Sept. 17, 1963 D. DE VRIES ETAL 3,103,976

PIPE JOINT LOCATOR FOR UNDERWATER WELLS

Filed May 10, 1961 2 Sheets-Sheet 1

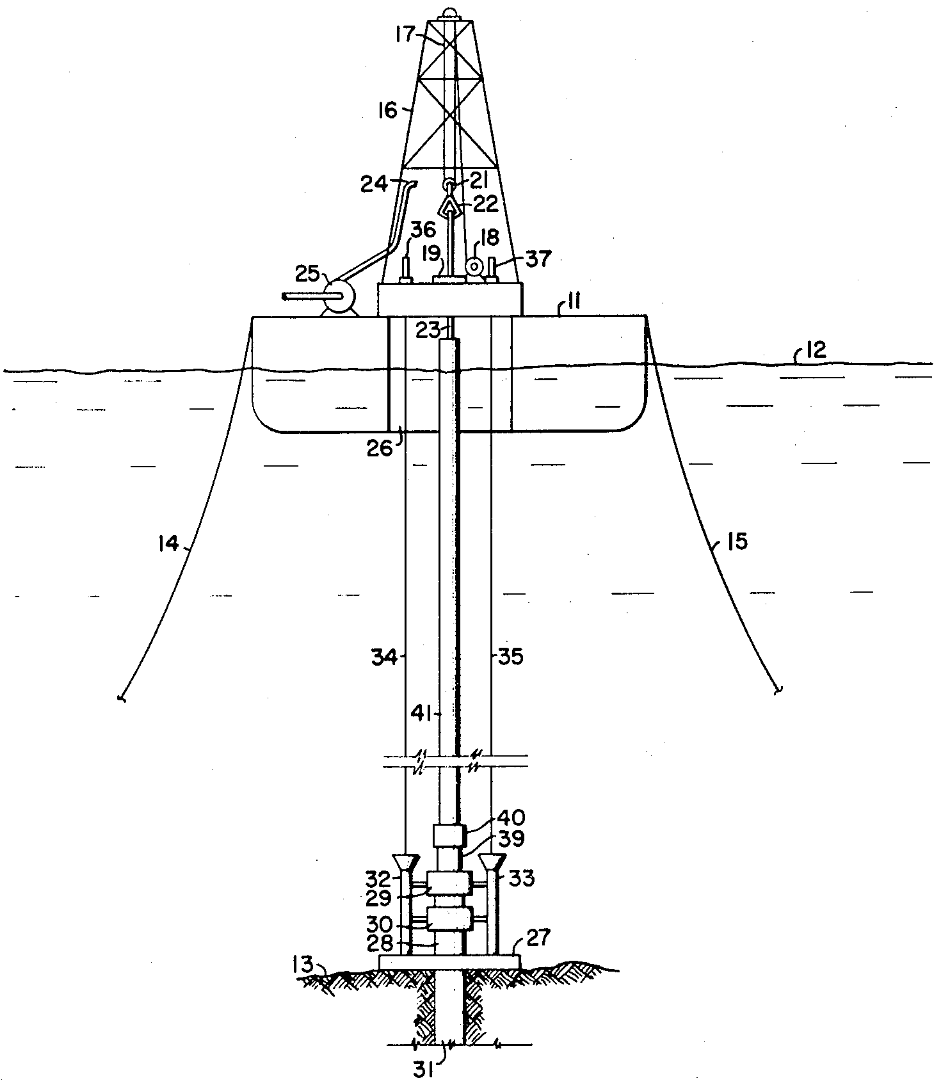

FIG. I

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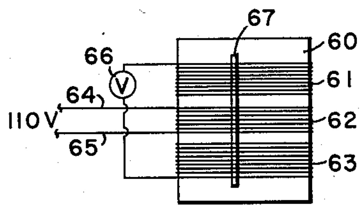

