Feb. 7, 1967 W. R. POSTLEWAITE 3,302,709

METHOD FOR ATTACHING AND DETACHING A WORKING BASE TO AN UNDERWATER WELL BASE

Original Filed Nov. 5, 1962 9 Sheets-Sheet 1

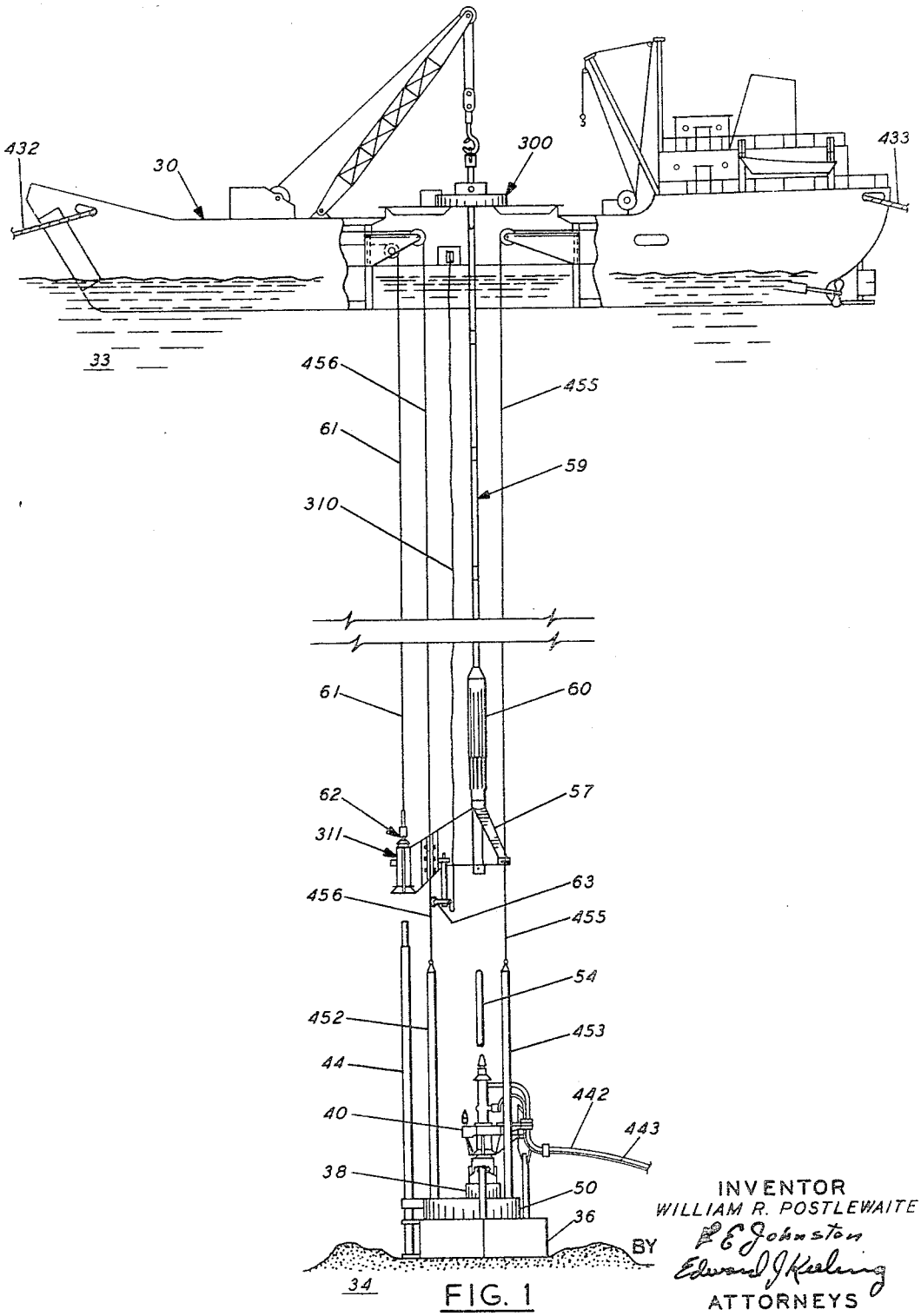


FIG. 1

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METHOD FOR ATTACHING AND DETACHING A WORKING BASE TO AN UNDERWATER WELL BASE

Original Filed Nov. 5, 1962 9 Sheets-Sheet 2

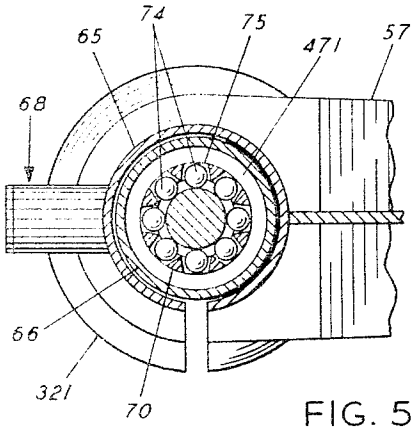


FIG. 5

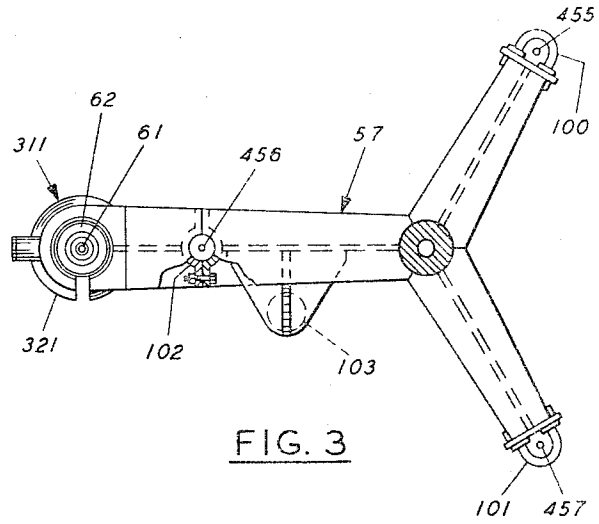


FIG. 3

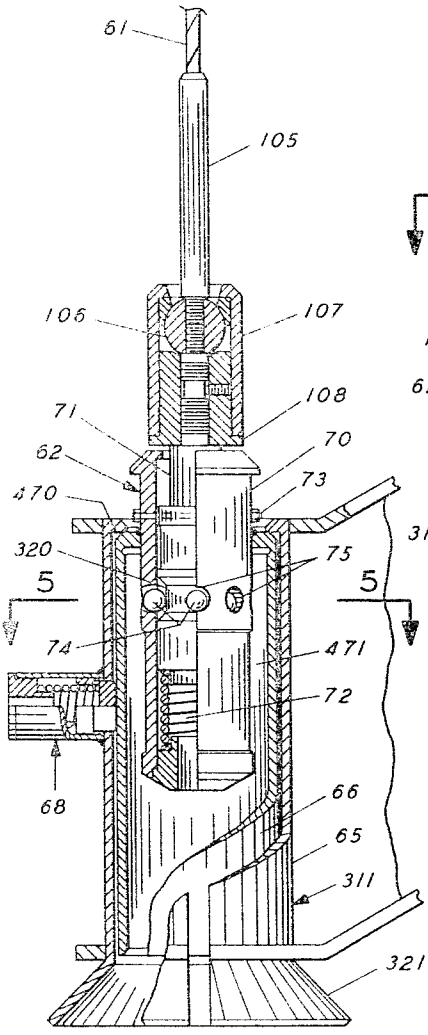


FIG. 4

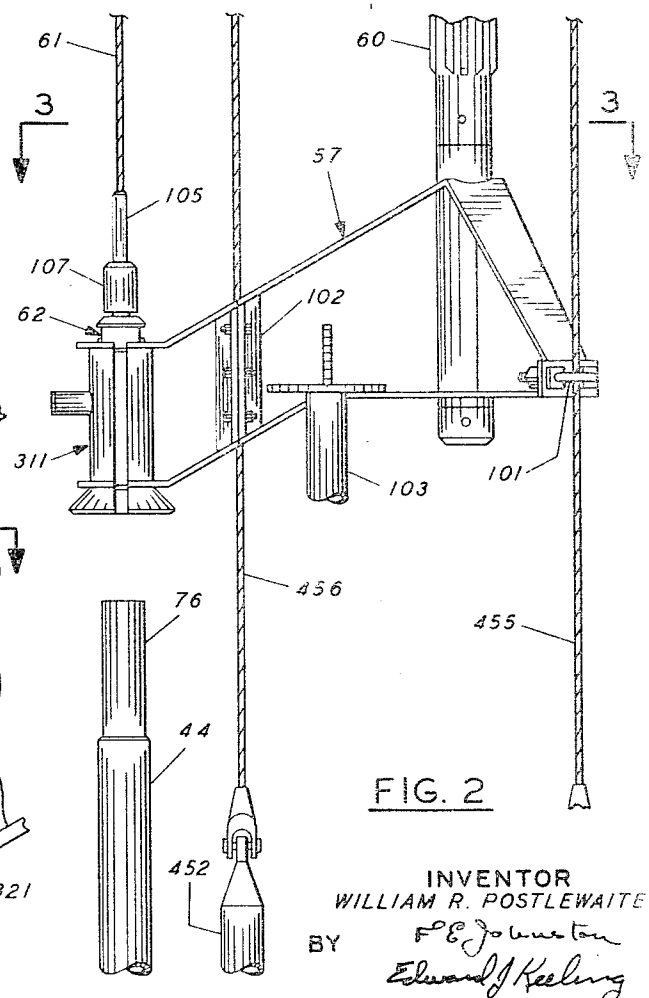


FIG. 2

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METHOD FOR ATTACHING AND DETACHING A WORKING BASE TO AN UNDERWATER WELL BASE

