Oct. 28, 1969 N. B. NEWMAN ET AL 3,474,857

WELLHEAD CLOSURE APPARATUS

Original Filed July 30, 1959 5 Sheets-Sheet 1

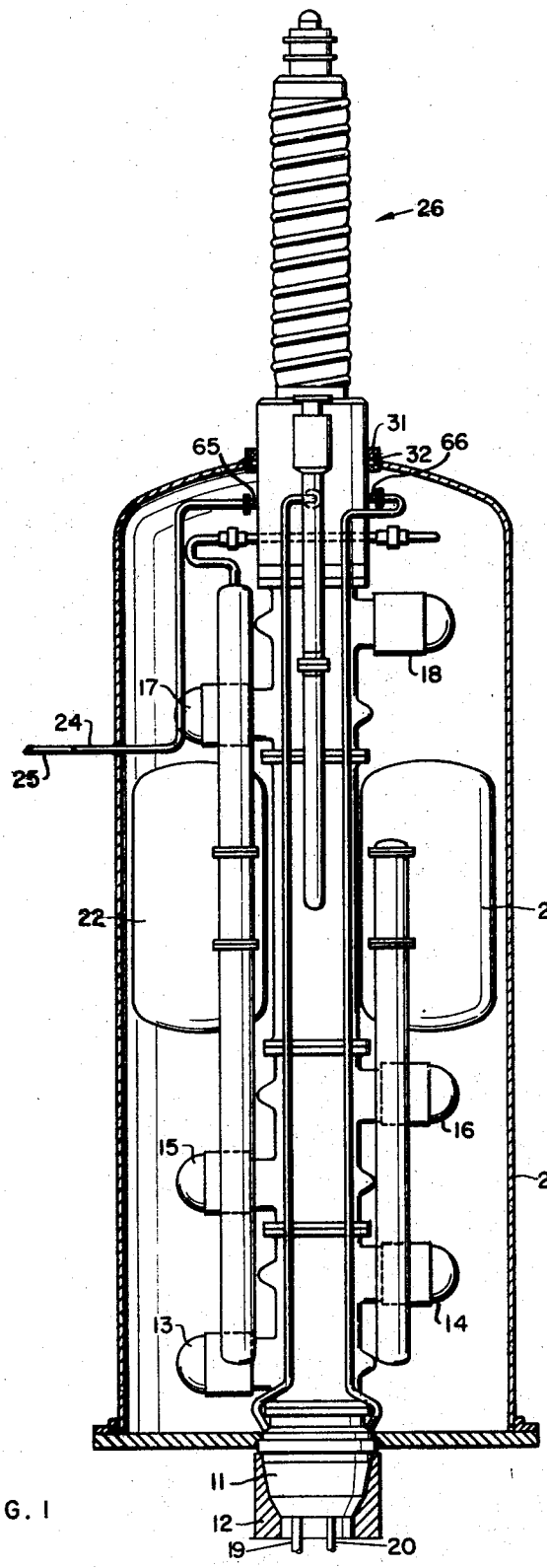


FIG. 1

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WELLHEAD CLOSURE APPARATUS

Original Filed July 30, 1959 5 Sheets-Sheet 2

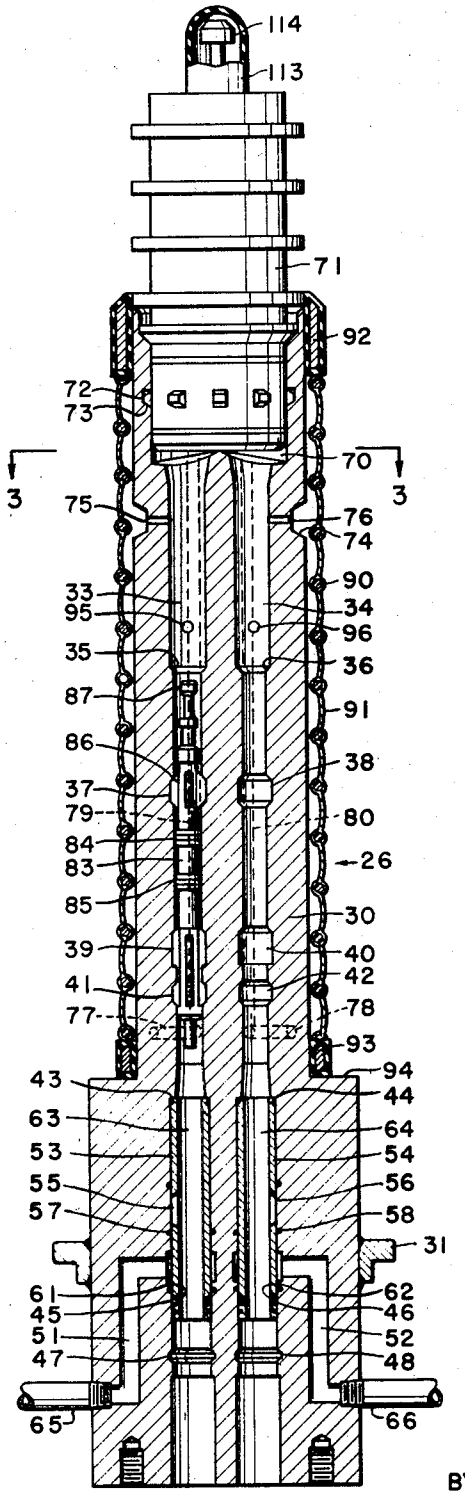


FIG. 2

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Original Filed July 30, 1959 5 Sheets-Sheet 3

