Jan. 13, 1970 C. R. HUTCHISON 3,489,213

UNDERWATER WELL COMPLETION SYSTEM

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FIG. 1

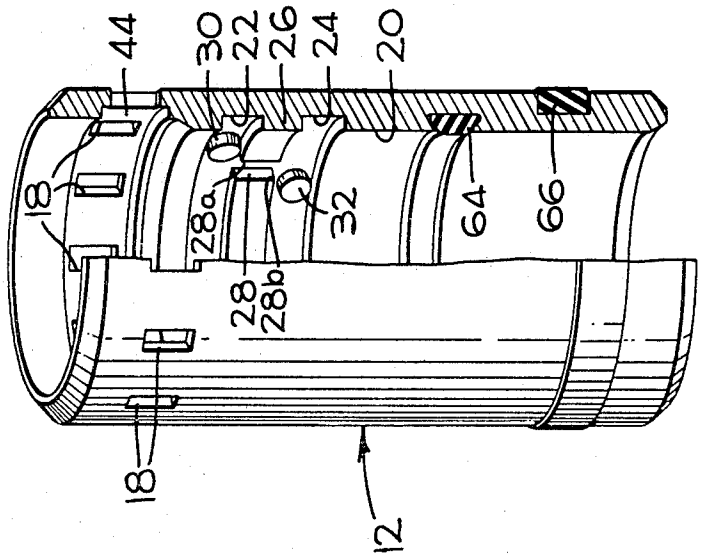



FIG. 3

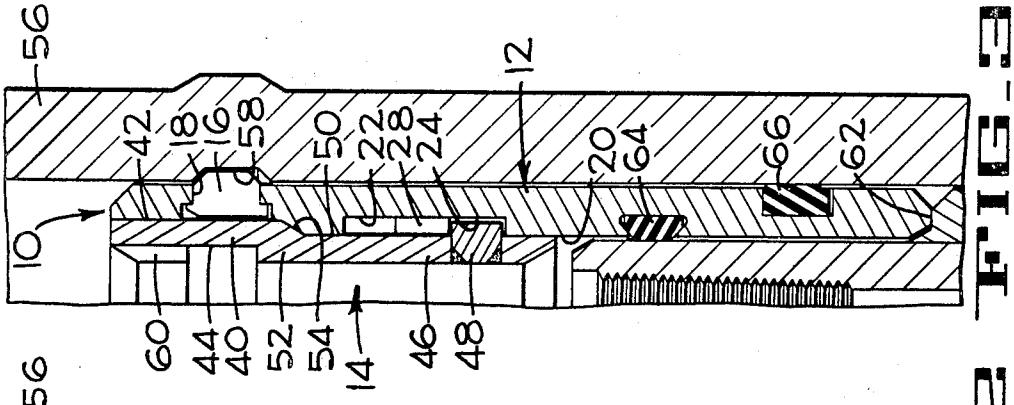
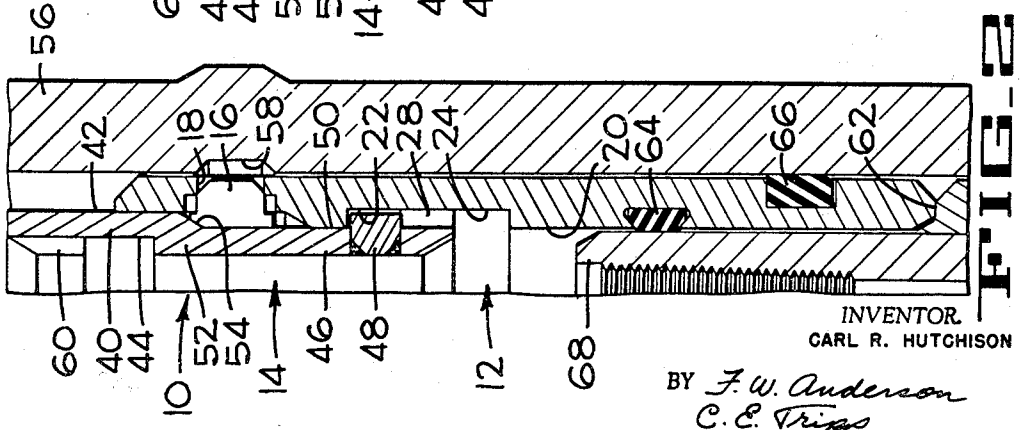



