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METHOD OF REMOVING A WELLHEAD ASSEMBLY FROM THE OCEAN FLOOR

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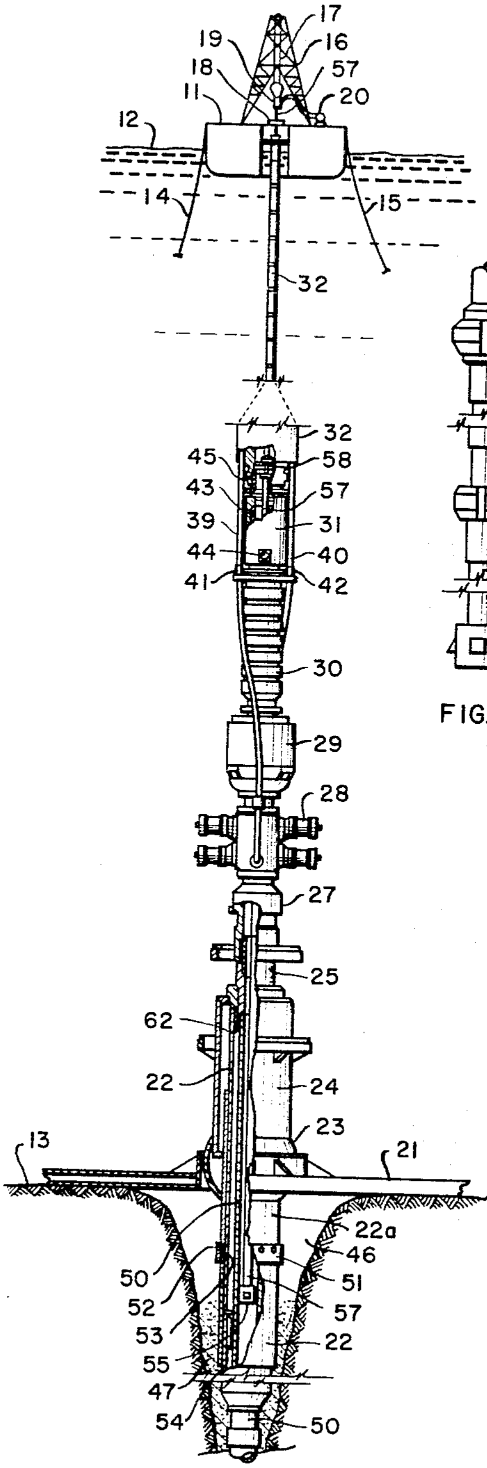

