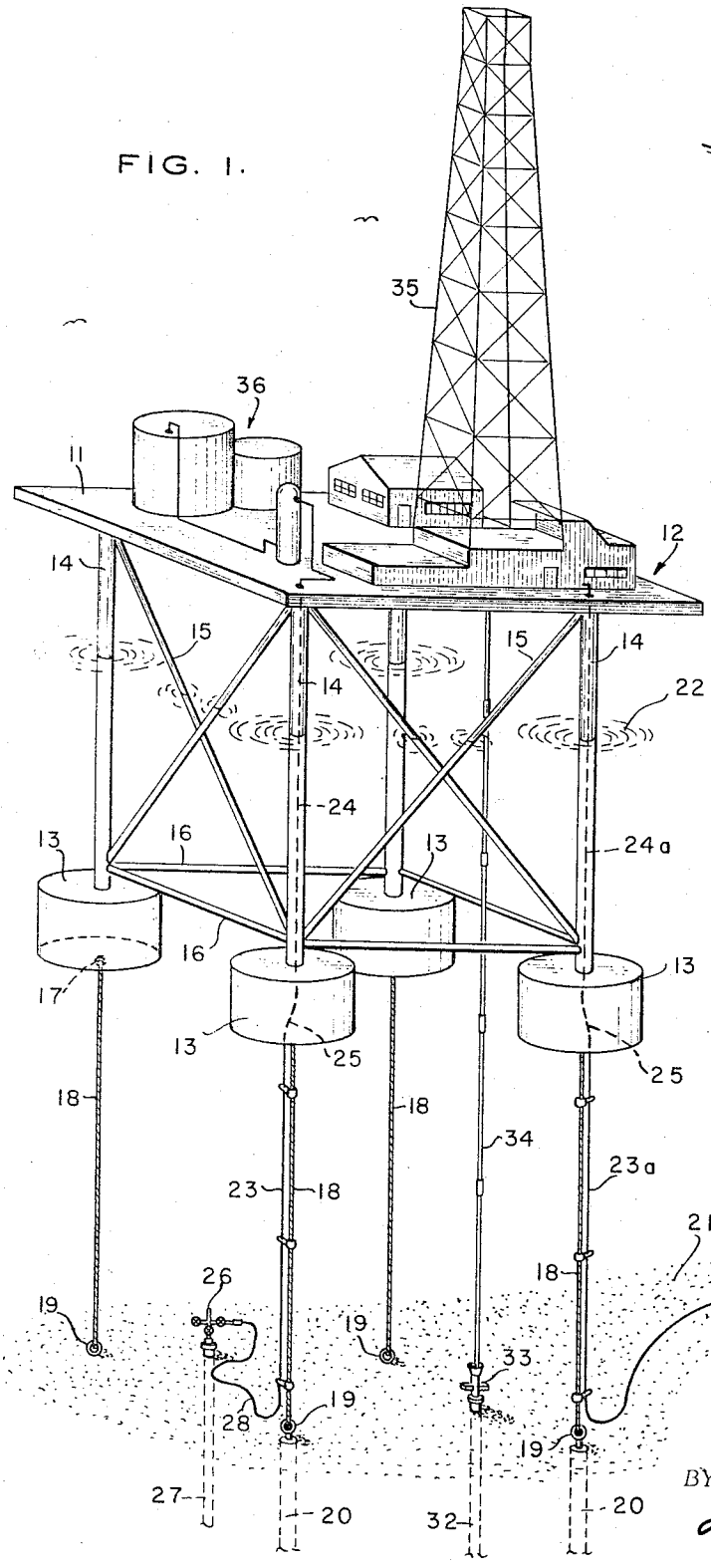
June 27, 1967 R. P. KNAPP ET AL 3,327,780

CONNECTION OF UNDERWATER WELLS

Filed March 15, 1965

FIG. 1.



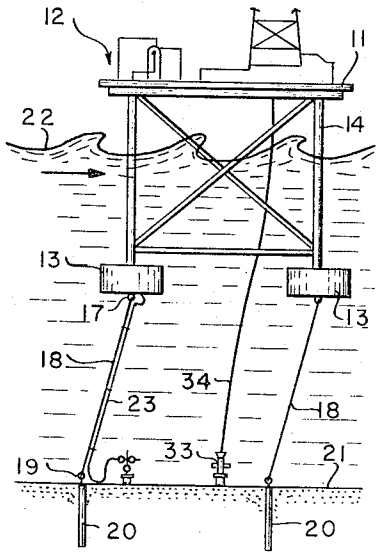


FIG. 2.

