

SPECIFICATION **Drilling guidance device**

Background of the Invention

Field of the Invention

5 This invention relates to a guidance device for drilling wells in a sea floor from a floating vessel.

In recent years there has been considerable attention attracted to the drilling and production of wells located in water. Wells may be drilled in the ocean floor from either fixed platforms in relatively shallow water or from floating structures and vessels in deep water. The most common means of anchoring fixed platforms includes the driving, or otherwise anchoring, of long piles in the ocean floor. Such piles normally extend above the surface of the water and support a platform attached to the top of the piles. This works fairly well in shallow water but, as the water gets deeper, the problems of design and accompanying cost become prohibitive. In deeper water, it is common practice to drill from a floating structure.

In recent years there has been considerable attention directed toward many different kinds of floating structures. One system receiving attention is the so-called Vertically Moored Platform. Such a platform is described in U.S. Patent 3,648,638 issued March 14, 1972, Kenneth A. Blenkarn, inventor. Key features of the disclosure in that patent are that the floating platform is connected to an anchor only by elongated parallel members and the floating structure has buoyancy means designed especially with respect to the trough of a design wave so as to minimize variations in vertical forces imposed on the vertically elongated members which may be caused by passing waves. There are other types of floating drilling structures such as the semisubmersible and the floating drilling vessel with a "moon pool" or vertical opening through the center through which drilling operations are carried out. The drilling engineer selects a floating vessel which he believes will best fit the environmental conditions which are expected to be encountered.

The closest prior art relating to our invention, to the best of our knowledge, concerns frames on the ocean floor having a vertical passage through which a well may be drilled. The drilling tool is guided into the vertical passage by cables extending from the frame to a floating vessel. None of the prior art has means for sequentially guiding drilling pipe or mechanisms successively through each of an array of vertical holes through a sea floor template.

According to the present invention there is provided a drilling guidance device for use in drilling underwater wells from a floating vessel which comprises:

- a carousel guidance frame,
- a carousel guidance frame well slot in said carousel guidance frame,
- a vertical turning post slot extending through said carousel guidance frame,
- an orienting and turning post mounted in said post slot, and

65 guideposts arranged in a pattern about said carousel guidance frame well slot and secured to said carousel guidance frame.

The invention also includes a combination of a drilling guidance device as defined above and a subsea template comprising:

- a template frame,
- a group of well slots arranged in a pattern and supported by said template frame, and
- guide rails supported by said template frame and extending adjacent said pattern of well slots, said guide rail means supporting said guidance frame.

Preferably the guide rail supported by the frame extends about each well slot and said guidance system includes a carousel guide frame having a well slot therethrough mounted on said guide rail and means to move said carousel guide frame along said guide rails from one well slot in said template frame to another well slot.

85 According to a preferred aspect of the present invention there is provided a drilling guidance carousel for use in drilling underwater wells from a floating vessel which comprises:

- a carousel guidance frame,
- a carousel guidance frame well slot in said carousel guidance frame,
- guideposts arranged in a pattern about said well slot and secured to said carousel guidance frame,
- a vertical turning post slot extending through said carousel guidance frame,
- an orienting and turning post mounted in said slot,
- means permitting limited vertical movement of said post through said post slot,
- spline means between said post and said carousel guidance frame,
- locking gears surrounding the periphery of said turning post below said carousel guidance frame, and
- torque resistance means in the upper end of said post and in which said post is hollow.

Apparatus according to the present invention is of particular use for guiding a drilling mechanism, such as a drill bit, casing string, blowout preventer, etc., into any selected one well slot of a sea floor template. The sea floor template is provided with a number of well slots or vertical openings arranged in a selected pattern. Guidelines may be attached between the floating vessel and the movable carousel guidance frame. Means may be provided to align the opening of the movable frame with any of the well slots of the template.

Preferably, the sea floor template is arranged so that it has four corners which define a rectangle. Preferably, at each of these corners there is provided a plurality of well slots which are arranged in a pattern approximating a circle. Two concentric circular rails are provided which are also concentric to the circle of template well slots. One such guide rail is of smaller diameter than said circle, and the other is larger. The carousel guidance or anchor frame may be mounted so it can move along these two concentric rails.

