Aug. 19, 1969 C. C. BROWN 3,461,958

METHODS AND APPARATUS FOR INSTALLATION AND REMOVAL OF PREVENTER STACKS IN OFFSHORE OIL AND GAS WELLS

Filed Jan. 16, 1967 6 Sheets-Sheet 1

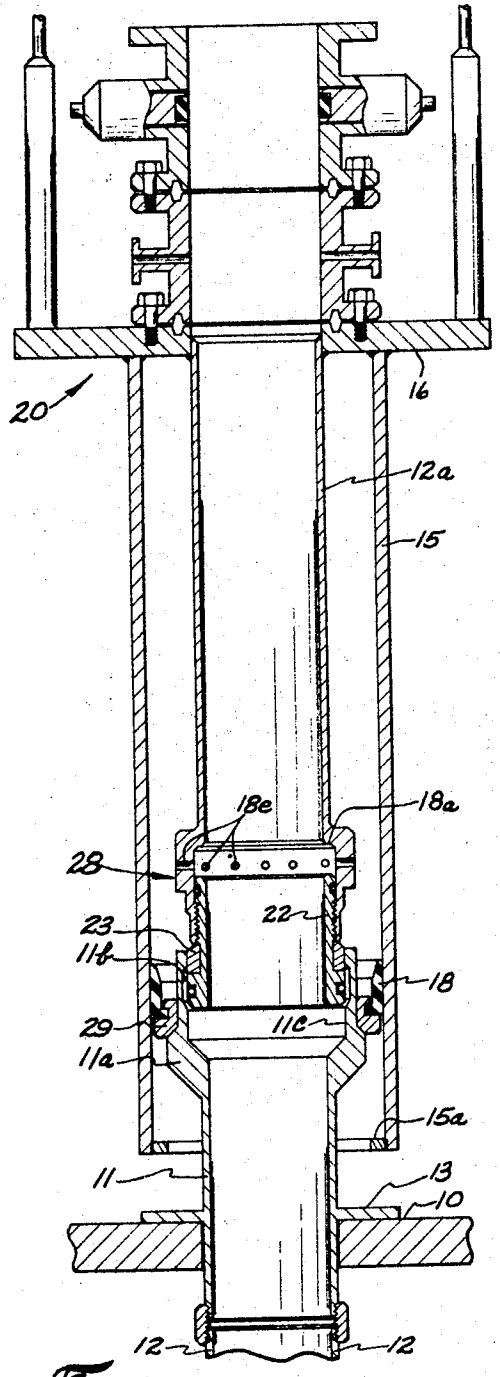


Fig. 1

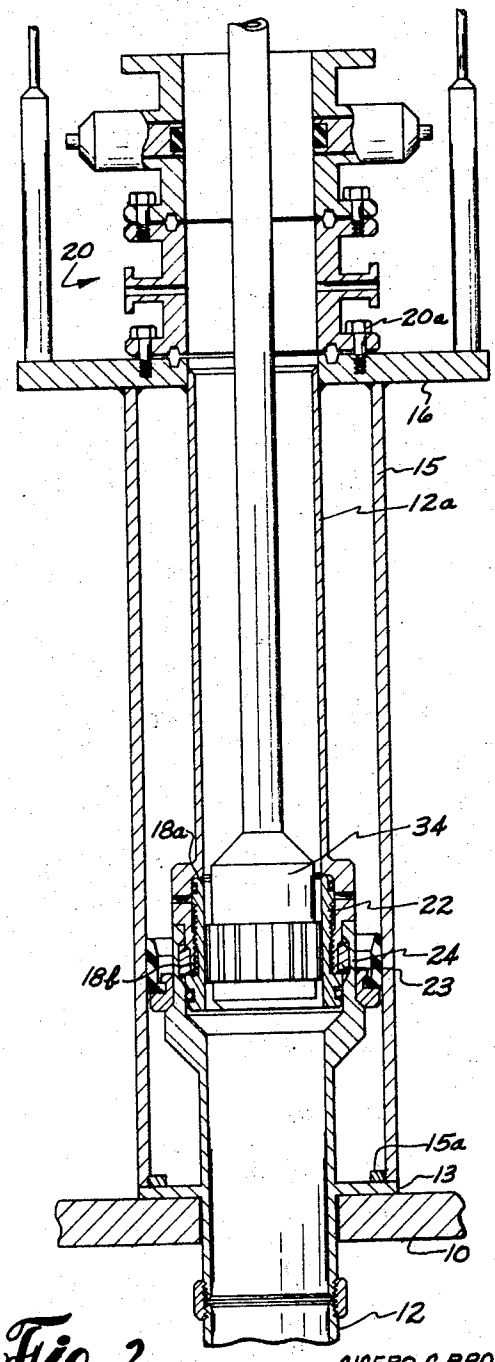


Fig. 2

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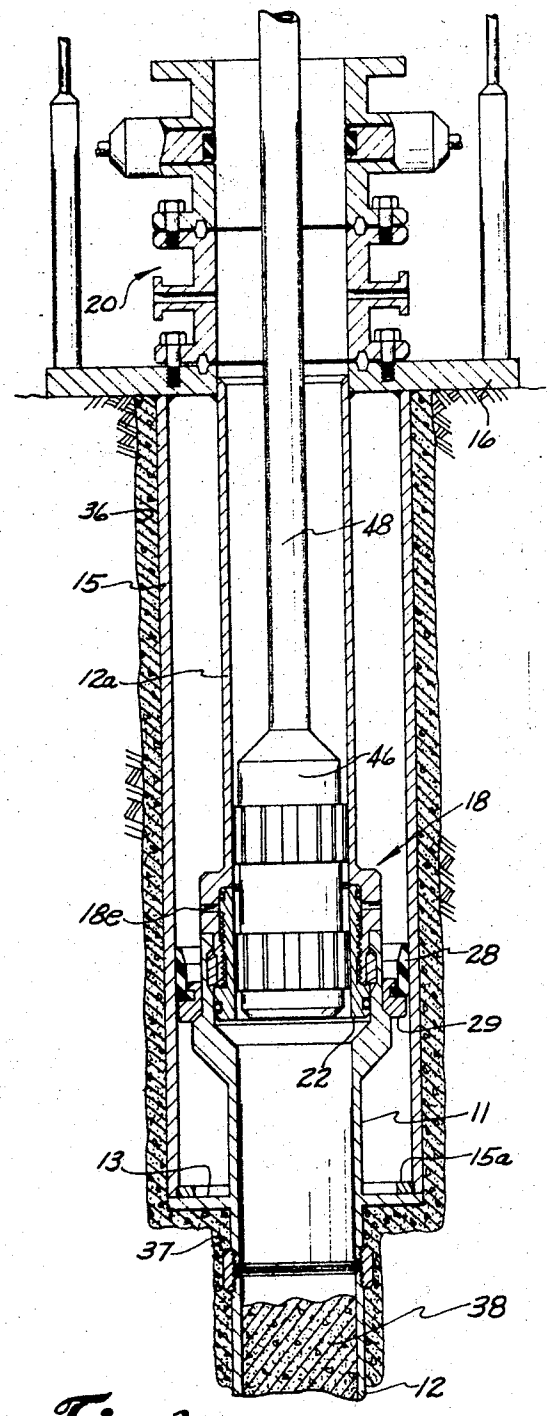