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United States Patent Office 3,327,780
Patented June 27, 1967

3,327,780

CONNECTION OF UNDERWATER WELLS

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Filed Mar. 15, 1965, Ser. No. 439,557
4 Claims. (Cl. 166—.5)

The present invention is directed to a method of exploitation of hydrocarbon reservoirs and the like in deep water. More particularly, the invention is concerned with making a connection to an underwater well to a location which is accessible from the water surface. More specifically, the invention is concerned with the connection of an underwater well having a submerged wellhead to an accessible location.

The present invention may be briefly described as a method for connecting an underwater well having a submerged wellhead to an accessible location in which a first fluid passageway is provided from a point adjacent to the wellhead of the underwater well to a point intermediate to the wellhead and water surface. A second fluid passageway is provided from the intermediate point to a point at least at water surface or adjacent thereto. The lower end of the first fluid passageway is connected to the wellhead by means of a movable connection and the upper end of the first fluid passageway is movably connected to the lower end of the second fluid passageway. The other end of the second fluid passageway terminates at an accessible location which may be a platform at, or above, the water surface. The wellhead may be on water bottom or may be located at a point above water bottom but below water surface, such as on a submerged platform or other structure below water surface.

The present invention is also concerned with apparatus for connecting an underwater well having a submerged wellhead to an accessible location which may be at or above water surface which comprises a first flow line extending from a point adjacent to the submerged wellhead to a point intermediate to the submerged wellhead and water surface. A second flow line extends from the intermediate point to at least water surface and means are provided for movably connecting the lower end of the first flow line to the wellhead. Means are also provided for movably connecting the upper end of the first flow line to the lower end of the second flow line. The second flow line terminates at an accessible location which may be on a platform at, or above, water surface.

In accordance with the present invention, the fluid passageway is suitably in a flow line extending from a point adjacent to the wellhead to an intermediate point between the wellhead and water surface. This member is maintained under tension suitably by providing buoyancy to the member. The second fluid passageway is provided in a second member which extends from the intermediate point to at least water surface, the second member may be maintained under compression by providing weight thereon, but maintenance of the second passageway under compression is not necessary.

In the practice of the present invention, the first flow line is maintained under tension by connecting the upper end of the first flow line to a buoyant member. Tension members (mooring lines) may be tubular, cables, chains, or solid rods. Flow lines may be supported inside or outside of tubular tension members or outside of cables, chains, or rods. Suitably, tension is provided by installing the flow lines in a sea drome platform which will be illustrated further. In accordance with the present invention, a combination of tension members and compression members is separated by a submarine float or

underwater buoyancy means with the tension member being maintained under tension by the float or buoyancy means and the compression members being maintained under compression by weight such as a platform supported thereon. Supporting members between anchors and float are necessarily in tension. Supports between floats and deck will be in compression; however, flow lines may be in tension or compression depending on their attachment to the supporting members. The essence of this invention is to use the main tension members to support (internally or externally) the flow lines.

Heretofore offshore oil and gas field operations and the like ordinarily have required a fixed foundation for drilling and production operations. However, the cost of a tower or other available type of artificial island increases rather rapidly as the water depth increases, while available technology and equipment limits conventional type of installations to areas of relatively shallow water. For example, existing installations may currently reach out to a maximum water depth of the order of 200 to 250 feet.

Floating vessels have provided suitable foundations for conducting drilling operations in water depths of more than 350 feet, but these vessels lack characteristics necessary for the conducting of oil or gas field operations. In a few instances, floating vessels have been used for drilling oil and gas wells in an offshore area and then the wells so drilled have been completed with wellhead installations on the ocean floor with submarine flow lines extending to production facilities on the nearest coast. The cost of this type of installation increases rapidly as the distance from the wellhead to the coastline increases.

Others have proposed the installation of production facilities on a floating vessel with flexible flow lines conducting production from an underwater well to the floating vessel. In this operation, detachable connections at the vessel are used to permit the release of the flow line when wave action or subsurface ocean current threatens axial loading and breakage of the fluid conduits. At the present time flow lines with sufficient flexibility and other necessary characteristics for this type of installation are unavailable. If such flow lines should become available, the cost may well exceed that of ordinary steel pipe. Moreover, the necessity for release and recovery of all flow lines on every occurrence of storm waves or strong currents points to frequent loss of production and high operation costs.

The disadvantages of the prior art practices are overcome in the practice of the present invention. Thus, in accordance with the present invention, method and apparatus are provided, for connecting an underwater well to an accessible location above water surface, which are quite useful and which provide a solution to problems which have plagued the industry for a long time.

In accordance with the present invention, hydrocarbon reservoirs may be explored and/or drilled from a floating or bottom-supported mobile drilling rig. The wells may be plugged and abandoned or capped for re-entry at a later time or completed on the ocean floor for later remote control of production.