Moving and orienting means may be provided to move this frame from above one template well slot to any other selected one. A well may then be drilled from the floating vessel through the well slot in the carousel guide frame and the well slot in the sea floor template. This includes the running of casing, etc. After a well is drilled, the carousel guide frame is moved to the next selected template well slot.

A better understanding of the invention may be had from the following description taken in conjunction with the drawings.

Drawings

FIGURE 1 illustrates a drilling guidance carousel being lowered by a running string from a floating vessel to a sea floor template.

FIGURE 2 illustrates a simplified plan view of a sea floor template.

FIGURE 3 illustrates an isometric view of one corner of the sea floor template illustrated in Figure 2.

FIGURE 4 illustrates, partly in section, a drilling guidance carousel in engagement with the sea floor template.

FIGURE 5 is a partial cutaway perspective view of the locating mechanism of Figure 4 for orienting the well slot of the carousel guidance frame and a selected well slot of the sea floor template.

FIGURE 6 is similar to Figure 4, but illustrates a device whereby the pivot post of the carousel guidance system is run separately from the carousel guidance frame.

FIGURE 7 illustrates the upper end of a pivot post of Figure 6.

FIGURE 8 is similar to Figure 1, but using a modified drilling guidance carousel.

Detailed Description

Attention is next directed to the drawings, and in particular to Figure 1. Shown thereon is a floating vessel 10 supported in a body of water 12 above the sea floor 14. Located on the floor 14 is a sea floor template 16 having a plurality of vertical well guides or slots 18. The template 16 can be lowered to the position shown in Figure 1 by cables supported from a floating barge. A drilling guidance carousel 20 is suspended at the lower end of a running string 22 supported from the floating vessel 10. The running string 22 can be a small diameter steel pipe, e.g., 2½ inches in diameter. Vessel 10 can be substantially any floating vessel. Vessel 10 has anchor mooring lines 24. It is also possible that vessel 10 might be provided with dynamic positioning means. Near the lower end of the drilling guidance carousel 20 is an acoustic location device 26. The drilling guidance carousel also preferably is provided with a TV camera and light 28. Acoustic location device 26 and TV camera and lights 28 may not always be necessary, but will usually aid in the rapid orientation of the drilling guidance carousel 20 with the sea floor template 16. Guidelines 30 are provided between drilling guidance carousel 20 and the floating vessel 10. The upper end of

guidelines 30 are connected on the vessel to drums or constant tension devices which are well known. Shown on vessel 10 is a drilling rig 32 and other drilling equipment is indicated thereon. If desired, thrust means 34 such as a water jet can be provided at the lower end of running string 22 to move the lower end as may be necessary. Proper orientation of drilling guidance carousel 20 with the sea floor template 16 is facilitated by use of TV camera 28, acoustic location device 26 in conjunction with transponder 46 (indicated in Figure 3) on the sea floor template, the jetting means 34, and by manipulating the running string at the surface of vessel 10.

Attention is next directed to Figure 2, which illustrates a plan view of a preferred arrangement and pattern of sea floor template 16 of Figure 1. This template has frame members 36, which define a square and in which there is a pattern of vertical well slots 38 in each corner of the configuration. Well slots 38 are arranged in a circle about a center carousel guidance slot 40. These vertical well slots 38 are supported by means from the sea floor template 16. Concentric guide rails 42 and 44 are provided. These guide rails are also concentric with the circle formed by the center of well slots 38.

Attention is next directed to Figure 3 which illustrates one corner in isometric form of the template of Figure 2 with the drilling guidance carousel in position. Shown in Figure 3 is template frame 36 having vertical template well guides 38. These well guides 38 are supported from frame 36 by means not specifically shown, but support can be by essentially any conventional method such as by welding of cross braces, etc. Mounted in a concentric circle on either side of well guides 38 are outer guide rail 42 and inner guide rail 44, which are also supported from frame 36. Rails 42 and 44 have guide rails engaging slots 50, 52, 54, and 56. The purpose of these guide rail engaging slots is to permit the lower rollers of the carousel guidance system to enter under the top of the rails 42 and 44 and resist upward pull on the carousel guidance frame as will be seen hereinafter.

