given like reference numerals and in which:—

Figure 1 is a side view of a platform with a preferred embodiment of a conductor casing in accordance with the present invention inserted through the vertical guides, with its angularly offset or "dog-leg" tip portion just beginning to penetrate the substrata and the curved course it will take being shown by broken lines,

Figure 2 is a "flow chart" diagram of the preferred embodiment of the method of the present invention,

Figure 3 is a partial, and axial cross-sectional view taken down the center-line of the preferred embodiment of the conductor casing of the present invention, showing the added "dog-leg" portion at its tip,

Figure 4 is a transverse cross-sectional view of the conductor casing taken along the section lines 4—4 of Figure 3 and

Figure 5 is a generalized schematic diagram showing the diverting forces that are utilized in performing the present invention.

The preferred embodiment of the present invention is applicable to the placement of diverted or deflected conductor casings or conductors from an offshore well drilling platform, particularly where there is included on the platform a series of standard conductor guides which are vertically aligned, and hence the preferred embodiment will be discussed with respect thereto. However it should be understood that some of the benefits of the present invention can be realized even when the guides are not vertically aligned.

Referring to Figure 1, a platform structure 10 is illustrated in the normal partially submerged, position in an offshore body of water for the purpose of drilling exploratory gas or oil wells. To fully explore the substratum, a number of wells are normally drilled to assume one or more directions radially outward from the platform 10. The marine platform comprises a deck 11 which is supported above the water's surface by downwardly extending legs 12. The illustrated platform is in general of a well-known design for a stable vehicle used to drill such offshore wells and in itself forms no part of the present invention.

While only two support legs 12 are shown, it should be appreciated that this is merely an illustrative embodiment into which the invention is incorporated. The respective legs may constitute any reasonable number depending on the condition of the substrate, the depth of the water and other design and engineering factors.

To provide platform 10 with stability regardless of water turbulence and weather at the offshore location, a series of vertically spaced cross-braces 12' extend between, and are rigidly connected to the respective legs 12. The number and size of such braces is dependent upon the depth of

the water in which the platform is used as well as on other design considerations.

The platform top deck 11 supports a drilling rig 16 which embodies in essence a derrick adapted to raise or lower and suspend a drill string with the associated draw works and rotary table. One or more cranes (not illustrated) are spaced about the deck to handle materials and transfer equipment to and from boats. The rotary table provides a means for the drill string to be controllably rotated for insertion into the well. In the normal manner, the derrick is generally vertical. Further, the derrick as well as the draw works is so mounted as to be horizontally movable about the deck's surface to allow proper orientation over a particular deck opening.

The mobility of the rig units with respect to the deck 11 is necessary to permit alignment over any of the conductors for drilling in diverse directions.

Platform 10 is provided with conductor guide means 13a to 13d adapted to receive a downwardly moving, normally straight, conductor and to guide the latter vertically down to the sea-bed or mudline 20. Each conductor guide means 13 typically comprises a cylindrical section 14 with a flared top 15.

Conductors are normally formed of an elongated cylindrical member approximately 16 to 36 inches in diameter, fabricated of steel pipe or tubing, normally made up in short incremental lengths varying from forty to sixty feet. Again, following normal practice, the conductor pipe 1 is lowered into place from deck 11 until the lower end is disposed adjacent the sea-bed 20. The conductor pipe is progressively elongated by welding additional sections to the upper end as said conductor is lowered.

As best seen in Figure 3, a conductor pipe, modified in accordance with the present invention, includes a short angularly offset or "dog-leg" section 1a welded with an offset of angle δ with respect to the longitudinal axis of the initial conductor segment 1b by means of weldments 4. The angularly offset section 1a can be typically eight feet in length, although it may be longer or shorter as may be indicated or required, with a typical offset from one end to the other of approximately one-half inch. This offset may vary from one-half inch to the total clearance allowed by the guides 13.

