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(54) **PARALLEL DRILLING AND COMPLETION FOR A DRY TREE FLOATING PRODUCTION FACILITY**

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(57) **ABSTRACT**

Field development drilling and completion/production work are performed from a floating facility having a deck with a moon pool and a well bay, a first drilling rig fixed to the deck over the moon pool, and a second drilling rig movably mounted on the deck over the well bay. In use, the facility is positioned in a first position for field development drilling by the first drilling rig through the moon pool at a first well location. The facility is moved to a second position for field development drilling by the first drilling rig through the moon pool at a second well location. During the field development drilling at the second well location, the facility is moved so that the first well location is accessible through the well bay. Well completion/production work is performed at the first well location through the well bay with the second drilling rig.

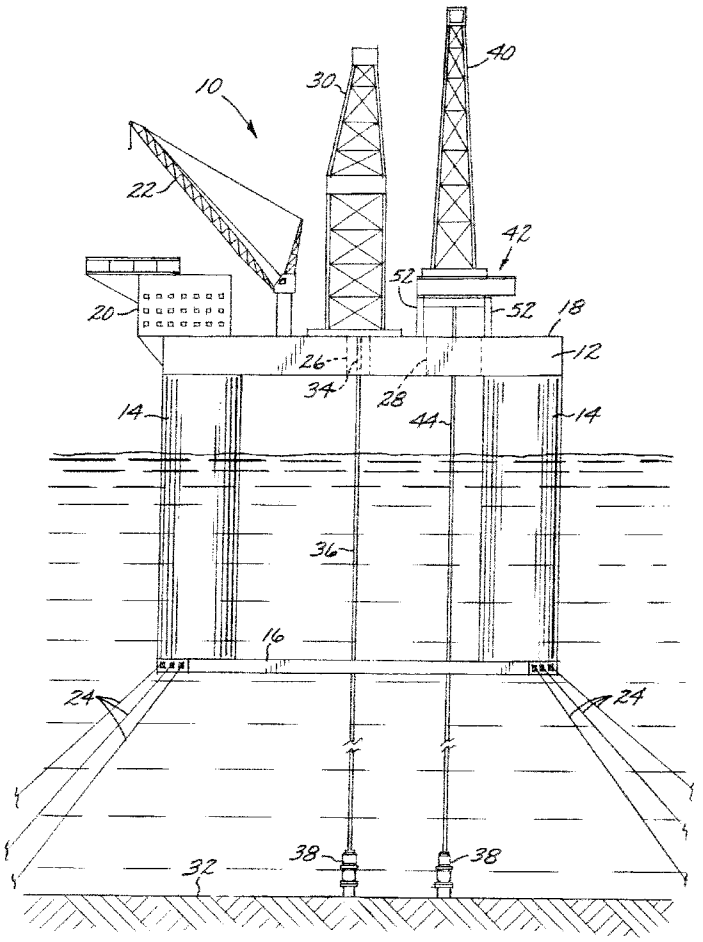

FIG. 1

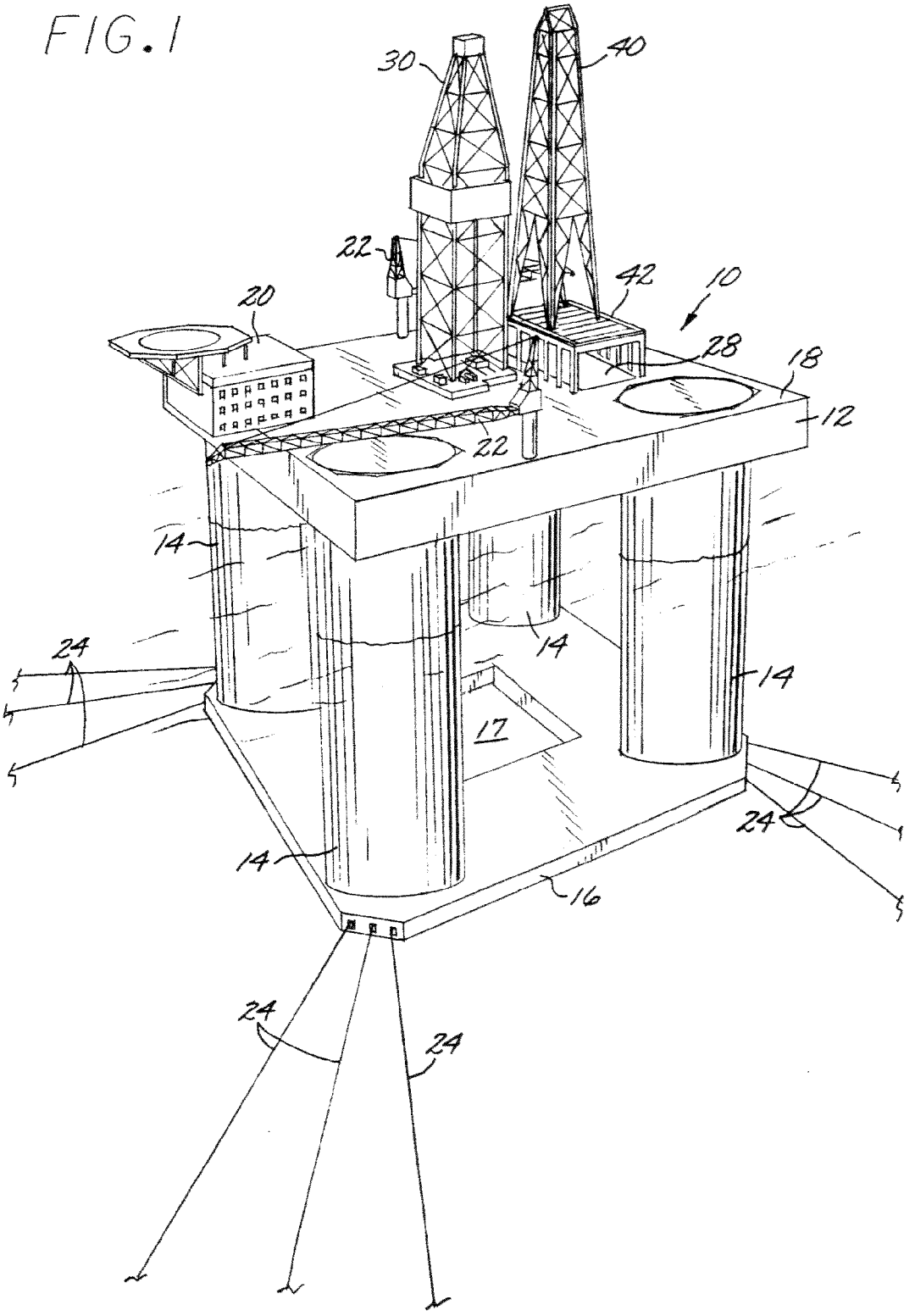

FIG. 2

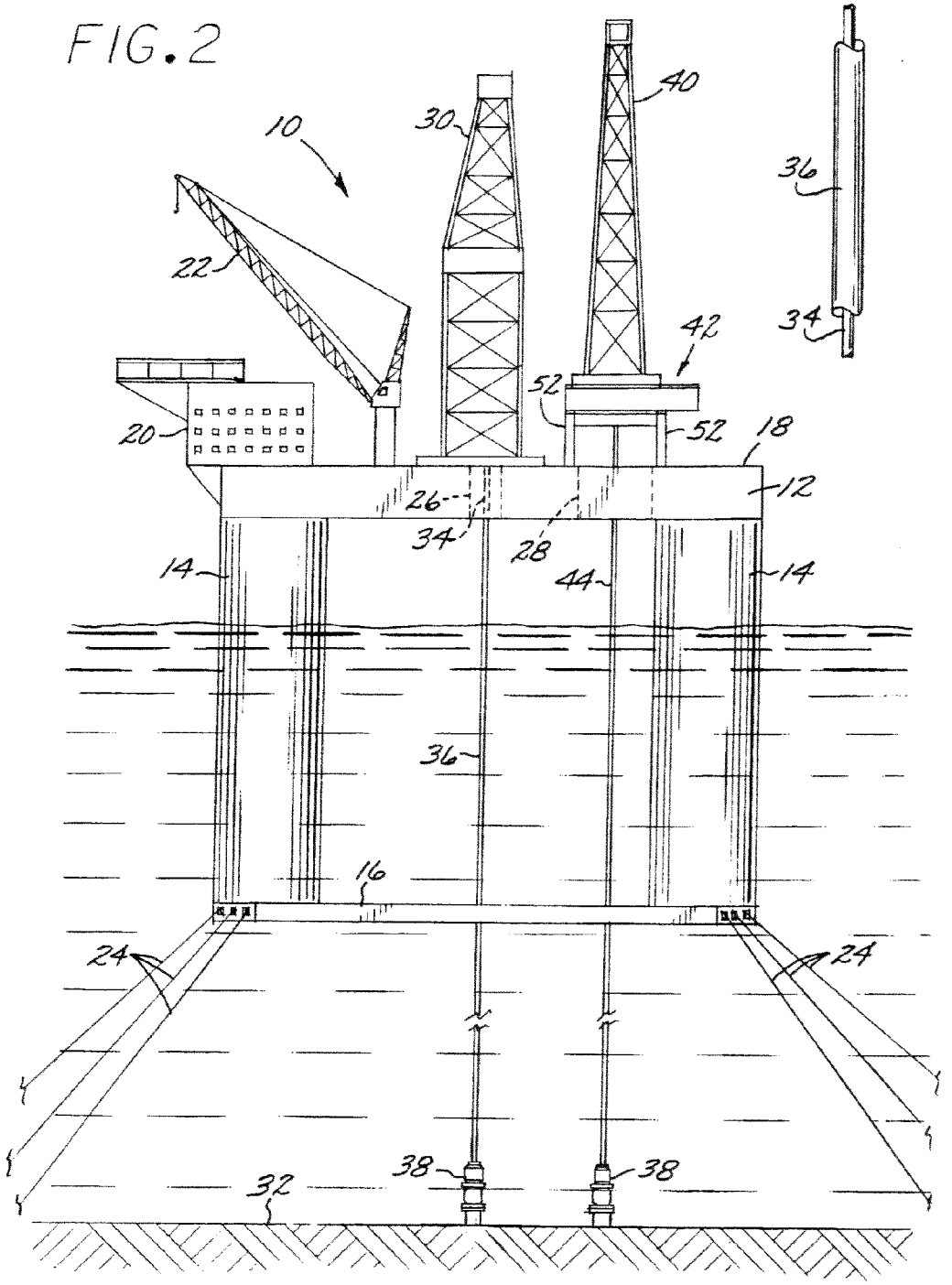
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FIG. 2A

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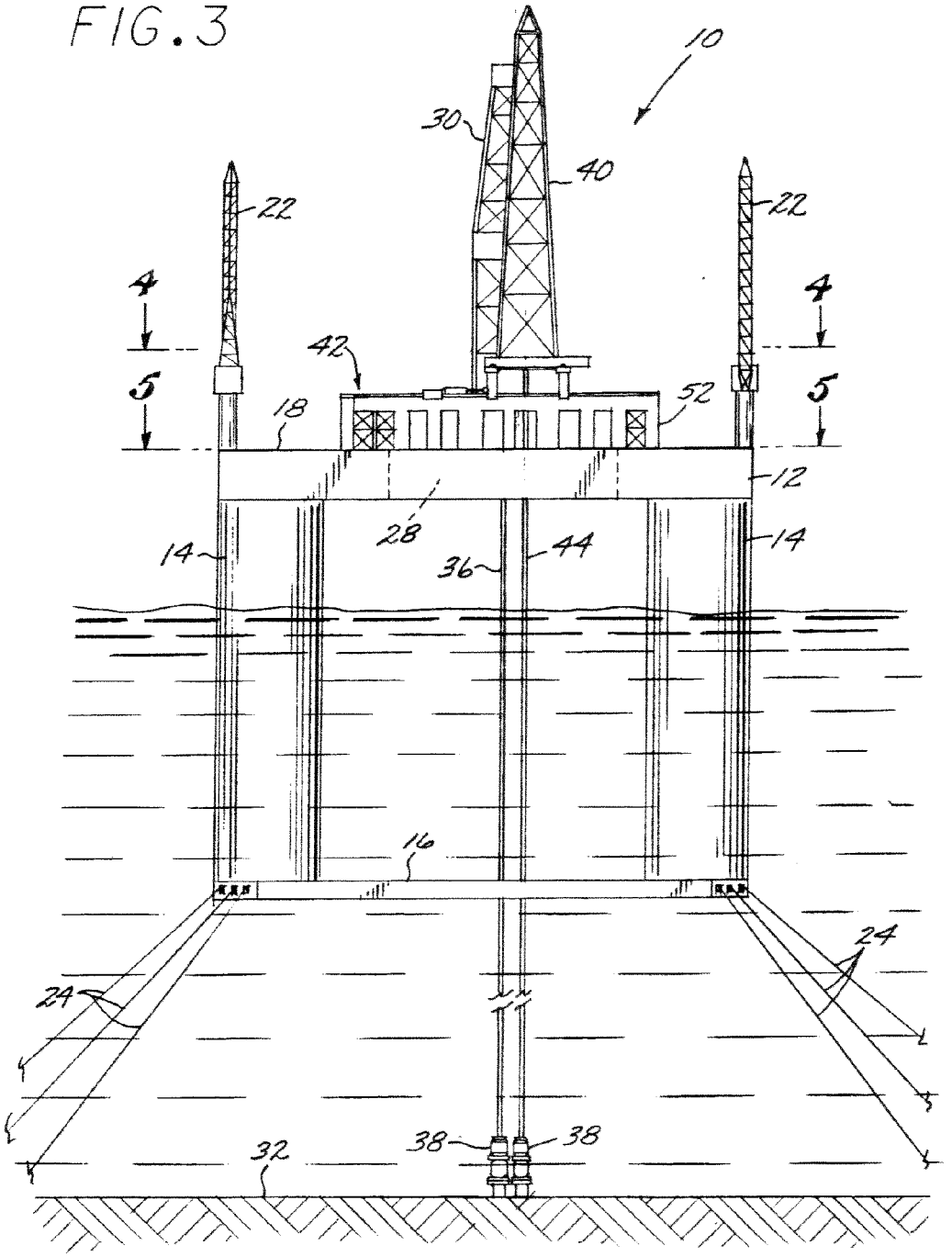
FIG. 3



