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METHOD AND APPARATUS FOR LOCATING SUBMARINE WELLS  
AND LOWERING WELL TOOLS INTO SAID WELLS

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2 Sheets-Sheet 1

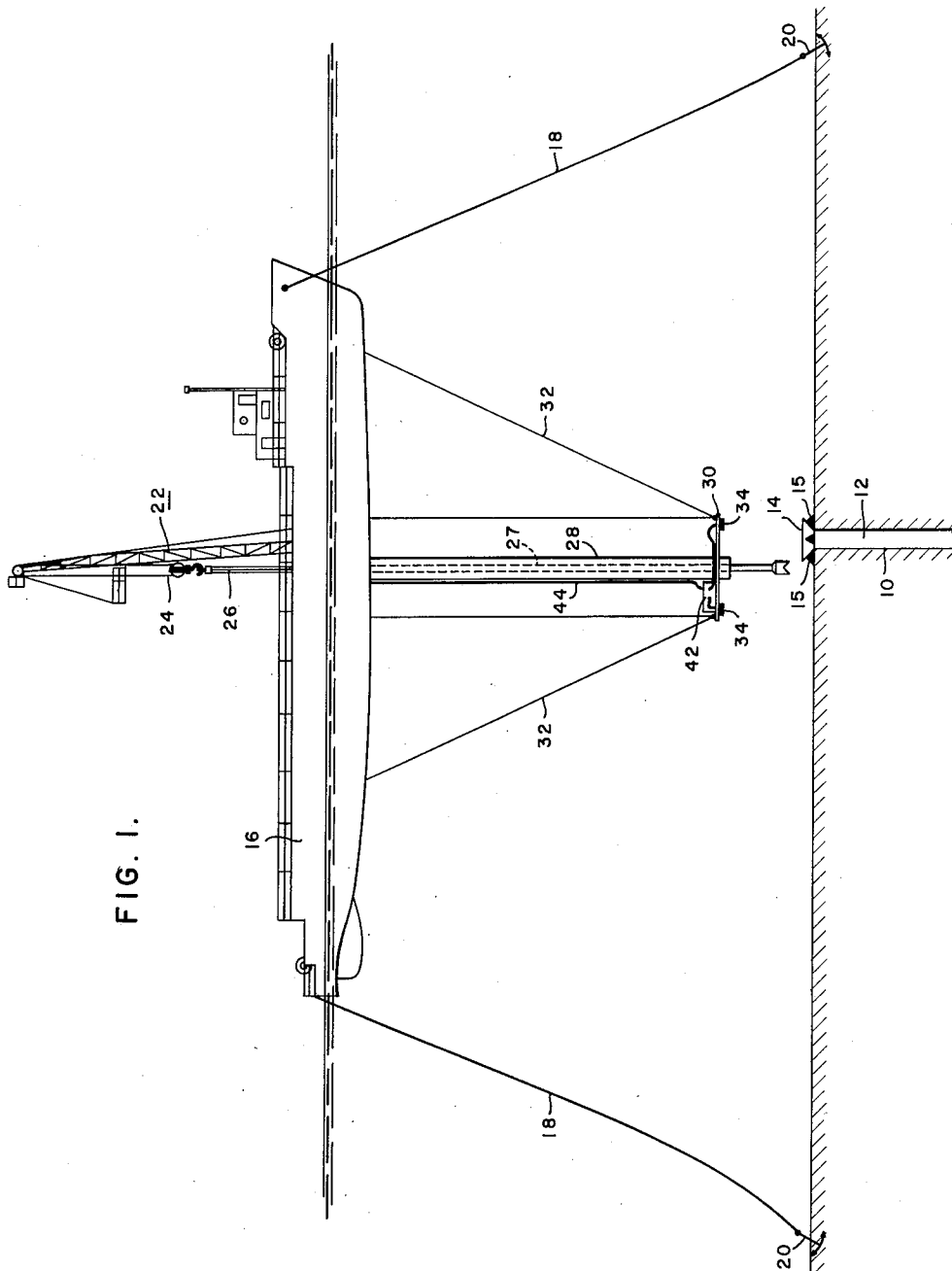


Fig. 1.

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FIG. 2.

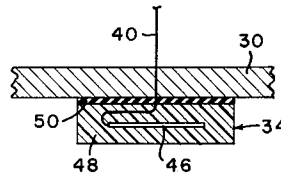
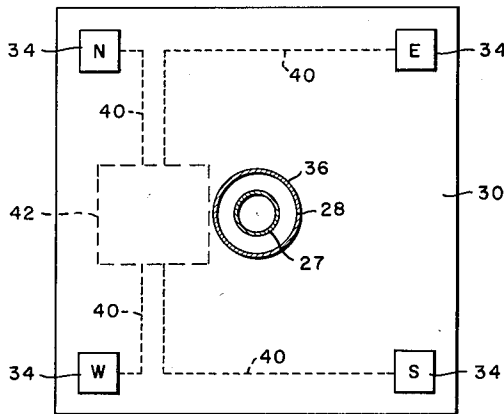


FIG. 3.