FIG. 3

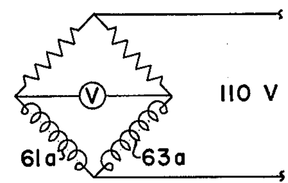

FIG. 4

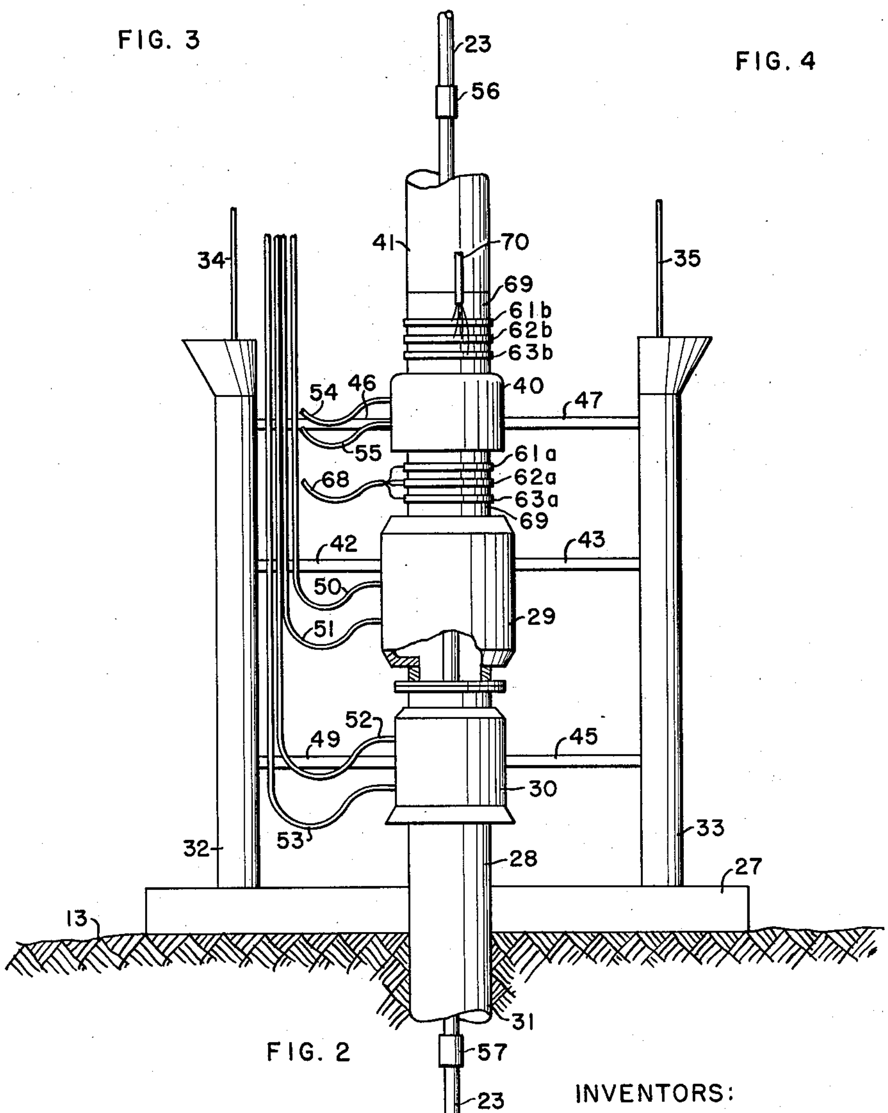

FIG. 2

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United States Patent Office

3,103,976
Patented Sept. 17, 1963

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3,103,976
PIPE JOINT LOCATOR FOR UNDERWATER WELLS

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Filed May 10, 1961, Ser. No. 109,062
7 Claims. (Cl. 166—46)

This invention relates to apparatus for use in drilling offshore wells and pertains more particularly to apparatus adapted to be mounted adjacent to a blowout preventer at a well installation positioned below the surface of a body of water for locating pipe joints of a drill string relative to the blowout preventer when drilling an offshore well.

In an attempt to locate new oil fields, an increasing amount of well drilling has been conducted at offshore locations, such for example, as off the coast of Louisiana, Texas and California. As a general rule, the strings of casing in a well, together with the tubing string or strings, extend to a point well above the surface of the water where they are closed in the conventional manner that is used on land wells, with a conventional wellhead assembly being attached to the top of the casing. Attempts have been made recently to provide methods and apparatus for drilling, completing and working over a well wherein both the well casinghead and the various wellhead components secured thereto are suspended therefrom and located underwater at a depth sufficient to allow ships to pass over them. Preferably, the casinghead and its associated equipment is located close to the ocean floor. In order to drill wells wherein the drilling wellhead assembly is positioned on the ocean floor, it has been necessary to design entirely new equipment for this purpose. Thus, during the drilling and completion of an oil or gas well at an offshore location in a manner described in copending patent application, Serial No. 830,538, filed July 30, 1959, and entitled, "Underwater Well Completion Method," it is necessary to know at all times the position of any tool joint or coupling in the drill stem relative to the blowout preventers.