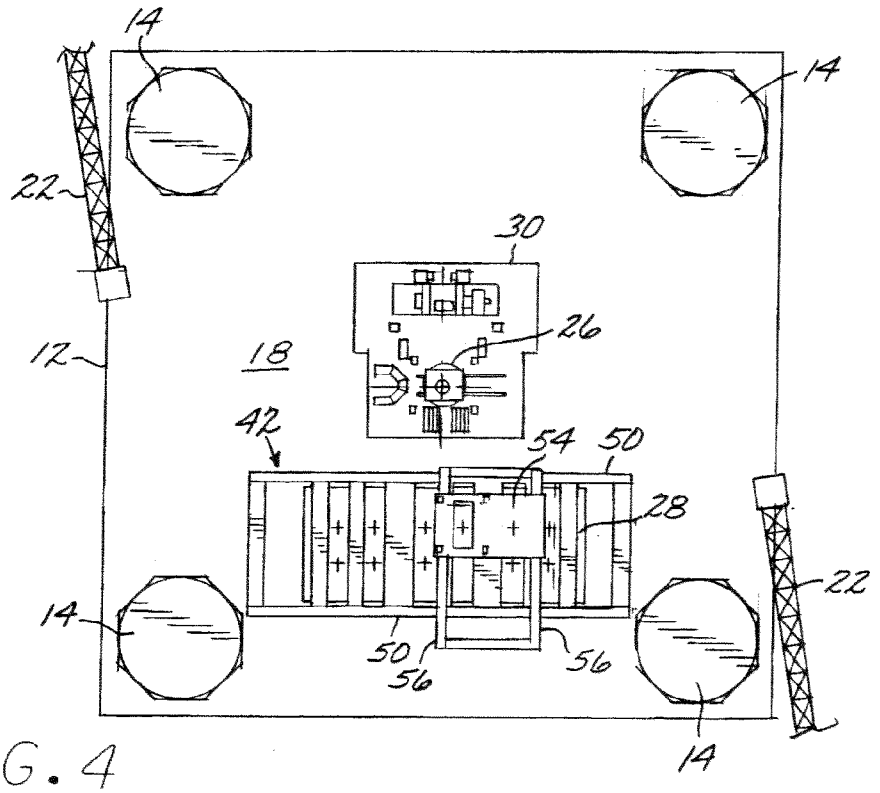

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FIG. 4

FIG. 5

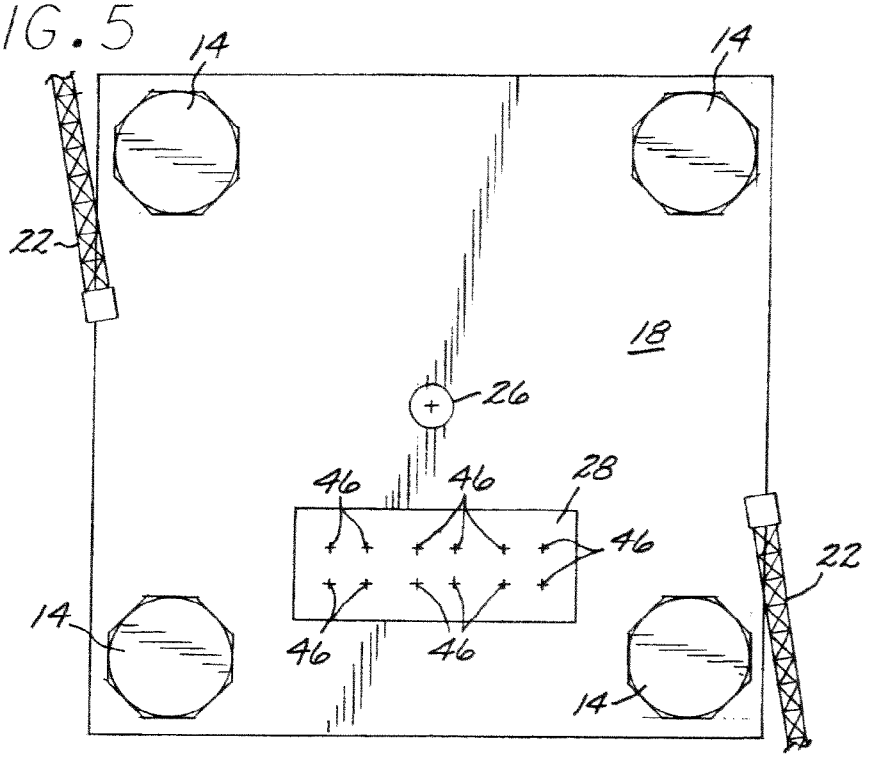
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FIG. 6