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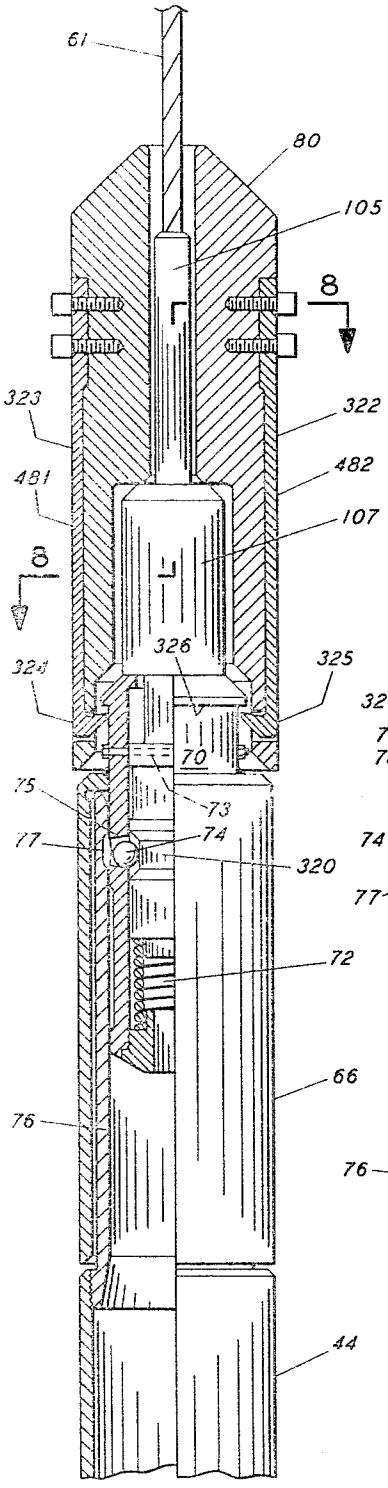


FIG. 7

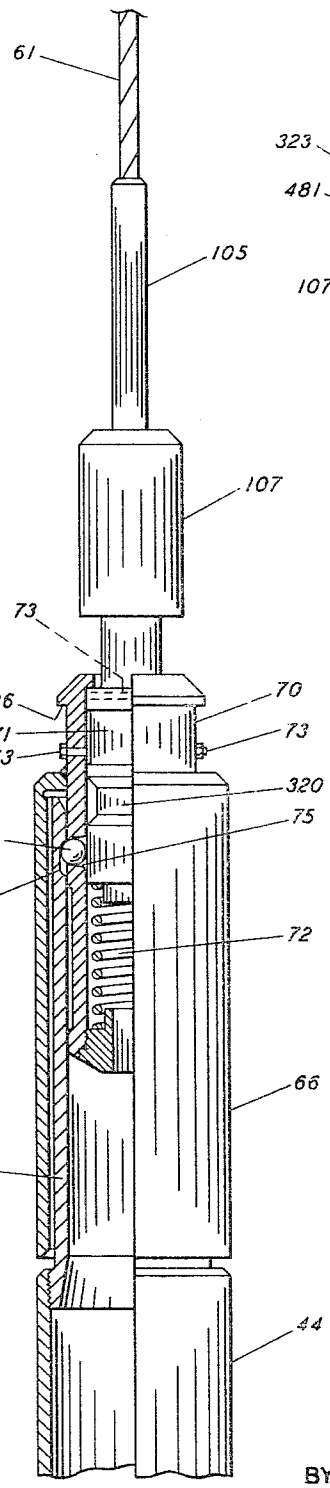


FIG. 6

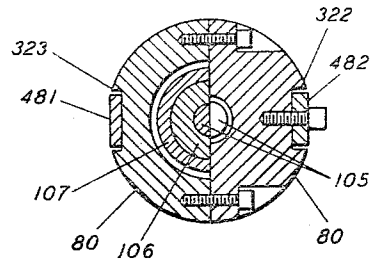


FIG. 8

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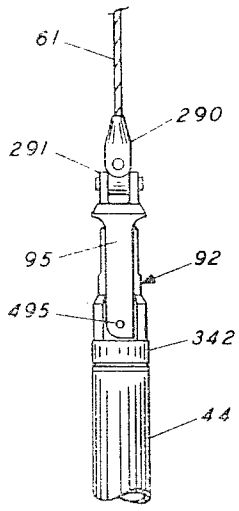


FIG. 12

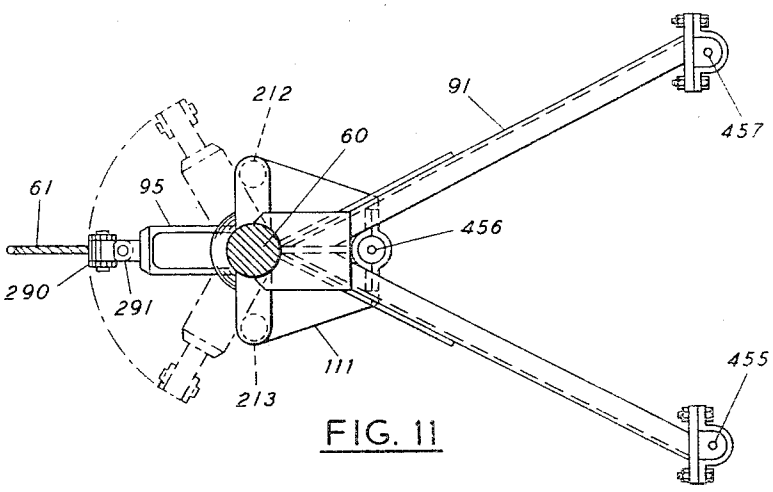


FIG. 11

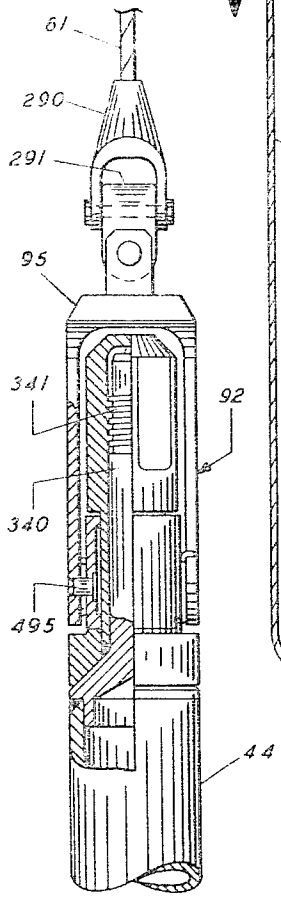


FIG. 13

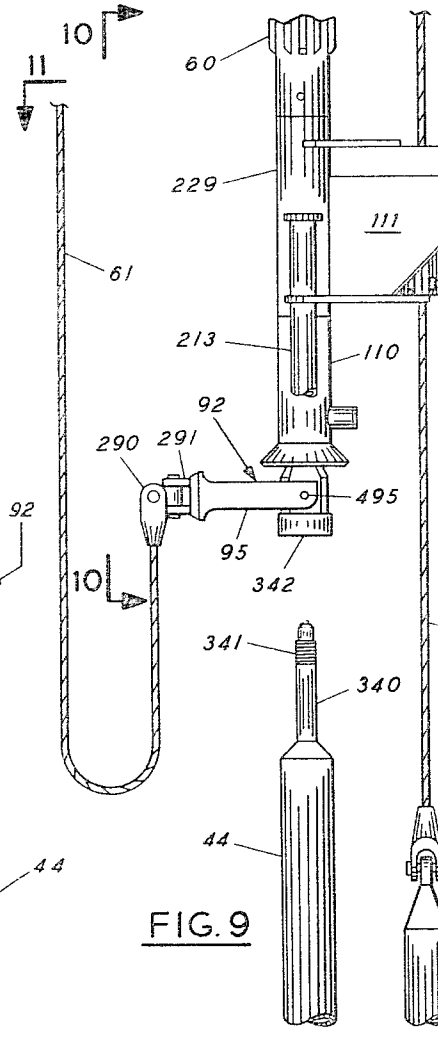


FIG. 9

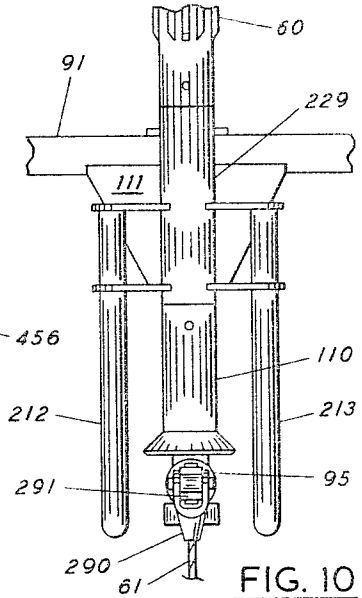


FIG. 10

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Feb. 7, 1967 W. R. POSTLEWAITE 3,302,709

METHOD FOR ATTACHING AND DETACHING A WORKING BASE TO AN UNDERWATER WELL BASE

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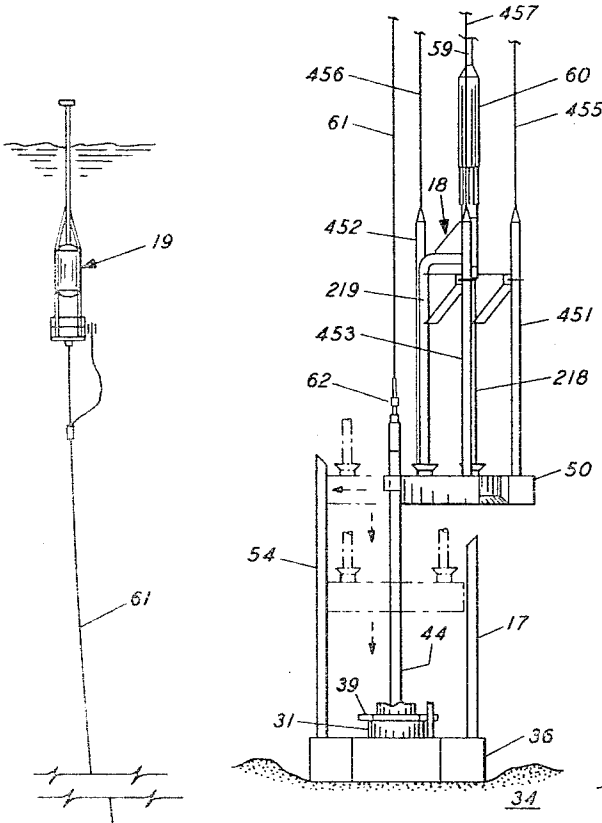