It is contemplated in the present invention that a sea drome platform will be installed at a central location in the offshore hydrocarbon field prior to initiating development drilling operations. However, drilling may be from other types of platforms, a sea drome being moved in only for production operations as may be desired. The type of platform which may be used in the practice of the present invention obtains support through a combination of tension members and compression members separated by a submarine float or underwater buoyancy means. At least three tension members which are parallel and of equal

length extend upward from hinged attachments at the ocean floor to hinged connections on the lower side of the submarine float. The submarine float may be a single vessel or a combination of separate buoyancy means which supports a framework that reaches upwardly to an elevation above the water surface where a horizontal deck provides a working surface. Such a platform is described in U.S. Patent No. 3,154,039 issued Oct. 27, 1964 in the name of Richard P. Knapp.

As disclosed in the above-identified Knapp patent, a drilling rig may be installed on the platform deck from which one or more submarine wells may be drilled. In the practice of the present invention it is contemplated that a plurality of wells may be drilled from the floating platform. Wells may be drilled from other platforms or floating vessels. Satellite wells may be drilled by other platforms, before or after installation of production platform. Wells directly below the production platform may be drilled by other rigs before installation of production platform, as well as later from the production platform.

After one or several wells have been drilled and completed on ocean bottom, flow lines from the underwater Christmas trees are installed on the tension members. The flow lines may be installed on tension members before wells are drilled, thus anticipating remote connection to the wellhead at a later time. These flow lines are suitably carried externally or internally by the tension members up to the buoyancy members which support the flow line. A passageway through the buoyancy members connects to a second flow line which extends through or is carried by the compression members which support the platform on the buoyancy members. Thus, the first and second flow lines being carried respectively by the tension members and the compression members are suitably protected from buffeting by wave and sea current action. Thereafter conventional production facilities may be installed on the platform deck and connected to the second flow line for storage of hydrocarbons. Tankers and barges may be loaded from the storage by suitable connections thereto. Production from several wells may also be connected to a large pipeline leading to the coast, central storage at offshore location, or other tanker loading facility.

It is specifically contemplated in the practice of the present invention that the invention may be employed for well connections which may extend a mile or more from the platform. In other words, a well may be drilled from the floating platform or some other platform or support, and then the floating platform or other support may be moved to another location and then serve as a production facility for several wells on a radius of a mile or more from the floating platform.

It is also contemplated that the submerged wellhead may be above water bottom. For example, the submerged wellhead may be arranged on a submerged platform or other support at depths below violent wave and current action.

The present invention will be further illustrated by reference to the drawing in which:

FIG. 1 is a view of the floating platform illustrating the connection to an adjacent submarine wellhead and to a remote wellhead while a third well is in the course of being drilled; and

FIG. 2 is a general view illustrating the slight lateral displacement of the floating platform during violent wave action.

Referring now to the drawing and particularly to FIG. 1, numeral **11** designates the deck of a floating platform generally indicated by the numeral **12**. The floating platform **12** is provided with a plurality in excess of three floats or buoyant means **13** which support the platform or deck **11** by support members **14** which are suitably cross braced by structural members **15** and **16**. The float may be a single unit, barge-like, a torus, a square torus, or other shape. However, three mooring lines (tension members) are necessary. The support members **14** extend from the buoyancy means **13** to the deck **11** and therefore are under compression. Connected movably to the buoyant means **13** such as by hinged connection **17** are tension means **18** which are connected by hinged connection **19** to an anchor **20** which may be buried in the water bottom **21** or which may be a separate member on the ocean floor. It will be noted that the deck **11** is at a distance substantially above water surface **22**.

Supported or carried by the tension means **18** either externally or internally is a first flow line **23** which extends to the buoyant means **13** and which is movably connected through the buoyant means **13** to a second flow line **24** which is carried internally or externally by the support member **14**. The first flow line **23** communicates with the second flow line **24** by means of a passageway **25** formed in the buoyant means **13**. The first and second flow lines **23** and **24** may be constructed or formed integrally with tension means **18** and support member **24**, respectively.

The first flow line **23** is connected movably to a wellhead **26** of a submarine well **27** which penetrates at least one hydrocarbon productive formation. The wellhead **26** is connected movably by connection means **28** to the flow line **23**.

Another of the tension means **18** may be provided with a first flow line **23***a* which is carried by the tension means **18** and which likewise extends to a buoyant means **13** and which is suitably connected by passageway **25** to a second flow line **24***a*, the upper end of which terminates on platform **11** as will be described further. Flow line **23***a* connects by a ground flow line **29** to a remote wellhead **30** on a submarine well **31** which had previously been drilled and which may be at a distance of a mile or more from the platform **12**.

It will be noted that a third well **32** provided with a wellhead **33** is being drilled through a drilling riser **34** from the deck **11** employing a drilling rig **35** thereon. The upper end of the second flow lines **24** and **24***a* may suitably terminate at and connect to oil and gas production and storage facilities on the deck **11** generally indicated by the numeral **36**.