The amount of this offset is a function of several factors. The limiting factor which governs the maximum offset is the amount of clearance between the outer circumference of the conductor casing when placed vertically through the guides 13 and the inner surface of the platform guides 13. Normally this clearance is approximately two inches. It has been found that an offset of approximately one-half inch is sufficient for most soils. However, this can be increased according to the requirements of the particular soils encountered. Additional offset can be obtained by reducing the diameter of the conductor, thus allowing for greater guide clearance which in consequence permits greater offset.

If desired, and as illustrated in Figure 3, a standard drive shoe 2 also can be provided at the distal end of the conductor 1.

In addition to the welding of the short "dog-leg" segment 1a at the bottom of the conductor, it is also possible to prevent or minimize any tendencies of the pipe to rotate by means of welding at least one continuous flat bar 3 of steel along the exterior of this angularly offset segment 1a parallel to the axis thereof, as illustrated in Figures 3 and 4. It is noted that the location of additional guide bars 3' are suggested in Figure 4 by means of the dotted-lines. The size of this flat bar 3 is limited by the guide clearance available. In well consolidated substrata soils the flat bar or bars will act to prevent the end of the pipe 1 from rotating in an undesirable direction. In addition, each guide bar 3 may be extended past the welded connection 4 between "dog-leg" segment 1a and the adjoining pipe 1b so as to provide additional reinforcing for this welded joint as shown by the extension 3a in Figure 3.

As generally illustrated in Figure 2, the preferred method of the present invention thus comprises the method of diverting a conductor by means of welding a short section of pipe on the bottom of the conductor at a slight angle δ to a vertical axis of the conductor. Before the conductor casing is inserted in the vertically aligned guides 13a to 13d, a short section 1a is cut off and re-welded at an acute angle δ to the axis of the conductor thus creating what is commonly known as a "dog-leg".

It has been found by experience that this angularly offset portion 1a is sufficient to divert the conductor 1 in a given direction from the vertical axis 23 as the conductor pipe 1 is forced through the substratum soils 21 by means of a pile-driving hammer to produce a total angular deviation Δ which progressively gets greater. The present invention contemplates the installation of the angularly offset or "dog-leg" section 1a, as noted, on the first incremental length only before installation of the total pipe conductor 1 through the vertically aligned platform guides 13, the conductor 1 though

being otherwise made of axially aligned segments.

The orientation of the "dog-leg" section 1a with respect to a given direction is maintained by means of providing a longitudinal line on each incremental segment of the conductor pipe 1 as it is added on. The initial line is preferably put on and in line with the same side of the pipe where the "dog-leg" section 1a is pointing and thereafter a painted line added at each joint matched with the line of the preceding section. Thus, when the "dog-leg" section 1a of the conductor pipe 1 reaches the mudline 20, the direction in which this pipe section 1a is pointing is established. At this point normal driving operations can commence.

It has been found that the angularly offset pipe section will cause the conductor 1 to be diverted in the direction of its orientation. Depending upon the type of soil encountered and based on experience and the amount of "dog-leg" or angular offset, the conductor 1 will be found to assume a smooth curved shape (not the phantom line portion 22 of Figure 1) which permits the easy installation of smaller casings and eventually the drill string required for final completion of the well.

As generally illustrated in Figure 5, the forces which cause the desired deflection are a combination of the driving force down conductor 1 being met by the strata resistance acting on the angular or offset "dog-leg" segment 1a to produce a resulting direction of deviation.

If excessive curvature should occur due to the formation being encountered, there is available a method for controlling this excessive curvature. By drilling out through the casing 1 at periodic intervals, a survey of the amount of curvature can be obtained in accordance with standard procedures. If the survey indicates excessive curvature, the stratum of soil below the conductor pipe 1 can be drilled out with an under-reamer type drill or other means for a short distance beyond the end of the conductor 1. This creates an enlarged hole or cavity and it will be found that the end of the conductor pipe 1 will then tend to drop down in such a manner as to decrease the curvature in accordance with directional requirements.

The amount of angular offset of the inclined pipe section 1a, as noted above, is based on a study of the soil data as well as field experience with various soils encountered. In addition, some control can be achieved by varying the amount of energy applied to the pipe by means of the pile-driving hammer.