The drilling guidance carousel includes a carousel guide frame 58 having a guidance frame well slot 60 and a pivoting and orienting means 62. Carousel guidance frame 58 is provided with a plurality of guideposts 64 which are connected to guidelines 30 which extend to drilling support structure such as floating vessel 10 as shown in Figure 1. A transponder 46 is also illustrated which is helpful in orienting the drilling guidance carousel when it is first being lowered to the sea floor template. There are shown four guideposts 64 which are arranged in a square about carousel guidance frame well slot 60. These guidelines 30 are used to guide drilling equipment, casing, etc., through the slot 60 and the well slot 38 with which it is aligned.

Attention is next directed to Figure 4 which shows partly in vertical section the drilling guidance carousel in place on the sea floor template. Guide rails 42 and 44 are typically

shaped as I-beams with the upper portion having an upper riding surface 70 and lower undersurfaces 72A and 72B on each side of the vertical support portion of the I-beam. Guide rails 42 and 44 support carousel guide frame 58, which has upper or main rollers 74 which ride, or bear, against the upper surface 70 of the guide rails. Carousel guidance frame 58 also has retaining rollers 76 and 78 which pass downward through guide rail engaging slots 50, 52, 54, and 56 (shown in Figure 3). After these rollers pass through the engaging slots, the guidance frame is rotated away from the slots before applying tension sufficient to lift guidance frame 58. Upon rotational movement of the carousel guiding frame, rollers 76 and 78 bear against lower surface 72a and 72b of the guide rails when upward tension is applied to guide cables 30. In other words, main roller 74 is for supporting the guidance frame 58 when it is being rotated about the guidelines or when guidelines 30 are not in tension. When guidelines 30 are under tension, then retaining rollers 76 and 78 restrain the carousel guide frame 58. There are four sets of rollers 74, 76, and 78, one being at each corner of guidance frame 58.

Carousel guidance frame 58 rolls along guide rails 42 and 44 which are fixed to a sea floor template frame 36 about a pivot point. The center of the circles defined by guide rails 42 and 44 is the center of the centerline 41 of carousel guidance slot 40. This is accomplished by use of an orienting and turning pin, or post 80. Turning post 80 extends through a vertical slot 82 in the arm of carousel guidance frame 58. Orienting and turning post 80 has turning splines 84 which mate with internal splines 86 within passage 82 of the carousel guidance frame 58. Turning splines 84 are of less (e.g., one-half) vertical length than splines 86. This is to permit vertical movement of post 80 with respect to carousel guidance frame 58 so that the orienting and turning post 80 can have limited vertical movement with respect to the carousel guidance frame 58. Orienting and turning post 80 extends into carousel guidance slot 40 of sea floor template 16 which has a centering ring 88 at the lower portion thereof. This is primarily to add stability to the post 80. As seen more clearly in Figure 5, post 80 has locating gear teeth 90. On the interior of carousel guidance slot 40 there are provided mating gear teeth 92 which mate with locating gear teeth 90.

We will now describe that portion of Figure 4 which has to do with (a) lifting the carousel and (b) turning it. This includes a running and turning J-slot 97, which is provided in the upper end of orienting and turning post 80. Running string 22 is provided with a running and turning tool 94, which has a running and turning lug 96.