Fig. 3

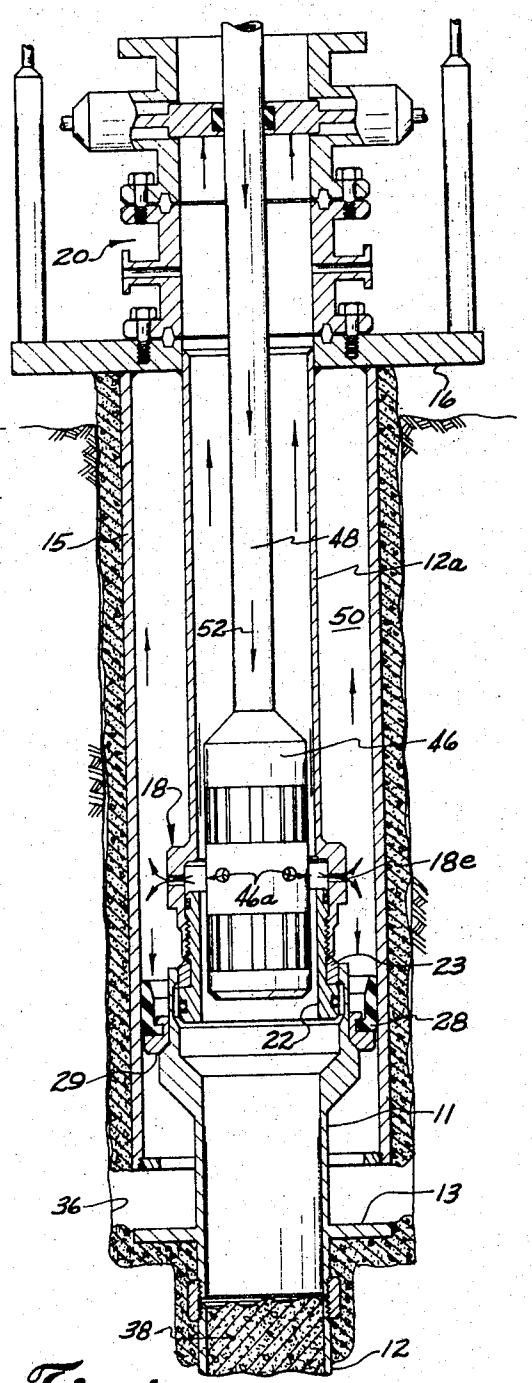


Fig. 4

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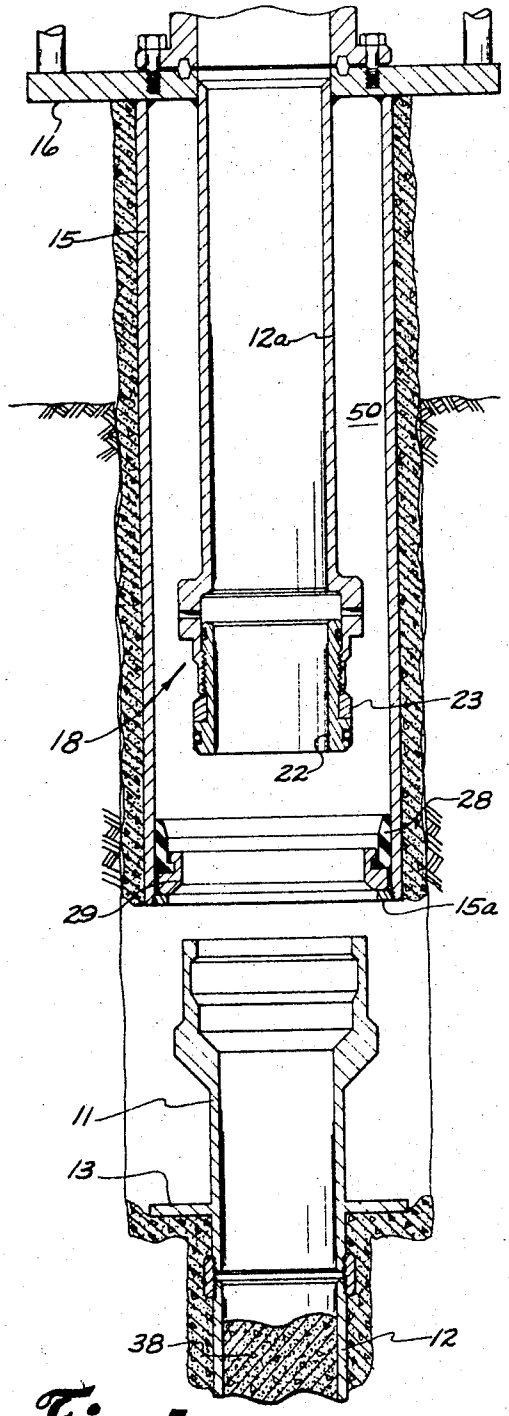