FIG. 2




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UNDERWATER WELL COMPLETION SYSTEM

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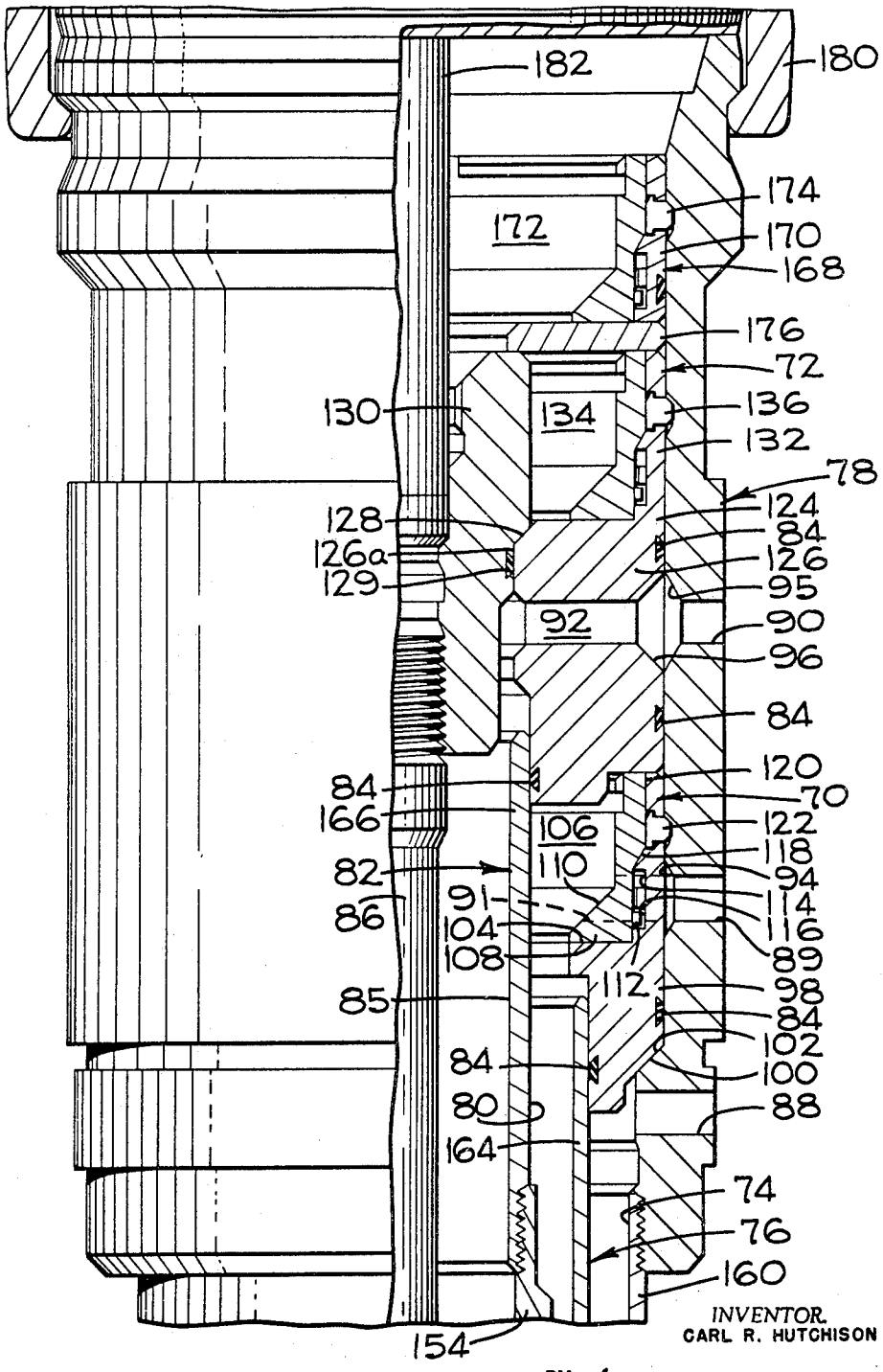