The turning tool 94 is used for lowering, raising, and turning the carousel guidance frame 58. The running tool 94 is shown in FIGURE 1 as engaged with the running and turning J-slot 97 of pin 80. When in this position, lifting shoulder 98 on post 80 is in engagement with lower shoulder 100 of

the portion of carousel guidance frame 58 having vertical passage 82. The running string 22 is lowered until the drilling guidance carousel 20 is in position above the selected well slot 38 of the sea floor template. This is accomplished by use of the acoustic locating device 26 in relation with transponder 46 on the template. TV camera 28, with lights, is also utilized and, if necessary, fluid is passed down through running string 22 and out jetting means 34 to drive the pipe in the proper direction. The proper direction can be obtained by rotating the running string 22 at the surface. One first must make a decision as to which one of the corners of the template shown in FIGURE 2 it is desired to drill. Then the running string lowers the drilling guidance carousel until post 80 is aligned with the selected carousel guidance slot 40. Then the carousel guidance frame 58 is rotated until rollers 76 and 78 are aligned with the guidance rail engaging slots 50, 52, 54, and 56 which are illustrated in FIGURE 3. Then the running string is lowered until each of rollers 76 and 78 is passed through the slots. The carousel guidance frame 58 is next rotated so that the frame is secured to guide rails 42 and 44. During this time, orienting and turning post 80 is in its upward position so that shoulder 98 is against lower shoulder 100 of the carousel guidance frame 58. The running string 22 is used to rotate the carousel guidance frame 58 until the carousel guidance frame well slot 60 is aligned with the selected well slot 38 of the sea floor template. At this time, running string 22 is lowered so that locating gear teeth 90 of orienting and turning post 80 engages mating gear teeth 92. The carousel guidance frame is thus locked in position.

There are two points which should be considered at this time. One is that the carousel guidance frame is so designed in connection with the template that when carousel guidance frame well slot 60 is above a selected well slot 38 of the sea floor template, then a selected gear tooth 91 of locating gear teeth 90 is in an oriented position with respect to tooth space 93 of mating gear teeth 92. Locating gear teeth 90 and mating gear teeth 92 are of proper size and design so that there is orientation for each of the well slots 38 of the sea floor template. Secondly, it is important to note that turning spline 84 of orienting and turning post 86 has a vertical movement with respect to splines 82 of the carousel guidance frame 58 so that locating gear teeth 90 can be raised to the position shown in Figure 5 while the rollers 78 and 76 are in full engagement with tracks 42 and 44. Whenever the carousel guidance frame well slot 60 is aligned with well slot 38 of the sea floor template, drilling tools can be run along guidelines 30 and drilling can progress in the usual manner. This carousel guidance frame can be rotated so that each well slot 38 of the selected corner of the sea floor template 16 is drilled. When all the wells have been drilled in the well slots 38 as desired, the drilling guidance carousel is removed. This is easily accomplished by aligning the rollers of the

carousel guidance frame 58 with the guide rail engaging slots 50, 52, 54, and 56. At this time, all that is necessary to remove the drilling guidance carousel 20 is to raise up on running string 22.

Cables 30 should also be lifted or wound on a drum at the surface. It will normally be desired to move over to another corner of the sea floor template shown in Figure 2. Then the sequence of events described for lowering, engaging, rotating and removing the carousel guidance device is repeated for each corner of the sea floor template. This is continued until wells have been drilled through each of the well slots desired.

In the device described above in connection with Figures 4 and 5, the drilling guidance carousel 20 was lowered at the same time that running string 22 was lowered. Attention is now directed to Figures 6 and 7 in which the running string 22 is first run and lowered into anchored position and then the guidance frame 58 is lowered down over the running string 22. The main modification in Figures 6 and 7 is in the orienting and turning post 110, which serves the same functions as orienting and turning post 80 of Figure 4. The sea floor template is provided with a carousel guidance slot 112, which is modified from the carousel guidance slot 40 of Figure 4. In Figure 6 the lower end of slot 112 is provided with a running tool locking means 114 such as a J-slot. The running tool 22 is provided with running tool lugs 116. In operation, before the carousel guidance frame 58 is lowered, running tool 22 is lowered and lugs 116 engage running tool locking means 114 in the bottom of carousel guidance slot 112. At this time, as shown in Figure 2, the drilling guidance carousel 20 is lowered by cables 30 over running string 22 which has previously been centered and locked in guidance slot 112. Orienting post 110 of the carousel 20 arrangement of Figures 6 and 7 is modified to provide for a vertical passage therethrough with funnel 115 at the top for receiving running tool 22. There is also provided a turning device such as J-slot 118 in the upper end of post 110. The locking gears 95 and the turning splines 84 and 86 of the device in Figure 6 can be the same as those of Figures 4 and 5. An advantage of the device of Figure 6 over that of Figure 4 is that it permits the running string 22 to be locked into the carousel guidance slot 112 before the drilling guidance carousel is lowered. This permits the running string 22 to be manipulated without the additional weight of the carousel guidance device thereon, which simplifies the orientation problem. If desired, a camera and acoustic locating device can be run with running tool 22 until the lugs 116 are locked into J-slot 114. Then the camera transponder can be recovered by cables which were attached at the time it was lowered with the running string 22. The carousel guidance device 20 is then lowered by cables 30. The device of Figure 6 can be used in the same manner as that of Figure 4 for drilling through a selected well slot 38 of the sea floor template.