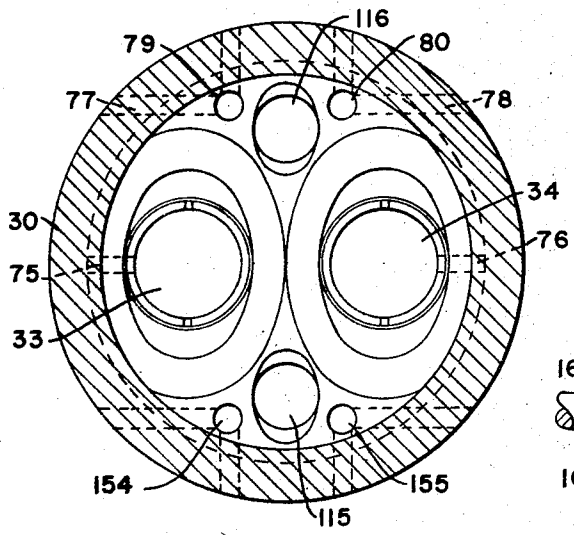


FIG. 3

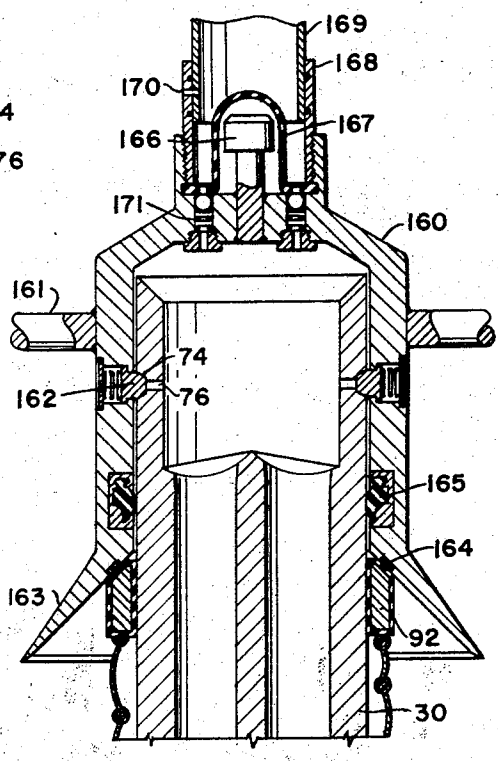


FIG. 8

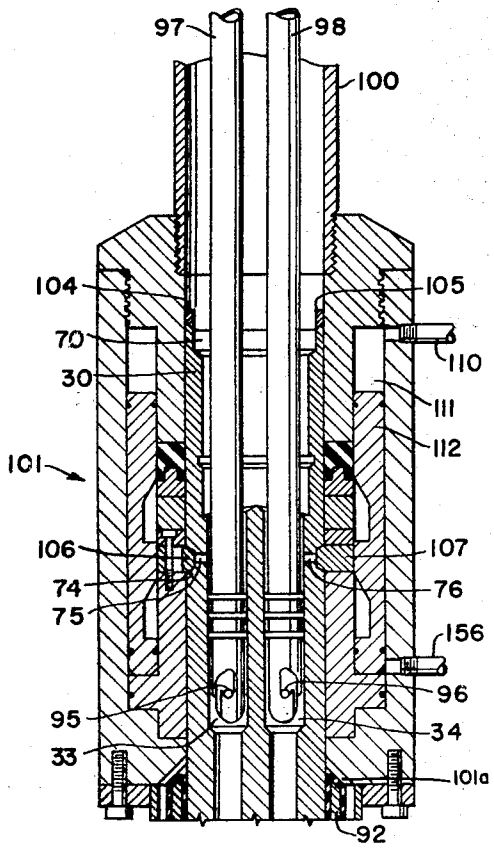


FIG. 4

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Original Filed July 30, 1959 5 Sheets-Sheet 4