Tool joints of a drill stem are generally larger in outside diameter and have a greater mass than the normal diameter of the rest of the drill stem. Blowout preventers that are employed on a well for controlling well pressures under emergency conditions are normally provided with closure members, such for example, as rubber-faced rams, which are designed and built to close around a tubular member of a predetermined diameter. Thus, during drilling operations, the rubber-faced rams of a blowout preventer can at any time be closed in a fluid-tight manner around a drill pipe but not around the larger-diameter tool joints thereof. It is, therefore, necessary to know the location of the tool joints in the drill stem closest to a blowout preventer before closing the rams thereof.

In drilling land wells, it is a relatively simple matter to determine the location of a tool joint relative to the blowout preventer on the well since the operating platform is at a known short distance above the blowout preventer. Thus, knowing the distance between the blowout preventer and the operating floor and being able to judge the distance between the operating floor and the top of a pipe section or kelly, the position of the tool joint nearest to the blowout preventer is known. However, in drilling at an offshore location from a floating drilling platform or barge which moves up and down from the surface of the water to some degree, the problem of determining the position of a tool joint relative to a blowout preventer, which may be several hundred feet below the barge on the ocean floor, is much more difficult. In an emergency drilling situation requiring a prompt closure of the blowout preventers, the drilling operator may not have sufficient time to consult the vessel position indicators, pipe string, depth indicators, etc., and make the calculations needed to tell him whether a tool joint is between the rams of his blowout preventer.

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It is, therefore, a primary object of the present invention to provide apparatus associated with a blowout preventer for indicating at a remote location the position of a tool joint relative to the rams of a blowout preventer.

Another object of the present invention is to provide apparatus for indicating the presence of a tool joint passing through the apparatus regardless of whether the tool joint is motionless, is moving from side to side, or is moving axially and/or rotating.

A further object of the present invention is to provide apparatus adapted to be positioned adjacent a blowout preventer for transmitting a signal to a point above the surface of the body of water so as to indicate the presence of tool joints passing through the apparatus regardless of the speed at which the pipe string is moving in the sensing apparatus.

A still further object of the present invention is to provide apparatus which will indicate the presence of tool joints passing through the indicating apparatus without the necessity of providing feeler elements or other contacting devices which would physically contact the pipe or the tool joints.

Still another object of the present invention is to provide a pipe-joint sensing device adapted to be positioned outside a large-diameter pipe while indicating movement of a pipe joint over a relatively small vertical distance within the large-diameter pipe.

These and other objects of this invention will be understood from the following description taken with reference to the drawing, wherein:

FIGURE 1 is a diagrammatic view illustrating a floating drilling barge anchored to the ocean floor over a drilling location while a string of drill pipe extends through a marine conductor pipe down through the blowout preventers in a wellhead assembly which is provided with the pipe joint locator of the present invention;

FIGURE 2 is a diagrammatic view of a wellhead installation showing two alternative mountings of the pipe joint locator of the present invention relative to a blowout preventer;

FIGURE 3 is a schematic view of one form of a pipe joint locator with its indicating circuit means in accordance with the present invention; and

FIGURE 4 is a circuit diagram of another form of a circuit for a pipe joint locator employing two coils.

Referring to FIGURE 1 of the drawing, a drilling barge **11** of any suitable fixed or floatable type is illustrated as floating on the surface of the water **12** and substantially fixedly positioned over a preselected drilling location by being anchored to the ocean floor **13** by anchor lines **14** and **15** running to anchors (not shown) sunk in the ocean floor. Equipment of this type may be used when carrying on well drilling, well completion, or well maintenance operations in water varying from about 100 to 1500 feet or more. The drilling barge is equipped with a suitable derrick **16** containing fall lines **17** and a hoist **18**, as well as other auxiliary equipment needed during the drilling or servicing of a well, such for example, as a rotary table **19**. In this instance, the drilling rig is also shown as being provided with a traveling block **21** to which is secured a pair of elevators **22** or other suitable means for connecting the hoist system to a string of pipe, such as a drill stem **23**. During drilling operations, a swivel nozzle (not shown) would be connected to the top of the drill stem. A flexible hose **24** is provided which is adapted to be secured to the top of the drill stem or nozzle while drilling so that a drilling fluid may be pumped down through the drill stem **23**. The flexible hose **24** is in communication with a pump **25** for pumping the drilling mud.