The turning mechanisms in Figures 4 and 6 are shown to be at the pivot point or center of the circles of the rails 42 and 44. However, if desired, the turning mechanism could be made, for example, by providing J-slots elsewhere at any position where it may be determined to be more desirable on the carousel guidance arm 58, which would match with a turning lug such as 116 of running string 22.

Reference is made to our copending UK Patent Application No. 36566/78 (Serial No. 2003960) which describes and claims a sea floor template for use in conjunction with a guidance carousel in the drilling of underwater wells, said template comprising:—

- 80 a template frame,
- a group of well slots supported by said frame and arranged in a circle, and
- outer and inner guide rails arranged for engagement by the guidance carousel, the guide rails being supported by the template frame and arranged concentrically with the group of well slots, the outer guide rail extending along a circular path lying radially outwardly of the well slots and the inner guide rails extending along a circular path lying radially inwardly of the well slots, and wherein each of the guide rails is in the form of a beam having a laterally extending rim portion providing on its underside a surface for engagement by part of the guidance carousel, a section of the rim portion being cut away to provide a space through which said part of the guidance carousel may pass enabling the carousel to be moved to a position in which said part can engage said surface on the underside of the rim portion.

CLAIMS

1. A drilling guidance device for use in drilling underwater wells from a floating vessel which comprises:

- 105 a carousel guidance frame,
- a carousel guidance frame well slot in said carousel guidance frame,
- a vertical turning post slot extending through said carousel guidance frame,
- 110 an orienting and turning post mounted in said post slot, and
- guideposts arranged in a pattern about said carousel guidance frame well slot and secured to said carousel guidance frame.
- 115 2. A drilling guidance device as claimed in Claim 1 including means to prevent rotation of said post with relation to said carousel guidance frame.
- 3. A drilling guidance device as claimed in Claim 2 including a J-slot in the upper end of said post.
- 4. A drilling guidance device as defined in any preceding Claim including:
- locking gears surrounding the periphery of said turning post below said carousel guidance frame.
- 125 5. A drilling guidance device as claimed in any preceding claim including means permitting limited vertical movement of said post through

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carousel guidance frame 58 with the guide rail engaging slots 50, 52, 54, and 56. At this time, all that is necessary to remove the drilling guidance carousel 20 is to raise up on running string 22.

5 Cables 30 should also be lifted or wound on a drum at the surface. It will normally be desired to move over to another corner of the sea floor template shown in Figure 2. Then the sequence of events described for lowering, engaging, rotating and removing the carousel guidance device is repeated for each corner of the sea floor template. This is continued until wells have been drilled through each of the well slots desired.