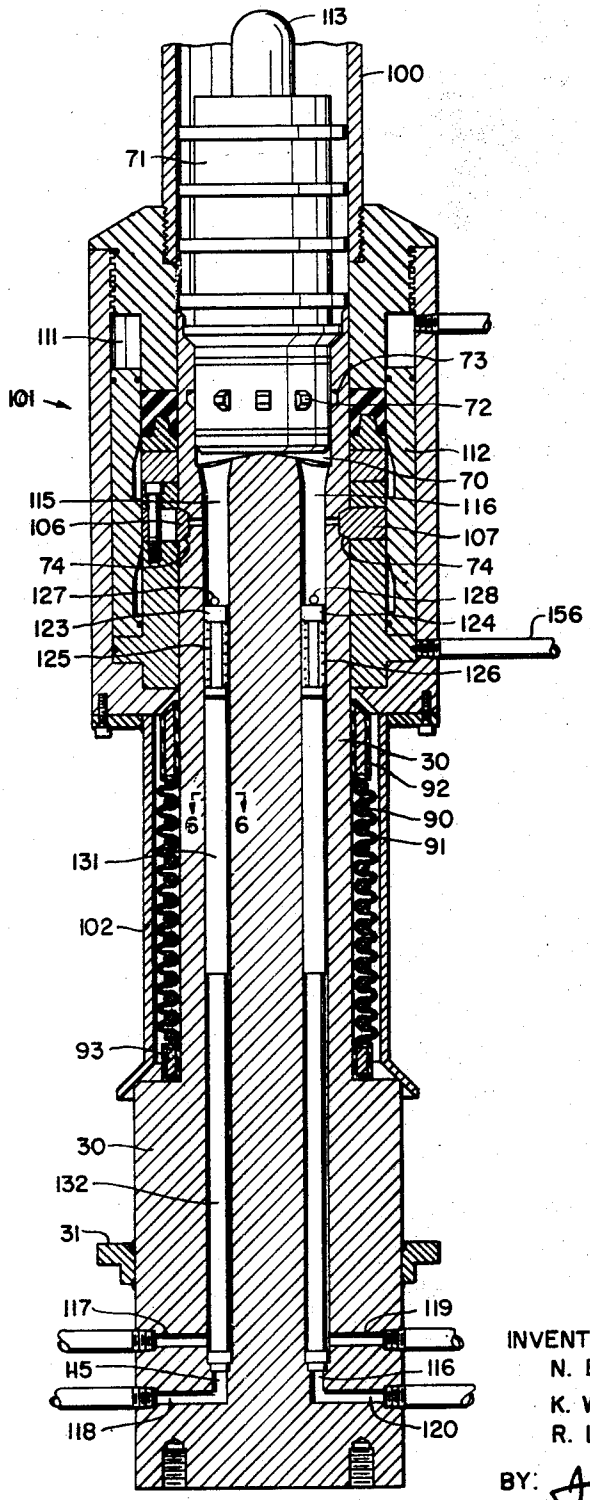


FIG. 5

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WELLHEAD CLOSURE APPARATUS

Original Filed July 30, 1959 5 Sheets-Sheet 5

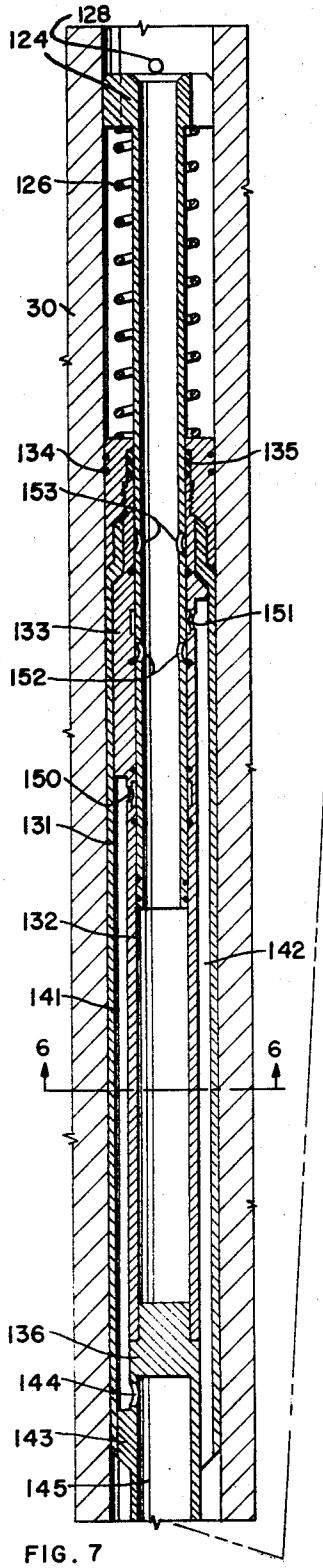


FIG. 7

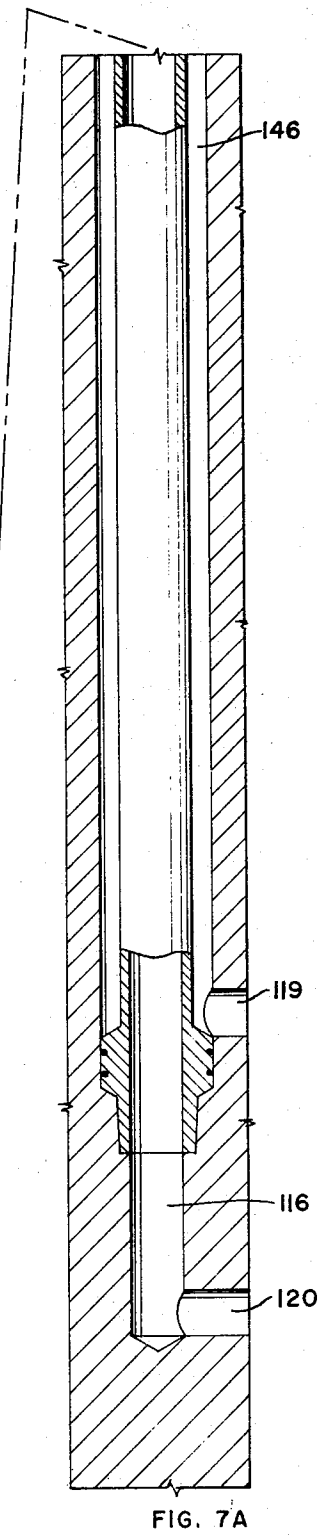


FIG. 7A

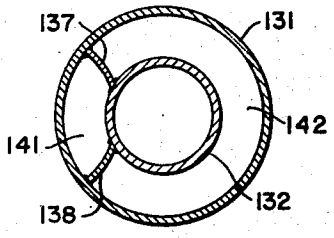


FIG. 6

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United States Patent Office 3,474,857 Patented Oct. 28, 1969

3,474,857

WELLHEAD CLOSURE APPARATUS

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Continuation of application Ser. No. 830,587, July 30, 1959. This application Aug. 16, 1962, Ser. No. 218,482

Int. Cl. E21b 33/035

U.S. Cl. 166—.5 27 Claims

The present apparatus relates to oil well equipment for use at underwater locations and pertains more particularly to a wellhead closure apparatus for closing the top of a wellhead assembly in a fluid-tight manner while protecting it from the harmful effects of salt water and marine life encountered at offshore locations.

The present application is a continuation application of copending patent application, Ser. No. 830,587, filed July 30, 1959, now abandoned.

The wellhead closure of the present invention is adapted to be used to close wellhead assemblies of the type found in copending application, Ser. No. 830,538, filed July 30, 1959, now Patent No. 3,256,937, issued June 21, 1966. A recent development in the field of oil well drilling is the completion of wells at offshore locations with the wellhead assembly positioned on or close to the ocean floor out of the way of ships which may damage it in the event of a collision. Equipment on the ocean floor, however, faces problems such as the corrosive nature of the sea water and the presence of marine life which tends to grow and become encrusted on metallic structures below the surface of the water.

Since it is necessary from time to time to go back into a well wherever it has been completed, it is desirable to have an underwater wellhead structure in suitable condition so that pieces of equipment can readily be lowered from the surface of the water and attached to the wellhead structure. It is therefore a primary object of the present invention to provide a wellhead closure apparatus by which an underwater wellhead assembly may be entered for the purpose of carrying out workover operations in the well.

A further object of the present invention is to provide suitable connecting means by which equipment can be lowered from the surface of the water into engagement with metallic surfaces of an underwater wellhead, which surfaces have been protected against exposure to the sea water and to marine life.

Another object of the present invention is to provide an apparatus for normally closing the top of a wellhead assembly while providing means for direct vertical access into the well to carry on workover operations therein.

A still further object of this invention is to provide a well closure apparatus including valves and fluid manifold means whereby tubing strings may be connected to the wellhead assembly through the closure means to actuate any of the various components of the wellhead assembly.

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

FIGURE 1 is a schematic view illustrating several of the components which may be arranged as an underwater wellhead assembly.

FIGURE 2 is a longitudinal view taken partially in cross-section of the wellhead closure of the present invention;

FIGURE 3 is a cross-sectional view taken along the line 3—3 of FIGURE 2;

FIGURE 4 is a longitudinal view taken in cross-section of the wellhead closure of FIGURE 3 with a running string, running head and tubing strings attached thereto;

FIGURE 5 is a longitudinal view taken in cross-section of the wellhead closure of FIGURE 2 when taken in a view 90 degrees thereto;

FIGURE 6 is a cross-sectional view taken along the line 6—6 of FIGURE 7;

FIGURES 7 and 7A are a longitudinal view taken in cross-section showing the valve and manifold system of FIGURE 5 in enlarged detail; and

FIGURE 8 is a cross-sectional view of another type of closure plug for sealing the top of the present wellhead apparatus.

Referring to FIGURE 1 of the drawing a wellhead assembly or production control unit for an offshore well completed underwater is shown as comprising a closure apparatus **11** for closing the top of a well casing **12** and securing the wellhead assembly thereto, the wellhead assembly comprising a group of power-actuated components including flow line control valves **13**, **14**, **15** and **16**, swabbing valves **17** and **18**, an electro-hydraulic package unit **21** containing a motor, reservoir and pump, and a second package unit **22** containing the various controlling pilot valves which are preferably solenoid-actuated. The entire wellhead assembly may be encased in a container **23**. The wellhead assembly may be provided with a pair of hydraulic pressure lines **24** and **25** which extend through the wall of the container **23** to operate a well component such, for example, as a flow line connector shown and described in copending patent application, Ser. No. 835,931, filed Aug. 15, 1959, now abandoned. The casing closure unit **11** and the wellhead assembly hold-down unit are described in greater detail in copending application Ser. No. 830,538, filed July 30, 1959. The present invention is concerned with a closure apparatus **26** for closing the top of an underwater wellhead assembly and permitting re-entry thereto in order to service or perform other operations on the well.

A wellhead closure apparatus **26**, in accordance with the present invention, is shown in FIGURE 2 as comprising an elongated cylindrical housing or body member **30** having a flange **31** adapted to be bolted to a flange **32** (FIGURE 1) fixedly secured to the container **23**, or to the wellhead assembly contained therein. Other suitable means for connecting the wellhead closure apparatus to the wellhead assembly may be employed in place of flange **31**.

One or more vertical conduits, such for example as conduits **33** and **34** of FIGURE 2, extend through the entire length of the closure means body member **30** and are in fluid communication with tubing strings **19** and **20** which depend within the well casing **12**. These conduits **33** and **34** are preferably provided with one or more seating shoulders or annular recesses such as those illustrated by numerals **35–48** whereby various tools, valves and/or other devices may be definitely positioned at various points therein.

Extending through the side wall of the body member **30**, preferably near the lower end thereof, are side conduits **51** and **52** in communication between the vertical conduit **33** and **34** and the space outside the body member **30**. The ends of the conduits **51** and **52** terminating in the vertical conduits **33** and **34** are normally closed by suitable valves, such for example as slidable sleeve valves **53** and **54** having openings **55** and **56**, respectively, therein, which openings are adapted to register with the conduits **51** and **52** when the valves **53** and **54** are in their

open position. Either the outer wall of the valves **53** and **54** or the inner wall of the vertical conduits **33** and **34** which they contact, are provided with suitable O-ring seals. The valves **53** and **54** may also be provided with positioning rings **61** and **62** which keep the valves anchored in the position which they are set.

Valves of this particular design are well known to the oil field art and may be moved from their open to closed positions by various sleeve valve shifting tools which may be run down into a well on a string of pipe or a wire line. A typical sleeve valve shifting tool is shown and described in FIGURES 2, 3 and 4, page 1976 of the 1957 edition of Composite Catalog of Oil Field Equipment and Services, published by World Oil. The valves **53** ad **54** themselves are preferably of the "fullbore" type, that is, the bores **63** and **64** of the sleeve valves **53** and **54** are at least equal to the inner diameter of the tubing strings used in the well.