FIG. 15

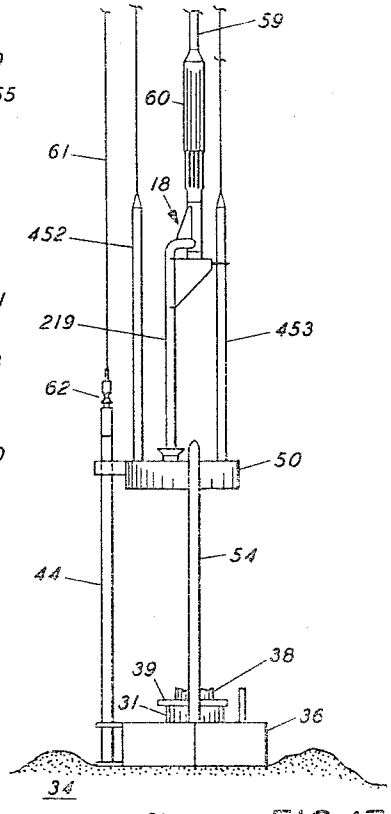


FIG. 17

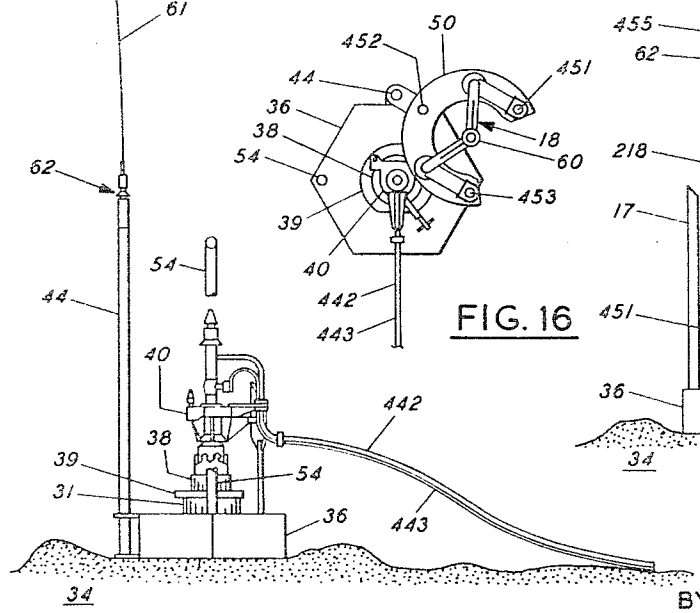


FIG. 14

FIG. 16

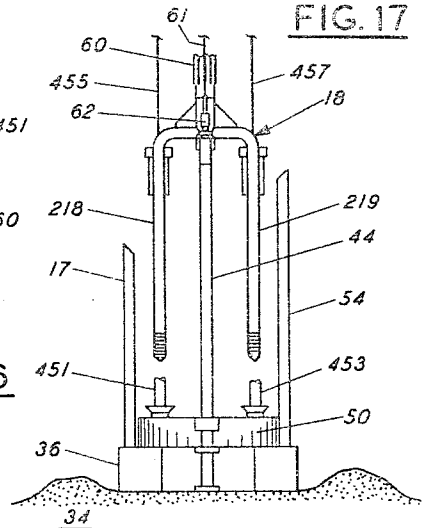


FIG. 18

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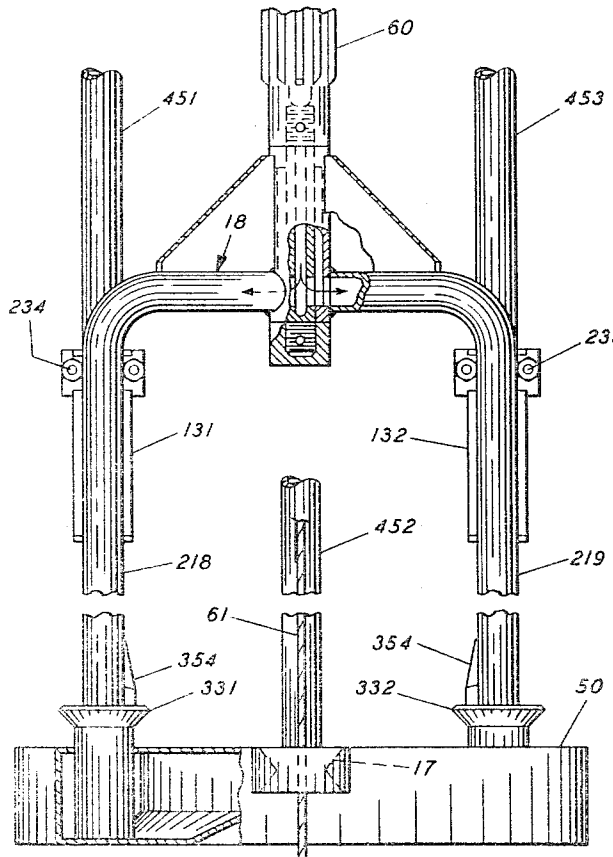


FIG. 21

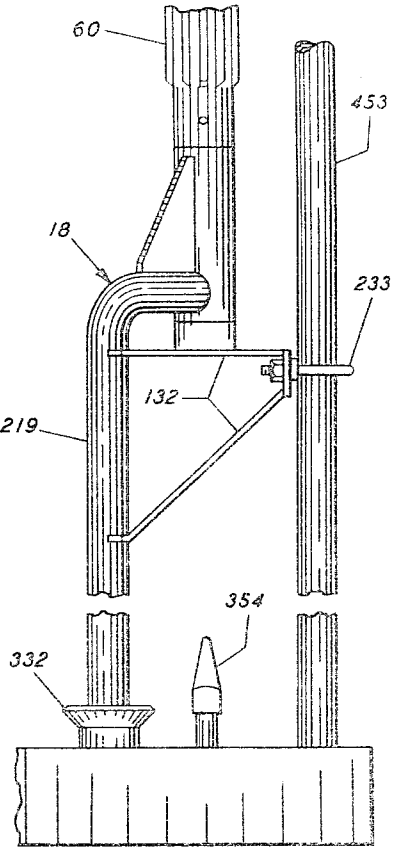


FIG. 22

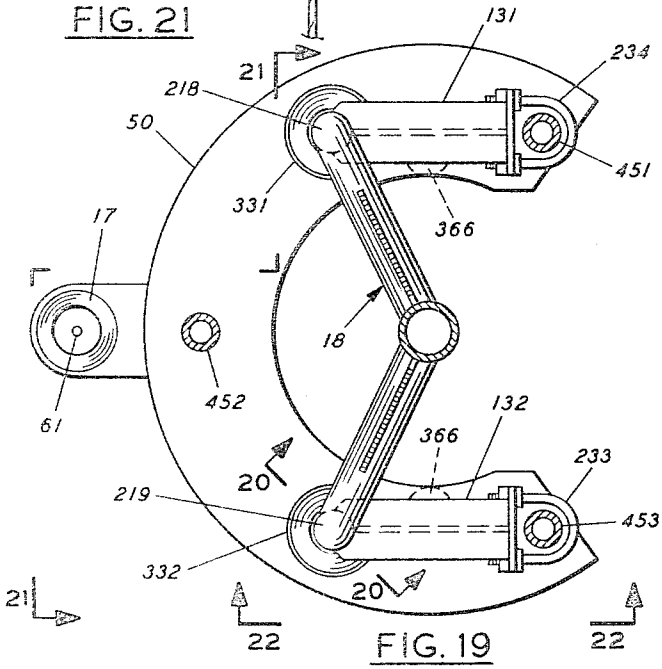


FIG. 19

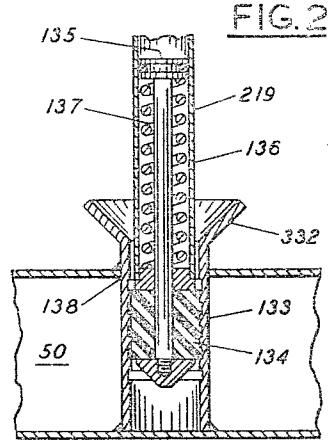


FIG. 20

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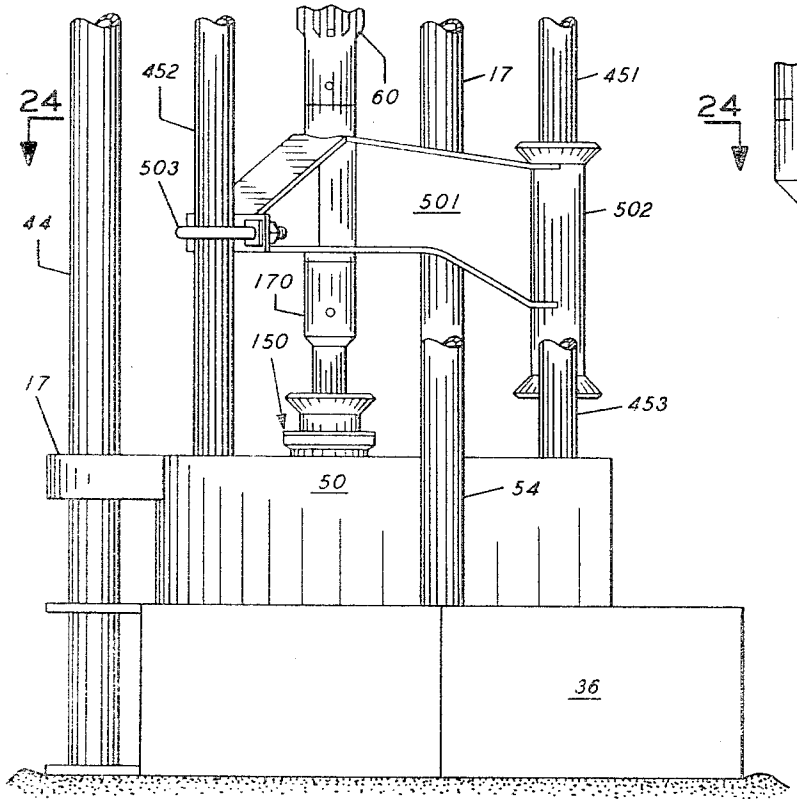