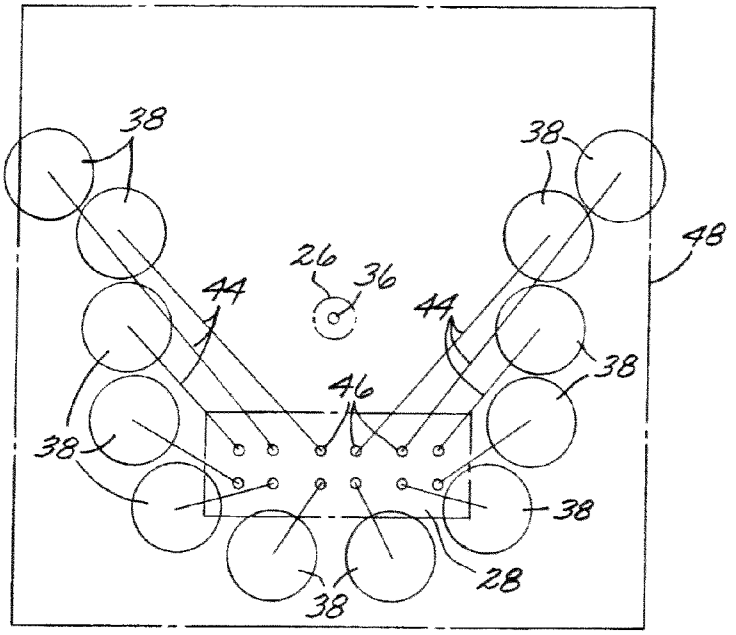
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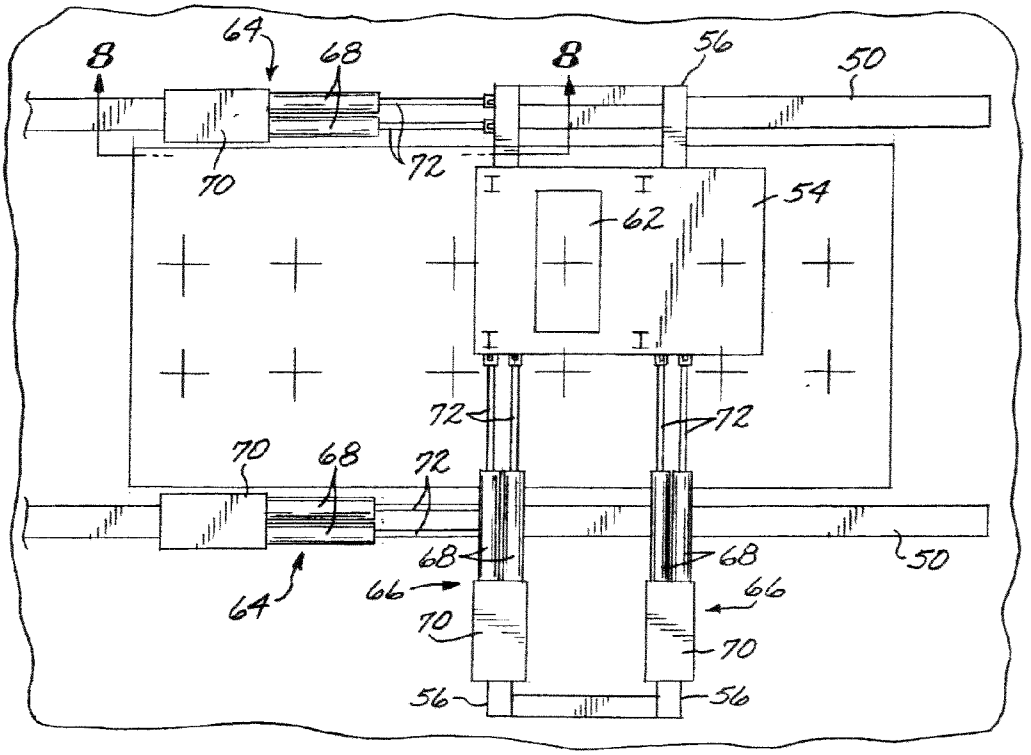
FIG. 7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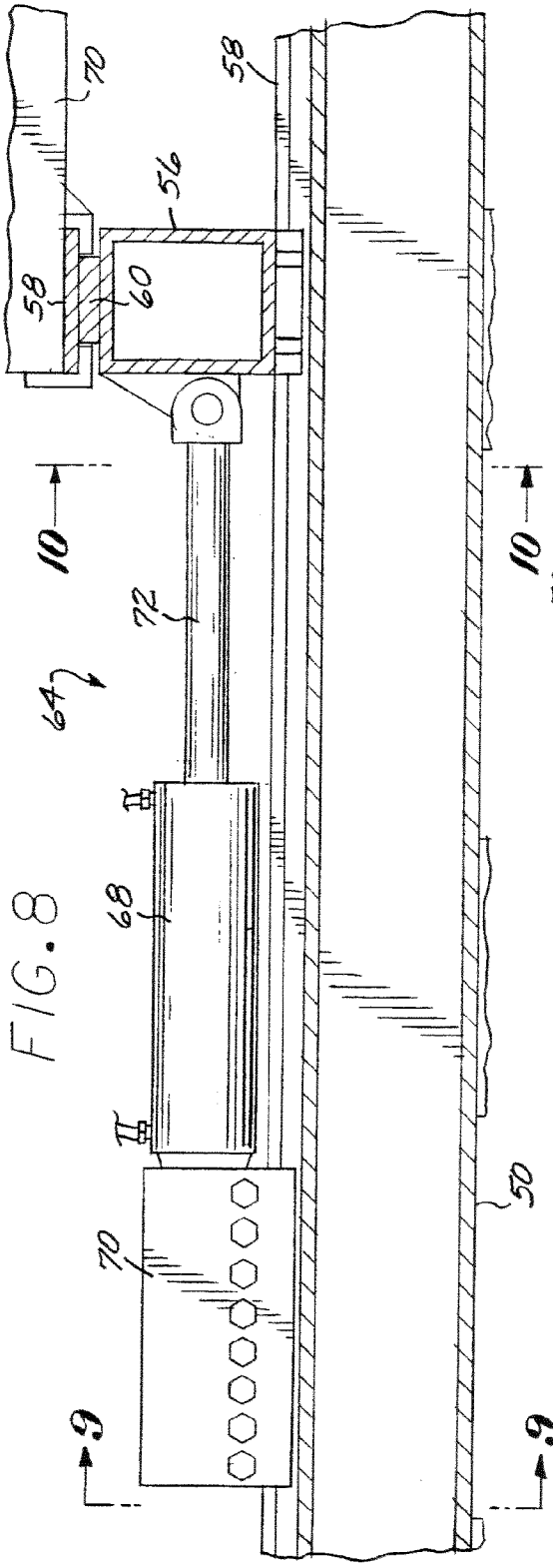