The other ends of the side conduits **51** and **52**, that is, the ends of the conduits terminating at the outer surface of the body member **30**, are adapted to be connected to other conduits **65** and **66** which lead to any of the various power-fluid-actuated components, such as valves, hold-down devices, etc., employed in the wellhead assembly as those found in copending application, Ser. No. 830,-538, filed July 30, 1959. A typical well head control valve **13–14** (FIGURE 1) is shown and described in the 1957 Composite Catalog, page 5277 as a WKM Company valve R5008NH–D66 having any suitable type of a hydraulic operator on it such for example as those on page 4964 of the 1957 Composite Catalog of Oil Field Equipment, manufactured by Joe Stine Company, which operators are remotely controlled.

The top of the body member **30** may be recessed, as at **70**. The recess **70** is provided to receive a suitable plug **71** having at least a portion of the outer surface made of rubber whereby a fluidtight seal is formed between the plug **71** and the inner wall of the body member **30** within the recess **70** so that the top of the one or more vertical conduits, for example, **33** and **34**, passing down through the body member, are closed in a fluidtight manner. Preferably, the plug member **71** is provided with dogs or fingers **72** which are preferably spring-loaded and adapted to seat within recesses **73** in the inner surface of the wall of the body **30**. The construction of a preferred plug for sealing the upper end of a body member of the present invention is described in detail in copending application Ser. No. 830,538, filed July 30, 1959. It is to be understood that rather than forming the recess **70** in the top of the body member **30** to receive a plug **71**, a cap-type plug may be employed instead which fits down over the outside of the top of the body member **30** to seal the top of the body in a fluid-tight manner. The lower edge of a cap-type closure member may seat in an annular recess **74** which is normally provided to receive the locking dogs of a device for lowering the present wellhead closure member together with the entire wellhead assembly down into place in the top of a well casing, as will be described hereinbelow.

In a preferred embodiment of the present invention the body member may be provided with one or more grease ports **75** and **76** in communication with the conduits **33** and **34** above slide valves **53** and **54** and the space outside the body member **30**. Additional grease ports **77** and **78** are shown as communicating with grease channels **79** and **80** which pass down through the body member **30**.

If desired, auxiliary means for shutting the conduits **33** and **34** may be provided by employing a pair of tubing plugs such as those known as Type S tubing plugs, manufactured by Otis Engineering Company. A typical plug **83** is shown positioned in conduit **33** and comprises a body member having packing rings **84** and **85** mounted thereon to seal against the inner wall of the conduit **33**. The tubing plug **83** is also provided with one or more sets of locking dogs **86** adapted to expand radially into annular recess **37** in the body member **30** to lock the tubing plug **83** in place. The dogs **86** may be retracted by running an overshot tool on a wire line down to engage the fishing head **87** at the top of the tubing plug **83**. An upward pull on the fishing head **87** causes the dogs **86** to retract in a manner well known to the art, thus allowing the removal of the tubing plug from the conduit **33**.

In the event that the outer surface of the body member **30** is provided with an annular recess **74** cut in the outer surface thereof, or any other suitable anchoring device formed on the outer surface thereof, at least the upper portion of the body member **30** is preferably encased in a temporarily removable or retractable sleeve which may act as an outer casing to minimize corrosion and the growth of marine organisms on the outer surface of the body member **30** which might prevent the orientation of a running tool head, as will be described hereinbelow. Such a protective outer casing on the body member **30** may take the form, as illustrated in FIGURE 2, of a spring-loaded bellows sleeve having a spring **90** integrally formed in a thin flexible wall **91** of a fluid-impermeable material, which, when compressed, takes the form of a bellows unit as shown in FIGURE 5. The top and bottom of the spring-loaded bellows unit **90–91** may be fixedly secured to ring members **92** and **93**, the upper ring member **92** being slidably mounted in a low-pressure fluid-tight engagement with the outer surface of the body member **30**. The ring members **92** and **93** may be covered with rubber or any other suitable sealing means to form a substantially low-pressure fluid-tight seal around the body member **30**. The lower ring **93** may be secured against downward displacement, as by fixedly securing it to the body member **30**, or allowing it to rest on a shoulder **94** thereof. The spring-loaded protective bellows unit **90–91** extends from the top of the body member **30** downwardly a distance sufficient so that in its operative position the bellows unit covers at least all of the outer surface of the body member from the top thereof to a point below the annular groove **74** to be engaged by a running head, and also extends a sufficient distance below this point so that the spring-loaded bellows may be compressed without being injured. A spring-loaded chemically inert bellows is preferred. The wall **91** of the bellows can be made of metal or any flexible rubber-like or plastic material. The ports **75, 76, 77, 78, 154** and **155** in the wall of the body member **30** provide means by which a grease may be injected into the annular space between the outer surface of the body member **30** and the inner surface of the bellows unit. This displaces any sea water which has entered.

The open upper ends of each of the bores **33** and **34** are preferably bevelled, as illustrated in FIGURE 2, to facilitate the entry of tubing strings thereinto. Additionally, if more than one vertical conduit **33** is provided in the body member **30**, they may be of different diameters to facilitate the running of tubing string into the varous conduits **33** and **34** and maintain identity as to which one is connected to which tubing, to be later inserted. Thus, if vertical conduit **33** had a diameter an eighth of an inch larger than conduit **34**, the larger of two tubing strings would be run into the well first to make sure that it was seated in conduit **33**. If desired, one or more pins **95** and **96** may be provided which extend into the bore of each of the conduits **33** and **34**, respectively, and are used to lock the lower ends of the tubings **97** and **98**, thereto, as illustrated in FIGURE 4. In the event that conduits **33** and **34** are of the same size, one conduit could be provided with a single pin **95** while the other conduit could be provided with two pins in order to identify the conduit into which a certain tubing was run and locked. For ease in illustrating the present invention, only one tubing plug **83** is shown in FIGURE 2, it being understood that conduit **34** would also contain a similar plug.

In order to enter a wellhead assembly closed by a wellhead closure apparatus in accordance with the present invention a string of pipe **100** having a running head **101** secured to the lower end thereof would be lowered from a drilling barge down through the water to the ocean floor in a manner described in copending applicaton, Ser. No. 830,538, filed July 30, 1959. As the running and latching head **101** is lowered down on the top of the body member **30**, which at that time would be still closed at the top by means of a plug **71** (FIGURE 2), the lower end **101***a* of the running head **101** comes in contact with the top ring of slidable unit **92** of the bellows unit **90–91**, forcing it downwardly along the side of the body member **30**. Lowering of the running head **101** continues until a skirt **102** depending from the running head **101** contacts the shoulder **94** on the outer surface of the body member **30**. By providing a skirt **102** on the running head **101**, damage to the bellows unit **90–91** by extreme compression is prevented. Alternatively, instead of employing the skirt **102** to limit the downward travel of the running head **101**, one or more stop means **104** and **105** may be welded to the inner wall of the running head **101** to contact the upper end of the body member **30**.

With the running head **101** seated on the top of the body member **30** of the present well closure apparatus, a series of locking dogs, such as illustrated at **106** and **107** are forced radially inwardly into the annular groove **74** in the body member **30**. Movement of the dogs **106** and **107** is accomplished by applying a pressure fluid through conduit **110** into the annular chamber **111** above a piston member **112** carried within the housing of the lowering head **101**.