The derrick **16** is positioned over a drilling slot or well **26** which extends vertically through the barge **11** in a conventional manner. When using the equipment of the present invention, the slot **26** and the barge **11** may be either centrally located or extend in from one edge. However, operations with the apparatus of the present invention may be carried out over the side of the barge without use of a slot. Additionally, the apparatus of the present invention may be employed on an underwater well installation when drilling wells from a fixed platform rather than a barge.

A wellhead support structure, which is represented by a horizontally-extending support frame **27** having a casinghead **28** secured thereto and centrally positioned thereon, is illustrated as being anchored to the ocean floor by means of a conductor pipe or surface casing **31** which is installed and preferably cemented in the ocean floor **13**. A blowout preventer **29** is coaxially mounted on the top of the casinghead in any suitable manner, as by bolts or by any suitable connector **30** well known to the art. Secured to the wellhead support frame **27** are two or more guide columns **32** and **33** having guide cables **34** and **35** extending vertically therefrom to the drilling barge **11** where they are preferably secured to the barge by means of constant tension winches **36** and **37**. The guide cables **34** and **35** are provided for the purpose of guiding pieces of equipment from the barge **11** into alignment on, or in, the casinghead **28** positioned on the ocean floor. The pipe joint locator of the present invention is positioned on a tubular member **39** which is fixedly secured to the top of the blowout preventer **29** in the arrangement shown in FIGURE 1. Additionally, a wellhead connector **40** is illustrated as connecting the lower end of a marine conductor pipe **41** to the top of the tubular member extending vertically from the blowout preventer **29**, in a manner described in copending patent application, Serial No. 830,538, filed July 30, 1959. However, it is to be understood that the use of a marine conductor pipe **41** is not essential and the pipe joint locator of the present invention may be used in any other suitable type of a drilling wellhead positioned below a body of water, such for example as shown and described in U.S. Patent 2,808,230, entitled "Offshore Drilling," which issued to R. C. McNeill et al. on October 1, 1957.

Referring to FIGURE 2 of the drawing, the blowout preventer **29** and the wellhead connector elements **30** and **40** are shown as being provided with guide arms **42** and **43**, **44** and **45**, and **46** and **47**, respectively. The guide arms are adapted to have their extending ends guided down through the vertical guide columns **32** and **33**. Additionally, the blowout preventer **29** and the wellhead connectors **30** and **40** are also provided with hydraulic pressure fluid hoses, **50** and **51**, **52** and **53**, and **54** and **55**, respectively. Two of the tool joints **56** and **57** of the drill stem **23** are illustrated.

The pipe joint locator of the present invention is diagrammatically illustrated in FIGURE 3 as comprising the non-magnetic tubular member or coil housing **60** having three coils wound thereon and axially displaced one from the other. The intermediate coil **62**, or the exciting coil, is connected to a suitable power source which is normally provided through leads **64** and **65** which extend upwardly to the drilling barge **11** at the surface. The coils **61** and **63** above and below the exciting coil **62**, are known as the pickup coils of the present system and are differentially connected or oppositely wound and connected to a volt meter **66** for indicating any difference in the mutual inductance between each of the pickup coils and the exciting coil. A voltage output signal is obtained when there is a greater mass of metal passing through or positioned in one of the coils as compared to the other coil. Thus, in the event that a tool joint **56** was positioned within the coil housing **60** opposite the pickup coil **61**, there would be a greater mass of metal inside pickup coil **61** than inside pickup coil **63** so that a voltage reading would be obtained, giving an indication of the location of the tool joint **56**. In the event that the tool joint **56** is outside both of the coils, there would be no difference signal obtained on the indicating volt meter **66**. The mutual inductance of the present system would also change as the pipe within the coils moves from side to side during drilling operations, but since the change would be equal and opposite in both pickup coils, there would be no change in the output signal.