FIG 4

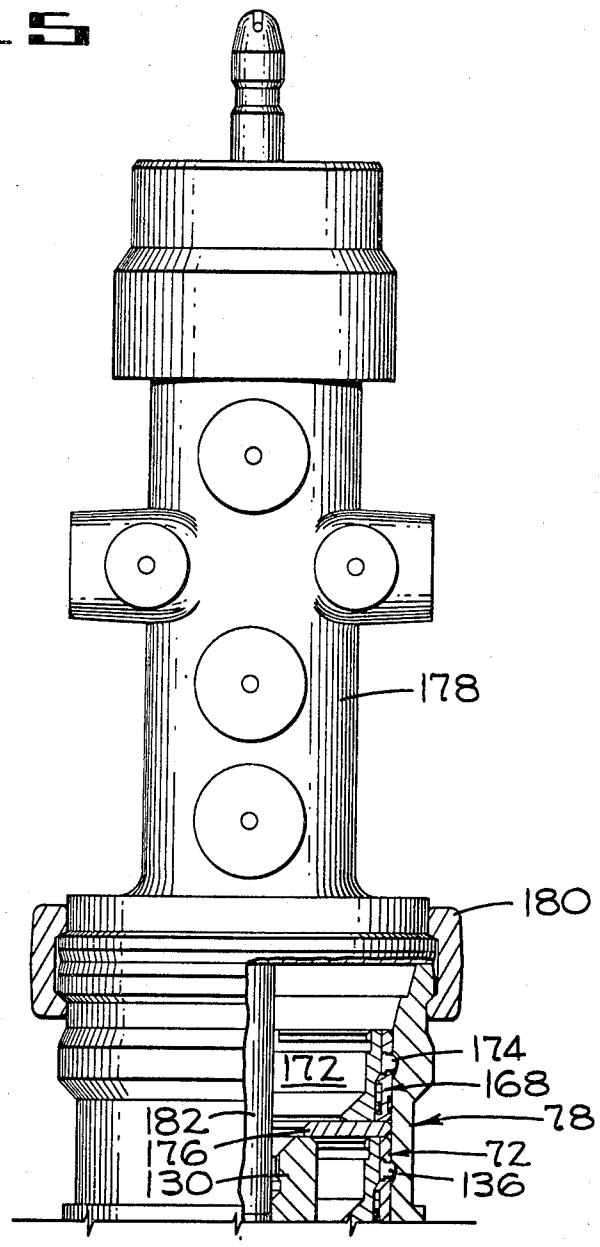
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UNDERWATER WELL COMPLETION SYSTEM