A fishing tool (not shown) is run down through the marine conductor pipe string **100** (FIGURE 4) to cut through the rubber covering **113** (FIGURE 2) surrounding the fishing neck **114** of the plug **71**. An upward pull on the fishing neck **114** disengages the locking dogs **72** of the plug and allows the plug to be withdrawn upwardly to the surface. In the event that the covering **113** on the fishing neck **114** is of a relatively hard material, such as a hard plastic material or a soft metal such as aluminum, an overshot tool may be run on a pipe string down to cut away the covering **113** before running the fishing tool on a wire line.

With the plug seal **71** removed, separate tubing strings **97** and **98** (FIGURE 4) are run into conduits **33** and **34** and locked onto pins **95** and **96**. A wire-line fishing tool is then run down through the tubing strings **97** and **98** and into the conduits **33** and **34** to remove the tubing plugs **83** therefrom, in a manner similar to the removal of plug **71**. A wire-line valve-shifting tool, well known to the art, is then lowered from the drilling barge on the surface, through tubing **97** to contact sleeve valve **53** and move it downwardly so that its port **55** is in register with the end of conduit **51**. Simultaneously, or subsequently, another valve-shifting tool is lowered through tubing string **98** to move sleeve valve **54** so that its port **56** can register with conduit **52**.

With both sleeve valves **55** and **56** open, a pressure fluid may be pumped down through tubing string **97**, conduit **33**, and side conduit **51** to furnish an actuating pressure fluid to any of the many pressure-actuated components of an underwater well head described in copending application, Ser. No. 830,538, filed July 30, 1959. During this operation conduit **66** (FIGURE 2), side conduit **52**, vertical conduit **34** and tubing string **98** serve as a return line for the pressure fluid, or as a release line for pressure fluid on the other side of the component being actuated. After the necessary operation of operating one of the wellhead pressure-actuated components has been carried out, the valve-shifting tools are again lowered to close valves **53** and **54**. With the valve-shifting tools withdrawn from the tubing string **97** and **98**, it may be seen that a pair of vertical conduits through tubings **97** and **98** and conduits **33** and **34** are provided whereby tools may be run down through the well head and tubing systems of the well installation when the well head control valves are open, so as to carry out any of the many operations within the well.

In FIGURES 2 and 4 a wellhead closure apparatus in accordance with the present invention is shown as being provided with a pair of vertical conduits **33** and **34**, each being connected to the single side conduit **51** and **52**, respectively. With this apparatus a single wellhead component could be opened or closed if a relief line is needed from the pressure-actuated component. However, if the wellhead components are arranged, through suitable spring-loading or other means, for maintaining a fixed position while being pressure-actuatable to a second position, the wellhead closure apparatus of FIGURES 2 and 4 is designed to supply two different pressure fluids, one to each of the two components of the wellhead. It will generally be found however that a self-contained underwater wellhead assembly will contain several components, thus requiring a more complicated well closure apparatus than that illustrated in FIGURES 2 and 4.

Another embodiment of the present wellhead closure apparatus is shown in FIGURE 5. Actually, by referring to FIGURE 3 of the drawing it may be seen that the apparatus of FIGURES 4 and 5 may be combined by the proper location of the various vertical conduits, FIGURE 5 being a view taken in longitudinal cross-section in a plane 90 degrees to that shown in FIGURE 4. While it is preferable to have a pair of vertical conduits **33** and **34** extend entirely through the wellhead closure apparatus, as shown in FIGURES 2 and 4, in order to permit entry into the well, it is realized that some wellhead closures need not permit entry into a well, but merely permit the connection of pressure-fluid tubing strings to various wellhead components.

Referring to FIGURE 5, the elongated cylindrical body member **30** of the present apparatus is shown as being provided with a second pair of vertical conduits **115** and **116** which extend a substantial length thereof. Near the lower end of vertical conduit **115** a pair of side conduits **117** and **118** extend through the side wall of body member **30** while another pair of side conduits **119** and **120** are in communication through the side wall of body member **30** with the vertical conduit **116**.

The vertical conduits **115** and **116** are provided with spring-loaded slide valves **123** and **124**, respectively. Compression springs **125** and **126** urge the valves **123** and **124** upwardly against positioning pins **127** and **128** which extend inwardly into the bore of the vertical conduits **115** and **116**.

In FIGURE 7 a valve and manifolding system for one of the conduits, say conduit **116** is shown as comprising a pair of concentric tubes **131** and **132** closed in a fluid-tight manner by a closure **133** which may be provided with O-ring seals **134**. The spring-loaded valve **124** is arranged in a telescopic manner through a packing gland **135** so as to slide in and out of the innermost tube **132**. The innermost tube **132** is closed at a point below the furthermost travel of valve **124** by means of a plug or other suitable means **136**.

From FIGURE 6, it may be seen that a pair of radially extending partitioning walls **137** and **138** divide the space between the tubes **131** and **132** into two fluid flow passages **141** and **142**. The lower end of the flow passage **141** is closed in a fluid-tight manner by a closure **143** positioned below closure **136** so that port means **144** may extend through the innermost tube **132** at a point below closure **136**, thus putting the flow passage **141** in communication with the bore **145** of the inner tube **132**. The lower end of the bore **145** of inner tube **132** communicates through the lower end of vertical conduit **116** with the side conduit **120**. The flow passage **142** communicates in a like manner with the annular space outside the tube **132** below the closure **143**, and hence through side conduit **119**.

Near the top of tube **132** (FIGURE 7) a port **150** extends through the wall thereof in communication between the flow passage **141** and the interior of tube **132**. A second port **151** extends through the wall of the inner tube **132** near the top thereof in communication between the flow passage **142** and the interior of the tube **132**. Both ports **150** and **151** are normally closed by the slide valve **124** when it is in its uppermost position. The sleeve valve **124** is provided with two sets of ports **152** and **153** which are adapted to register with ports **150** and **151**, respectively. The spacing between the ports **152** and **153** is such that only one port **150** or **151** can be opened at a time.

In operation, after a landing head **101** (FIGURE 5) has been run on the lower end of the marine conductor **100** down to the well closure member **30** and locked in place thereon, as shown in FIGURE 5, the sealing plug **71** is removed in a manner previously described. Small diameter tubing strings are run down into the vertical conduits **115** and **116** and seated against the pins **127** and **128** therein. Each of the tubing strings has a longitudinal slot of predetermined length cut upwardly from the bottom edge of the tubing, said slot being of a width to pass over the pin **127** and **128**. The length of the slot is equal to either the distance between ports **150** and **152**, or between ports **151** and **153**. Thus, if the tubing string (not shown) has a slot in its lower end as long as the distance between ports **151** and **153**, the pin **128** will pass up the slot allowing the lower edge of the tubing string to force down the spring-loaded sleeve valve **124** until ports **151** and **153** are in register. With the same ports opened by a similar movement of sleeve valve **123** a pressure fluid could be pumped down through the tubing string, through the sleeve valve **124** out port **153** thereof, and through ports **151**, thence downwardly through conduit **142**, annular space **146** and side conduit **119** to actuate any pressure-fluid-operated device or control member of the wellhead assembly, such as, for example, the wellhead assembly lock-down unit described in copending application, Ser. No. 830,538, filed July 30, 1959. At the same time, return fluid from the two-way flow line connector would pass in through conduit **117** and up through valve **123** and its manifold system.