FIG. 8

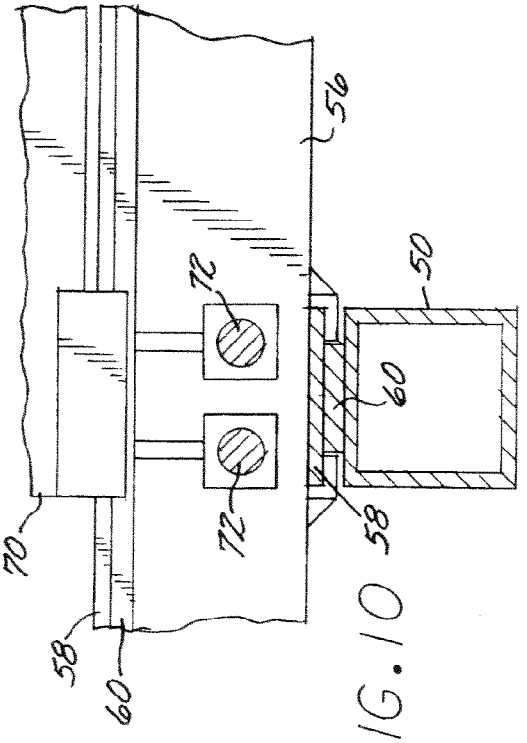

FIG. 10

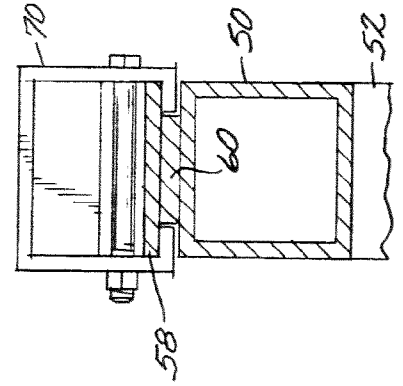

FIG. 9

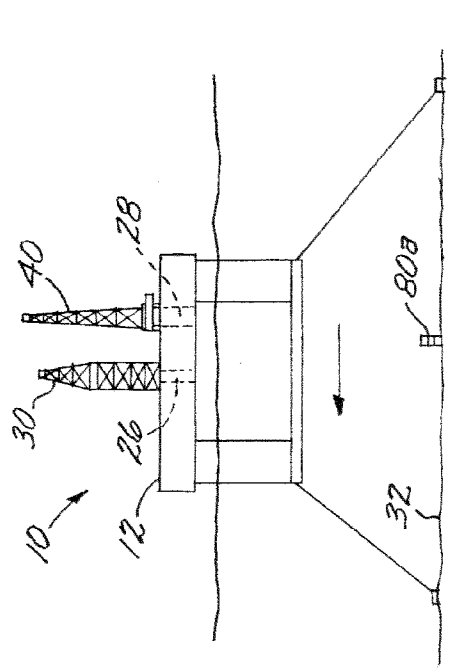

FIG. 11B

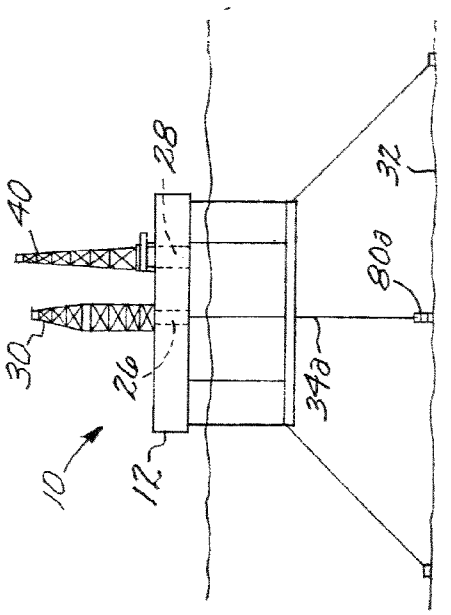

FIG. 11A

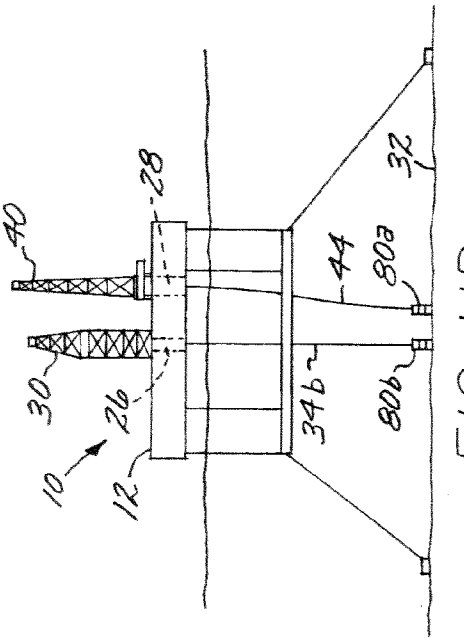

FIG. 11D

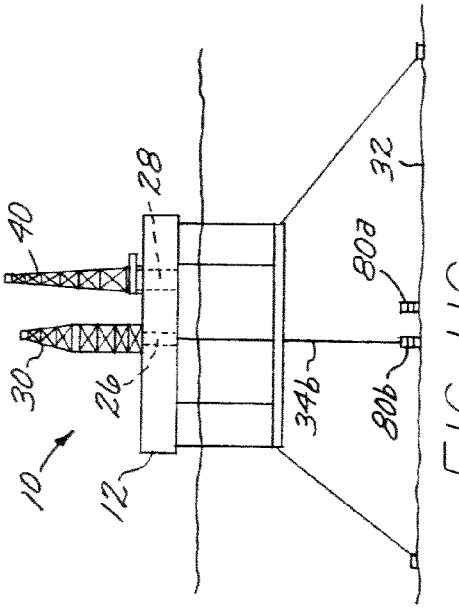

FIG. 11C

PARALLEL DRILLING AND COMPLETION FOR A DRY TREE FLOATING PRODUCTION FACILITY

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit, under 35 U.S.C. §119(e), of Applicant's co-pending U.S. Provisional application No. 60/896.988. filed Mar. 26, 2007, the disclosure of which is incorporated herein by reference in its entirety.

BACKGROUND

[0002] This disclosure relates to the field of offshore drilling for, and production of, undersea liquid and gaseous hydrocarbon deposits (i.e., natural gas and petroleum). More specifically it relates to a system and a method for performing exploratory and/or field development drilling simultaneously with performing completion and production work from the same offshore structure.

[0003] The floating structures or facilities used for the development and production of offshore hydrocarbon deposits frequently employ "dry production trees" (production structures and equipment installed at the topside of the production riser system), either by themselves, or in combination with "wet production trees" at the bottom or seabed end of the riser system. The dry production trees are an extension of the well bore through a riser and production tubing system from the seabed and up to the floating facility production deck area or well bay. This riser and production tubing is hung off in a surface wellhead system, this system being supported by a top tensioned riser hang-off system. The purpose of this top-tensioned riser system is to support the surface wellhead loads and to compensate for the relative motion between the surface wellhead and the floating facility. For a floating facility to be able to support such a riser system, strict requirements are set for its motion characteristics with respect to limitations in the overall relative motions, such as vertical heave and pitch and roll characteristics.

[0004] There are presently several different approaches for achieving a dry tree-based drilling and completion program. One method is based on pre-drilling the development wells using a Mobile Offshore Drilling Unit (MODU) prior to installing the permanent floating facility. The subsequently-deployed permanent facility will employ a smaller tie-back and completion rig for doing tie-back on the production risers and then doing the final completion work to start production.

[0005] Alternately, offset drilling may be used, in which a MODU performs field development drilling in close proximity to a Dry Tree Unit (DTU) that performs conviction and production work. A fixed or skiddable drill set is installed onto the DTU to perform a sequential drilling and completion program. This drill set can be a full drilling rig with support systems or a Tender Assisted Drill (TAD) set.