Referring to FIG. 2, it will be seen that the water surface **22** has been disturbed by violent wave action which is proceeding in the direction of the arrow. It will be noted that the deck **11** of platform **12** has been displaced laterally a slight amount by the violent wave action. It will be further noted, however, that the tension means **18** remain parallel as the buoyancy means **13** supporting the compression means **14** and the deck **11** have moved to the right and the deck **11** remains substantially parallel to the horizontal. Thus, in accordance with the present invention, the flow lines are completely protected and are not subject to damage or breakage due to buffeting by wave and current action and therefore would not be destroyed.

In the practice of the present invention the wellhead may suitably be lowered on top of the conductor pipe of a well and seated thereon by means of a guideline technique known to the art. The flow line **23** may be connected to the wellhead at the deck **11** using a sufficient amount of slack therein such that it may be lowered to water bottom **21**. Other means may be used for connecting the wellhead **26** to the flow line **23** such as by remote guideline technique. While the flow lines may be attached to the wellhead at the deck, they may also be attached to the wellhead by using well-known remote connectors at the underwater wellhead location. Underwater connection methods that may be employed include the setting of a guide base on the sea floor or above the sea floor for a single well under the floating platform. The well is drilled and completed; then using drilling guidelines and guidance means on the tension supports of the platform, the distance from the wellhead to the tension members is measured. A flow line riser is fabricated of suitable length and height and the riser is run to the elevation of

the wellhead using guidelines from the drilling and guidance means on the tension members. These may be connected to the wellhead with hydraulic devices available in the industry for making remote connections underwater.

Also a multiple well guide base may be set in association with the platform anchor installation in known alignment with the platform anchor and the tension support members. This base provides spacing for several wells directly below the platform and may include means for anchoring flow lines from remote wells a mile or more distant from the platform location. Guide cables or other guidance devices may be employed to direct remote flow lines to the underwater anchor. Wellheads below the platform and flow lines from remote wells are in known alignment with tension members supporting the platform, thus permitting the use of remote hydraulic or mechanical connections to one or more flow lines supported by the tension members.

Other means for connecting the wellhead to the flow line may include tubular guides inside or outside of the tension members which may have a generous radius at the lower end permitting the use of flexible internal cables to pull a flow line into the lower end of the tubular guide and on up the guide for connection at an accessible elevation.

Also, short lengths of high pressure flexible conduit may extend from the flow line to the wellhead or flow line anchor also permitting the use of commercially available remote connectors with guidelines to the wellhead flow line anchor or to the flow line. In many locations, the water depths at which drilling operations take place allow the use of divers to make the connection between the wellhead and the flow line. It is contemplated that divers may be employed.

While the present invention has been described and illustrated by connection to storage and production facilities, it is apparent that it is also applicable to workover and recompletion operations by running tools such as gun perforators and the like through the flow lines and into and out of the wells as desired or required.

From the foregoing description taken with the drawing it will be clear that the present invention is quite important and useful and avoids and solves many problems confronting the oil and gas producer from offshore locations.

The nature and objects of the present invention having been clearly described and illustrated and the best mode and embodiment thereof set forth, what we wish to claim as new and useful and secure by Letters Patent is:

1. A method of connecting an underwater well having a submerged wellhead to a platform floating at least adjacent the water level and supported in the water by a plurality of buoyancy means arranged below water level and anchored to water bottom by tension members, the platform being connected to the buoyancy means by rigid compression members, which comprises:

installing a first flow line extending from a point adjacent said wellhead along one of said tension members to said buoyancy means;

installing a second flow line extending from said buoyancy means along one of said compression members to the floating platform;

connecting the lower end of the first flow line to the wellhead for lateral movement of said first flow line relative to the wellhead; and

connecting the upper end of the first flow line to the lower end of the second flow line for lateral movement of the second flow line relative to the first flow line.

2. The method in accordance with claim 1 in which the submerged wellhead is on the water bottom.

3. The method in accordance with claim 1 in which the submerged wellhead is at a point above water bottom.

4. Apparatus for connecting a submerged wellhead of an underwater well to a platform floating at least adjacent the water level and supported in the water by a plurality of buoyancy means arranged below water level and anchored to water bottom by tension members, the platform being connected to the buoyancy means by rigid compression members comprising:

a first flow line extending from the wellhead along one of said tension members to one of said buoyancy means;

a second flow line extending from the buoyancy means along one of said compression members to the platform;

the lower end of the first flow line being connected to the wellhead for lateral movement of the first flow line relative to the wellhead; and

the upper end of the first flow line being connected to the lower end of the second flow line for lateral movement of the second flow line relative to the first flow line.

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