FIG. 1

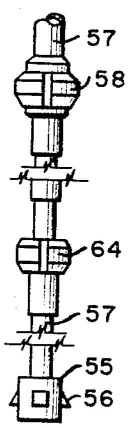

FIG. 3

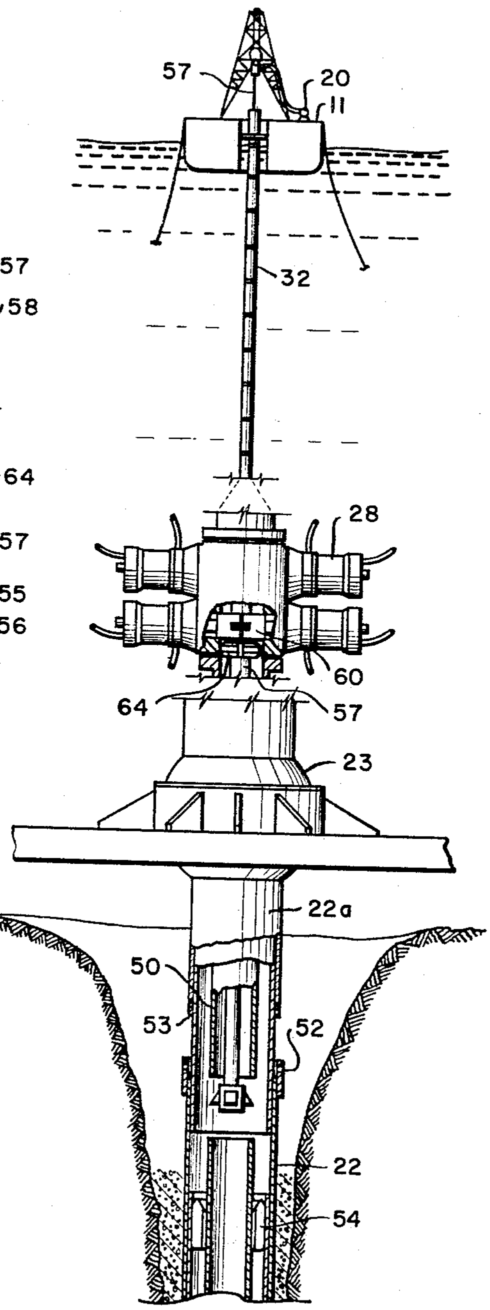

FIG. 2

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METHOD OF REMOVING A WELLHEAD ASSEMBLY FROM THE OCEAN FLOOR

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This invention relates to a method and apparatus for use after drilling an oil or gas well at an offshore location, and pertains more particularly to a method adapted to be carried out from a vessel at the surface of a body of water whereby a wellhead assembly positioned on the ocean floor may be retrieved and brought back to the vessel.

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 above the surface of the water where they are closed in a conventional manner that is used on land wells, with a conventional wellhead assembly being attached to the top of the casing. Recently, methods and apparatus have been developed for drilling a completing well wherein both the wellhead casing, and subsequently the wellhead assembly and casing closure device, are located underwater at a depth sufficient to allow ships to pass over them. Preferably the casinghead and wellhead closure assembly are located close to the ocean floor. In order to install and retrieve well drilling equipment located underwater at depths greater than the shallow depth at which a diver can easily operate, it has been necessary to design entirely new equipment for this purpose and develop new methods.

Wells drilled in deep water are generally drilled from vessels of varying designs, commonly known as drilling barges, vessels or platforms. Deep water wells are generally drilled by one of two methods. In one method the string of drill pipe extends downwardly from the drilling vessel to the drilling wellhead assembly, on the ocean floor, which is closed at the top by a circulation head with a flexible hose running from the circulation head back to the surface and to the drilling vessel so that drilling fluid may be circulated down the drill pipe, through the drill bit, and thence upwardly along the outside of the drill pipe, out the circulation head and up the flexible hose to the vessel again. In a second method, a large-diameter pipe known as a marine conductor pipe is put together and arranged to extend from the drilling wellhead assembly near the ocean floor to the vessel on the surface of the water. In the latter method, the drill string rotates within the conductor pipe with drilling fluid being circulated down through the drill pipe, through the bit at the bottom thereof, up the outside of the drill pipe within the well and thence upwardly through the annular space between the conductor pipe and the drill pipe, returning to the vessel in the conventional manner. The present invention is concerned with retrieving, from an ocean floor location, apparatus used in either of the above-described methods.

One of the problems of drilling underwater wells is the tremendous cost of the equipment used, particularly the cost of an ocean floor drilling wellhead assembly which may vary between one and two hundred thousand dollars. Because of the high cost of drilling underwater wells and the cost of the equipment associated therewith, most wildcat wells drilled at offshore locations are drilled on a "look-see" basis, that is, the well is drilled in an attempt to study the underlying geological formations by suitable well tools or logging instruments. Thus, there is no attempt to complete the well even if an oil or gas formation was found during drilling. After studying the formation, the well would be plugged in any suitable manner, as by pouring cement down it.

It is therefore a primary object of the present invention to provide a method and apparatus whereby a drilling wellhead assembly positioned on the ocean floor may be retrieved and brought back to the vessel at the surface.

In present known methods of retrieving a wellhead assembly, it has been a common practice to lower an explosive charge from the drilling vessel on the surface down through the connecting pipe strings to the drilling wellhead assembly on the ocean floor and thence to a position somewhere below the drilling wellhead assembly. The explosive charge would be detonated so as to shear the strings of pipe extending from the drilling wellhead assembly on the ocean floor, and then the drilling wellhead assembly would be retrieved. Several problems arose with the use of explosive for shearing off pipe below a wellhead assembly on the ocean floor. In some instances, if there were several strings of pipe extending into the ocean floor with considerable amounts of cement between them and outside the outermost pipe, it was not always possible to select the correct amount of explosive that would shear all of the pipe. At other times, if too large an explosive charge was employed, components of the drilling wellhead assembly itself would be destroyed or severely damaged.