Fig. 5

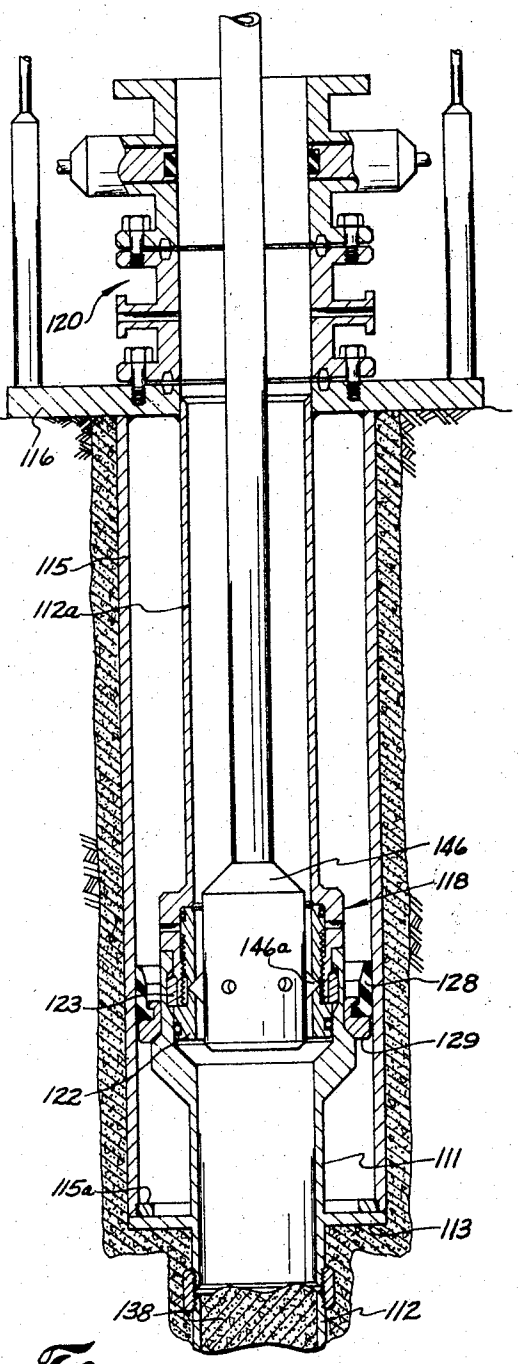


Fig. 6

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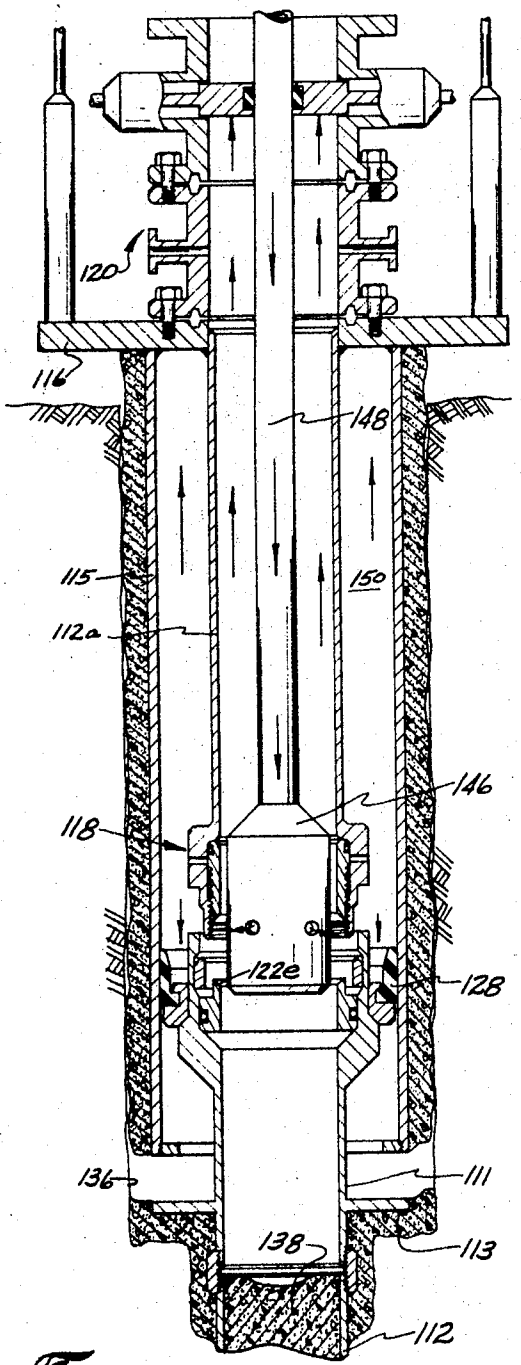


Fig. 7

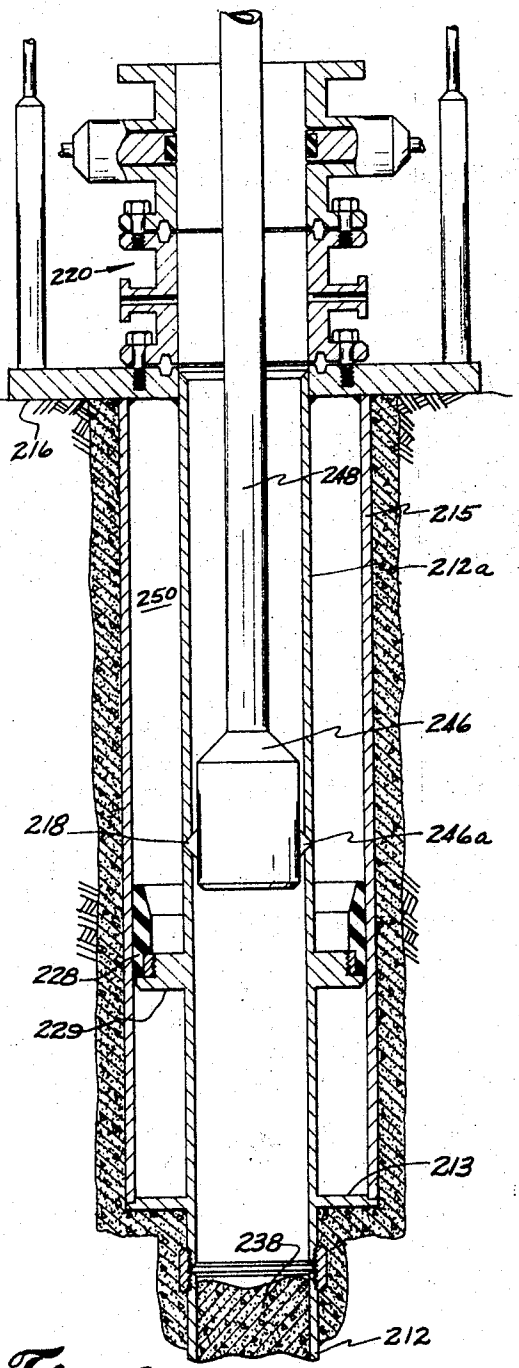


Fig. 8

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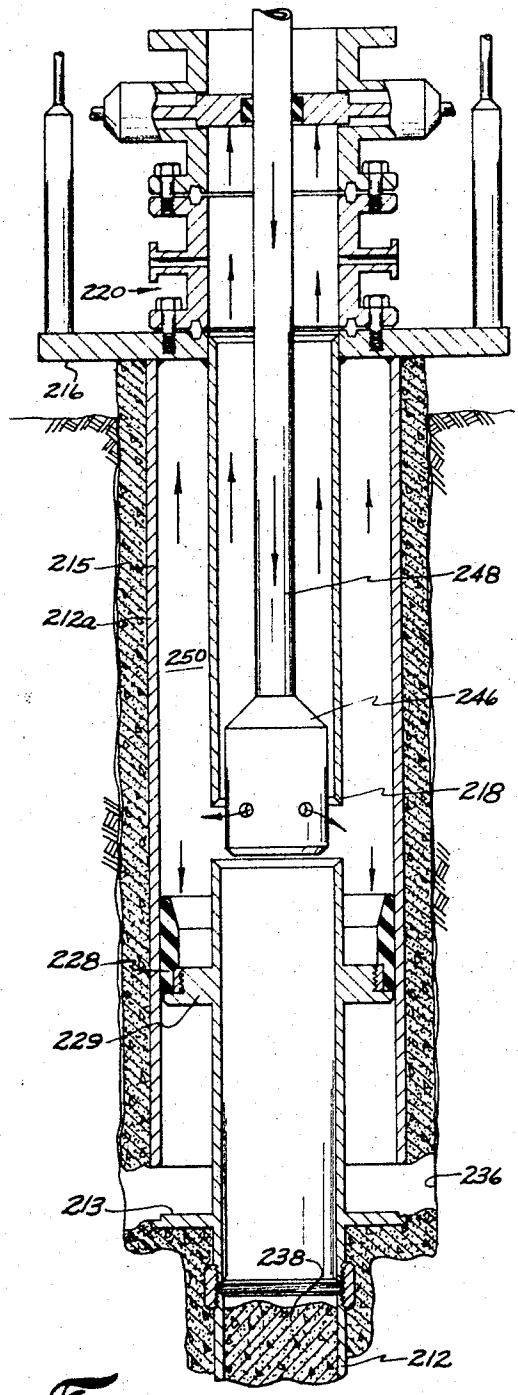