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FIG_5



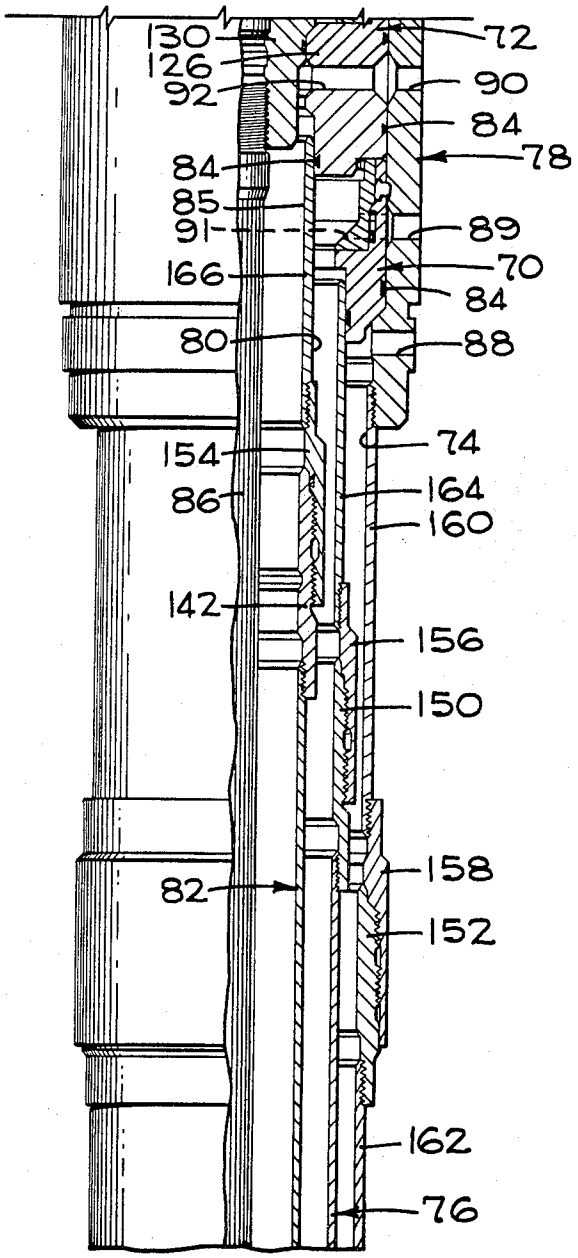

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UNDERWATER WELL COMPLETION SYSTEM

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FIG_6




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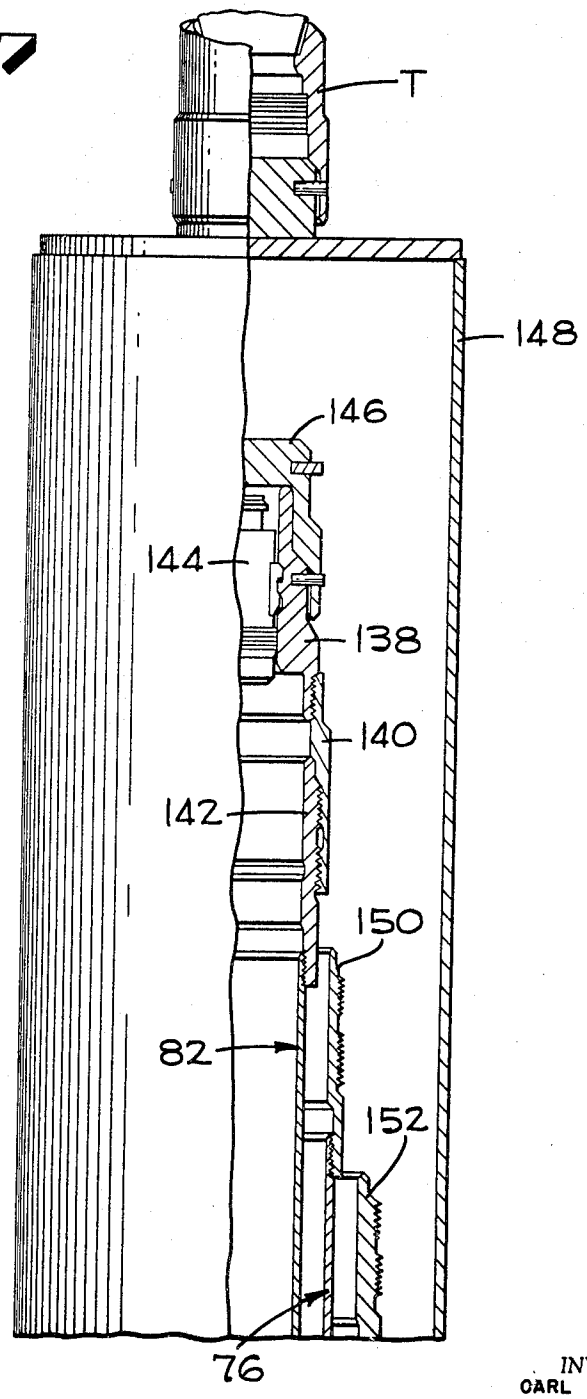
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FIG_7




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United States Patent Office 3,489,213 Patented Jan. 13, 1970



3,489,213

# UNDERWATER WELL COMPLETION SYSTEM

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Original application Nov. 8, 1966, Ser. No. 592,864. Divided and this application Apr. 18, 1968, Ser. No. 739,593

Int. Cl. E21b 7/12, 15/02

U.S. Cl. 166—.5 4 Claims

## ABSTRACT OF THE DISCLOSURE

A method of completing an underwater well which has several casings already suspended therein involving landing a wellhead on an outer casing, adding a length of casing to the next inner casing so that its top is in the wellhead, installing sealing means between these two casings, repeating the steps of adding lengths of casing to serially inner casings and installing serially inner sealing means. Tubing is landed in the wellhead and a Christmas tree is then coupled to the tubing and to the wellhead.