It is therefore a further object of the present invention to provide a method and apparatus for shearing off downwardly-extending pipe below a drilling wellhead assembly at a point below the ocean floor, after which the entire wellhead drilling assembly can be reutrned to the drilling vessel on the surface in an undamaged condition.

Another object of the present invention is to provide a method for removing a drilling wellhead assembly from the ocean floor without the use of explosives.

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

FIGURE 1 is a diagrammatic view taken in longitudinal projection and partly in cross section illustrating a floating vessel positioned at the surface of the ocean with an underwater wellhead drilling assembly positioned on the ocean floor;

FIGURE 2 is a longitudinal view taken partially in cross section illustrating a portion of the drilling wellhead assembly shown in FIGURE 1 at a time when concentric strings of pipe extending downwardly from the drilling wellhead assembly have been sheared so that the drilling wellhead assembly can be returned to the vessel at the surface; and,

FIGURE 3 is a longitudinal diagrammatic view illustrating one form of a tool which may be employed by the method of the present invention.

The present invention provides a method for retrieving a tubular underwater drilling wellhead assembly from the ocean floor and pulling it back to a drilling vessel on the ocean surface. In most cases the wellhead assembly is provided with at least two concentric pipe strings which extend into the ocean floor and at least one and often both are cemented therein. The wellhead assembly is also provided with closure means for closing the innermost pipe string and disconnect means on the outermost pipe string. In the method of the present invention, a separation is formed in the innermost pipe string of the wellhead assembly at a point below the ocean floor, after which the innermost pipe string is closed at a point above the separation. Subsequently, a pressure fluid is applied from the vessel into the innermost pipe string below the closed pipe and thence through the separation point in the innermost pipe to the space between the innermost pipe string and the outer pipe string so as to apply a vertically-directed hydraulic lift to the drilling wellhead assembly, after which the drilling wellhead assembly can be hoisted back to the vessel. Preferably, the hydraulic lift from below the wellhead assembly is applied at the same time that a hoisting lift is applied from the vessel itself by suitable hoist means.

Referring to FIGURE 1 of the drawing, a drilling vessel, barge or platform is generally represented by numeral **11**. The drilling vessel is of any suitable type preferably, as illustrated, floating on the surface of a body of water **12** and being substantially fixedly positioned over the preselected drilling location by suitable vessel-positioning means or by being anchored to the ocean floor **13** by suitable anchors (not shown) connected to anchor lines **14** and **15**. Equipment of this type may be used when carrying on well drilling operations in water depths varying from about 100 to 1500 feet or more. The drilling vessel is equipped with a suitable derrick **16** as well as other auxiliary equipment needed during the drilling of a well, such as a hoist system **17**, rotary table **18**, power swivel **19** and mud pump **20**. The derrick **16** may be positioned over a drilling slot or well which extends vertically through the vessel in a conventional manner. When using the equipment of the present invention, the slot of the vessel may be centrally located or extend in from one edge. However, drilling operations may be carried out over the side of the vessel without the use of a slot, as from a portion of the deck of the vessel which is cantilevered out over one end. Additionally, it is to be understood that the equipment of the present invention may also be used when drilling a well from a suitable operational base positioned above the surface of the water, such for example, as from a drilling barge having legs extending from the ocean floor, or from a platform permanently positioned on the ocean floor.

A typical underwater wellhead drilling assembly is illustrated in FIGURE 1 as comprising a base member **21** which is positioned on the ocean floor **13** and is fixedly secured to a conductor pipe or large-diameter well casing **22*a*** by means of a ball-and-socket joint **23**. During drilling operations, the drilling wellhead assembly is removably secured to the top of a foundation pile **24** which in turn is secured to the top of the ball and socket joint **23**. In the wellhead structure illustrated, the drilling wellhead assembly is secured to the top of a casinghead **25** which in turn is mounted on the top of the foundation pile **24**. The combined casing **22**, foundation pile **24** and casinghead **25** form a continuous tubular member or pipe extending up from the ocean floor through which drilling operations are conducted.