10 In the device described above in connection with Figures 4 and 5, the drilling guidance carousel 20 was lowered at the same time that running string 22 was lowered. Attention is now directed to Figures 6 and 7 in which the running string 22 is first run and lowered into anchored position and then the guidance frame 58 is lowered down over the running string 22. The main modification in Figures 6 and 7 is in the orienting and turning post 110, which serves the same functions as orienting and turning post 80 of Figure 4. The sea floor template is provided with a carousel guidance slot 112, which is modified from the carousel guidance slot 40 of Figure 4. In Figure 6 the lower end of slot 112 is provided with a running tool locking means 114 such as a J-slot. The running tool 22 is provided with running tool lugs 116. In operation, before the carousel guidance frame 58 is lowered, running tool 22 is lowered and lugs 116 engage running tool locking means 114 in the bottom of carousel guidance slot 112. At this time, as shown in Figure 2, the drilling guidance carousel 20 is lowered by cables 30 over running string 22 which has previously been centered and locked in guidance slot 112. Orienting post 110 of the carousel 20 arrangement of Figures 6 and 7 is modified to provide for a vertical passage therethrough with funnel 115 at the top for receiving running tool 22. There is also provided a turning device such as J-slot 118 in the upper end of post 110. The locking gears 95 and the turning splines 84 and 86 of the device in Figure 6 can be the same as those of Figures 4 and 5. An advantage of the device of Figure 6 over that of Figure 4 is that it permits the running string 22 to be locked into the carousel guidance slot 112 before the drilling guidance carousel is lowered. This permits the running string 22 to be manipulated without the additional weight of the carousel guidance device thereon, which simplifies the orientation problem. If desired, a camera and acoustic locating device can be run with running tool 22 until the lugs 116 are locked into J-slot 114. Then the camera transponder can be recovered by cables which were attached at the time it was lowered with the running string 22. The carousel guidance device 20 is then lowered by cables 30. The device of Figure 6 can be used in the same manner as that of Figure 4 for drilling through a selected well slot 38 of the sea floor template.

The turning mechanisms in Figures 4 and 6 are shown to be at the pivot point or center of the circles of the rails 42 and 44. However, if desired, the turning mechanism could be made, for example, by providing J-slots elsewhere at any position where it may be determined to be more desirable on the carousel guidance arm 58, which would match with a turning lug such as 116 of running string 22.

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80 a template frame,
a group of well slots supported by said frame and arranged in a circle, and
outer and inner guide rails arranged for engagement by the guidance carousel, the guide rails being supported by the template frame and arranged concentrically with the group of well slots, the outer guide rail extending along a circular path lying radially outwardly of the well slots and the inner guide rails extending along a circular path lying radially inwardly of the well slots, and wherein each of the guide rails is in the form of a beam having a laterally extending rim portion providing on its underside a surface for engagement by part of the guidance carousel, a section of the rim portion being cut away to provide a space through which said part of the guidance carousel may pass enabling the carousel to be moved to a position in which said part can engage said surface on the underside of the rim portion.

CLAIMS

1. A drilling guidance device for use in drilling underwater wells from a floating vessel which comprises:

105 a carousel guidance frame,
a carousel guidance frame well slot in said carousel guidance frame,
a vertical turning post slot extending through said carousel guidance frame,
110 an orienting and turning post mounted in said post slot, and
guideposts arranged in a pattern about said carousel guidance frame well slot and secured to said carousel guidance frame.

115 2. A drilling guidance device as claimed in Claim 1 including means to prevent rotation of said post with relation to said carousel guidance frame.

120 3. A drilling guidance device as claimed in Claim 2 including a J-slot in the upper end of said post.

4. A drilling guidance device as defined in any preceding Claim including:

125 locking gears surrounding the periphery of said turning post below said carousel guidance frame.

5. A drilling guidance device as claimed in any preceding claim including means permitting limited vertical movement of said post through



said post slot.

6. The combination of a drilling guidance device as claimed in any preceding claim and a subsea template comprising:

- 5 a template frame,
- a group of well slots arranged in a pattern and supported by said template frame,
- guide rail means supported by said template frame and extending adjacent said pattern of well
- 10 slots, said guide rail means supporting said guidance frame.

7. A combination according to Claim 6 in which

- 15 said pattern is a circle and said subsea template includes a carousel central vertical guidance slot located in the center of said circle and supported by said template frame and in which said vertical guidance slot includes orienting gear teeth arranged in a circular pattern about the interior of said slot and arranged to mesh with locking gears
- 20 surrounding the periphery of said turning post.

8. A drilling guidance device according to Claim 1 and substantially as hereinbefore described with particular reference to any of Figs. 3, 4 and 6 of the accompanying drawings.