This application is a division of applicant's co-pending application Ser. No. 592,864, filed Nov. 8, 1966, now abandoned, and entitled "Underwater Well Completion System."

This invention pertains to a system for completing an underwriter well. More specifically, this invention relates to a method for completing underwater, and entirely from a remote position, a well that has been drilled and cased with ocean-bottom suspension equipment, and to apparatus for use in carrying out this method.

Exploratory well drilling in off-shore locations has become a significant facet of the petroleum industry, and projections for the future indicate it will retain its importance in the world-wide quest for crude oil and natural gas. When an off-shore well is drilled for exploratory purposes and producible quantities of oil and/or gas are found, the well is either completed at that time or is abandoned, the latter usually on a temporary basis with the thought of reentry and completion, at a later date. An increasing number of off-shore wells are being drilled and cased with so-called ocean-bottom suspension (hereinafter referred to as OBS) equipment designed for suspending the casing at the ocean floor and then completing the well at the surface, for in many instances this procedure has been found desirable over other techniques for underwater well drilling, the chief one being cost.

When OBS wells are temporarily abandoned, all of the risers between the ocean floor and the surface are removed, to be replaced later when the well is completed at the surface. Such replacement can involve problems, especially in areas where weather and water conditions are apt to be uncertain and thus unsafe for diver assistance. Furthermore, when divers must be used the depth of the water is a limiting factor, even though all other conditions might be ideal. Other problems arise when an operator uses OBS equipment and then decides to complete the well at the bottom of the water, for this equipment is not designed for bottom completions.

Accordingly, a general object of this invention is to provide a new system for completing underwater wells drilled and cased with OBS equipment.

Another object of this invention is to provide a new method for underwater completion of wells drilled and cased in the OBS manner, and then temporarily abandoned.

Another object of this invention is to provide a new method for completing OBS wells at the floor of the ocean or other body of overlying water entirely by remote control from the surface.



Still another object of this invention is to provide improved apparatus for completing wells drilled and cased with OBS equipment.

A further object of this invention is to provide an improved casing packoff that can be run and set by remote control from the surface without the assistance of divers or use of hydraulic equipment.

A still further object of this invention is to provide an improved type of casing packoff that can be run and set in a remote location and then retrieved therefrom, all with conventional drilling equipment.

These and other objects and advantages of the present invention will become apparent from the following description, taken with the accompanying drawings, in which:

FIGURE 1 is a view in side elevation and partially in section of the body of a casing packoff according to this invention;

FIGURE 2 is an enlarged fragmentary view in side elevation and in section of the packoff body of FIGURE 1 and its mandrel, after it has been landed in an outer housing but before it is locked in place;

FIGURE 3 is a view like FIGURE 2, showing the packoff locked between the outer housing and an inner casing;

FIGURE 4 is a view in side elevation and partially in section of a type of wellhead that can be used in practicing this invention, installed on a well casing and with two packoffs of this invention locked in position between the wellhead and an inner casing string;

FIGURE 5 is a view in side elevation and partially in section, on a reduced scale, of the upper portion of the wellhead of FIGURE 4 together with a Christmas tree installed on its upper end;

FIGURE 6 is a view in side elevation and partially in section of the lower portion of the wellhead of FIGURE 5, showing the connections between it and the several casing strings; and

FIGURE 7 is a view similar to FIGURES 5 and 6, showing the same well as it appeared when temporarily abandoned and before completion had begun according to this invention.

Broadly considered, the method of this invention comprises (a) running and landing a unitized wellhead on an outer casing string of the underwater OBS well at the general level of the floor of the body of water overlying the well; (b) extending the first inner casing string adjacent the outer string into the wellhead; (c) packing off the annulus between the wellhead and the first inner casing string; (d) repeating steps (b) and (c) on all remaining inner casing strings, in consecutive order from the outermost to the innermost; (e) running at least one production tubing string and landing it in the wellhead; and (f) running and landing a Christmas tree onto the wellhead and connecting it to the production tubing. Using apparatus of the type described later, this method can be carried out entirely by remote control from the surface without diver assistance, and thus the depth of the water overlying the well is not a limiting factor. Furthermore, although this method has been devised primarily for underwater completion of OBS wells that have been temporarily abandoned, it also can be employed to complete new OBS wells, i.e. those that have been drilled and cased, yet not abandoned.