Assuming for purposes of illustration that side conduit **118** (FIGURE 5) is connected to operate a spring-closed hydraulically-opened swabbing valve in the wellhead assembly (not shown), which it is desired to open. A tubing having a slot in the end equal to the distance between ports **150** and **152** would be used to push valve **123** downwardly until these ports were open. If desired, the same tubing string may have slots of different length in the end of the tubing, the slots being positioned diametrically opposite each other. Thus, for example, after releasing a flow line connector (not shown) by applying a pressure fluid down through vertical conduit **115** and side conduit **117**, the tubing string could be raised a few inches and rotated 180 degrees and then lowered again to force valve **123** downwardly so that ports **151** and **153** are in register. A pressure fluid now applied through the tubing string, to vertical conduit **115**, through the valve **123** and its ports **153**, thence through port **151**, flow passage **141**, port **144** and flow passage **145** through side outlet conduit **118**, to pressure a normally spring-closed valve and open it. At the same time the vertical conduit **116** and side conduit **120** could be employed to open another valve, pair of valves, or other mechanism on the wellhead assembly. Thus, it may be seen that by uniting the vertical conduits **33** and **34** of FIGURE 4 and **115** and **116** of FIGURE 5 in a single embodiment of the present invention as shown in FIGURE 3, at least three and as many as six pressure-operated components for wellhead assembly may be energized, either opened or closed, connected or disconnected, etc.

When all of the necessary operations have been carried out on the wellhead assembly (not shown), tubing strings, such as elements **97** and **98** of FIGURE 4, are withdrawn from the wellhead closure apparatus of the present invention and raised to the surface, leaving pipe string **100** empty. The sealing head plug **71** is then run down through the pipe string **100** of FIGURES 2 and 5 and seated in the recess **70** at the top of the body member **30**. The head plug **71** may be run down into position in any one of three ways. It may be pumped down the normally empty pipe string **100** by pumping a fluid down above it, or it may be lowered into place by being removably connected to the bottom of a small diameter pipe string that will pass through pipe string **100** with the plug being disconnected either hydraulically or mechanically. Additionally, a plug may be run into place on a wire line in a collapsed position and set in any manner used for a wire line tool. After the plug **71** has seated, the dogs or locking fingers **73** snap into place. Preferably, a quantity of grease is inserted into the pipe string **100** ahead of the plug **71** so that when the plug **71** is forced into place the grease will be forced down grease channels **79**, **80**, **154** and **155** (FIGURE 3). The grease from these channels will be forced through grease ports such as **75**, **76**, **77** and **78** within the wellhead closure to lubricate all areas of the wellhead closure to be protected from corrosion. At this time the space between the bellows unit **90–91** and the wellhead closure body **30** is filled.

With the plug **71** in place, a pressure fluid is applied through conduit **156** (FIGURES 4 and 5) to drive piston **112** of the running head **101** upwardly to unlatch the locking dogs **107** and allow the running head **101** together with the pipe string **100** to be withdrawn upwardly to the drilling barge. Removal of the running head **101** allows the bellows unit **90–91** to move upwardly and entirely cover the body member **30**. The bellows unit is constructed so that during the injection of grease into the annular space between the outer surface of the body member **30** and the inner surface of the bellows unit any sea water present is replaced by the grease, and during the upward movement of the bellows unit the body of injected grease is rearranged so that it fills the thus-extended annular space to prevent any subsequent entry of sea water.

Rather than employ a plug **71** that fits within a recess in the top of the body member **30** as shown in FIGURE 5, a cap type plug **160** (FIGURE 8) may be used. In order to run the cap plug into place, it would be provided with two or more guide arms **161** by which it could be run into place on guide lines (not shown) in a manner described with regard to the equipment in copending patent application Ser. No. 830,538, filed July 30, 1959. The plug type cap would be provided with several spring-loaded hold-down dogs **162** adapted to seat in the annular groove **74** of body member **30**. Preferably, a guide skirt **163** is provided at the lower end of the plug to guide it into place over the top of the body member **30**. A suitable ring of packing material **165** is provided on the inner surface of the cap plug to seal the space between the cap plug **160** and the body member **30**. If desired, a second sealing ring **164** may be provided which would seat on the top of the ring **92**. The top of the cap plug would be provided with a fishing neck or head **166**, preferably covered by a thin rubber-protected cap **167**. If it is desired to run the cap **160** into place on the lower end of a pipe string, a running sub or collar **168** may be provided on the top of the cap plug **160** which would be connected to the running pipe or tubing string **169** by means of a shear pin **170**. After lowering the cap plug **160** into place on the lower end of the tubing string **169**, the cap void is completely filled with an inhibited grease through check valve **171** to seal out any sea water. By a continued downward pressure on the string **169**, the pin **170** is sheared, allowing the tubing string to be withdrawn to the surface. While the valves **53** and **54** which control the flow of fluid through conduits **51** and **52** have been illustrated as being positioned within the vertical conduits **33** and **34**, it is readily apparent that they may be positioned in the

side conduits themselves, or partially in the side conduits and partially in the vertical conduits.

We claim as our invention:

1. In a well installation located underwater at an offshore location comprising well casing means cemented in said well, well tubing means suspended in said casing means, a wellhead assembly closing said casing means and tubing means, apparatus for closing the top of said wellhead assembly and permitting re-entry thereto, said apparatus comprising a body member fixedly secured coaxially to the top of said wellhead assembly in a fluidtight manner, vertical conduit means in said body member, side conduit means through the wall of said body member adapted to be in communication between said vertical conduit means and a pressure-fluid actuated component of said wellhead assembly, valve means in said vertical conduit means for opening and closing said side conduit means, removable closure means normally closing the top of said body member in a fluidtight manner.

2. In a well installation located underwater at an offshore location comprising well casing means cemented in said well, well tubing means suspended in said casing means, a wellhead assembly closing said casing means and tubing means, apparatus for closing the top of said well head assembly and permitting re-entry thereto, said apparatus comprising a cylindrical body member fixedly secured coaxially to the top of said wellhead assembly in a fluidtight manner, vertical conduit means in said body member in communication through said wellhead assembly with the well tubing means, side conduit means through the wall of said body member adapted to be in communication between said vertical conduit means and a pressure-fluid actuated component of said wellhead assembly, valve means in said vertical conduit means for opening and closing said side conduit means, and removable closure means normally closing the top of said body member in a fluidtight manner.

3. In a well installation located underwater at an offshore location comprising well casing means cemented in said well, dual well tubing means suspended in said casing means, a wellhead assembly closing said casing means and tubing means, apparatus for closing the top of said wellhead assembly and permitting re-entry thereto, said apparatus comprising a cylindrical body member fixedly secured coaxially to the top of said wellhead assembly in a fluidtight manner, at least two vertical conduits in said body member in communication through said wellhead assembly with the dual well tubing means, side conduit means through the wall of said body member adapted to be in communication between said vertical conduits and a pressure-fluid actuated component of said wellhead assembly, slidable sleeve valve means in said vertical conduits for opening and closing said side conduit means, and remotely removable closure means normally closing the top of said body member in a fluidtight manner.