The drilling wellhead assembly illustrated includes a detachable wellhead connector or drilling bonnet **27** of any suitable type well known to the art. Fixedly secured above the wellhead connector **27** is a ram-type blowout preventer unit **28**, a bag-type blowout preventer unit **29**, a flexible joint **30**, a remotely-operable quick-disconnect coupling and sealing apparatus **31**, and a sectionalized marine conductor pipe assembly **32** extending to the vessel **11** at the surface **12**. The remotely-operable quick-disconnect coupling and sealing apparatus **31** may also be designated hereinbelow as a wellhead connector. Passing down alongside the wellhead connector **31** (FIGURE 1) are a pair of small-diameter auxiliary pipes **39** and **40** which may be readily disconnected by any suitable type of pull-out connector, as at points **41** and **42**. The wellhead connector **31** is adapted to pass downwardly over and latch onto a tubular member **43** which is fixedly mounted atop the flexible joint **30** in this particular arrangement. The connector **31** is provided with suitable laterally-extending latches **44** adapted to move inwardly to engage the tubular member **43** positioned within the connector **31**. Preferably, the upper end of the connector is provided with an internally projecting landing surface or seating shoulder **45**.

The drilling wellhead assembly and base structure described hereinabove may be lowered as a unit from the vessel **11** at the surface of the ocean, with the large-diameter well casing **22** extending below the base member **21** into a hole **46** formed or drilled in the ocean floor **13**. Generally, a certain amount of cement **47** is positioned in the hole **46** to secure the base member **21** to the ocean floor. In a typical wellhead installation, the foundation pile **24** may be 30 inches in diameter with the next innermost pipe or well casing **22** being 24 inches in diameter. A smaller-diameter string of well casing, say a 13⅜ inch string of pipe **50**, is hung from the casinghead **25** with the lower end of the pipe or a continuation thereof extending downwardly into the well **46** where it is cemented. It is to be realized that in drilling wells to considerable depths, additional strings of casing may be positioned within the casing string **50**, such for example, as a 9⅝ inch string of casing (not shown) which may be the size of the next string of pipe hung in the well.

In order to retrieve all of the drilling equipment above platform **21** after drilling operations have been concluded, the outermost well casing **22** below the base member **21** is formed in two sections, **22** and **22*a***, respectively. The two sections of casing **22** and **22*a*** are provided with a quick disconnect coupling which, in this particular arrangement, is in the form of a collar **51** welded to the lowermost casing section **22** while being secured to the upper section **22*a*** by means of a series of shear pins **52** which extend through the collar **51** and into the upper section of casing **22*a***. It is to be noted that the two sections of casing **22** and **22*a*** meet at a point **53** within the collar **51**. After the pin **52** has been sheared by a force being applied in an upward direction, the upper section of casing **22*a*** may be lifted out of the collar **51**. The collar **51** is normally positioned at a pre-selected distance, say 25 feet, below the the surface of the ocean floor **13**. If desired, the casing **22** may be provided with a wing-type centralizer **54** for centering the smaller diameter string of casing **50** therein.

The object of the present invention is to provide a method of separating the various concentric strings of pipe at a point below the ocean floor after a well has been plugged so that there is no structure extending above the ocean floor to become a hazard to fishing. Thus, in accordance with the present invention at least one of two concentric strings of pipe extending into the ocean floor is provided with a tension-actuated disconnect joint while an inner concentric pipe is cut by means of any suitable type of pipe or casing cutter. One suitable form of pipe-cutting mechanism is diagrammatically shown in FIGURE 3 which illustrates a pipe cutter **55** having radially extendible cutting elements **56**. The pipe cutter **55** is fixedly secured to the lower end of a small diameter pipe string **57** which extends upwardly to the vessel at the surface. The pipe cutting head **55** may be automatically rotatable at the lower end of the pipe string **57** or the pipe string **57** itself may extend through the rotary table on the vessel **11** on the surface and be rotated in a manner well known to the art. Since there is some vertical motion of the vessel **11** due to wave action at the surface of the ocean, a stop member **58** is provided on the pipe string **57** which stop member is adapted to seat on landing surface or shoulder **45** above the disconnect joint **31** of the assembly shown in FIGURE 1. The spacing between the cutter head **55** and the stop member **58** should be at least equal to the distance between the shoulder **45** and the level at which it is desired to cut off the pipe within the well.