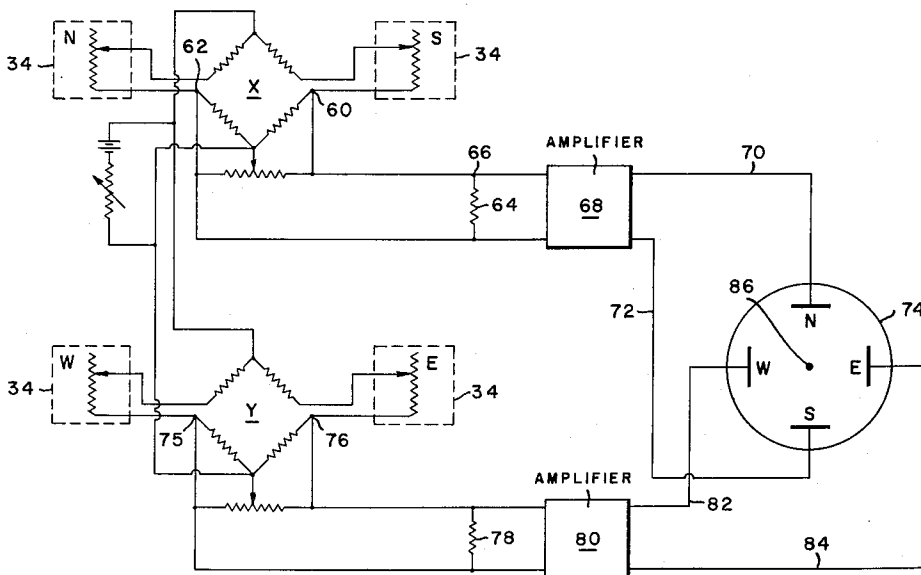


FIG. 4.

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## METHOD AND APPARATUS FOR LOCATING SUBMARINE WELLS AND LOWERING WELL TOOLS INTO SAID WELLS

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5 Claims. (Cl. 175—10)

This invention relates to production of oil and gas. More particularly, this invention relates to a method and apparatus for locating a submarine well and then placing a well tool, such as a drill bit, into the submarine well.

The invention to be described herein is described with relation to its application to the locating of a submarine well entrance and then placing a drill bit into the well. It is to be understood, however, that the method can be practiced using the apparatus to locate and place commonly used well tools other than drill bits into the well.

After the drilling of a submarine well has begun, the drill bit is often removed from the submarine well for various reasons. It often occurs that contact between the vessel and the well bore is lost after the drill bit has been removed from the well entrance. One of the major problems associated with underwater drilling from a floating vessel or other support is the problem of locating the submarine well and then re-entering the drill bit into the submarine well.

Conduits and other guide means extending to the sea surface from the submarine well have been used with some success, but these means have not been completely satisfactory. Conduits connected to the well pipe or casing and extending to the sea surface or other location of the drilling rig restrict the motion of the rig support, present large resistance to the passage of ocean waves and currents, and constitute a menace to navigation when the drilling vessel or other rig support is removed.

Guide cables and similar devices offer only a limited range of motion to a floating and drilling vessel and generally must be cast adrift when adverse seas or currents move the vessel or other rig-supporting means a substantial distance away from the desired vertical alignment with the well bore. When the presently available guide means are dropped from the vessel or other drill-supporting means and contact between the vessel and well bore is lost, it is necessary to employ divers to make an underwater search for the lost well bore. This can be time consuming and costly, with no assurance of success in the vast ocean areas.

With our invention, the submerged well bore may be located from the floating drilling vessel with no mechanical connection between the two. The vessel or other rig-supporting means may be moved off the drilling location any desired distance and returned to permit the entry of the drill pipe or other tools into the submerged well.

The new method to be described herein and apparatus for carrying out the method is particularly useful in locating a submarine well which has been previously provided with magnetic field generating members such as electromagnets or magnets. Briefly described, the method includes the step of lowering the well tools and magnetic field detecting means to a point just above the water bottom and adjacent to the submarine well. A continuous

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indication of the magnetic field intensity detected by the detecting means is obtained at the surface. Thereafter, the well tool and magnetic field detecting means are moved toward the submarine well until the continuous indication shows that the well tool is located directly above the submarine well entrance. The well tool is then lowered into the submarine well.