The described invention provides a method and technique for a deflected or non-vertical emplacement of a conductor casing at a desired curve and orientation in order to facilitate directional drilling of a well in the substratum of an offshore well site. The method provides for the installation of a relatively short, offset portion of the conductor casing at only the bottom of the conductor pipe string and thereby utilizing this offset portion to force the conductor string in a desired direction and orientation by driving or forcing the conductor casing through a substratum in such a manner that the casing will assume the desired curvature and direction as it advances through the substratum. In addition to the offset or "dog-leg" segment at the bottom, longitudinal guide bars can be added to resist undesired rotation of the conductor casing.

WHAT WE CLAIM IS:—

1. A method of providing a diverted conductor system at a site in a offshore body of water for enabling directional drilling of a well, said method comprising providing an open ended conductor casing; securing an open ended section of casing to the distal end of the conductor casing, the axis of said open ended section being inclined with respect to the axis of the adjacent part of said casing to produce an angularly offset portion of said casing extending laterally beyond one side of the outer circumference of the adjoining portion of the conductor casing, setting said conductor down through vertically aligned guides until the mudline is reached, while maintaining or positioning the angularly offset portion of the casing in a pre-selected directional orientation; successively adding further portions of said conductor casing to the upper end thereof, and driving said conductor with said upen ended angularly offset portion through the substratum causing the conductor casing to be laterally diverted due to the interaction of the substratum against the side surfaces of said angularly offset portion of the casing from its point of entry into the substratum to its final position.

2. A method according to Claim 1, wherein said method further includes the step of determining the curvature and orientation of the diverted conductor casing and applying a correctional step to alter the diversion.

3. A method according to Claim 1 wherein said angularly inclined portion of the casing is provided by cutting off an end portion of the conductor casing and rewelding said end portion to the casing with its axis at an angle to the axis of the adjoining portion of the conductor casing.

4. A method according to any one of Claims 1 to 3 and including the step of

being otherwise made of axially aligned segments.

The orientation of the "dog-leg" section 1a with respect to a given direction is maintained by means of providing a longitudinal line on each incremental segment of the conductor pipe 1 as it is added on. The initial line is preferably put on and in line with the same side of the pipe where the "dog-leg" section 1a is pointing and thereafter a painted line added at each joint matched with the line of the preceding section. Thus, when the "dog-leg" section 1a of the conductor pipe 1 reaches the mudline 20, the direction in which this pipe section 1a is pointing is established. At this point normal driving operations can commence.

It has been found that the angularly offset pipe section will cause the conductor 1 to be diverted in the direction of its orientation. Depending upon the type of soil encountered and based on experience and the amount of "dog-leg" or angular offset, the conductor 1 will be found to assume a smooth curved shape (not the phantom line portion 22 of Figure 1) which permits the easy installation of smaller casings and eventually the drill string required for final completion of the well.

As generally illustrated in Figure 5, the forces which cause the desired deflection are a combination of the driving force down conductor 1 being met by the strata resistance acting on the angular or offset "dog-leg" segment 1a to produce a resulting direction of deviation.

If excessive curvature should occur due to the formation being encountered, there is available a method for controlling this excessive curvature. By drilling out through the casing 1 at periodic intervals, a survey of the amount of curvature can be obtained in accordance with standard procedures. If the survey indicates excessive curvature, the stratum of soil below the conductor pipe 1 can be drilled out with an under-reamer type drill or other means for a short distance beyond the end of the conductor 1. This creates an enlarged hole or cavity and it will be found that the end of the conductor pipe 1 will then tend to drop down in such a manner as to decrease the curvature in accordance with directional requirements.

The amount of angular offset of the inclined pipe section 1a, as noted above, is based on a study of the soil data as well as field experience with various soils encountered. In addition, some control can be achieved by varying the amount of energy applied to the pipe by means of the pile-driving hammer.