Fig. 9

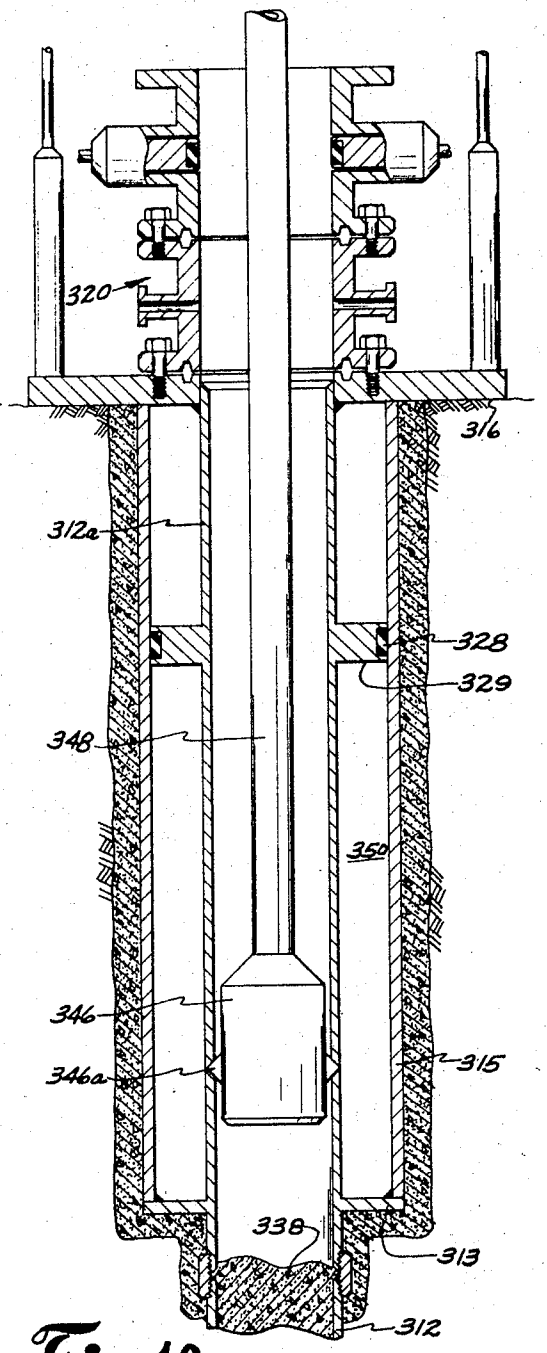


Fig. 10

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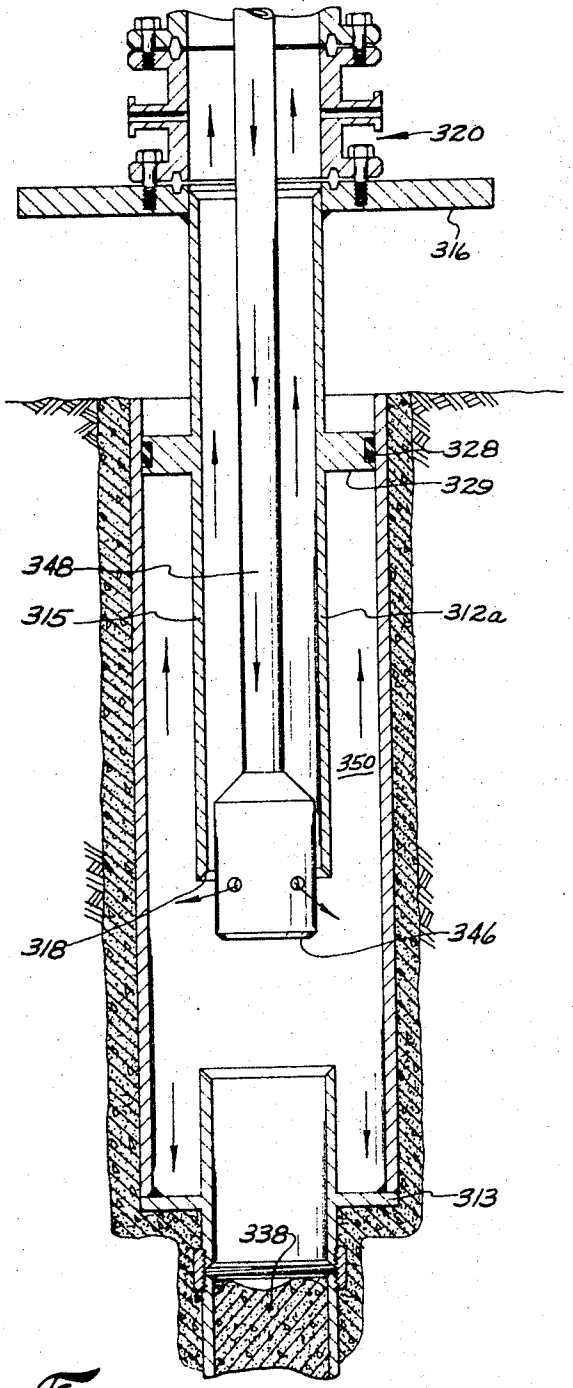


Fig. 11

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United States Patent Office

3,461,958

Patented Aug. 19, 1969

3,461,958

METHODS AND APPARATUS FOR INSTALLATION AND REMOVAL OF PREVENTER STACKS IN OFFSHORE OIL AND GAS WELLS

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Filed Jan. 16, 1967, Ser. No. 609,572
Int. Cl. E21b 33/035, 33/06
U.S. Cl. 166—.5 10 Claims

ABSTRACT OF THE DISCLOSURE

In the installation and recovery of stacks of blowout preventers in offshore oil wells, the preferred apparatus providing a pressure fluid chamber below the preventer stack and adjacent the casing string, a releasable or severable connection in the casing string, a path for conducting pressure fluid into the chamber for expansion to lift the preventer stack from the well bore, the chamber communicating an upward lifting force to the preventer stack in response to pressure increase in the chamber.

Summary of problem and invention

This invention relates to a method and means for installing preventer stacks in underwater wells for ease of removal, and further relates to a method and means providing recovery of preventer stacks and associated apparatus.

It is readily apparent that drilling oil and gas wells is an expensive proposition, and this is especially true in offshore operations. One way of holding the cost of drilling operations to a minimum is the recovery of as much equipment installed in or at the drilling site as possible, and especially so in recovering the more expensive apparatus used in offshore operations. One of the more expensive items required in drilling oil and gas wells is the stack of blowout preventers. Blowout preventers are installed at the well head to limit upward flow through the well bore and also to prevent upward movement of the drill string should the drill bit enter a formation having exceedingly high internal pressures. High pressure formations suddenly penetrated by the well bore have ejected the drill string upwardly through the well head to cause substantial damage to the drilling equipment and serious injuries to the personnel. The problem is also present in drilling operations in offshore locations where the preventer stack is installed beneath the body of water at the well head.

In all drilling operations, the drilling operation is eventually terminated and the blowout preventers are removed from the well. This is true whether the well is a dry hoe or provides oil in substantial quantities. The method of removing blowout preventers from the offshore wells has been less than successful. The preventer stack is customarily joined to the casing and a protector casing placed about the casing string. In view of the substantial length of protecter casings, and in further view of the fact that the well casing extends several thousand feet in the well, the preventer stack is usually firmly cemented in place and difficult to recover.