FIG. 23

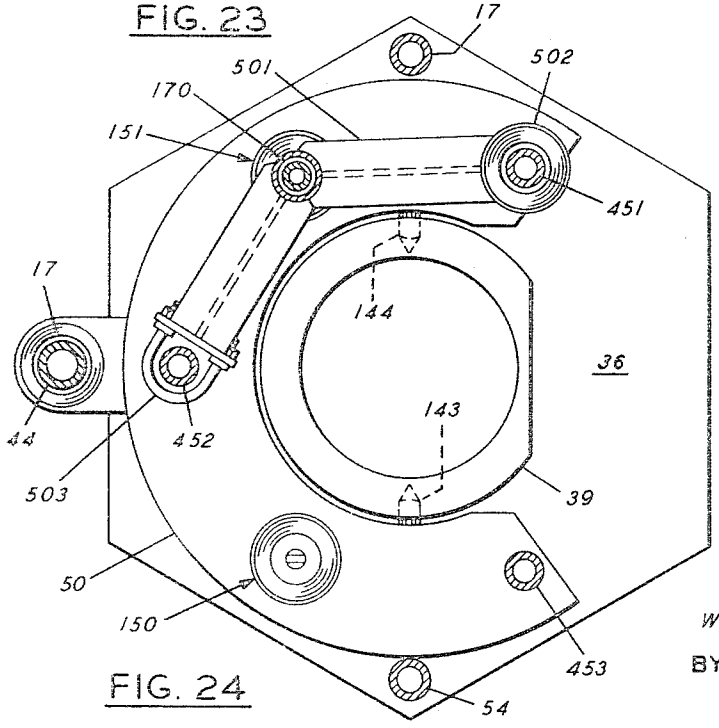


FIG. 24

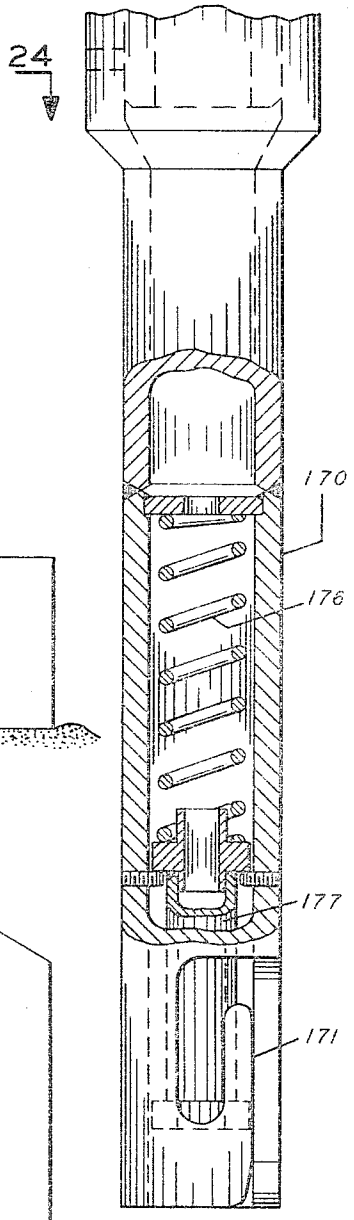


FIG. 28

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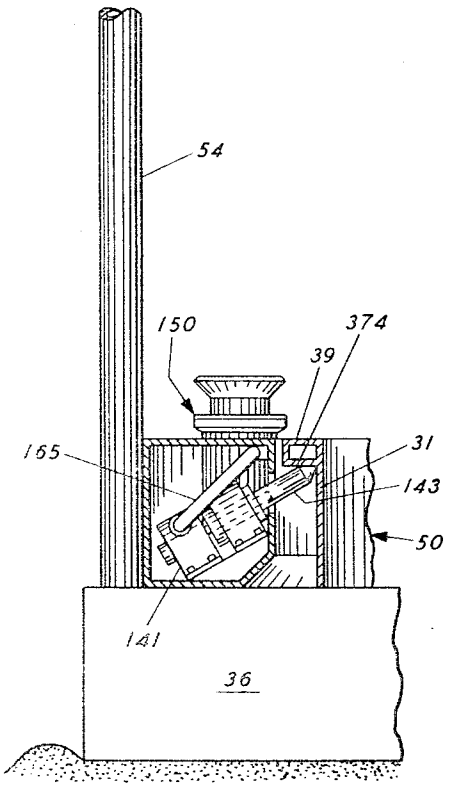


FIG. 26

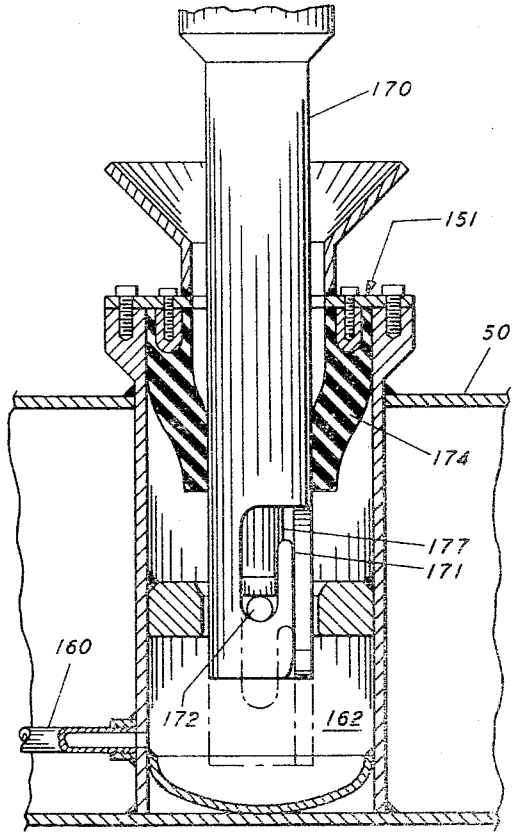


FIG. 27

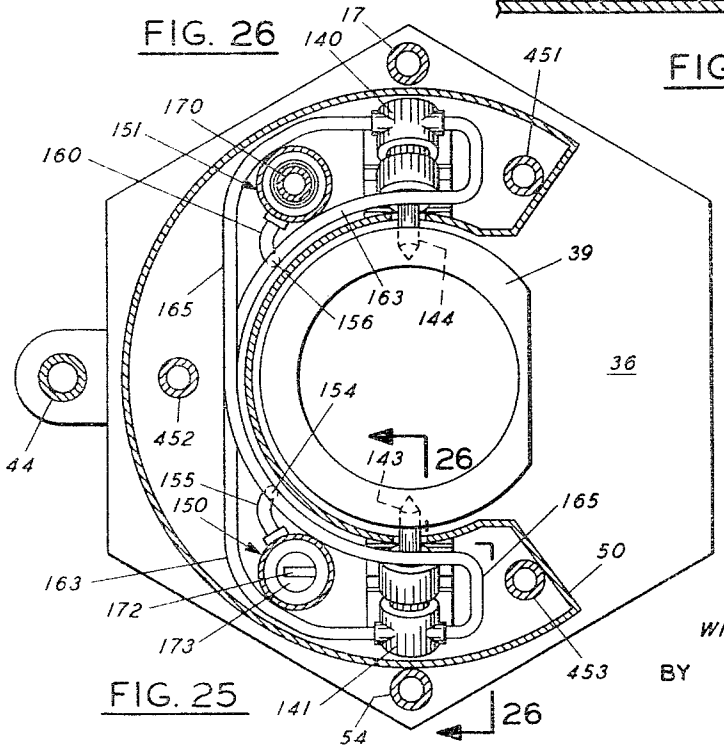


FIG. 25

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METHOD FOR ATTACHING AND DETACHING A WORKING BASE TO AN UNDERWATER WELL BASE

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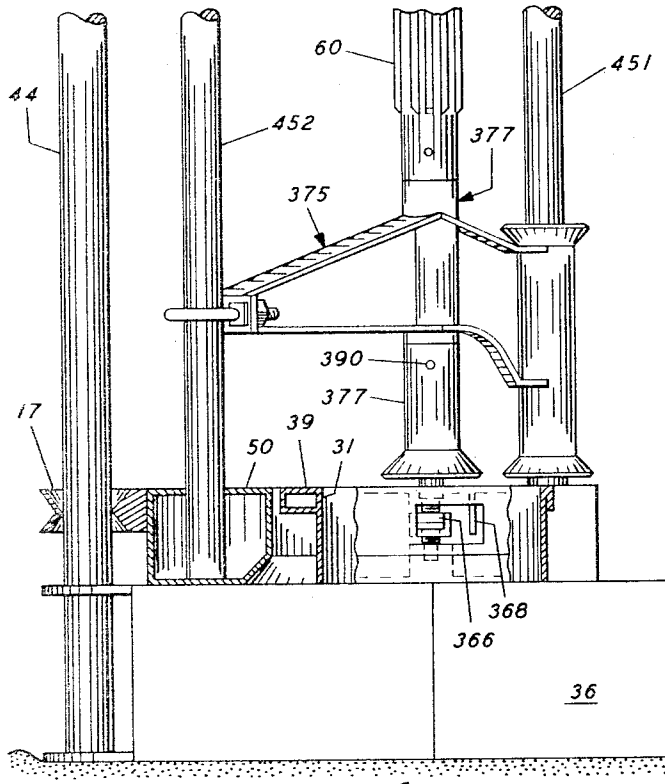


FIG. 30

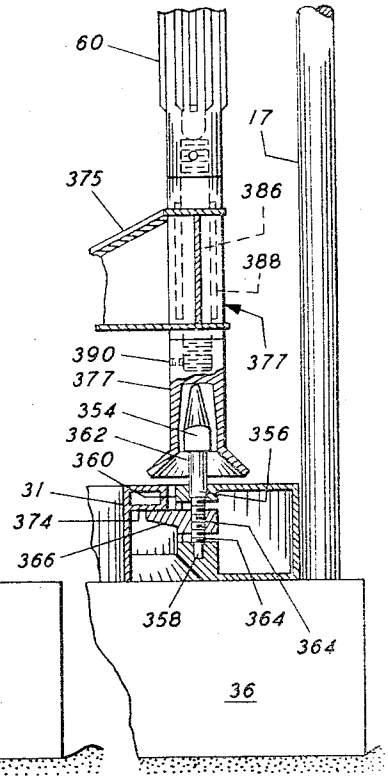


FIG. 31

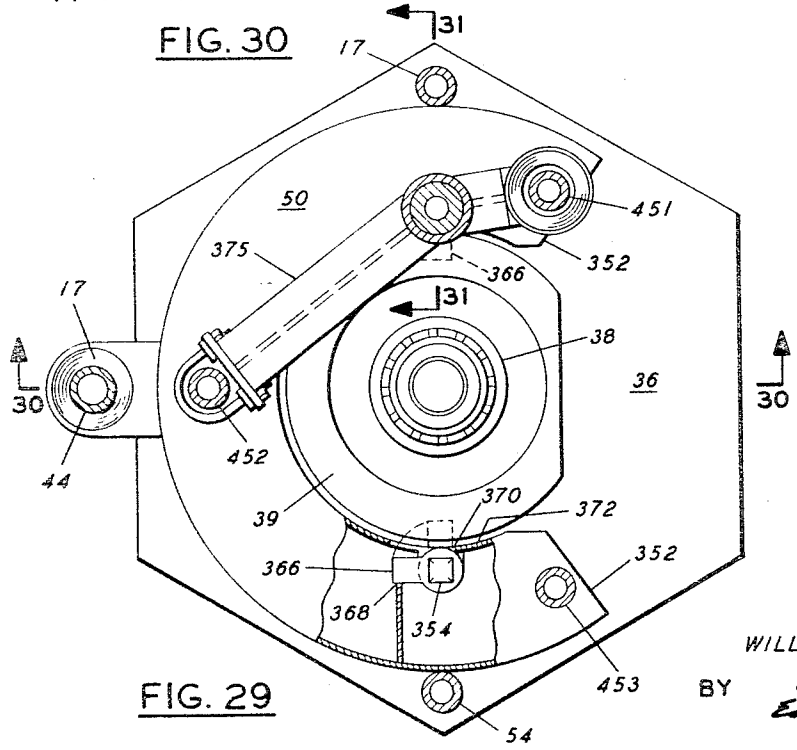


FIG. 29

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United States Patent Office 3,302,709 Patented Feb. 7, 1967

3,302,709

METHOD FOR ATTACHING AND DETACHING A WORKING BASE TO AN UNDERWATER WELL BASE

William R. Postlewaite, Menlo Park, Calif., assignor to Chevron Research Company, a corporation of Delaware

Original application Nov. 5, 1962, Ser. No. 235,215, now Patent No. 3,236,302, dated Feb. 22, 1966. Divided and this application June 3, 1965, Ser. No. 482,959

7 Claims. (Cl. 166—.6)

This application is a division of application Serial No. 235,215 filed November 5, 1962, now U.S. Patent No. 3,236,302.