The described invention provides a method and technique for a deflected or non-vertical emplacement of a conductor casing at a desired curve and orientation in order to facilitate directional drilling of a well in the substratum of an offshore well site. The method provides for the installation of a relatively short, offset portion of the conductor casing at only the bottom of the conductor pipe string and thereby utilizing this offset portion to force the conductor string in a desired direction and orientation by driving or forcing the conductor casing through a substratum in such a manner that the casing will assume the desired curvature and direction as it advances through the substratum. In addition to the offset or "dog-leg" segment at the bottom, longitudinal guide bars can be added to resist undesired rotation of the conductor casing.

WHAT WE CLAIM IS:—

1. A method of providing a diverted conductor system at a site in a offshore body of water for enabling directional drilling of a well, said method comprising providing an open ended conductor casing; securing an open ended section of casing to the distal end of the conductor casing, the axis of said open ended section being inclined with respect to the axis of the adjacent part of said casing to produce an angularly offset portion of said casing extending laterally beyond one side of the outer circumference of the adjoining portion of the conductor casing, setting said conductor down through vertically aligned guides until the mudline is reached, while maintaining or positioning the angularly offset portion of the casing in a pre-selected directional orientation; successively adding further portions of said conductor casing to the upper end thereof, and driving said conductor with said upen ended angularly offset portion through the substratum causing the conductor casing to be laterally diverted due to the interaction of the substratum against the side surfaces of said angularly offset portion of the casing from its point of entry into the substratum to its final position.

2. A method according to Claim 1, wherein said method further includes the step of determining the curvature and orientation of the diverted conductor casing and applying a correctional step to alter the diversion.

3. A method according to Claim 1 wherein said angularly inclined portion of the casing is provided by cutting off an end portion of the conductor casing and rewelding said end portion to the casing with its axis at an angle to the axis of the adjoining portion of the conductor casing.

4. A method according to any one of Claims 1 to 3 and including the step of

adding at least one radially projecting elongated flat bar to the exterior of the conductor casing parallel to the longitudinal axis of the angularly offset portion thereof to counteract any tendency of the conductor to rotate.

5. A method according to any one of Claims 1 to 4 and including the step of continuously marking the directional orientation of the angularly offset portion of the casing, on each successive portion of the conductor casing.

6. A method according to Claim 5 wherein the directional position of the angularly offset portion is recorded by painting a longitudinal line on each incremental portion of the conductor casing as it is added to the preceding one.

7. A method according to any one of Claims 1 to 6 and including the step of drilling out the substratum of soil below the tip of the conductor casing for a predetermined distance beyond the end of the conductor casing, causing the conductor casing to drop down to decrease the angle of deflection.

8. A deviated conductor system for a marine structure anchored at a site in an offshore body of water and adapted for the directional drilling of a well in accordance with any one of Claims 1 to 7 and which comprises a conductor casing guide means carried on said structure being adapted to receive and guide a conductor passed downwardly therethrough, said conductor guide means including discrete guide units spaced vertically apart in substantially vertical alignment; and an elongated open ended conductor casing passing vertically downwardly and registered in said discrete guide units of said conductor casing guide means and penetrating into the substratum of said body of water, and diverted laterally into the substratum by a predetermined distance away from the vertical axis defined by said guide means, said conductor casing having an open ended angularly offset portion at its distal end which is inclined with respect to the longitudinal axis of said guide means, which open ended, angularly offset portion extends laterally beyond one side of the outer circumference of the adjoining portion of the conductor casing.

9. A conductor casing for producing a diverted conductor system for a marine structure anchored at a site in an offshore body of water and adapted for directional drilling of a well which comprises an elongated open ended conductor casing made upon of a plurality of individual conductor casing segments welded together; the distal end of said conductor casing comprising an open ended conductor casing segment secured to the end of the adjoining casing segment with its axis inclined to the axis of said adjoining segment such that said distal end projects laterally beyond one side of the adjoining conductor casing, the conductor otherwise being made of axially aligned straight segments.

10. A method of providing a diverted conductor system for a well substantially as hereinbefore described with reference to the accompanying drawings.

11. A diverted conductor system for a well substantially as hereinbefore described with reference to the accompanying drawings.

12. A conductor for a diverted conductor system in a well, substantially as hereinbefore described with reference to the accompanying drawings.

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