One method found in the prior art requires upward lifting forces on the preventer stack to free the preventer stack from the casing and the preventer casing which are

cemented in place. In view of the limitations of the prior art, the present invention may be summarized as providing a pressure fluid expansion chamber below the preventer stack for lifting the stack from the well on admission of pressure fluid through the well casing. The chamber is not used until the preventer stack is no longer needed at which time fluid communication between the well head and chamber is established. Pressure fluid in the chamber acts against a surface to lift the preventer stack. The chamber expands by use of a sliding seal permitting continued admission of pressure fluid to substantially lift the appendages to the preventer stack free of the well. With the present summary in view, it is, therefore, an object of the present invention to provide a method of installing and removing preventer stacks in underwater wells in which the separation of the preventer stack from the casing is achieved by pressure fluid lifting the preventer stack.

A related object of the present invention is to provide a new and improved apparatus for recovery of preventer stacks from underwater wells wherein the drilling vessel lifts only the preventer stack and is not used to free the frictional engagement of the cement jacket with the well bore.

One object of the present invention is to provide a new and improved method for installing and removing preventer stacks in underwater wells wherein separation between the preventer stack and well casing is achieved by disconnection as opposed to rupture of the well casing and cement jacket.

Yet another object of the present invention is to provide a new and improved method for recovering preventer stacks from underwater wells wherein movements against substantial friction between the cement jacket and the well bore is achieved by hydraulic pressure supplied to the well to lift the preventer stack.

One object of the present invention is to provide a new and improved method of retrieving preventer stacks in which the annulus between the protector casing and well casing is used as an expansion chamber for lifting the preventer stack from below to avoid damage to the expensive apparatus.

Yet another object of the present invention is to provide a new and improved method of removing preventer stacks from underwater wells in which the installation is effected with a view of easy removal without interfering with the function of the blowout preventers or drilling of the well.

One object of the present invention is to provide a new and improved apparatus for removing installed blowout preventers from underwater wells which incorporates means for freeing the well casing from the preventer stack and thereafter uses a chamber for receiving pressure fluid to lift the preventer stack from the well.

Other objects and advantages of the present invention will become more readily apparent from a consideration of the specification and drawings wherein:

FIG. 1 is a longitudinal sectional view of the apparatus of the present invention during assembly on a drilling vessel before placement in the well bore;

FIG. 2 is a longitudinal sectional view similar to FIG. 1 after assembly and prior to placement in a well bore;

FIG. 3 is a longitudinal sectional view of the apparatus shown in FIGS. 1 and 2 after cementing in the well bore which further illustrates operation of a tool to separate the casing from the preventer stack;

FIG. 4 is a view similar to FIG. 3 showing the step of separating the casing from the preventer stack and further illustrating pressure fluid flow for lifting the preventer stack;

FIG. 5 is a view similar to FIG. 4 illustrating completion of the step of lifting the preventer stack;

FIG. 6 is similar to the step shown in FIG. 3 and also illustrates an alternative embodiment of the present invention;

FIG. 7 illustrates an additional step in the method using the embodiment shown in FIG. 6;

FIG. 8 is a sectional view of an additional embodiment of the present invention showing use of an inside cutter for separating the preventer stack from the well casing;

FIG. 9 is similar to FIG. 8 and illustrates separation of the preventer stack from the well casing;

FIG. 10 illustrates an additional embodiment of the present invention; and

FIG. 11 is a view similar to FIG. 10 illustrating the preventer stack during the step of lifting the preventer stack while the protector casing remains in the cemented well bore.

Attention is first directed to FIGS. 1–5, inclusive, which illustrate the method and apparatus of the present invention in detail. The apparatus associated with FIGS. 1–5 will be first described, and thereafter, the steps of the method of the present invention will be also related, particularly with reference to the drawings which illustrate various steps in the method. Therefore, attention is first directed to FIG. 1 of the drawings which illustrates the apparatus in a state of assembly prior to installation in a well bore.

In FIG. 1, a joint of casing **12** is preferably integrally joined to a tubular connector **11** for use in making up the casing string to be placed in the well bore (not shown). The connector **11** is held in a predetermined position by resting a flange **13** on a removable support **10**, the support **10** customarily located on the drilling barge or vessel in the water near the drilling site of the well.

Aboard the drilling vessel, the upper portions of the well casing string are assembled relative to the protector casing as will be described. In further particular, a base member **16** serves as mounting means for the blow-out preventers **20** which are located thereabove and as a support for a casing member **12***a* suspended therebelow. Positioned concentrically about the casing member **12***a* is a protector casing **15** which is somewhat greater in length than the casing **12***a*.

In drilling oil and gas wells located beneath bodies of water, the protecter casing **15** length is varied over a wide range depending on the conditions encountered. Thus, for instance, the preventer casing may be relatively short should solid, non-porous geological strata be encountered. The members **12***a* and **15** are arranged concentrically of one another and have a length best determined by conditions at the drilling site.

Considering the blow-out preventers **20** further, attention is directed to FIGS. 1 and 2 which illustrate the preventers secured to the upper side of the base plate **16**. In the drawings, the preventer stack is secured to the base plate by conventional bolts **20***a* and a seal member is placed interiorly of the bolts **20***a* for maintaining a pressure tight seal. The rams of the preventer stack are represented generically in the drawings as will be understood by those skilled in the art.

Attention is next directed to the means indicated generally at **18** at the lower end of the casing member **12***a* which comprises a male connector means for releasable connection with the tubular member **11**. A setting sleeve **22** is threaded into the lower end of the casing member **12***a*, it being noted that the casing member is somewhat enlarged at the threaded connection whereby the setting sleeve is equal in inside diameter to the casing member **12***a* and the connector member **11** therebelow. The setting sleeve **22** incorporates conventional seal means at both ends thereof to provide integrity of fluid communication through the well casing string. Of particular interest is the expander ring **23** adjacent the setting sleeve which is in a relaxed condition in FIG 1. Use of the expander ring **23** will be noted in greater detail hereinafter.

Attention is next directed to the tubular connector means **11** engaged with the male connector means **18**. The means **11** incorporates the outwardly extending shoulder means **11***a* for engaging additional means placed within the protector casing **15** as will be described. An internal recess **11***b* is provided within the connector means **11** for receiving the expander ring **23**. A sealing surface **11***c* within the connector is provided for engaging the seal member on the setting sleeve **22** to maintain fluid communications through the well casing string. Additional details concerning the female connector member **11** will be noted hereinafter.

Attention is next directed to the apparatus carried within the protector casing **15** and engaging the shoulder **11***a* on the connector member **11**. Attention is first directed to the encircling resilient cup **28** which is held in position by a support ring **29**. The support ring **29** is carried by the shoulder **11***a* on upward movement of the shoulder relative to the protector casing **15** whereby the rubber ring **28** is sealed against the interior wall of the member **15**. A retainer ring **15***a* is engaged at the lower end of the protector casing **15** for initially inserting the seal cup **28** within the casing member **15**. The ring **15***a* is threaded to the interior of the casing member **15**.