This invention relates to methods for working on a submerged well by operations performed on a platform on the surface of the water, and more particularly it relates to methods for attaching and detaching without the use of divers a working base including a plurality of guide posts and the guide lines associated therewith to a permanent, submerged base of subsea well by remote control from an operational base located on the platform at the surface of the water.

The art of drilling in water has progressed to a stage where the depth of the water over an oil-bearing formation does not place a practical limitation on drilling into these formations. However, there are needs for methods and apparatus for drilling and well completion which will be certain without the use or aid of divers and which are not too costly to construct and install, and which will not present any undue difficulties or expense in the operation and maintenance of a well.

It is a broad aspect of the invention to provide methods for remotely connecting and disconnecting a plurality of spaced apart guide posts including the flexible guide lines associated therewith to and from a permanent base of a subsea well. The invention provides for establishing a flexible pilot line between a permanent base fixedly located under the water and the surface of the water. The flexible pilot line extends, for example, from a pilot post fixedly attached to a permanent base of a subsea wellhead. One end of the flexible pilot line is disconnectably coupled to the guide post of the permanent base of the subsea wellhead. The other end of the flexible pilot line is attached to a buoy or float and is thus held at the surface or near the surface of the water.

A floating platform or vessel having an operational base is positioned on the water's surface in approximate vertical relationship with the fixed permanent subsea base. The floating end of the pilot line is captured and operably connected with the operational base of the vessel. The flexible pilot line provides a flexible connecting element between the operational base and the subsea permanent base. A working base, said base including at least a pair of spaced apart guide posts and the flexible guide lines associated therewith said lines having one end operably attached to each of said posts and the other ends operably connected at said operational base on said vessel, is lowered into the water by a suitable means, such as a drill string and is guided toward the permanent base by means of the flexible pilot line. The guide lines are extended between the operational base of the vessel and the working base as it is lowered into the water.

The working base is guided by the pilot line to a position immediately above the pilot post attached to the permanent base of the subsea well. A portion of the working base is slidably and pivotally engaged on the pilot post. The working base is aligned to a predetermined alignment with the permanent base by suitable means such as torquing by the drill bit. The aligned

working base is then slidably lowered along the pilot post to contact the permanent base.

The working base is disconnectably connected to the subsea permanent base remotely from the surface without the use of divers. The guide posts which are fixedly held in spaced apart relationship by the working base and the guide lines connected between each of the guide posts and the operational base of the vessel are operably positioned in the water and provide a connection between the vessel on the surface and the subsea well site. The pilot line is disconnectably attached to the pilot post, and if desired, the pilot line may be removed after the working base is in place. When the operations at the subsea permanent base and the working base disconnectably connected thereto are completed the flexible pilot line is guided to the pilot post for connection thereto by means of the flexible guide lines extending between the operational base on the vessel to the working base attached to the permanent base. The pilot line is disconnectably connected to the pilot post.

When the pilot line is connected to the pilot post the working base, including the guide posts attached thereto, is disconnected from the permanent subsea base and removed from the permanent base. In this manner a minimum of equipment remains at the underwater well site during periods when it is not connected by guide lines and guide posts to a drilling vessel. However, when it again is desired to do work on the underwater well site, the methods and apparatus of this invention provide for establishing the working base on the well site and connecting the working base with the operational base of a vessel by means of guide lines and guide posts.

It is a particular object of this invention to provide methods for attaching and detaching a working base including the guide posts and flexible guide lines associated therewith to a permanent base at an underwater well site, said attaching and detaching being accomplished from a surface location without the use of divers.

Further objects and advantages of the present invention will become apparent from the following detailed description read in light of the accompanying drawings which are a part of this specification and in which:

FIG. 1 illustrates, in side elevation with parts broken away for clarity of presentation, apparatus assembled in accordance with this invention;

FIG. 2 illustrates, in side elevation, an enlarged view of a portion of the apparatus illustrated in FIG. 1 and better shows one form of apparatus for disconnectably connecting the pilot line to the pilot post;

FIG. 3 is section 3—3 of FIG. 2;

FIG. 4 is a side elevation partially in section illustrating a coupling member for disconnectably connecting the pilot line to the pilot post;

FIG. 5 is section 5—5 of FIG. 4;

FIG. 6 is an elevation view partially in section illustrating the coupling member of FIG. 4 disconnectably connecting the pilot line and the pilot post;

FIG. 7 is an elevation view partially in section illustrating a means for disconnecting the coupling member from the pilot post;

FIG. 8 is section 8—8 of FIG. 7;

FIG. 9 is an elevation view illustrating an alternate coupling member and apparatus associated therewith for disconnectably connecting the pilot line to the pilot post;

FIG. 10 is a side view taken at section 10—10 of FIG. 9;

FIG. 11 is a sectional view taken at section 11—11 of FIG. 9;

FIG. 12 is a partial elevation view illustrating the pivotal connection of the alternate coupling member con-

necting the pilot line to the alternate coupling member and the pilot line;

FIG. 13 is an elevation view partially in section illustrating the alternate coupling member disconnectably connecting the pilot line and the pilot post;

FIG. 14 is a side elevation illustrating apparatus assembled in accordance with this invention and including a pilot line extending from a pilot post on subsea well to the surface of the water;

FIG. 15 is an elevation view illustrating the working base pivotally and slidably connected to the pilot post;

FIG. 16 is a top view of the apparatus appearing in FIG. 15;

FIG. 17 is a side elevation view of the working base after it has been aligned for seating on the permanent base;

FIG. 18 is an elevation view of the working base positioned on the permanent base of the subsea well site;

FIG. 19 is a top view illustrating a working base operably engaged by a fork member on a drill string;

FIG. 20 is section **20**—**20** of FIG. 19;

FIG. 21 is section **21**—**21** of FIG. 19;

FIG. 22 is section **22**—**22** of FIG. 19;

FIG. 23 is an elevation view illustrating a working base operably positioned in contact with a permanent base;

FIG. 24 is section **24**—**24** of FIG. 23;

FIG. 25 is a view similar to FIG. 24 with parts broken away for clarity of presentation and illustrating a means for disconnectably connecting the working base to the permanent base;

FIG. 26 is section **26**—**26** of FIG. 25;

FIG. 27 is an elevation view with parts broken away for clarity, illustrating a means for connecting the drill string into the working base to provide a hydraulic conduit from the surface to the working base;

FIG. 28 is an elevation view partially in section of the nozzle end of the drill string;

FIG. 29 is a plan view with parts broken away for clarity of presentation illustrating an alternative means for disconnectably connecting the working base to the permanent base;

FIG. 30 is section **30**—**30** of FIG. 29;

FIG. 31 is section **31**—**31** of FIG. 29.

Referring to the drawings and particularly to FIG. 1, there is illustrated an offshore drilling vessel, generally designated by the numeral **30**, which has been anchored by lines **432** and **433** over a body of water **33** in approximate vertical relationship over the site where a well has been drilled in the underwater bottom **34**. The drilling vessel **30** has an operational base which is generally indicated by numeral **300**.

The operational base **300** of the vessel **30** is suitably maintained to run drill pipe and handle cables and to perform the other functions that are well known in the underwater drilling art. A permanent base **36** is located at a subsea well site and forms part of the fixed well site control apparatus. The permanent base has been secured to the well casing (not shown) which is cemented in the well bore. The upper end of the casing terminates in a fitting **38** which projects above the permanent base **36** and to which the wellhead control apparatus **40** is secured. Production lines **442** and control lines **443** are coupled to the well control apparatus **40** and extend to any suitable location. It has been assumed for ease in describing the present invention that the well has been drilled and completed to a stage where it has the wellhead control apparatus in place and is ready to or has been produced. The invention, however, is not limited to use in a well completed to this stage. For the purpose of this invention it is only necessary that a permanent base is fixedly positioned at a subsea location.

A pilot post **44** is fixedly connected to permanent base **36** by suitable means. A working base **50**, including at least a pair of guide posts **452** and **453** fixedly mounted thereon, is disconnectably connected to the permanent base **36**. The guide posts **452** and **453** and the flexible guide lines **455** and **456** associated therewith extend between the working base **50** at the subsea well site and the operational base **300** of the drilling vessel **30**. Means for taking up and letting out the flexible guide lines are provided on the operational base **300**. A secondary pilot post element **54** is connected to permanent base **36** to aid in aligning the working base **50** when it is moved into position over permanent base **36**.

Again referring to FIG. 1, the flexible guide lines **455** and **456** are fixedly connected to the guide posts **452** and **453** which in turn are fixedly connected to working base **50**. A guide line, for example guide line **456**, which is connected to a guide post, for example guide post **453** extends between the guide post and the drilling vessel **30**. Any suitable operable connection for the guide lines is provided on the operational base **300** of vessel **30**. It is noted that the present invention is not limited to any particular number of guide posts and associated guide lines. Any number of guide posts and guide lines deemed operationally desirable may be used in accordance with this invention. A guide arm member **57** is slidably engaged on the guide lines **455** and **456**.

The guide arm member **57** is connected to a drill string **59** by a suitable connecting member such as a bumper sub **60**. The drill string **59** serves to move the guide arm member **57** slidably along the guide lines **455** and **456** between the drilling vessel **30** and the working base **50**. The guide arm member **57** releasably holds pilot line **61** and coupling member **62** by means of friction sleeve **311**. The guide arm member **57** acting in co-operation with the guide lines **455** and **456** guides the coupling member **62** to pilot post **44**. The guide arm member **57** also carries television camera **63** and suitable lighting equipment for underwater observation. A cable **310** provides for electrical contact between the television camera **63** and associated equipment and the operational base **300** of the floating vessel **30**.