The new apparatus to be described herein includes a magnetic detector support which is adapted to be lowered from the water surface, as from a drilling vessel, to a point adjacent to the submarine well. The support includes an opening centrally located therein through which the well tool may be lowered. At least one magnetic field detector is mounted on the support to be used to detect the magnetic field intensity at the point to which the detector is lowered. An electrical current corresponding to the intensity of the detected magnetic field is generated by an electrical circuit interconnecting the magnetic field detector and a continuous indicating device. By getting a continuous indication of the magnetic field intensity, the well tool can be directed toward the center of the submarine well, and when it is directly aligned above the submarine well, lowered into the well.

The invention as well as its many advantages will be further understood by reference to the following detailed description and drawings in which:

FIG. 1 shows schematically a preferred method and apparatus for practicing our invention;

FIG. 2 is a bottom view showing the location of a preferred embodiment of magnetic field detectors on the detector support;

FIG. 3 is an enlarged sectional view showing a preferred type of detector; and

FIG. 4 is an electrical schematic diagram illustrating one form of electrical circuit in which a visual continuous indicator of magnetic field intensity is utilized.

Referring to FIG. 1, a submarine well 10 is shown. The submerged well bore was initially cased with a large diameter conduit or pipe 12 having a large funnel 14 at the upper end that extends a short distance above the sea's bottom. The well 10 is provided with magnetic field generating members 15. These magnetic field generating members may be magnets or electromagnets.

The floating vessel 16 may be anchored in the vicinity adjacent to the submarine well 10 by means of the mooring lines 18 anchored to the ocean floor by anchors 20.

A drilling rig 22 is shown constructed on the deck of the drilling vessel 16 and includes the usual drilling bit supports, such as the conventional traveling and crossover block assembly 24 supporting kelly 26 which is attached to the drill string 27.

A drill stem guide 28 is lowered to a point not too far above the ocean floor. Mounted upon the lower portion of the drill stem guide 28 is a platform 30. The drill stem guide 28 is braced by two or more guy lines 32, which permit controlled movement of the lower end of the drill stem guide 28.

The magnetic field provided by the permanent or electromagnets 15 is such that the greatest intensity is centered at the well bore 10. Proper positioning of the magnets 15 about the well 10 so that their magnetic poles are properly located, will provide the desired centered intensity. One or more magnetic detectors 34 is mounted on the detector support 30 and used to measure the intensity of this magnetic field.

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As shown in FIG. 2, one form of the invention utilizes four magnetic field detectors 34 mounted rigidly on the substantially flat underside of the detector support 30 and spaced an equal distance from the center of the drill stem guide 28 and an equal distance from each other. The drill stem guide extends through a circular opening 36 provided through the platform 30. Each of the four detectors measures the density of the magnetic field at its location. Signals proportional to the magnetic field densities are generated by proper electrical circuitry, amplified, and then transmitted to a recording device located aboard the floating drill vessel. By correlating the magnitudes of these signals at any one time, it is possible to determine the direction that the drill stem must be moved to obtain vertical alignment with the well bore. When the magnetic field densities at all four detectors are the same, the drill stem is in vertical alignment with the well bore.

Electrical conductors 40 lead from each of the magnetic detectors 34 to a waterproof instrument compartment 42 located on the substantially flat top of the detector support 30. Compartment 42 contains a battery power source, bridge circuits, balancing and sensitivity controls and amplifiers. An electrical cable 44 (see FIG. 1) extends along the outside of the drill stem guide 28 to carry signals from the instrument compartment 42 to recording equipment located aboard the portable drill vessel 16.

FIG. 3 is an enlarged sectional view showing one of the magnetic field detectors 34 in more detail. Each of the magnetic field detectors consists of a magnetoresistive element 46, a solid state device in which the electrical resistance is a function of an applied magnetic field density. A thin wafer of indium antimonide has proved to be one of the best compound semiconductors yet developed for use as a magnetoresistor. Each magnetoresistive element is encased in plastic 48 to provide protection from mechanical damage and to exclude water from interfering with the electrical circuit. A shield 50 is inserted between the detector support 30 and each detector so that the magnetoresistive element will be sensitive only to a magnetic field from beneath the element.

FIG. 4 is an electrical schematic diagram of one form of means for obtaining an indication of the magnetic field intensity detected at each of the detectors. The two bridge circuits X and Y, shown in the electrical schematic diagram, operate in a like manner. Assuming the drill stem 27 (FIG. 1) is being moved in a direction so that it is approaching the magnetized wellhead 10 directly from the south, the magnetoresistive element N will be subjected to a greater magnetic field density than will element S. The electrical resistance of element N will therefore increase to a greater degree than will that of element S. Thus, an electrical potential difference will exist between junction 60 and junction 62. This will result in a voltage drop across resistor 64 with positive polarity at point 66 due to the unbalanced current in the X bridge. This signal is amplified by amplifier 68 and then transmitted through lines 70 and 72 to the N and S deflection plates of a cathode ray tube 74 located aboard the portable drill vessel 16. As positive polarity is applied to plate N and negative polarity to plate S, the spot 86 visible on the viewing screen of the cathode ray tube 74 caused by an impinging stream of electrons on the viewing screen, will move upward toward plate N and away from plate S. The position of the spot indicates that the wellhead is located directly north from the position of the drill stem. There is no deflection of the spot in an east-west direction since both magnetoresistive elements E and W, being an equal distance from the well bore, are subjected to an equal magnetic field density and the Y bridge remains in balance.