The size of the coils employed may be of any suitable dimension depending upon the size of the coil housing **60** employed, the vertical height of the tool joints **56**, etc. For example, if pickup coils of a relatively small vertical height are employed, the spacing between the pickup coils **61** and **63** should be at least equal to the vertical height of a tool joint **56** to pass therethrough so that there would be no chance of a tool joint **56** being in both coils at the same time. However, in the event that each of the pickup coils **61** and **63** extended over a vertical distance of eight or ten inches or more, the lower edge of coil **61** and the upper edge of coil **63** could be close together and could even overlap the exciting coil **62**, if desired. The non-magnetic coil housing **60** is provided with a longitudinal slot through the wall thereof which extends vertically a distance greater than the span of the pickup coils **61** and **63**. This slot may be relatively small in width, say $\frac{1}{16}$ of an inch, and may be filled with a material such as an epoxy resin. Since the slot **67** would weaken the coil housing **60**, the coil housing **60** could either surround or be encased within the tubular member **39** (FIGURE 2) extending upwardly from the blowout preventer **29**. Although the coils **61**, **62** and **63** have been illustrated in FIGURE 3 as being wound on the non-magnetic coil housings **60**, it is to be understood that they may be prewound on another mandrel and inserted within recesses formed or cut on the inner surface of the coil housing **60**.

In FIGURE 2, the tubular member **39** extending upwardly from the blowout preventer **29** is shown as being provided with the pickup and exciter coils **61*a***, **62*a*** and **63*a***. The electrical leads from the coils **61*a***, **62*a*** and **63*a*** are joined together in a single electrical transmission cable **68** which passes upwardly to the surface along with the hydraulic pressure hoses. In this arrangement, the tubular member **39** would be of non-magnetic material and would have a slot therein as described with regard to FIGURE 3. Another arrangement of the coils are shown in FIGURE 2 wherein an exciter coil **62*b*** and pickup coils **61*b*** and **63*b*** are shown as being mounted on a non-magnetic tubular coil housing which is secured between the wellhead connector **40** and the rest of the marine conductor pipe string **41** so as to be retractable therewith. The electrical leads from the coils **61*b***, **62*b*** and **63*b*** are combined together in a single electrical cable **70** which is secured to the outside of the marine conductor string **41**. It is to be understood that the pipe joint locator of the present invention could also be located below the blowout preventer **29**, if desired.

When carrying out drilling operations while using the apparatus of the present invention on an underwater well drilling assembly, in the event that an emergency arose so that the blowout preventer **29** had to be closed around the drill stem **23**, the operator would look at the signal indicating device **66**, which in this case is described as a volt meter, and would know if any signal appeared thereon. If there was no signal indicated, the operator would raise or lower the drill string **23** until a signal was obtained. This would indicate that a tool joint **56** was positioned opposite one of the pickup coils and hence out of the way so that the rams of the blowout preventer **29** could be closed.

FIGURE 4 illustrates a bridge circuit which could be used for coils **61*a*** and **63*a*** when it is not desired to use an exciter coil *62a*. In this case the two coils *61a* and *63a* are additively connected and compared against each other in a simple bridge circuit. There would be no unbalance of the circuit in the event that a pipe moved from side to side in the coils as the impedance of both coils would be influenced in the same direction, hence no resulting false output signal.

We claim as our invention:

1. An underwater wellhead installation comprising a vertically-extending casinghead fixedly positioned below the surface of a body of water, blowout preventer means having a bore therethrough and being secured coaxially to the top of said casinghead, vertically-extending tubular means having one end thereof fixedly posiitoned relative to said blowout preventer and coaxial with the bore therethrough, horizontally-disposed electrical coil means carried by said tubular means adjacent the bore thereof and at a predetermined distance relative to said blowout preventer, and circuit means including a current source, coil means and electrical signal transmission means connected to said coil means and extending upwardly through said body of water, and signal indicating means positioned above said body of water operatively connected to said signal transmission means.

2. An underwater wellhead installation comprising a vertically-extending casinghead fixedly positioned below the surface of a body of water, blowout preventer means having a bore therethrough and being secured coaxially to the top of said casinghead, vertically-extending tubular means having one end thereof fixedly secured to said blowout preventer coaxial with the bore therethrough, a portion of the length of said tubular means being made of non-magnetic material and forming a coil housing, horizontally-disposed electrical coil means carried by said coil housing at a predetermined distance relative to said blowout preventer, said electrical coil means comprising exciting coil means and pickup coil means for sensing any change in the mass of a metal member disposed within said electrical coil means, and circuit means including a current source connected to said exciting coil means and electrical signal transmission means connected to said pickup coils and extending upwardly through said body of water, and signal indicating means positioned above said body of water operatively connected to said signal transmission means.