[0006] The above-described current methodologies, other than offset drilling, require a sequential execution program in which doing field development drilling precedes completion by dry tree well drilling and then well completion. Offset drilling, while permitting simultaneous field development and completion/production, is dependant upon favorable environmental conditions for conducting close proximity operations with the MODU and DTU.

[0007] The above-described sequential or environmentally-restricted operations have up to now been acceptable from an execution time perspective to achieve first oil and plateau rate production, as the water depths and reservoir depths have been sufficiently shallow to enable drilling and completion of each well within a two-to-four month time frame. With the new significant energy reserves confirmed in ultra-deep water areas (e,g., water depths of 2000-3500 meters or more), and hydrocarbon reservoirs below the sub-salt or pre-salt formations, the combination of water depth, reservoir depth, high pressures and temperatures, and formation challenges, has had a significant impact on the drilling and completion time for each individual well. Exploration wells may require six to nine months drilling time, and in a field development program the drilling time can be an additional three to six months, with a subsequent three month completion program. Thus, for an average size field in an ultra-deep water environment in the Gulf of Mexico), a total field development drilling program of seven to nine years could be envisioned for a sub-salt field development program.

[0008] It would therefore be an advance in the state of the art to provide a system and a method for improving the efficiency of performing field development drilling and well completion/production for deep-water offshore reserves and thus reducing the time expended to bring such reserves into production. It would also be advantageous to increase this efficiency and thus reduce the overall time span from initiation of field development to commencing production in a way that is less sensitive to environmental conditions than has heretofore been achievable. Furthermore, it would be advantageous to provide such a system and method that would allow field development work and completion/production work to be performed simultaneously, and yet fully independently so as to avoid the one interfering with the other.

SUMMARY

[0009] Broadly, the present disclosure, in one aspect, relates to a system for performing both field development drilling and completion/production work in "parallel" (in the temporal, rather than physical sense). The system comprises a floating facility having a deck with a moon pool and a well bay, a first or drilling rig fixed to the deck over the moon pool and that is operable for field development drilling (including exploratory drilling) through the moon pool, and a second or completion rig movably mounted on the deck over the well bay, and that is operable for performing well completion and production functions through the well bay while the first rig is performing field development drilling.

[0010] In another aspect, the present disclosure relates to a method for simultaneously performing field development drilling and well completion and production functions from a single floating facility having a deck with a drilling moon pool and a well bay, comprising (a) positioning the facility in a first field development position for performing field development drilling at a first well location through the drilling moon pool; (b) using a first or drilling rig fixed to the deck over the drilling moon pool to perform field development drilling at the first well location through the drilling moon pool; (c) moving the facility to a second field development position for field development drilling at a second well location; (d) using the drilling rig to perform field development drilling at the second well location through the drilling moon pool; (e) during the performance of the field development drilling at the second well location, positioning the facility, as necessary, to a first completion position in which the first well location is accessible through the well bay; and (t) using a

second or completion rig movably mounted on the deck above the well bay to perform well completion work at the first well location through the well bay while field development drilling is being performed at the second well location.

[0011] This brief summary has been provided so that the nature of the disclosure may be understood quickly. A more complete understanding of the disclosure may be obtained by reference to the following detailed description of the preferred embodiments thereof in connection with the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIG. **1** is an axonometric perspective view of a floating offshore facility or structure incorporating the parallel field development drilling and completion system of the present disclosure;

[0013] FIG. **2** is a side elevational view of the facility of FIG. **1** showing a drilling riser deployed from a, fixed drilling rig, and a completion/production riser deployed from a movable completion rig in accordance with the present disclosure;

[0014] FIG. **2**A is a detailed view of a drill string and drilling riser as may be deployed by the fixed drilling rig of the facility of FIG. **1**;

[0015] FIG. **3** is a rear elevational view of the facility of FIG. **1**, as viewed from the right side of FIG. **2**;

[0016] FIG. **4** is plan view of the of the facility of FIG. **1**, taken along the line **4-4** of FIG. **3**;

[0017] FIG. **5** is a top plan view of the deck of the facility of FIG. **1**, taken along line **5-5** of FIG. **3**;

[0018] FIG. **6** is a diagrammatic view showing the riser slot configuration through the hull structure of the facility of FIG. **1**, showing the drilling moon pool and the well bay used for completion/production work, with the corresponding layout of the seabed wellheads;

[0019] FIG. **7** is a top plan view of the movable completion rig and its associated hydraulic jack skidding apparatus situated over the well bay of the facility of FIG. **1**.

[0020] FIG. **8** is a cross-sectional view of a portion of the hydraulic jack skidding apparatus shown in FIG. **7**, taken along line **8-8** of FIG. **7**;

[0021] FIG. **9** is a cross-sectional view taken along line **9-9** of FIG. **8**;

[0022] FIG. **10** is a cross-sectional view taken along line **10-10** of FIG. **8**; and

[0023] FIGS. **11**A-**11**D are semi-schematic devotional views of the facility of FIG. **1**, showing the steps of the method of performing field development drilling in parallel with completion/production work, in accordance with the present disclosure.

DETAILED DESCRIPTION

[0024] Referring to the drawings, FIGS. **1**, **2**, and **3** show a floating offshore facility or structure **10**. The specific structure shown is a platform of the type known as an extended-draft platform (EDP), but other types of structures known in the art, such as tension-leg platforms (TLP's), SPARs, and deep-draft semi-submersible platforms, may be used. Indeed, is will be readily appreciated, any floating structure capable of supporting a dry tree completion/production system may be employed. EDP's, such as the structure **10**, are well-known in the art, as exemplified by U.S. Pat. No. 7,037,044, the disclosure of which is incorporated herein by reference. Briefly, the structure or EDP **10** comprises a hull structure **12** supported above the water surface by several (typically three or four) adjustable-buoyancy columns **14**, attached at their bottom ends to a heave-plate **16** having a central aperture **17**. The hull structure **12** includes several decks, of which only an upper deck or top deck **18** is shown. The upper or top deck **18** supports the drilling, completion, and production apparatus, as will be described in detail below, as well as other structures and equipment, such as, for example, a crew quarters **20** and one or more cranes **22**.

[0025] The EDP **10** is secured to the seabed by a mooring system comprising a set of mooring lines **24** extending from the structure, such as from the heave plate **16**, as shown. The mooring lines **24** are controlled by winches (not shown), which are operable to shift the position of the EDP **10** relative to the seabed, as will be discussed below. Alternatively, a dynamic (powered) positioning system, of a type well-known in the art, may be employed.