It should be noted that the foregoing description is directed to the details of construction of the apparatus shown arranged in FIG. 1. However, the apparatus of FIG. 1 is also illustrated in FIGS. 2–5, inclusive, during various stages in the practice of the method of the present invention. Relying on the foregoing description of the apparatus, attention is next directed to FIGS. 1–5 for an understanding of the method of the present invention. FIG. 1 illustrates the assembly stage of the present method. The setting sleeve **22** is threaded to the lower end of the casing member **12***a* and thereafter the protector casing **15** is positioned in the concentric relationship illustrated in the drawings relative to the casing **12**. The cup **28** is placed within the protector casing **15** and the retainer member **29** is inserted thereafter and the two members are locked within the protector casing by the retainer ring **15***a*. The female connector means **11** is placed in protector casing **15** about the setting sleeve **22** as shown in FIG. 1. Upward movement of the shoulder **11***a* urges the support ring **29** and the rubber cup **28** to the illustrated position of FIG. 1 wherein the female connector is positioned for later engagement with the male connector.

Attention is next directed to FIG. 2 of the drawings which illustrates the step of the present method wherein the tubular connector **12***a* which carries the preventer stack **20** is joined to the casing string **12**. A torque-wrench **34** is inserted through the preventer stack **20** and positioned adjacent the setting sleeve and engaged therewith. The setting sleeve is preferably provided with left-hand threads engaging interior threads of the connector means **18**. The setting sleeve fully threads against an abutting shoulder **18***a* illustrated in FIG. 2.

Attention is next directed to the expander ring **23** which is in the expanded position in FIG. 2. The expander ring **23** is forced into the internal recess **11***b* of the female connector means **11** which is positioned adjacent the expander ring, the extreme end **18***b* of the tubular member **18** moving beneath the ring to expand it into the recess **11***b*. It will be noted that the two portions of the casing string, the members **11** and **18** in particular, have been joined to one another by the expander ring **23**. Reference is made to the fact that the recess **11***b* is defined by a pair of facing shoulders which lock the expander ring **23** in place.

In the assembly step shown in FIG. 2, it should be noted that the connecter members **11** and **18** are moved

axially toward one another by threaded engagement with the setting sleeve **22**. The movement contacts the flanges **13** carried on the connecter **11** against the open lower end of the casing **15** and provides an adequate seal to prevent intrusion of materials under pressure into the annulus between the two casing members.

At this juncture, the support member **10** is removed and the preventer stack, including the casing **12**, is inserted into the hole drilled beneath the drilling platform or vessel. Attention is next directed to FIG. 3 which illustrates the preventer stack and casing string in the well bore. The protecter casing **15** is cemented within the well bore **36** which has an enlarged diameter sufficiently deep to accommodate the enlarged protector casing **15**. The casing string **12** is also cemented in place at **37** to an adequate depth. The base plate **16** is rested on the floor of the body of water.

At some point in time in the drilling operations conducted through the well casing **12**, it becomes necessary to either plug the well prior to abandonment or to remove the preventer stack because production has been obtained. Using the well plug as an example of terminated drilling, known techniques are used to insert a cement plug **38** in the well casing **12**. A reversing tool **46** is run into the casing string and positioned adjacent the setting sleeve **22** preliminary to disengaging the preventer stack **20** from the well casing string. The reversing tool **46** is used to disengage the setting sleeve for release of the connectors **11** and **18**.

Attention is redirected to FIG. 1 which illustrates the male connecter means **18** as including a plurality of ports **18***e*. The ports **18***e* are adjacent the shoulder **18***a* whereby communication from the interior of the casing string **12** is obtained to the annulus thereabout when the setting sleeve **22** is in the partially threaded position of FIG. 1. Conversely, FIG. 2 illustrates complete engagement of the setting sleeve **22** whereby the ports **18***e* are sealed against communication from the casing string **12**. The ports **18***e* are sealed during the drilling operations until the termination of drilling.

Attention is next directed to FIG. 4 which illustrates the use of the ports **18***e* after the reversing tool **46** has returned the setting sleeve to the position illustrated in FIG. 1. The downward movement of the setting sleeve relative the connecter means **18** exposes the ports **18***e* for communication from the casing string into the annulus defined by the protector casing **15**. The annulus or chamber, indicated by the numeral **50**, is defined by the protector casing **15**, the casing member **12***a*, and the base plate means **16**. The base plate means **16** provides a surface which communicates upward force to the preventer stack **20** on accumulation of fluid in the chamber **50** under pressure. The chamber means **50** is particularly defined by the facing walls of the casing members **12***a* and **15** which extend downwardly to the rubber cup **28** carried on the support ring **29**. The rubber cup **28** is constructed and arranged to respond to pressure fluid in the chamber means **50** to slidingly seal against the wall of the preventer casing **15**.

A closed fluid system is defined within the casing string for receiving pressure fluid from the drilling platform or vessel. In this regard, attention is directed to the reversing tool **46** which is retained in the well bore after disconnection of the setting sleeve **22** between the male and female connectors **18** and **11**, respectively (see FIG. 4). The reversing tool **46** includes a plurality of ports **46***a* communicating with a tubing string **48** for directing pressure fluid to the well annulus **50**. A pair of rams **20***b* are positioned against the exterior of the tubing string **48** to seal the casing string **12** against flow upwardly in the string. Pressure fluid is delivered through the tubing string **48** as indicated by the arrows **52**. The pressure fluid passes through the ports **46***a* and the reversing tool **46** and is limited in upward or downward escape in the well casing by the cement plug **38** and the rams **20** of the preventer stack means. The constraints on flow limit the fluid to passage through the ports **18***e* into the annulus means **50**.

On delivering an adequate quantity of pressure fluid to the chamber **50**, the pressure fluid acts upwardly against the base plate **16** to provide an axial strain upwardly on the casing members **12***a* and **15**. Since the casing member **12***a* was disengaged from the casing string **12** by setting sleeves **22**, the member **12***a* is free to move upwardly with the base plate **16**. Likewise, the protector casing **15** is not joined to the casing string **12** at the flange **13**, but merely rests thereon for relatively easy disengagement as shown in FIG. 4. The casing member **15**, joined to the base plate **16**, imparts a failure circumferentially of the cement at the flange plate **13**. A substantial force is required for this failure, although it will also be appreciated that cement is inherently weak in tension and therefore fails without requiring excessive axial strain on the casing **15**.

The step of pumping pressure fluid into the tubing string **48** is continued indefinitely until the tubular portion connected to the preventer stack breaks free of the cement bond with the open hole **36**.

As noted above, the step of pumping pressure fluid into the chamber **50** is continued whereby the seal cup **28** slides axially toward the lower end of the protecter casing **15** as the tubular members attached to the preventer stack **20** are expelled from the well bore under pressure. This step is represented in FIG. 4 and FIG. 5 wherein the upward movement frees the seal cup member **28** and the support ring **29** from the lower connecter **11**. At this point, with the protector casing **15** substantially expelled from the well bore, and with reduced frictional engagement with the well bore, the preventer stack is easily retrieved by the drilling platform or vessel.