The position of the apparatus as illustrated in FIG. 1 might occur after the completion of some work at the well site, for example opening or closing a valve on wellhead control apparatus **40**. After this operation has been completed and it is desired to disconnect the working base **50** from the well the pilot line **61** is guided to the pilot post **44** where it is disconnectably connected to the pilot post by coupling member **62**. After the flexible pilot line **61** is connected to the pilot post **44** the working base **50** is disconnected from the permanent base **36** and the working base **50**, including the guide posts **452** and **453** and the flexible guide lines **455** and **456** connected thereto, is removed from the permanent base **36** and, if desired, taken from the water to vessel **30**. The flexible pilot line **61** is then the only connection between permanent base **36** and the operational base **300** of vessel **30**. The flexible pilot line **61** is connected to a float or buoy and released from the vessel **30** to mark the location of the underwater well and to provide a flexible connecting element extending therefrom.

In FIG. 2, an enlarged view of a portion of the apparatus illustrated in FIG. 1, is shown. Guide arm member **57** is slidably mounted on flexible guide lines **455**, **456** and **457** by suitable means such as U-bolts **100** and **101** and sleeve **102**. A bracket **103** for the television camera and lights is also connected to the guide arm member **57**. A cable **310** provides contact between the surface and the television camera and lights. The guide arm member **57** releasably secures coupling **62** and the attached flexible pilot element **61** by means of friction sleeve **311**. Friction sleeve **311** is prepositioned on the guide arm member **57** to cause the coupling member **62** to contact the pilot post **44** as the guide arm member **57** is lowered along the guide lines **455**, **456** and **457**. The operation and use of guide

arms and guide lines are well known to those skilled in the art and need not be exhaustibly described herein. FIG. 3 which is section 3—3 of FIG. 2 clearly shows the interaction between the guide arm member **57**, guide lines **455**, **456** and **457** and the bumper sub **60** which serves to connect the drill string and the guide arm member.

In FIGS. 4, 5, 6, 7, and 8 an embodiment of apparatus for disconnectably connecting the pilot line **61** to the pilot post **44** is illustrated. FIG. 4 is a side elevation partially in section of a coupling member which is generally indicated by numeral **62** held in friction sleeve **311**. Coupling member **62** is one means of disconnectably connecting the pilot line **61** to the pilot post **44**. The pilot line, which may be, for example wire cable, is rotatively connected to coupling member **62**. For example the pilot line **61** is fixedly secured in fitting **105**. A ball **106** is connected to the other end of fitting **105**. A ball and socket joint is provided for ball **106** by a socket formed by cooperation between female member **107** and male member **108**. Male member **108** is fixedly attached to the piston member **71** of the coupling member **62**.

The guide arm member **57** holds coupling member **62** in a releasable manner. For example, a friction sleeve indicated generally as **311** is fixedly attached to guide arm member **57** and is positioned slidably over the tubular member **66** of coupling **62**. The cylindrical body **65** of friction sleeve **311** has a shoulder **470** which engages the upper portion of the tubular member **66** to prevent the tubular member **66** from sliding through the friction sleeve **311** as it is lowered into the water. A spring loaded piston **68** forces tubular member **66** against the interior of the cylindrical body **65** of the friction sleeve **311** to give a frictional contact between the members to maintain them in a normally contacting position. The friction sleeve **311** may, however, be slidably removed from coupling member **62** in an upwardly direction.

To further describe the cooperation between coupling member **62** and pilot post **44** to disconnectably connect the pilot line **61** and the pilot post **44**, particular reference is now made to FIG. 4 and FIG. 6. The operating chamber **70** of coupling member **62** is fixedly mounted on tubular body member **66** and a portion of the operating chamber **70** extends interiorly of the tubular body member **66**. The outside dimension of the operating chamber **70** is sufficiently less than the inside dimension of tubular body member **66** so as to provide an annular space between the two as indicated by numeral **471**. The annular space or annulus is adapted to receive the end **76** of the pilot post **44**. A piston member **71** is slidably positioned in the operating chamber **70** for limited reciprocating motion therein. A spring **72** is positioned in compression below the piston member **71** to urge it in an upward direction. Initially, the piston member **71** is forced down on the spring **72** and is releasably held in this position by shear pin **73** which extends through the piston member **71** and is secured to the operating chamber **70**. The piston member **71** is provided with an annular groove **320**. The groove **320** is provided with cammed walls and is deep enough to accommodate a number of spaced apart balls **74** in a recessed position in the ports **75** in the walls of the operating chamber **70** as shown in FIG. 4.

The coupling member **62** is positioned on the end **76** of the pilot post **44** by guide arm member **57** slidably moving on guide lines **455**, **456** and **457** and by the use of the television camera **63** if necessary. The flared end **321** of friction sleeve **311** aids in engaging the end **76** of the pilot post **44**. The end **76** of the pilot post **44** is slidably received into the annular chamber between the tubular body member **66** and the operating chamber **70** of coupling member **62**. When the coupling member **62** is thus seated on the pilot post **44** shear pin **73** is broken by suitable means such as by simultaneously pulling up on pilot line **61** and holding down on guide arm member **57**. The now freed piston member **71** moves upwardly and forces the balls **74** to extend out of ports **75**.

With reference to FIG. 6 the end **76** of the pilot post **44** is provided with an annular interior groove **77** for receiving the extended balls **74**. As the piston member **71** moves up in the operating chamber **70** the cammed walls of piston member **71** forces the balls **74** to extend out beyond the operating chamber through ports **75**. Ports **75** are formed to allow a portion of the balls to extend through the ports **75** but not to allow the balls **74** to escape out of the operating chamber **70**. The balls **74** are forced out and are received in the groove **77** formed in the interior of the end **76** of the pilot post **44** to thus provide a connection between coupling member **62** and pilot post **44**. The friction sleeve **311** fixedly connected to guide arm member **57** is then slidably removed over coupling member **62** by pulling up guide arm member **57** along the guide lines **455**, **456** and **457**.

With reference now to FIG. 7 one means for disconnecting coupling member **62** from pilot post **44** is illustrated. A striking bar **80** having a hollow interior adapted to slide along pilot line **61** and to strike the coupling member **62** in the position illustrated in FIG. 7 is dropped from the surface. FIG. 7 illustrates the interaction between the striking bar **80** and the coupling member **62** just as the impact between the two has occurred. Striking bar **80** is provided with a plurality of springable latch members, for example latch members **481** and **482** which normally are located in grooves **322** and **323** on the exterior surface of striking bar **80**. The latch members **481** and **482** have fingers **324** and **325** for engaging a flange **326** on the operating chamber **70**. When the striking bar strikes coupling member **62** the impact causes the piston member **71** of coupling member **62** to move forceably in a downwardly direction and to compress spring **72**. The groove **320** in piston member **71** comes alongside balls **74** and the balls **74** retreat into the groove **320**. The fingers **324** and **325** of latch members **481** and **482** engage the flange **326** on the operating chamber **70** and the piston member **71** is captured in the down position. Since the balls **74** are recessed in groove **320** the coupling member **62** is disconnected and can be removed from the pilot post **44**.

In FIGS. 9, 10, 11, 12 and 13 an alternative embodiment of apparatus for disconnectably connecting the pilot line **61** to the pilot post **44** is illustrated. In this embodiment a drill string acting through bumper sub **60** and guide arm member **91** is used to supply rotational motion to couple and uncouple the coupling member from the pilot post. With particular reference to FIG. 9 the pilot post **44** is provided with an end **340** having male threads **341**. A disconnectable coupling member represented generally by the numeral **92** is positioned over the end **340** of the pilot post **44** by means of a guide arm member **91** traveling on the guide lines. The guide arm member **91** may also carry a television set and lights (not shown) to allow visual inspection of the positioning of coupling member **92** on pilot post **44**. The coupling member **92** has a cap member **342** containing mating threads for the male threaded end **340** of the pilot post **44**. The coupling member **92** is disconnectably connected on the bumper sub **60** of the drill string by a friction sleeve **110** arranged as described heretofore. A prong member **95** is pivotally connected by pins **495** to the cap member **342**. The pilot line **61** is connected by suitable means to the free end of the prong member **95**. For example, connecting means **290** and **291** form a suitable connection for pilot line **61** to prong member **95**. When the pilot line **61** is connected to the coupling member **92** in the above manner the pilot line **61** can move eccentrically with the drill string **93** into the water. A bracket **111** fixedly mounted on the guide arm member **91** holds a pair of poles **212** and **213** in position to engage prong member **95** and to thus prevent the frictionally held coupling member **92** from rotating with the drill string while cap member **342** is screwed onto the threaded end **340** of the pilot post **44**. FIG. 11 illustrates in phantom

the interaction between the prong member **95** and the poles **212** and **213**.

To connect the pilot post **44** and the pilot line **61** the coupling member **92** is positioned on the end **340** of the pilot post **44**. The drill string is rotated and the rotational motion is transmitted by the bumper sub **60** and through the guide arm member **91** by a rotatable drive link carried interiorly of sleeve **229** to friction sleeve **110** to cause the threaded portions of the coupling member **92** and the pilot post **44** to mate. After the connection is made the drill string and bumper sub **60** and guide arm member **91** are pulled free. The pilot line **61** may be pulled to move prong member **95** to an upright position as is illustrated in FIG. 12. FIG. 13 is a view partially in section clearly showing the interaction between the coupling member **92** and the threaded end **340** of the pilot post **44** when the two are connected together. The pilot line is disconnected from the pilot post **44** by making use of the drill string to unscrew coupling member **92** from pilot post **44**. The use of the drill string as an underwater tool to perform operations such as described above is fully disclosed in my copending application Serial Number 235,433 now U.S. Patent No. 3,225,826.

In FIG. 14 an underwater well site is shown and is indicated generally by the numeral **201**. A permanent base **36** is included on the well site. The permanent base **36** has a collar **31** fixedly connected thereto. The collar **31** has a flange **39**. Well control apparatus indicated generally by the number **40** is operably positioned on permanent base **36**. Control and production lines **442** and **443** are operably connected to well control apparatus **40**. Pilot post **44** is fixedly attached to base **36**. A supplementary pilot post **54** is also attached to base **36**. A flexible pilot line **61** is disconnectably connected to the pilot post **44** by a coupling member **62**. A float member **19** is connected to the other end of pilot line **61** to maintain the pilot line **61** in a position where it is easily accessible from the operational base of a floating vessel.