[0026] The hull structure **12** is provided with two openings or "moon pools" extending through all of the decks to provide access to the seabed. The first, smaller moon pool is a drilling moon pool **26** (see FIGS. **2**, **5**, and **6**), while the second, larger moon pool is a well bay **28** that accommodates a plurality of production riser slots, as will be described below.

[0027] Fixed to the upper deck **18** over the drilling moon pool **26** is a first or fixed drilling rig **30** that is operable for field development drilling into an undersea hydrocarbon reservoir (not shown) beneath the seabed **32**. The field development drilling is performed with a drill string **34** operated from the fixed drilling rig **30** and deployed through the drilling moon pool **26**. The drill string **34** is advantageously deployed through a high-pressure drilling riser **36** fixed to a sub-sea wellhead **38** installed by the fixed drilling rig **30**.

[0028] A second, movable completion rig **40** is movably supported over the well has **28** so as to allow it to be shifted or translated relative to the well bay **28**, in a plane substantially parallel to the top deck **18**. The shifting or translation of the movable rig **40** may advantageously be accomplished by a hydraulic jack skidding apparatus **42** (to be described in detail below) that is fixed to the upper or top deck **18** over the well bay **28**. The completion rig **40** performs the "tie-back" operation by deploying a production riser **44** that extends through the well bay **28** and connects, at its bottom end, to the wellhead **38**. Production tubing (not shown) is deployed by the completion rig **40** through the production riser **44** down into the well (not shown) through the seabed wellhead **38**. The tubing is suspended from a connection at the dry tree apparatus (not shown) that is fixed to the top end of the production riser **44**. The upper end of the production tubing within the production riser is hydraulically and mechanically connected to the dry tree apparatus by conventional means well-known in the art. The well bay **28** is dimensioned to accommodate a plurality (typically six to twelve or more) of predefined positions or "slots" **46** (see FIGS. **5**-**7**), each of which receives one production riser **44**. To this end, a grid structure (not shown) may be installed in the well bay **28** to define the riser slots **46**. See, for example, U.S. Pat. No. 6,692,193, the disclosure of which is incorporated herein by reference.

[0029] FIG. **6** shows, schematically, a typical layout of the wellheads **38** ("well splay") after completion is performed on a number of wells within a particular subsea wellhead area **48** corresponding to the number of production riser slots **46** in the well bay **28**. The drilling moon pool **26** and the drilling riser **36** are shown within the subsea wellhead area **48**, and a plurality of production risers **44** is shown within the well bay

28. The arrangement of the well has 28 relative to the drilling moon pool 26 is such that the drilling riser 36 and the production risers 44 can be deployed and accessed independently and without interference, using the method of parallel development drilling and well completion/production described below.

[0030] FIGS. 7-10 illustrate the hydraulic jack skidding apparatus 42 on which the movable completion rig 40 is advantageously mounted. The skidding apparatus 42 comprises an elevated rail structure comprising a pair of parallel longitudinal beams 50 supported above or on the upper or top deck 18 by a plurality of vertical supports 52 (FIGS. 2 and 3). A skid platform 54 is slidably mounted on a pair of parallel transverse beams 56 that, in turn, are slidably mounted on the longitudinal beams 50. Each of the beams 50, 56 has horizontal flange 58 fixed to its top surface by means of a rail element 60. The completion rig 40 is fixed to the skid platform; therefore, the skid platform 54 has an aperture 62, over which the completion rig 40 is mounted, through which the production risers 44 are deployed.

[0031] The skid platform 54 is translatable longitudinally with respect to the top deck 18 along each of the longitudinal beams 50 by a first or longitudinal hydraulic gripper jack system 64, and it is translatable transversely along each of the transverse beams 56, by a second, or transverse hydraulic gripper jack system 66. Thus, there are preferably two longitudinal hydraulic gripper jack systems 64 acting in concert, and two transverse hydraulic gripper jack systems 66 acting in concert. The hydraulic gripper jack systems 64, 66 may advantageously of the type marketed by Bardex Corporation, of Goleta, Calif. (www.bardex.com), under die trade name "Bardex Gripper Jack." Briefly described, each of the gripper jack systems 64, 66 comprises a pair of hydraulic jacking cylinders 68 fixed to a hydraulic friction lock device 70. Each of the cylinders 68 contains a hydraulic piston rod 72. In the longitudinal hydraulic gripper jack systems 64, the piston rods 72 are connected to one of the transverse beams 56. In die transverse hydraulic gripper jack systems 66, the piston rods 72 are connected to the slid platform 54. Each of the friction lock devices 70 is slidably mounted on the flange 58 of one of the beams 50, 56.

[0032] To move the platform 54 longitudinally in a first or forward direction, the friction lock devices 70 of the two longitudinal gripper jack systems 64 are actuated to lock onto the flanges 58 of their respective longitudinal beams 50. The cylinders 68 of the longitudinal gripper jack systems 64 are then actuated to extend their respective piston rods 72 to effect longitudinal translation of the platform 54 by an increment distance up to the full extendable length of the piston rods 72. To move the platform 54 by the next distance increment, the friction lock devices 70 are actuated to release their locking engagement with the flange 58, and the piston rods 72 are retracted, which pulls the friction lock devices 70 in the first or forward direction. The friction lock devices 70 are then locked onto the flange 58, and the process is repeated until the desired longitudinal position is achieved. Longitudinal movement in a second, or reverse direction is achieved by operating the cylinders 68 and the friction lock devices 70 so as to push the friction lock devices 70 in the reverse direction. Movement of the platform 54 transversely along the transverse beams 56 is achieved by similarly operating the cylinders 68 and the friction lock devices 70 of the two transverse gripper jack systems 66. Thus, by appropriately moving the platform 56 longitudinally and transversely over the well bay 28, each of the production riser slots 46 can be accessed for deployment of a production riser 44 through it.

[0033] It will be appreciated that the above-described hydraulic jack skidding apparatus 42 is merely one particularly advantageous mechanism for shifting or translating the movable rig. Other suitable shifting or translating mechanisms will suggest themselves to those skilled in the pertinent arts.

[0034] The floating facility 10 described above is operable for performing field development drilling and well completion/production work in "parallel," in a temporal, rather than physical, sense. That is, completion and production work can be performed from a single facility or structure at a first well that has previously been drilled by field development drilling from that structure while field development drilling is simultaneously being performed from that structure for a second well in the development field.