Attention is next directed to FIGS. 6 and 7 which illustrate an alternative method of the present invention. The steps of installing the preventer stack in the well (as illustrated in FIGS. 1 and 2) are omitted, but reference is made to the foregoing description for understanding of the method presently omitted. FIG. 6 is generally similar to FIG. 3 in illustrating a plug in the casing after the well has been abandoned.

The apparatus illustrated in FIG. 6 which bears a similarity to the apparatus shown in FIGS. 1–5, inclusive, bears the identical reference numerals increased by one hundred, and the foregoing description is adequate for FIGS. 6 and 7. In FIG. 6, an inside cutter tool means **146** is run in the casing string **112**, and positioned adjacent the setting sleeve **122**. Those skilled in the art will appreciate the somewhat schematic representation of the cutter tool **146** which carries the cutting elements **146***a* against the setting sleeve **122**. The setting sleeve **122** is shown in FIG. 6 in the locking position whereby the tubular members **112***a* and **111** are joined to one another by expansion of the expander ring **123** into the locking position previously illustrated in FIG. 3. The tool means **146** is positioned with the cutting elements immediately adjacent the setting sleeve **122** whereby the cutters **146***a* are gradually extended as the tool is rotated to form an ever deepening cut circumferentially interiorally of the setting sleeve **122**. When the cutters extend fully through the setting sleeve, the cutting blades are retracted, permitting separation of the male and female connectors **118** and **111**, respectively. It should be noted that the cut in the setting sleeve not only destroys the structural integrity of the joint and effects a disconnection in the well casing string, but the cut also provides access from the interior of the casing string to the annulus **150** for admission of pressure fluid. The chamber means **150** operates in the same manner as the chamber means **50** above noted. At this juncture, reference is made to FIG. 7 which illustrates the next step of the present method.

The cutter tool **146** communicates pressure fluid through the tubing string **148** axially of the well string. Again, sealed means are effected near the well head, and for

purposes of illustration, the rams of the preventer stack **120** are extended to seal off the well casing string against upward flow of fluid. The fluid passes through the tubing string **148** and the cutter head **146** into the cut about the circumference of the setting sleeve **122**. Reference is made to the separated portions of the setting sleeve attached to the connectors **111** and **118**. When the pressure fluid admitted through the tubing string **148** fills the chamber **150** and acts against the base plate means **116**, the lifting force on the preventer stack **120** moves it upwardly. Also, the protector casing **115** is lifted upwardly and expelled from the well bore **136**. Upward movement of the protector casing imparts circumferential break to the cement about the protector casing **115**.

The upwardly movement of the base plate **116** and associated tubular members expands the chamber means **150** by moving the seal cup **128** along the wall of the protector casing **115** to maintain fluid integrity within the chamber means **150**. Upward movement of the protector casing **115** is accompanied by upward movement of the casing segment **112***a* as the preventer stack **120** is retrieved. Hydraulic retrieval of the preventer stack is continued until the preventer stack and tubular segments associated therewith are substantially expelled from the well bore **136** whereupon the friction of the cement jacket against the well bore **136** is substantially reduced. The preventer stack is lifted by conventional apparatus aboard the drilling barge or vessel. Reference is made to FIGS. 4 and 5 associated with the previously described method for illustration of the last steps of the method of the present invention.

Attention is next directed to FIGS. 8 and 9 of the drawings which illustrates an additional alternative in the method of the present invention. Apparatus similar to the apparatus previously noted in FIGS. 1–7, inclusive, bears numerals increased by one hundred. In FIG. 8, the preventor stack means **220** is mounted on the base plate **216**, and the casing member **212***a* is connected to the casing string **212**. In addition, the protector casing **215** is placed thereabout and joined to the base plate **216**. The casing **215** extends longitudinally of the casing string **212** and rests on a flange plate **213** integrally formed with the casing member **212***a*.

Of particular interest and contrast in the apparatus shown in FIGS. 8 and 9 is the fact that connecters (see connecters **18** and **11** in FIG. 1) are absent from the embodiment. While no connector means are specified, connection of the casing string to the base plate **216** has the form of integral construction for purposes of the claims. The chamber means **250** is defined by the lower face of the plate **216** and the annulus between concentric tubular members **212***a* and **215**. The lower end of the chamber means **250** is defined by the seal cup **228** which is a circumferential seal carried on the support ring **229**. Of particular interest is the variation shown in FIG. 8 wherein the seal support ring **229** is integrally formed with the tubular member **212***a* comprising a portion of the casing string. While the support ring **229** is illustrated as an integral portion of the tubing string, it will be appreciated that the support ring may be welded or otherwise joined to the casing string. At any event, the support ring **229** carries the seal cup **228** against the interior of the protector casing **215** whereby the chamber means **250** is delimited for receiving pressure fluid therein.

The method of installation in the well bore of the completed assembly shown in FIG. 8 is preferably the same as the foregoing described methods. An inside cutter tool **246** is run on the tubing string **248** for cutting the casing portions **212***a* into two segments, an upper segment above the cut at **218** and a lower segment below the cut which is left with the remainder of the casing string. The inside cutter tool **246** is a conventional device known to those skilled in the art. After cutting, the cutter blades **246***a* are retracted and the casing string is sealed thereabove, perhaps near the well head, preferably by use of the blow out preventer means **220** as illustrated in FIG. 9. At this juncture, the device is ready for admission of pressure fluid through the tubing string **248** and the cutting tool **246**.

The pressure fluid fills the casing above the plug **238** and also fills the chamber means **250** previously described. The chamber means is filled to the base plate **216** and an increase in pressure in the chamber means **250** lifts the base plate **216** and the preventor stack **220**. The cement jacket joined to the protector casing **215** is fractured near the flange plate **213**. As in the previous embodiments noted hereinabove, the seal cup **228** permits expansion of the chamber means **250** but maintains pressure within the chamber means **250** for further expansion. After elongation of the chamber means **250**, the seal means **228** is disengaged from the protector casing **215** when the preventor stack **220** has been substantially lifted free of the well bore **236**. Then, conventional lifting apparatus on the drilling barge or vessel is used to recover the preventor stack **220**.

Attention is next directed to FIGS. 10 and 11 which illustrate further modifications of the method and apparatus of the present invention. In FIG. 10, the apparatus is again shown in the assembled condition in the well bore and reference is made to the foregoing descriptions for an understanding of the method of assembly and placement in the well bore. At the illustrated step of the present method, FIG. 10 shows an abandoned well with a plug **338** in the casing **312**. As in the previous descriptions, similar parts have reference numerals similar to previously used reference numerals, increased by one hundred. The casing string is joined or connected to the preventer stack means **320** by the casing member **312***a* which extends from the base plate **316** to the casing string **312**. The member **312***a* is welded or otherwise joined to the base plate **316** as will be noted in the drawing. The flange **313** on the casing string **312** supports the protector casing **315** which is welded thereto in the preferred embodiment. Of particular interest is the fact that the casing **315** is not joined to the base plate **316** as described in previously noted embodiments.