A particular feature of this invention includes the ability to remove the guide posts and the guide lines associated therewith from a well and to leave the well with only a single pilot line communicating with the surface. Thus, the well may be put on production or from some other reason temporarily removed from actual contact with the drilling vessel without leaving a large amount of equipment including guide posts and guide lines attached to the well. Yet the guide posts and guide lines may be reattached easily at some later time. It is in accordance with the present invention to provide the underwater well site with a permanent base and to establish a flexible pilot line extending between a pilot post on said base and a floating buoy on the water's surface. When it is desired to establish guide lines and guide posts communicating between a surface vessel and the well site a vessel is floated over the site and the pilot line is captured from the water and operably secured on the operational base of the vessel. A working base including at least a pair of fixedly spaced apart guide posts thereon and the guide lines attached to said posts is guided along the pilot line to the subsea permanent base. The working base is then aligned to a predetermined alignment and seated on the permanent base and disconnectably connected thereto. The pilot line may then be removed from the water for examination, etc. Replacement of the pilot line is accomplished prior to removing the working base and guide lines. By the interplay between the pilot line on one hand and the working base and guide posts and guide lines on the other it is possible to leave the well with only a minimum of equipment on it but to return and easily provide the equipment for operating the well.

In accordance with the invention a well site including a permanent base **36** and a pilot post **44** having a pilot line **61** attached thereto and floated by appropriate means **19** at a surface or near surface location can be left unattended. When for some reason it is desired to do some work on the well, for example, to adjust the production valves, a vessel having an operations base picks up the pilot line from the water and orients itself in approximate vertical relationship to the underwater well site. A working base including at least a pair of guide lines attached thereto is lowered into the water and guided along the pilot line to a position immediately above permanent base **36** and in slidable and pivotal contact wth the pilot post **44**. The working base **50** is aligned with the permanent base **36** and seated thereupon. The working base **50** is disconnectably connected to the permanent base **36**. The pilot line **61** may be then removed for inspection or to clear the area around the well so as not to interfere with workover operations. When operations are completed the pilot line **61** is replaced and the working base **50** removed to thus leave a minimum amount of equipment at the underwater well site.

With respect now to FIGS. 15, 16, and 17 a method and means for aligning a working base **50** to a predetermined alignment and for seating the working base **50** on a permanent base **36** is illustrated. FIG. 15 is a side elevation and FIG. 16 is a plan view of how a working base **50** might, for example, initially contact pilot post **44**. The working base is slidably connected to the pilot line **61** and is guided from the operational base of the floating vessel to the underwater well site by the pilot line **61**. When the base **50** reaches the level of the pilot post **44** it slides onto the pilot post **44** and slidably and pivotally engages the pilot post. The working base **50** is preferably disconnectably attached to a drill string **59** by suitable means such as a bumper sub **60** and a fork member **18** attached thereto and lowered into the water on the drill string so that the weight of the working base **50** is carried on the drill string and not by the guide lines **455**, **456**, and **457**. The drill string is also useful to align the working base to predetermined alignment. The bumper sub **60** serves to connect the end of the drill string to the fork member. As is well known in the art a bumper sub is a connecting means useful in damping motion along a drill string.

A fork member **18** is fixedly connected to the drill string **59** by the bumper sub **60** to rotate with the drill string. The fork member **18** comprises at least a pair of prongs **218** and **219** for disconnectably connecting the working base **50** to the drill string as will be more fully described herein. The working base **50** must be aligned to clear any protruding wellhead apparatus such as, for example, the production and control lines **442** and **443**. The working base is, therefore, constructed generally in the shape of a horseshoe. The collar of the working base **50** is adapted to pass over the flange **39** of the collar **31** which is fixedly connected to the working base. The working base **50** is constructed so as to fit loosely around collar **31** and over flange **39**.

Once the working base reaches the position as shown in FIG. 15 where it is slidably and pivotally engaged on pilot post **44** the drill string **59** is torqued to pivot the working base to a predetermined position as illustrated in phantom in FIG. 15. In this position the working base **50** is aligned over the permanent base **36**. Supplementary pilot posts **54** and **17** may be made available on permanent base **36** to assist in aligning the working base **50**. After the working base **50** has been aligned to the predetermined position as illustrated in FIG. 17 the working base **50** is lowered and seated on the permanent base **36**. The working base **50** is then disconnectably connected to the permanent base **36** as will be more fully described herein, and the fork member **18** is caused to release the working base **50**. The drill string **59** and the fork member **18** connected thereto may be removed from the working base **50** and taken out of the water as is illustrated in FIG. 18.

With particular reference to FIGS. 19, 20, 21 and 22 means for guiding the working base to the subsea well site and for positioning the working base on the permanent base will be more fully described. The working

base 50 is provided with a means 17 for slidably and pivotally engaging the pilot line and the pilot post. The pilot line engaging means 17 is preferably a sleeve with a bushing which will loosely receive the pilot post 44.

A fork member generally designated by the number 18 is fixedly connected to the drill string by a suitable means such as bumper sub 60 and disconnectably connected to working base 50. It is preferred to use fork member 18 and the drill string to position the working base underwater because the weight of the working base is more easily borne by the drill string than it would be by the guide lines. The fork member includes at least a pair of spaced apart prong members 218 and 219 for releasably connecting the working base 50 to the drill string. The prong members 218 and 219 are hollow and are operably connected to a hydraulic system as shown in phantom in FIG. 21. The prong members 218 and 219 each carry a brace 131 and 132. The braces are fixedly mounted to the respective prong member. Each brace is provided with a means such as U-bolts 233 and 234 for slidably connecting the braces with the guide posts 451 and 453. The braces aid in releasably securing the working base 50 to the drill string.

FIG. 20 illustrates one means for disconnectably connecting the prong members 218 and 219 of the fork member 18 to the working base 50. Working base 50 is provided with wells 138 for receiving each of the prong members 218 and 219. The wells are provided with a receiving member 133 for receiving a deformable packer 134 fixedly attached to each of the prong members 218 and 219. Flared fittings 331 and 332 aid in guiding the prong members into the wells 138. The deformable packer 134 is located near the end of each of the prong members. A piston 135 having a piston rod 136 normally extended by spring 137 normally allows packer 134 to remain in a contracted position. However, when the piston 135 is forced in a downwardly direction the piston rod 136 deforms the packer 134 and forces it out against the walls of receiving member 133. One means of forcing the piston down includes the use of a hydraulic fluid under pressure forced down the drill string and through the bumper sub from the surface and directed through the passageways provided in the fork member 18 to the piston 135. The expanded packer 134 provides a suitable disconnectable connection between the fork member 18 and the working base 50.

When the working base 50 is in the desired position at sea bottom the pressure on the hydraulic system is released and the spring 137 forces the piston 135 and piston rod 136 up and the packer 134 is contracted. The prong members 218 and 219 are then removable from the receiving member 133. The working base 50 is now positioned in contact with the permanent base 36 using the methods described heretofore, and the fork member 18 is removed from the working base 50. All that remains to put the working base 50 in readiness for operation is to disconnectably connect the working base 50 to the permanent base 36.

Referring now to FIGS. 23, 24, 25, 26, 27, and 28 an embodiment of apparatus for disconnectably connecting the working base 50, including the guide posts 451, 452 and 453 and guide lines associated therewith, to the permanent base 36 of a subsea well is illustrated. FIG. 23 is a side elevation and FIG. 24 is a plan view of the working base 50 seated in position on permanent base 36. The working base 50 has been lowered into the water and guided to its present position by the methods heretofore described. In accordance with this embodiment of the invention, the drill string is utilized to conduct a hydraulic fluid under pressure to a hydraulic system located in the working base 50. The drill string is operably connected to the hydraulic system in working base 50 through bumper sub 60 and nozzle 170. The nozzle 170 is operably positioned in port 151 of working base 50 by means of an appropriately formed guide arm member 501. For example, the guide arm member 501 secures the nozzle in a predetermined position with respect to the guide posts 451 and 452 and is then lowered with the nozzle 170 and the drill string and guided along the guide lines. The guide arm member slidably engages the guide posts 451 and 452 by appropriate means such as U-bolt 503 and sleeve 502. The guide arm member 501 is then lowered along the guide posts, and the nozzle 170 penetrates into port 151.

The working base 50 is provided with hydraulic conduits and hydraulic motors to disconnectably connect the working base 50 to the permanent base 36. The hydraulic conduits of the working base 50 are operably connected with a source of hydraulic fluid. For example, the drill string is a means of supplying a hydraulic fluid to the working base. Clearly illustrated in FIGS. 26 and 27, where portions of the exterior of the working base 50 have been cut away to more clearly show the working of the hydraulic system, are a pair of fixedly mounted hydraulic motors 140 and 141. The motors 140 and 141 extend and retract latch members 143 and 144 under the edge 374 of the flange 39 on permanent base 36. The latch members 143 and 144, when expanded disconnectably connect the working base 50 securely on the permanent base 36.

The latch members 143 and 144 are extended by moving the hydraulic fluid into the hydraulic system in working base 50 through port 151. The latch members 143 and 144 are retracted by forcing the hydraulic fluid into the hydraulic system in working base 50 through port 150. For example, when it is desired to extend the latch members 143 and 144 to disconnectably connect the working base 50 to the permanent base 36 a hydraulic fluid is directed into the hydraulic system through port 151 into chamber 162 formed in working base 50. The fluid is caused to flow into a conduit 160 leading out of the chamber 162. Conduit 160 opens into conduit 163 at junction 156 and fluid is caused to flow in both directions in conduit 163 and into the hydraulic motors 141 and 140 to operate the motors and extend latch members 143 and 144. The hydraulic fluid is exhausted from the hydraulic motors 140 and 141 into conduit 165. Conduit 165 opens into conduit 155 at junction 154 which is vented through port 150. When it is desired to retract the latch members 143 and 144 the hydraulic fluid is caused to enter the hydraulic system through port 150 and to thus flow into the opposite direction through the system causing the motors to retract the latch members.

The hydraulic fluid is supplied to the hydraulic system in working base 50 by any suitable means. One suitable means includes connecting the drill string to the working base through port 151 or port 150 to serve a conduit for hydraulic fluid from the surface. A suitable means for connecting the drill string to serve as a conduit for transporting hydraulic fluid to the hydraulic system is illustrated in FIG. 27 and FIG. 28. Since it is usually desirable to use a bumper sub when working with the drill string the pumper sub 60 is provided with a fluid-tight connection to the drill string. The bumper sub 60 is provided with a nozzle 170 for entering port 151 or port 150. The nozzle is provided with a bayonet type latch 171 for engaging the fixedly mounted post 172 in the chamber 173 or a similar post which is located in chamber 162. A fluid seal member 174 is arranged to prevent fluid loss past nozzle 170 and out of the chamber 162 or 173 when the nozzle 170 is inserted. Thus, the only exit for fluid from the chamber 162 when the nozzle is inserted therein is through conduit 160 and thence into the hydraulic system. FIG. 28 illustrates the nozzle 170 in greater detail. A spring 176 and piston member 177 are springably connected to releasably capture post 172 when the nozzle 170 is connected in operable position in chamber 162 or 173. In this manner the nozzle 170 is held securely in chamber 162 or 173 while the hydraulic fluid

is forced into the hydraulic system in the working base 50.