3. An underwater wellhead installation comprising a vertically-extending casinghead fixedly positioned below the surface of a body of water, blowout preventer means having abore therethrough and being secured coaxially to the top of said casinghead, vertically-extending tubular means having one end thereof fixedly secured to said blowout preventer coaxial with the bore therethrough, a portion of the length of said tubular means being made of non-magnetic material and forming a coil housing, horizontally-disposed electrical coil means carried by said coil housing at a predetermined distance relative to said blowout preventer, said electrical coil means comprising exciting coil means and pickup coil means, said pickup coil means comprising a pair of oppositely-wound axially-displaced coils mounted on said coil housing on the wall thereof adjacent said exciting coil means for sensing any change in the mass of a metal member disposed within said electrical coil means, and circuit means including a current source connected to said exciting coil means and electrical signal transmission means connected to said pickup coils and extending upwardly through said body of water, and voltage signal indicating means positioned above said body of water operatively connected to said signal transmission means.

4. An underwater wellhead installation comprising a vertically-extending casinghead fixedly positioned below the surface of a body of water, blowout preventer means having a bore therethrough and being secured coaxially to the top of said casinghead, vertically-extending tubular means having one end thereof fixedly secured to said blowout preventer coaxial with the bore therethrough, the internal diameter of said tubular means being substantially equal to the bore of said blowout preventer, said tubular means extending from the blowout preventer to a point above the surface of the body of water, a portion of the length of said tubular means being made of non-magnetic material and forming a coil housing, horizontally-disposed electrical coil means carried by said coil housing on the outer surface thereof at a predetermined distance relative to said blowout preventer, said electrical coil means comprising exciting coil means comprising exciting coil means and pickup coil means, said pickup coil means comprising a pair of oppositely-wound axially-displaced coils mounted on said coil housing on the wall thereof adjacent said exciting coil means for sensing any change in the mass of a metal member disposed within said electrical coil means, and circuit means including a current source connected to said exciting coil means and electrical signal transmission means connected to said pickup coils and extending upwardly through said body of water, and voltage signal indicating means positioned above said body of water operatively connected to said signal transmission means.

5. A method of emergency control of an underwater well during well operations carried out while employing a blowout preventer secured to the underwater well and a number of pipe sections secured end-to-end by tool joints to form a pipe string extending through said blowout preventer upwardly to a vessel on the surface of a body of water, said method comprising

(*a*) determining at a point near the underwater well the presence or absence of a tool joint in a pipe string at a predetermined position relative to the blowout preventer at the well,
(*b*) transmitting a signal indicative of the presence or absence of a tool joint at the position to a remote location above the surface of the water,
(*c*) noting from said remote location above the surface of the water the presence or absence of said tool joint at a predetermined position,
(*d*) disposing the pipe string vertically in the blowout preventer so that the signal indicates a tool joint above and below the preventer, and
(*e*) closing the blowout preventer about the pipe string between two tool joints thereof.

6. A method of emergency control of an underwater well during well operations carried out while employing a blowout preventer secured to the underwater well and a number of pipe sections secured end-to-end by tool joints to form a pipe string extending through said blowout preventer upwardly to a vessel on the surface of a body of water, said method comprising

(*a*) electrically detecting at a point near the underwater well the presence or absence of a tool joint in a pipe string at a predetermined position relative to the blowout preventer on the well,
(*b*) transmitting a signal indicative of the presence or absence of a tool joint at the position to a remote location above the surface of the water,
(*c*) noting at said location on the vessel at the surface of the water the presence or absence of said tool joint at said predetermined position,
(*d*) moving the pipe string vertically in the blowout preventer to a position where the signal indicates no tool joint is inside the preventer, and
(*e*) closing the blowout preventer about the pipe string between two tool joints thereof.

7. A method of emergency control of an underwater well during well operations carried out while employing a blowout preventer secured to the underwater well and a number of pipe sections secured end-to-end by tool joints to form a pipe string extending through said blowout preventer upwardly to a vessel on the surface of a body of water, said method comprising

(*a*) mounting a tool joint detector adjacent an underwater well and coaxially therewith at a known distance from a blowout preventer thereon,

(b) detecting at a point near the underwater well the presence or absence of a tool joint in a pipe string at a predetermined position relative to the blowout preventer on the well,

(c) transmitting a signal indicative of the presence or absence of a tool joint at the position to a remote location above the surface of the water,

(d) noting at said remote location above the surface of the water the presence or absence of said tool joint at said predetermined position,

(e) positioning the pipe string vertically in the blowout preventer so that the signal indicates no tool joint inside the preventer, and

(f) closing the blowout preventer about the pipe string between tool joints thereof.

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