The apparatus shown in FIGS. 10 and 11 also incorporates a seal cup **328** which is carried on a laterally extending support member **329**. Of particular interest in this embodiment is the fact that the sealed means **328** is located relatively high adjacent the protector casing string. The seal support **329** is preferably welded or integrally formed with casing member **312***a*. The high location of the seal means **328** defines a chamber means **350** therebelow extending to the flange plate **313**. Again, the chamber means **350** is located in the annulus between the concentric tubular members **312***a* and **315**. The nether side of the support member **329** provides a surface communicating upward lifting force from pressure fluid in the chamber **350** to the preventer stack **320**. While the previously described embodiments utilize the base plate to communicate upward lifting to the preventer stack, the present invention utilizes the lower side of the support **329** which communicates the upward force to the tubular member **312***a* for lifting the preventer stack upwardly.

An inside cutter tool **346** carried on a tubing string **348** is run in the casing string after the cement plug **348** has been placed therein for cutting the well casing as illustrated.

The cutting tool **346** carries conventional cutters **346***a* extended to form upper and lower portions, it being noted that the upper portion is joined to the preventer stack **320** and the lower portion remains with the casing string **312**. Reference is made to FIG. 11 of the drawings which illustrates the use of the tubing string **348** as a conduit for pressure fluid supplied from the drilling barge or vessel. Again, provision is made for some sort of seal means near the well head for maintaining the pressure fluid in the well casing string for admission to the chamber means **350**. In any case, the pressure fluid is admitted through

the tubing string **348** and is exhausted through the inside cutter tool **346** at the cut **318** which forms a passage means communicating through the wall of the casing string into the chamber means **350**. The pressure fluid is admitted thereto and on increase of pressure, acts upwardly against the support member **329** and communicates an upward lifting force to the tubular member **312***a* which is imparted to the preventer stack carried on the base plate **316**. The base plate **316** is lifted free of the protector casing **315** since the protector casing is not joined structurally to the base plate **316** as in the previous embodiments.

FIG. 11 illustrates substantial upward expulsion of the casing portion **312***a* and the preventer stack **320** as a means of recovery of the preventer stack. Again, continued addition of pressure fluid to the chamber means **350** is dependent on the seal means **328** engaging the casing **315**. The preventer stack means **320** is freed of the well and retrieved to the drilling barge or vessel by conventional lifting apparatus. In contrast to the foregoing methods, it will be noted that the protector casing is left essentially intact and in the well bore joined to the cement jacket. By way of further contrast, it will be noted that the seal cup is recovered by the method presently described whereas the previously described methods left the seal cup and support member in the well bore.

While the foregoing describes the various methods utilizing the apparatus of the present invention, it will be appreciated that the scope of the present invention is defined by the claims appended hereto.

What is claimed is:

1. A method of installing and removing preventer stacks in underwater wells in which a protector casing is cemented in an open hole and a well casing is placed therein which comprises the steps of:

(a) Threadedly connecting the preventer stack to the well casing by means of a tubular connector;

(b) Forming a pressure fluid tight chamber below the preventer stack;

(c) Said chamber being defined by a surface communicating upward force to the preventer stack on admission of pressure fluid to the chamber;

(d) Disconnecting the well casing from the preventer stack at a point below the preventer stack by unscrewing said tubular connector;

(e) Pumping pressure fluid into the chamber for lifting the preventer stack upwardly on expansion of the chamber; and

(f) Extending the step of pumping pressure fluid into the chamber until the preventer stack and the tubular portion remaining connected thereto break free of the bond with the open hole.

2. The method of claim **1** wherein the step of forming the pressure tight chamber below the preventer stack includes the step of sealing the protector casing to the preventer stack.

3. The method of claim **1** wherein the step of forming the pressure tight chamber below the preventer stack includes the step of forming a seal in the annulus between the well casing and the protector casing.

4. The method of claim **1** wherein the step of pumping pressure fluid includes the steps of providing a path for fluid flow through the well casing into the pressure fluid tight chamber, pumping fluid down the well casing, directing the fluid along the path provided therefor.

5. The invention of claim **1** including the step of using an inside wrench to place a setting sleeve in the well casing to connect the preventer stack to the well casing, and simultaneously closing openings in the well casing communicating with the annulus.

6. The method of claim **1** wherein the step of joining the preventer stack to the well casing is followed by cementing the protector casing in the well bore.

7. An apparatus for installing preventer stacks on under-water wells, comprising:

(a) A tubular connector extending downwardly from the preventer stack, said connector being adapted to be connected to a well casing for use in a casing string;

(b) Chamber means defined by the well casing and exteriorly thereof;

(c) Said chamber means being at least partially defined by a cylindrical surface of predetermined longitudinal extent;

(c_1) Seal means slidably and sealingly engaging said cylindrical surface for confining fluid pressure admitted to said chamber, said surface communicating upward force on the preventer stack moving in response to increased pressure in said chamber means, and said surface movement also expanding said chamber by slidably moving said cylindrical surface relative to said seal means;

(d) Closable passage means for communicating pressure fluid to said chamber means to increase the pressure therein; and

(e) Means for disconnecting the preventer stack from the well casing to free same for movement in response to admission of pressure fluid to said chamber means acting against said surface.

8. An apparatus for installing preventer stacks on underwater wells, comprising:

(a) A tubular connector extending downwardly from the preventer stack, said connector being adapted to be connected to a well casing for use in the casing string;

(b) Chamber means defined by the well casing and exteriorly thereof;

(c) Said chamber means being at least partially defined by a surface communicating an upward force on the preventer stack on increase of pressure in said chamber means;

(d) Closable passage means for communicating pressure fluid to said chamber means to increase the pressure therein;

(e) Means for disconnecting the preventer stack from the well casing to free same for movement in response to admission of pressure fluid to said chamber means acting against said surface;

(f) The nether side of the preventer stack being sealingly joined to a protector casing to at least partially define said chamber means;

(g) A plurality of openings in the well casing; and

(h) Setting sleeve means in the well casing adapted to be positioned opposite said openings for closing said openings.

9. An apparatus for installing preventer stacks on underwater wells, comprising:

(a) A tubular connector extending downwardly from the preventer stack, said connector being adapted to be connected to a well casing for use in the casing string;

(b) Chamber means defined by the well casing and exteriorly thereof;

(c) Said chamber means being at least partially defined by a surface communicating an upward force on the preventer stack on increase of pressure in said chamber means;

(d) Closable passage means for communicating pressure fluid to said chamber means to increase the pressure therein;

(e) Means for disconnecting the preventer stack from the well casing to free the same for movement in response to admission of pressure fluid to said chamber acting against said surface;

(f) Said tubular connector being releasably connected to well casing by an axially movable setting sleeve, and the connecting position of said setting sleeve closing said passage means.

10. In underwater wells, the method of removing a preventer stack from a well casing which is cemented in place in a well bore, comprising,

(a) Forming a closed chamber about a portion of the well casing below the preventer stack by means providing a side wall concentric with said casing portion and longitudinally spaced end walls one of which fixedly connects said side wall to said casing portion and the other of which defines a slidable seal between said side wall and said casing portion,

(b) Severing said casing portion at a point between said end walls, and

(c) Introducing pressurized fluid into said chamber to elevate the severed upper section of said casing portion carrying the preventer stack relative to the casing section remaining in the well bore.

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U.S. Cl. X.R.

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