[0035] Specifically, as shown in FIG. 11A, the facility 10 is positioned in a first development position for performing field development drilling at a first well location 80*a* through the drilling moon pool 26. Field development drilling is performed at the first well location 80*a* through the drilling moon pool 26 with a first drill string 34*a* operated by the fixed drilling rig 30 through a drilling riser 36 (see FIG. 2A). As shown in FIG. 11B, the fixed drilling rig 30 removes the first drill string 34*a* and a first drilling riser 36 from the first well location 80*a,* and the facility 10 is moved (by means such as the mooring lines 24, or by a other means known in the art) to a second field development position for field development drilling at a second well location 80*b.* Then, as shown in FIG. 11C, field development drilling is commenced at the second well location 80*b* through the drilling moon pool 26 with a second drill string 34*b* operated by the fixed drilling rig 30 through a drilling riser 36. During the field development drilling at the second well location 80*b,* the position of the facility 10 may be adjusted, a, needed, to a first completion position in which the first well location 80*a* is accessible through the well bay 28. Finally, as shown in FIGS. 2, 3, and 11D, while field development drilling is still being performed at the second well location 80*b,* well completion/production work is commenced at the first well location 80*a* by the movable completion rig 40 which deploys a production riser 44 to the first well location 80*a* through the well bay 28.

[0036] The above-listed sequence of steps is repeated as field development drilling is commenced at each subsequent well location, while completion/production work is performed at the most recently-drilled well location. The position of the movable completion rig 40 is shifted over the well-bay 28 to access each successive production riser slot 46 by means of the hydraulic jack skidding apparatus 42 described above. The use of top tensioned production risers 44 and the production tubing therein) facilitates the position shifting of the facility 10 needed for the movable completion rig 40 to access each well location after field development drilling has been finished at that location.

[0037] As will be appreciated, the apparatus and method disclosed above and illustrated in the drawings are exemplary embodiments only, and are not to be construed as exclusive of other embodiments and equivalents that may suggest themselves to those skilled in the pertinent arts. Indeed, such equivalents as may reasonably suggest themselves are deemed to be within the spirit and scope of the invention as defined in the claims that follow.

What is claimed is:

1. A floating facility for performing field development drilling simultaneously with well completion or hydrocarbon production work, the facility comprising:

a hull structure including a deck and first and second openings, each opening providing access through the deck to a seabed;

a drilling rig fixed to the deck above the first opening, the drilling rig being operable for field development drilling through the first opening; and

a completion rig movably positioned on the deck above the second opening, the completion rig being horizontally movable with respect to the deck, and being operable to perform well completion and production work through the second opening;

wherein the drilling and completion rigs are operable simultaneously.

2. The floating facility of claim **1**, wherein the second opening is configured to accommodate a plurality of production riser slots.

3. The floating facility of claim **1**, wherein the drilling rig is operable to deploy and operate a drill string through the first opening.

4. The floating facility of claim **3**, wherein the drill string is deployed through a high-pressure drilling riser.

5. The floating facility of claim **1**, wherein the completion rig is operable to deploy a production riser and production tubing to the seabed.

6. The floating facility of claim **1**, wherein the completion rig is movable within a plane substantially parallel to the deck along a first axis and along a second axis that is substantially perpendicular to the first axis.

7. The floating facility of claim **1**, wherein the completion rig is mounted on a hydraulic jack skidding apparatus.

8. The floating facility of claim **7**, wherein the hydraulic jack skidding apparatus comprises a pair of parallel longitudinal beams supported on or above the deck.

9. The floating facility of claim **8**, wherein the hydraulic jack skidding apparatus further comprises a pair of parallel transverse beams slidably mounted on the longitudinal beams.

10. The floating facility of claim **9**, wherein the completion rig is mounted on a skid platform slidably mounted on the transverse beams.

11. The floating facility of claim **9**, wherein the hydraulic jack skidding apparatus further comprises a longitudinal hydraulic gripper jack system operable to translate the completion rig with respect to the longitudinal beams, and a transverse hydraulic gripper jack system operable to translate the completion rig with respect to the transverse beams.

12. A system for performing field development drilling and completion/production work, comprising:

a floating facility having a deck with a moon pool and a well bay;

a drilling rig fixed to the deck over the moon pool and operable to perform field development drilling into a seabed through the moon pool; and

a completion rig movably mounted on the deck over the well bay and operable to perform well completion and production work in the seabed through the well bay while the drilling rig is performing field development drilling.

13. The system of claim **12**, wherein the floating facility is selected from the group consisting of an extended-draft platform, a tension-leg platform, a SPAR, and a deep draft semi-submersible platform.

14. The system of claim **12**, wherein the drilling rig is operable to deploy and operate a drill string through the first opening.

15. The system of claim **14**, wherein the drill string is deployed through a high-pressure drilling riser.

16. The system of claim **12**, wherein the completion rig is operable to deploy a production riser and production tubing to the seabed.

17. The system of claim **12**, wherein the completion rig is movable within a plane substantially parallel to the deck along a first axis and along a second axis that is substantially perpendicular to the first axis.

18. The system of claim **12**, wherein the completion rig is mounted on a hydraulic jack skidding apparatus.

19. The system of claim **18**, wherein the hydraulic jack skidding apparatus comprises a pair of parallel longitudinal beams supported on or above the deck.

20. The system of claim **19**, wherein the hydraulic jack skidding apparatus further comprises a pair of parallel transverse beams slidably mounted on the longitudinal beams.

21. The system of claim **20**, wherein the completion rig is mounted on a skid platform slidably mounted on the transverse beams.

22. The system of claim **20**, wherein the hydraulic jack skidding apparatus further comprising a longitudinal hydraulic gripper jack system operable to translate the completion rig with respect to the longitudinal beams, and a transverse hydraulic gripper jack system operable to translate the completion rig with respect to the transverse beams.

23. A method for performing field development drilling simultaneously with well completion or production work from a floating facility having a deck with a drilling moon pool and a well bay, the method comprising:

(a) positioning the facility in a first field development position for performing field development drilling at a first well location;

(b) performing field development drilling through the drilling moon pool at the first well location with a drilling rig fixed to the deck above the drilling moon pool;

(c) moving the facility to a second field development position for performing field development drilling at a second well location;

(d) performing field development drilling through the drilling moon pool at the second well location with the drilling rig; and

(e) during the performance of the field development drilling at the second well location, performing well completion or production work through the well bay at the first well location with a completion rig movably positioned on the deck above the well bay.

24. The method of claim **23**, wherein when the facility occupies the second field development position, the first well location is accessible through the well bay.

25. The method of claim **23**, wherein the field development drilling at the first well location is performed with a first drill

string, and wherein the field development drilling at the second well location is performed with a second drill string.

26. The method of claim **25**, further comprising removing the first drill string with the drilling rig before moving the facility to the second field development location.

27. The method of claim **23**, wherein, after the performance of well completion or production work at the second well location, field development drilling is performed at a subsequent well location while completion or development work is performed at a prior well location at which field development drilling has most recently been completed.

28. The method of claim **27**, wherein the well bay includes a plurality of riser slots, each corresponding to a well location, and wherein the performance of well completion or production work comprises moving the completion rig over the well-bay to access each successive riser slot.

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