The start of the pipe cutting operation is shown in FIGURE 1 wherein the running string **57** has been run through the rotary table **18** until the stop member **58** carried on the running string **57** is seated on shoulder **45**. In this manner the pipe cutter **55** at the lower end of the running string **57** is positioned at a fixed distance below the shoulder **45**. The stop member **58** remains seated on the shoulder **45** during the cutting operation although the vessel **11** on the surface may rise and fall. In this case, the upper end of the running string **57** is free to slide up and down in the bushing of the rotary table **18** as it is rotated.

After the inner pipe string **50** has been cut at the desired level, an upward force is applied to the underwater assembly to cause the shear pins **52** to shear thus allowing the entire assembly, including the base member **21**, to be lifted off the ocean floor, as illustrated in FIGURE 2, and returned to the vessel. The lifting operation may be carried out by means of the hoist system **17** of the drilling vessel which would lift the marine conductor pipe **32** one section at a time and disassemble at the vessel until all the components of the drilling assembly and surface warhead structure had been retrieved and stored on the vessel. Alternatively, instead of applying tension to the upper end of the assembly from the drilling vessel **11**, fluid pressure may be utilized as the lifting force to cause the shear pins **52** to break and free the underwater structure from the ocean floor. Thus, by using a tubular running string **57**, which is left in place after cutting off the inner pipe by means of rotating cutter **55**, the pipe ram **60** (FIGURE 2) of the blowout preventer **28** or the bag within the blowout preventer **29** (FIGURE 1) may be closed around the pipe string **57**. Thereafter, hydraulic pressure fluid is applied through pipe string **57** from the vessel **11** by means of pump **20**. With the pipe rams **60** closed and suitable communication having been provided through the wall of the innermost pipe **50**, in this instance by means of the cut that has been made, the closed upper end between casing strings **22** and **50** and the closed pipe rams **60** serve as a piston against which pressure fluid may be applied when it is pumped down the running string **57**. With casing **22** having a diameter of 24 inches, a pump pressure of say 1,000 pounds is able to produce the equivalent of a 400,000 pound thrust tending to move the entire underwater structure upwardly so as to shear the shear pins **52**. After the pins have been sheared by this hydraulic force applied by the pump **20**, the structure may be lifted to the vessel at the surface as described hereinabove. If desired, a combination of the hydraulic thrusting force and a mechanical hoisting froce from the hoist system of the vessel may be utilized simultaneously to shear the pins **52** if necessary.

The above operations may also be carried out without the use of the running pipe string **57** as a pressure conduit if operations are carried out in the following manner. Thus, instead of closing the pipe rams **60** about the pipe **57**, as shown in FIGURE 2, the upper blind rams of the blowout preventer **28** would be closed after the pipe cutter and lowering pipe string **57** have been removed to the vessel. Thereafter, pressure fluid would be pumped from the vessel down conduit **39** and into the blowout preventer **28** (FIGURE 1) below the blind rams thereof with the result that pressure fluid would again enter the space between the two pipe strings **22** and **50** and exert a force causing the shear pins **52** to shear. The above-described operations can be carried out successfully if it is assumed that the remotely-operable quick-disconnect coupling and sealing apparatus **31** is of the type that stays positively locked at all times during drilling operations and the subsequent recovery of the equipment. If on the other hand, the wellhead connector **31** is merely a sealing element throughout drilling operations which may be readily pulled apart under a predetermined pressure, say 5,000 pounds, it is apparent that any upward pull on the marine conductor pipe assembly **32** from the surface would cause the assembly to part at the connector **31** without the equipment therebelow being recovered. In the event that a wellhead connector **31** of the sealing type was employed, it would be necessary to provide the running string **57** with a second stop element **64** arranged on the pipe **57** in spaced relationship with the stop element **58** so that the distance between these two stop elements **58** and **64** is slightly greater than the distance between the shoulder **45** (FIGURE 1) on which stop element **58** can rest and the pipe rams **60** (FIGURE 2) within the blowout preventer **58**.