4. In a well installation located underwater at an offshore location comprising well casing means cemented in said well, well tubing means suspended in said casing means, a wellhead assembly closing said casing means and tubing means, apparatus for closing the top of said wellhead assembly and permitting re-entry thereto, said apparatus comprising a cylindrical body member fixedly secured coaxially to the top of said wellhead assembly in a fluidtight manner, seating means carried by said body member for seating the open bottom end of a vertically positioned marine conductor pipe string thereon, an axially movable protective enclosure surrounding the outer surface of said body member from the top thereof down to at least said seating means, vertical conduit means in said body member in communication through said wellhead assembly with the well tubing means, side conduit means through the wall of said body member adapted to be in communication between said vertical conduit means and a pressure-fluid actuated component of said wellhead assembly, valve means in said vertical conduit means for opening and closing said side conduit means, and removable closure means normally closing the top of said body member in a fluidtight manner.

5. In a well installation located underwater at an offshore location comprising well casing means cemented in said well, well tubing means suspended in said casing means, a wellhead assembly closing said casing means and tubing means, apparatus for closing the top of said well-head assembly and permitting re-entry thereto, said apparatus comprising a cylindrical body member fixedly secured coaxially to the top of said wellhead assembly in a fluidtight manner, vertical conduit means in said body member in communication through said wellhead assembly with the well tubing means, side conduit means through the wall of said body member adapted to be in communication between said vertical conduit means and a pressure-fluid actuated component of said wellhead assembly, valve means in said vertical conduit means for opening and closing said side conduit means, remotely removable closure means normally closing the top of said body member in a fluidtight manner, means carried on the outside of said body member for seating and locking thereon the open bottom end of a vertically positioned marine conductor pipe, and a resilient collapsible bellows unit surrounding the outer surface of said body member from the removable closure means thereof down to at least said seating and locking means, said bellows unit being adapted to be forced downwardly to uncover the upper end of said body member.

6. In a well installation located underwater at an offshore location comprising well casing means cemented in said well, well tubing means suspended in said casing means, a wellhead assembly closing said casing means and tubing means, said wellhead assembly being equipped with pressure-fluid actuated components, apparatus for closing the top of said wellhead assembly and permitting reentry thereto, said apparatus comprising a cylindrical body member fixedly secured coaxially to the top of said wellhead assembly in a fluid-tight manner, vertical conduit means in said body member in communication through said wellhead assembly with the well tubing means, side conduit means through the wall of said body member adapted to be in communication between said vertical conduit means and at least one of said pressure-fluid actuated components of said wellhead assembly, valve means in said vertical conduit means for opening and closing said side conduit means, remotely removable closure means normally closing the top of said body member in a fluidtight manner, and removable tubing plug means above said valve means for closing the vertical conduit means in a fluidtight manner.

7. A method of closing an underwater wellhead assembly having a removable marine conductor pipe string extending to a point above the surface of the water, said wellhead assembly having at least two vertical conduits therein, said method comprising closing said vertical conduits at a point below the top of said wellhead assembly, inserting a quantity of a lubricating material through said pipe string into the top of said wellhead assembly, forcing said lubricating material under pressure into voids within the wellhead assembly, sealing the upper end of said wellhead assembly in a fluid-tight manner, and removing the marine conductor pipe string therefrom.

8. A method of closing an underwater wellhead assembly having a removable marine conductor pipe string extending to a point above the surface of the water, said wellhead assembly having at least two vertical conduits therein, said method comprising closing said vertical conduits at a point below the top of said wellhead assembly, inserting a quantity of a lubricating material through said pipe string into the top of said wellhead assembly, in serting a plug through said pipe string above said lubricating material, forcing said plug under pressure against said lubricating material to force said material into voids within the wellhead asembly, sealing the

upper end of said wellhead assembly in a fluid-tight manner and removing the marine conductor pipe string therefrom.

9. A method of closing an underwater wellhead assembly having a removable marine conductor pipe string extending to a point above the surface of the water, said wellhead assembly having at least two vertical conduits therein, said method comprising closing said vertical conduits with valve means at a point below the top of said wellhead assembly, inserting a quantity of a lubricating material through said pipe string, inserting a wellhead sealing plug in said pipe string above said lubricating material, pumping said plug under pressure through said pipe string and against said lubricating material to force said material into voids within the wellhead assembly, sealing the upper end of said wellhead assembly in a fluid-tight manner by seating said plug therein, and removing the marine conductor pipe string therefrom.

10. A method of closing an underwater wellhead assembly having a removable marine conductor pipe string extending to a point above the surface of the water, said wellhead assembly having at least two vertical conduits therein, said method comprising closing said vertical conduits with valve means and plug means at a point below the top of said wellhead assembly, inserting a quantity of a fluid sealing and lubricating material through said pipe string, inserting a wellhead sealing plug in said pipe string above said sealing and lubricating material, pumping a fluid through said pipe string in back of said plug to force said plug under pressure against said sealing and lubricating material to force said material into voids within the wellhead assembly, sealing the upper end of said wellhead assembly in a fluid-tight manner by seating said plug therein, and removing the marine conductor pipe string therefrom.

11. The method of closing an underwater well installation having casing means cemented into a well, tubing means suspended in the casing, a wellhead assembly enclosing the casing means and the tubing means, and, connected above the wellhead assembly, an open-topped cylindrical body member which is traversed by conduits leading into communication with the tubing means and the wellhead assembly, the body member being provided with external engaging-surface for intimately engaging cooperating surfaces on units which are telescoped over the body member, said method comprising mounting a flexible, cylindrical sheath containing a resilient, longitudinally-extending member around the cylindrical body member in sliding engagement, so that in substantially relaxed condition the sheath covers the external engaging-surfaces on the body member, providing a conduit extending from the upper portion of the body member interior into the annular space between the sheath and the body member during the closing in of the underwater well installation, extending a marine conductor pipe from a point above the water surface into a position in which lower portions of the marine conductor telescope over the body member and longitudinally-compress the flexible sheath and surfaces on the marine conductor intimately engage with the external engaging-surfaces on the body member, closing the conduits extending from the interior of the body member into communication with the tubing means and the wellhead assembly, pumping grease through the marine conductor and the body member into the annular space between the body member and the flexible sheath; closing the opening into the body member, and, removing the marine conductor, allowing the flexible sheath to longitudinally-extend to its substantially relaxed condition covering the external engaging surfaces on the body member.

12. In a well installation located underwater at an offshore location comprising well casing means extending into the well drilled in the ocean floor, a wellhead assembly closing said casing means, apparatus for closing the top of said wellhead assembly, said apparatus comprising a body member fixedly secured to the top of the wellhead assembly in a fluidtight manner, vertical conduit means in said body member, side conduit means through the wall of said body member in communication with said vertical conduit means, valve means carried by said body member for opening and closing said side conduit, and removable closure means normally closing the top of said body member in a fluidtight manner.

13. In a well installation located underwater at an offshore location comprising well casing means and well tubing means extending into the well drilled in the ocean floor with a wellhead assembly closing said casing means, apparatus for closing the top of said wellhead assembly, said apparatus comprising a body member fixedly secured to the top of the wellhead assembly in a fluidtight manner, fluid flow-line means in said wellhead assembly in communication at one end with well tubing means in said well, pressure-fluid actuated flow control valve means in said fluid flow-line means, vertical conduit means in said body member, side conduit means through the wall of said body member in communication with said vertical conduit means at one end and with at least one of said pressure-fluid actuated flow control valve means at the other end for actuating said valve means, and removable closure means normally closing the top of said body member in a fluidtight manner.