As shown in FIG. 30, which illustrates the base portion of the apparatus, the permanent base 36 has a cylindrical collar 31 extending vertically above it to the top of which a radially extending flange 39 is affixed in a unitary manner. The working base 50 is made in plan view in the form of a ring which fits loosely around the periphery of the flange 39 and carried a means for detachably interlocking it with the flange 39.

The working base portion 50 has a segment removed from one side of it, in the region indicated by numeral 352, FIG. 29, to provide clearance for portions of the submerged wellhead apparatus, such as for example, the production and control lines 442 and 443, which remain attached to the well when the removable working base 50 is lifted from the fixed base 36 on the wellhead apparatus. This horseshoe form of the working base 50 also enables the guide lines to be lowered and reattached to the submerged wellhead if at some later time the well is to be worked on.

FIGS. 29 to 31 illustrate an alternative means for disconnectably securing the working base 50 to the permanent base portion 36. A plurality of actuator elements, illustrated by the actuator element 354 are rotatably mounted in the working base portion 50 in bearings 356 and 358 and positioned radially outwardly from the inner circumferential edge 360 of this base portion. The shaft 362 of the actuator element is screw-threaded as at 364 in the region between its bearing supports and carries a lug 366 which has complementary screw threads mating with the screw threads 364 of the actuator element. Thus, as the actuator element is rotated, the lug 366 will move upwardly or downwardly on the shaft thereof. The mating screw threads between the lug 366 and the actuator element 354 engage with enough friction so that when the actuator element is rotated, and provided the lug is not against an abutment, the lug will be carried around in rotation with the shaft.

When the actuator element is rotated in a counterclockwise direction as viewed in FIG. 29, the lug 366 meets an abutment 368 recessed in the base portion 50 which holds the lug relatively stationary in rotation while it is screwed downwardly relative to the shaft of the actuator element. When the actuator element is screwed in a clockwise direction as viewed in FIG. 29, the lug is rotated into a contact with an abutment 370 formed in the peripheral wall 372 of the base portion 50, at which time the lug extends from the wall of the working base radially inwardly toward the center of the wellhead apparatus and projects under the collar 39 of the permanent base section. Continued rotation of the actuator element in a clockwise direction causes the lug to move upwardly relative to the shaft of the actuator element and finally to engage the lower surface 374 of the collar thereby securing the removable working base portion 50 to the permanent fixed base portion 36.

To disconnect the removable working base portion 50 from interlocking relationship with the fixed wellhead apparatus, the actuator element 354 is rotated in a counterclockwise direction to move the lug 366 downwardly relative to the actuator shaft so that it becomes disengaged from its contact with the lower surface 374 of the rollar 39 and subsequently moves in rotation with the rotating element until it comes against the abutment 368 at which time it is buried within a recess in the removable base portion and is entirely clear from interfering with the removal of this base portion from the fixed permanent base portion 36.

In disconnecting and connecting the auxiliary working base portion 50 from and to the permanent base 36, by means of the lugs described herein, the drill string is lowered from the vessel and guided by the particularly constructed transverse rigid guide member 375 to engagement with the actuator unit 354. The guide member 375 is guided along the guide lines and guide posts in the manner heretofore described. Depending on whether it is desired to connect or disconnect the base member, the top of the string of drill pipe is turned at the vessel to turn the actuator unit in the proper direction to clear the lug 366 from engagement or to cause the lug to engage with the collar 39 as described heretofore. This is done in turn for each of the lugs in turn, in each case a transverse guide member being used which is particularly constructed to seat the operator element 377 on the selected actuating unit.

As is fully described in my copending U.S. application Serial Number 235,433 filed on November 5, 1962, now U.S. Patent No. 3,225,826 the drill string is used to rotate the actuator elements to connect and disconnect the base portions as described above. With particular reference to FIGS. 30 and 31 a means for transferring the rotational movement of the drill string and the bumper sub 60 connected therewith through the guide arm member 375 to the actuator elements, such as actuator element 354, is illustrated. A rotatable element 386 is journaled in a bearing 388 for rotation about its vertical axis and means are provided for connecting the lower end of the bumper sub 60 to the upper end of the rotatable element, as for example, a screw-threaded connection. An operator element 377, seatable loosely over an actuator 354, is fixedly connected to the lower end of rotatable element 386 by suitable means such as set screw 390. The operator element 377 transfers the rotational movement to the actuator from the drill string and the bumper sub 60.

It is apparent that modifications other than those described herein may be made to the apparatus of this invention without departing from the inventive concept. It is intended that the invention embrace all equivalents within the scope of the appended claims.

I claim:

1. A method of providing a disconnectable working base on a permanent base of a subsea wellhead from a floating vessel and without the use of divers, said working base including at least a pair of flexible guidelines having one end operably attached to said working base and the other end operably connected to an operational base in said floating vessel comprising providing a flexible pilot line extending from a pilot post on the permanent base of a wellhead to a position easily accessible from the surface, positioning the operational base of the floating vessel in approximate vertical relationship to said wellhead, operably connecting said flexible pilot line to said operational base to provide a flexible connection between said pilot post and said operational base, lowering the working base including the guidelines attached thereto into the water from said operational base and guiding said working base by means of said flexible pilot line to a position where a portion of said working base is substantially vertically above said pilot post and said wellhead, slidably and rotatively engaging said working base with said pilot post, aligning said working base to a predetermined alignment with respect to the said permanent base of said wellhead, lowering the aligned working base to contact said permanent base of said wellhead, and disconnectably connecting said working base to said wellhead.

2. The method of claim 1 including the step of disconnecting said flexible pilot line from said pilot post after said working base has been disconnectably connected to the permanent base of said wellhead.

3. A method of remotely connecting a plurality of guide posts and associated guidelines to a permanent base of a wellhead located below the surface of a body of water, said method being carried out from an operational base of a floating vessel located at the surface of the water comprising establishing a flexible pilot line between the permanent base and a float located near the surface of said body of water, positioning the operational base

of said vessel on the surface of the water in approximate vertical relationship with said permanent base, operably connecting said pilot line with the operational base of said vessel to form a flexible connecting element between said operational base and said permanent base, positioning and maintaining a plurality of guide posts in fixed spaced-apart relationship on a working base, connecting one end of a flexible guideline to each of said guide posts while maintaining the other end of each guideline in operable position in said operational base of said vessel, lowering the said working base into said body of water while maintaining said guide posts in said fixed spaced-apart relationship and allowing the guide cables to be extended between said guide posts and said operational base of said vessel, guiding said working base along said pilot line to a predetermined position on said permanent base, and disconnectably connecting said working base to said permanent base.

4. A method of attaching and detaching a working base and the flexible guidelines attached thereto to a permanent base of a subsea well site from an operational base of a drilling vessel located on the surface of a body of water comprising disconnectably connecting a working base to said permanent base, said working base including at least a pair of flexible guidelines fixedly connected thereto and extending from said working base to an operable connection in the operational base of said vessel, lowering said working base and said permanent base from said vessel to the sea bottom, fixedly connecting said permanent base to said sea bottom, extending a pilot line from an operable connection on said operational base of said vessel into the water and guiding said pilot line along said guidelines to the subsea permanent base, disconnectably connecting said pilot line to said permanent base, disconnecting said working base from said permanent base, and removing said working base including the guidelines fixedly connected thereto from said permanent base.

5. A method of attaching and detaching a working base and the flexible guidelines attached thereto to a permanent base of a subsea well site from an operational base of a drilling vessel located on the surface of a body of water comprising disconnectably connecting a working base to said permanent base, said working base including at least a pair of flexible guidelines fixedly connected thereto and extending from said working base to an operable connection in the operational base of said vessel, lowering said working base and said permanent base from said vessel to the sea bottom, fixedly connecting said permanent base to said sea bottom, extending a pilot line from an operable connection on said operational base of said vessel into the water and guiding said pilot line along said guidelines to the subsea permanent base, disconnectably connecting said pilot line to said permanent base, disconnecting said working base from said permanent base, removing said working base including the guidelines fixedly connected thereto from said permanent base, disconnecting said pilot line from said operable connection on said operational base of said vessel, connecting said pilot line to a float, and placing said float in the water.

6. A method of providing a disconnectable working base on a permanent base of a subsea wellhead from a floating vessel, said working base including at least a pair of flexible guidelines having one end operably attached to said working base and the other end operably connected to an operational base in said floating vessel comprising providing a flexible pilot line extending from a permanent base of a wellhead to a position easily accessible from the surface, positioning the operational base of the floating vessel in approximate vertical relationship to said wellhead, operably connecting said flexible pilot line to said operational base to provide a flexible connection between said permanent base and said operational base, lowering the working base including the guidelines attached thereto into the water from said operational base and guiding said working base by means of said flexible pilot line to a position where said working base is operably seated on said permanent base of said wellhead, disconnectably connecting said working base to said permanent base, disconnecting said pilot line from said permanent base, guiding a well working tool from said operational base to said working base along said guidelines, performing an operation on said wellhead with said tool, extending a pilot line into the water from said operational base and guiding said pilot line along said guidelines to said permanent base of said wellhead, disconnectably connecting one end of said pilot line to said permanent base, disconnecting said working base from said permanent base, and removing said working base including the flexible guidelines attached thereto from said permanent base.

7. A method of providing a disconnectable working base on a permanent base of a subsea wellhead from a floating vessel, said working base including at least a pair of flexible guidelines having one end operably attached to said working base and the other end operably connected to an operational base in said floating vessel comprising providing a flexible pilot line extending from a permanent base of a wellhead to a position easily accessible from the surface, positioning the operational base of the floating vessel in approximate vertical relationship to said wellhead, operably connecting said flexible pilot line to said operational base to provide a flexible connection between said permanent base and said operational base, lowering the working base including the guidelines attached thereto into the water from said operational base and guiding said working base by means of said flexible pilot line to a position where said working base is operably seated on said permanent base of said wellhead, disconnectably connecting said working base to said permanent base, disconnecting said pilot line from said permanent base, guiding a well working tool from said operational base to said working base along said guidelines, performing an operation on said wellhead with said tool, extending a second pilot line into the water from said operational base and guiding said second pilot line along said guidelines to said permanent base of said wellhead, disconnectably connecting one end of said second pilot line to said permanent base, disconnecting said working base from said permanent base, removing said working base including the flexible guidelines attached thereto from said permanent base, connecting the other end of said second pilot line to a float, and releasing said second pilot line and said float from the operational base of said vessel.

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