As the drill stem is moved north, the spot will continue to be attracted to the N plate and repelled by the S plate until the N magnetoresistive element is directly above the wellhead. With further movement in a northerly direc-

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tion, the spot will begin to drop away from the N plate since the field density at element N will decrease while that at element S will increase. When both the N and S elements are at an equal distance from the wellhead, the field densities at both will be equal, the X bridge will become balanced, and the spot will be positioned in the center of the cathode ray tube 74 indicating that the drill stem 27 is in vertical alignment with the wellhead 10. If the drill stem is moved further north, the spot will begin to move toward plate S since the voltage developed across resistor 64 will have negative polarity at point 66 due to the unbalance of the X bridge in the opposite direction.

Bridge Y will likewise give indications of alignment in an east-west direction. Any difference in the resistances of magnetoresistive element W and magnetoresistive element E will cause a difference in potential at point 76 with respect to point 75. This potential difference develops a voltage drop across resistor 78. The resulting signal is fed through amplifier 80 and from amplifier 80 through leads 82 and 84 to the W plate and E plate, respectively, of the cathode ray tube 74.

If the wellhead is located in a northeasterly direction from the drill stem, the spot will be visible in the northeast (or upper right-hand) quadrant of the screen since a positive signal will be applied to deflection plates N and E while plates S and W will have a negative charge.

It may be desirable to operate the bridge circuit with alternating current in which case an inverter may be inserted between the battery source and the bridge circuits. The output signals may then be detected after amplification before being applied to the deflection plates.

Among other devices which may be used in the magnetic detection circuits in lieu of magnetoresistors are Hall effect elements and flux gate magnetometers. With the proper circuitry, these devices may be used to produce signals to give surface indications of displacement of the drill stem with respect to the well head.

An electronic computing device could be used in lieu of the cathode ray tube to correlate the output signals and give a readout of the relative position of the wellhead with respect to the drill stem.

We claim:

1. A method of positioning a well tool above a magnetized submarine well and then placing said well tool into said well comprising: lowering the well tool and magnetic field intensity detecting means to a point just above the water bottom and obtaining at the water surface a continuous indication of the magnetic field intensity detected by the detecting means the relative positions of the well tool and magnetic field intensity detecting means being such that said well tool and said magnetic field intensity detecting means can be simultaneously moved toward the submarine well; moving the well tool and magnetic field detecting means toward the submarine well until the continuous indication shows the well tool to be directly above the submarine well entrance; and then lowering the well tool into the submarine well.

2. Apparatus for use in positioning a well tool above a submarine well having magnetic field generating members arranged about the well comprising: a magnetic detector support adapted to be lowered from the water surface to a point adjacent the submarine well, said support having an opening therethrough to permit the well tool to be lowered therethrough, at least one magnetic field intensity detector mounted on said support for detecting the magnetic field intensity at said point and generating an electrical signal responsive to detected magnetic field intensity; magnetic field intensity indicating means located at the water surface; and an electrical circuit interconnecting the magnetic field intensity detector and the magnetic field intensity indicating means whereby a signal indicative of the magnetic field intensity detected by the detector is conducted to the magnetic field intensity indicating means.

3. Apparatus in accordance with claim 2 wherein the

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magnetic detector support has a substantially flat bottom portion and there are a plurality of magnetic field intensity detectors mounted on said bottom portion, said detectors being arcuately spaced from one another and at the same distance from the opening.

4. Apparatus in accordance with claim 3 wherein the bottom portion is substantially square-shaped and a magnetic field intensity detector is located at each corner thereof.

5. Apparatus in accordance with claim 4 wherein the

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magnetic field intensity indicating means is a visual indicator.

#### References Cited in the file of this patent

#### UNITED STATES PATENTS

|           |           |               |
|-----------|-----------|---------------|
| 840,018   | Schoultz  | Jan. 1, 1907  |
| 2,238,072 | Nelson    | Apr. 15, 1941 |
| 2,251,900 | Smith     | Aug. 5, 1941  |
| 2,629,027 | Piatt     | Feb. 17, 1953 |
| 2,783,970 | Gillespie | Mar. 5, 1957  |