By utilizing a running pipe string or retrieving string **57** as illustrated in FIGURE 3, the tool can be run into the well assembly so as to cut the pipe by means of the cutter **55**, apply pressure to the space below the pipe rams **60** (FIGURE 2) after they had been closed to cause or aid in the rupture of the shear pins **52**, and subsequently be employed to lift the entire assembly off the ocean floor with the pipe rams **60** being closed over the stop member **64**, as shown in FIGURE 2. It is to be understood that other types of stop elements of pipe wall-engaging means, such as actuatable slips, may be employed instead of stop member **64** so that together with the pipe string **57** they could be utilized to lift the entire assembly off the ocean floor. It is to be understood that if three or more concentric strings of pipe or casing are employed in a well that one or more of the inner strings may be cut by means of a pipe cutter while the outermost string is provided with a tension-actuable disconnect device as described hereinabove.

I claim as my invention:

1. A method of retrieving a tubular underwater drilling wellhead assembly from the ocean floor and pulling it back to a drilling vessel on the ocean surface, where the wellhead assembly has been provided with at least two concentric pipe strings which extend into the ocean floor and closure means for closing the innermost pipe string and disconnect means on the outermost pipe string, said method comprising the steps of

forming a separation of the innermost pipe string of said wellhead assembly at a point below the ocean floor,

closing said innermost pipe string at a point above said separation,

applying pressure fluid from said vessel into said innermost pipe string below said closed point and thence through said separation to the space between said innermost pipe string and the outer pipe string to shear said outer pipe string which is axially disconnectible into two portions, and

raising said drilling wellhead assembly back to the vessel by hoisting it from the vessel.

2. The method of claim **1** wherein the step of applying pressure fluid to the interior of the drilling wellhead assembly and the step of hoisting the assembly are carried out simultaneously until the assembly is lifted off the ocean floor, after which the application of pressure fluid is stopped while the assembly is hoisted to the vessel.

3. The method of claim **1** wherein said forming of said separation of said innermost pipe string comprises cutting said pipe string.

4. The method of claim **1** wherein the cutting of the innermost pipe string comprises lowering a cutting tool from the vessel down through said tubular wellhead assembly to a predetermined position below the ocean floor, and actuating said cutting tool to make a horizontal circumferential cut through said pipe string.

5. The method of claim **1** wherein a cutting tool is lowered through the tubular wellhead assembly on and near the lower end of an elongated pipe, the cutting tool is rotated to cut the pipe, then the closing of the innermost pipe string takes place around said elongated pipe with pressure fluid being applied through said pipe, and engaging the elongated pipe with said wellhead assembly whereby said assembly is raised by hoisting on said elongated pipe.

6. A method of retrieving a tubular underwater drilling wellhead assembly from the ocean floor and pulling it back to a drilling vessel on the ocean surface, said assembly having been provided with pressure-responsive disconnect means in an anchor pipe string at a point below the ocean floor and a blowout preventer above the ocean floor, said method comprising the steps of

closing said pipe string at a point above said disconnect means,

applying pressure fluid from said vessel into said pipe string below said closed point and in an amount sufficient to part the disconnect means of said assembly into upper and lower portions, and,

raising said upper disconnected portion of said assembly back to the vessel by hoisting it at the vessel.

7. The method of claim **6** wherein said pipe string is closed by closing the blowout preventer of said assembly.

References Cited

UNITED STATES PATENTS

2,988,145	6/1961	Clark	175—7 X
3,115,933	12/1963	Haeber	166—0.6
3,145,775	8/1964	McCarty	166—0.5
3,177,942	4/1965	Haeber	166—0.5
3,186,486	6/1965	Rhodes et al.	166—0.5
3,195,638	7/1965	Le Rouax	166—0.5
3,259,191	7/1966	McClintock et al.	166—0.5

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