14. The apparatus of claim 13 wherein a portion of said body member is provided with latching means on the outer surface thereof for receiving and cooperating with a wellhead connector carried at the lower end of a pipe string and lowerable into telescopic arrangement with said body member.

15. The apparatus of claim 13 wherein a portion of the outer surface of said body member forms sealing surface means adapted to receive thereagainst in a fluidtight manner an annular sealing element carried by a wellhead connector at the lower end of a pipe string.

16. The apparatus of claim 15 including retractible axially-movable sleeve means normally covering said sealing surface means.

17. A method of establishing communication with a tubing string of an underwater wellhead assembly where the tubing string is normally closed by a valve actuatable by pressure to an open position, said method comprising the steps of

(a) opening the top of the wellhead assembly
(b) extending down through a body of water from a position thereabove, a tubing string,
(c) inserting said tubing string through said open top of said wellhead assembly and placing it in communication with the upper end of a tubing of said wellhead assembly,
(d) extending conduit means down through said body of water from said position thereabove,
(e) placing the lower end of said conduit means through the open end of said wellhead assembly and in operative communication with said valve to actuate said valve, and
(f) applying a pressure fluid through said conduit means to open said valve in the tubing of said wellhead assembly to bring it into communication with said tubing string.

18. The method of claim 17 including the step of latching the lower end of said tubing string to said wellhead assembly.

19. The method of claim 17 including the prior steps of

(a) extending a marine conductor pipe down through the body of water to a wellhead assembly,
(b) positioning the lower end of the conductor pipe on the top of said wellhead assembly, and
(c) sealing the lower end of the conductor pipe in a fluidtight manner to the wellhead assembly.

20. In a well installation located underwater at an offshore location comprising well casing means cemented

in said well, well tubing means suspended in said casing means, a wellhead assembly closing said casing means and tubing means, apparatus for closing the top of said wellhead assembly and permitting re-entry thereto, said apparatus comprising a body member fixedly secured coaxially to the top of said wellhead assembly in a fluidtight manner, a portion of the outer surface of said body member forming sealing surface means adapted to receive thereagainst in a fluidtight manner an annular sealing element, vertical conduit means in said body member, side conduit means through the wall of said body member adapted to be in communication between said vertical conduit means and at least one of said pressure-fluid actuated components of said wellhead assembly, removable closure means normally closing the top of said body member in a fluidtight manner.

21. A latch head connectable to a plurality of flow conductors for use with well devices having locking means and sealing means including: a body having a plurality of longitudinal bores, said body having means at one end of each of said longitudinal bores for receiving and connecting a well flow conductor thereto with the well flow conductors opening into said bores when said latch head is connected to the flow conductors, each of said bores being provided with internal groove latch means engageable by locking means of well devices for releasably securing well devices in said bore; and an internal annular seal surface provided in each of said bores engageable by sealing means of well devices, said latch head body being provided with an external shoulder latch means engageable by running and pulling tools whereby the latch head and the flow conductors connected therewith may be lowered and raised by said tools.

22. In combination with the latch head of claim **21** means for connecting an operating member and flow conduit with said latch head including: a tubular body telescopable relative to said latch head and having a first means engageable with said external shoulder latch means of said latch head for releasably securing said tubular body to said latch head; lock means carried by said tubular body and movable between a first locking position wherein said first means is engaged and locked by said lock means against movement out of engagement with said external shoulder latch means and a second position wherein said lock means is out of locking engagement with said first means and said first means is free to move out of engagement with said external shoulder latch means upon movement of the tubular body from said latch head; and means operable from a remote point for moving said lock means between said first position and said second position.

23. In combination with the latch head of claim **21** means for connecting an operating member with said latch head and including: a tubular body telescopable relative to said latch head and having first means engageable with said external shoulder latch means of said latch head for releasably securing said tubular body to said head; lock means carried by said tubular body and movable between a first locking position wherein said first means is engaged and locked by said lock means against movement out of engagement with said external shoulder latch means and a second position wherein said lock means is out of locking engagement with said first means and said first means is free to move out of engagement with said external shoulder latch means upon movement of the tubular body from said latch head; means operable from a remote point for moving said lock means between said first position and said second position and a conduit secured to said tubular body and communicating with said bores when said tool is secured to said latch head.

24. A latch head connectable to a plurality of flow conductors for use with well devices having locking means and sealing means including: a body having a plurality of laterally spaced separate longitudinal bores, said body having means at one end of each of said separate longitudinal bores for receiving and connecting a well flow conductor thereto with the flow conductors opening into said bores when said latch head is connected to the flow conductors, each of said bores being provided with internal shoulder and groove latch means engageable by locking means of well devices for releasably securing well devices in said bore; and an internal annular seal surface provided in each of said bores adjacent said latch means and engageable by sealing means of well devices, said latch head body being provided with an external annular shoulder and groove latch means engageable by running and pulling tools whereby the latch head and its flow conductor may be lowered and raised by said tools, said latch head body having an upwardly facing stop shoulder engageable by running and pulling tools to limit downward movement of the running and pulling tools relative to said latch head.

25. A latch head connectable to a plurality of flow conductors for use with well devices having locking means and sealing means including: a body having a plurality of separate laterally spaced longitudinal bores, said body having means thereon at one end of each of said longitudinal bores for receiving and connecting a well flow conductor thereto with the flow conductors opening into said bores when said latch head is connected to the flow conductors, each of said bores being provided with internal annular groove and shoulder latch means engageable by locking means of well devices for releasably securing well devices in said bore; and an internal annular seal surface provided in each of said bores engageable by a sealing means of the well device, said latch head body being provided with an external shoulder and groove latch means engageable by running and pulling tools whereby the latch head and the flow conductors connected thereto may be lowered and raised by said tools, said latch head body being provided on its exterior with orienting means engageable with running and pulling tools for orienting said running tools relative to said bores.

26. A latch head connectable to a plurality of flow conductors for use with well devices having locking means and sealing means including: a body having a plurality of laterally spaced separate longitudinal bores, said body having means at one end of each of said bores for receiving and connecting a well flow conductor thereto with the flow conductors opening into said bores when said latch head is connected to the flow conductors, each of said bores being provided with internal annular groove and shoulder latch means engageable by locking means of well devices for releasably securing well devices in said bore; and an internal annular seal surface provided in each of said bores adjacent the latch means thereof engageable by sealing means of well devices, said latch head having an upper bore providing an internal annular seal surface above said longitudinal bores, said longitudinal bores opening upwardly into said upper bore and downwardly to the exterior of said body.

27. A latch head connectable to a plurality of flow conductors for use with well devices having locking means and sealing means including: a body having a plurality of laterally spaced separate longitudinal bores, said body having means at one end of each of said bores for receiving and connecting a well flow conductor thereto with the flow conductors opening into said bores when said latch head is connected to a well flow conductor, each of said bores being provided with an internal annular groove and an upwardly facing stop shoulder therein spaced longitudinally from said groove and providing with said groove latch means engageable by locking means of well devices for releasably securing well devices in said bore; and an internal annular seal surface provided in each of said bores adjacent the latch means thereof engageable by sealing means of well devices, said latch head having an upper bore providing an internal annular seal surface above said longitudinal bores, said longitudinal bores opening upwardly into said upper bore and downwardly

to the exterior of said body, said latch head being provided with an external annular shoulder and groove latch means.

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U.S. Cl. X.R.

166—87