As the drawings illustrate, the apparatus for carrying out this invention comprises a selection of connectors, casing extensions, landing subs and adapters, casing packoffs, production tubing, a tubing hanger, a hanger holddown, a unitized or integral wellhead, and a Christmas tree, all capable of assembly into a well-completion unit and attachment to an underwater well at a sub-surface

ɔcation entirely by remote control. These various elements are connected to the well and to one another by manipulation of conventional well drilling equipment, articularly drill pipe and running tools, thereby obviating ıe need for special devices or techniques.

The packoffs used in this completion system are especially significant, both in the manner in which they are un and set, and in their cooperation with the wellhead ɔ provide access to the annuli between the casing strings or pressure monitoring. FIGURES 1–3 illustrate one ɔrm of this type of packoff, and FIGURES 4–6 illustrate vo additional forms, all of these forms embodying the ame principles of locking and sealing. Perhaps these perations can best be explained by a description of the ackoff of FIGURES 1–3, it being understood that the ame procedures are followed with the other packoffs of 'IGURES 4–6.

As illustrated in FIGURES 1–3, the packoff **10** comrises a generally elongated tubular body **12**, a tubular ıandrel **14** slidably circumscribed by the body **12**, and plurality of locking dogs **16** slidably positioned in ports **8** that extend through, and are circumferentially spaced round, the body **12**. The inner or bore surface **20** of the ody **12** contains an upper annular groove **22**, a lower anular groove **24**, and an intermediate shoulder **26**, the houlder **26** being of equal diameter with the aforesaid ore surface **20**. A plurality of axially extending slots **28** xtend through the shoulder **26** and form a passageway etween the groove **22**, **24**, and tangentially adjacent the xtensions of the sides of the slots **28** are a plurality of adially inward projecting stop pins **30** and **32** (FIG. 1), he pins **30** tangentially adjacent an upward extension of ıe right-hand side **28***a* of the slots **28** when the body is iewed in its conventional upright position, and the pins 2 tangentially adjacent a downward extension of the ɛft-hand side **28***b* of the slots **28**. As will be described ater, these grooves, slots, and pins cooperate with the ıandrel **14** in running and setting, and also in retrieving, he packoff.

As shown in FIGURES 2 and 3, the mandrel **14** has an pper locking section **40** with an outer surface **42** and an ıner annular groove **44**, a lower section **46** of smaller utside diameter than the locking section **40** and with a lurality of ears **48** projecting radially outward from its xternal surface **50**, and an intermediate section **52** with n upwardly and outwardly extending camming surface 4.

When the body **12** and the mandrel **14** are assembled ı the unlocked condition (FIG. 2), i.e., the condition ı which the packoff **10** exists as it is being run into or etrieved from a well, the lower section **46** of the mandrel 4 opposes the locking dogs **16**, and the ears **48** extend ıto the upper groove **22** in the body **12**. From this conition the packoff **10** can be set in a housing **56**, such as unitized wellhead of the type disclosed in the copending V. L. Todd U.S. patent application, Ser. No. 446,788, iled Apr. 2, 1965, now Patent No. 3,299,958 and assigned ɔ the same assignee as the instant application, by rotating he mandrel **14** to the right (i.e., clockwise when viewed rom the top) until the ears **48** contact the stop pins **30**, owering the mandrel until the ears **48** pass downward hrough the slots **28** into the lower groove **24** (FIG. 3), nd then rotating the mandrel further to the right until he ears **48** come to rest against the stop pins **32**. As the ıandrel **14** moves downwardly in the body **12**, the camıing surface **54** forces the locking dogs **16** radially outvard until they project through the ports **18** into an anular groove **58** in the housing **56**, locking the packoff 0 into this housing **56**.

As is readily apparent from the foregoing description, he packoff **10** is mechanically run and set, and thus there s no need for hydraulic lines or other cumbersome or xpensive manipulating means. A plurality of axially exending slots **60** in the upper end of the inside surface of he mandrel **14** provide access for pins on a conventional -type running tool (not shown) to the groove **44**, facilitating installation and retrieval of the packoff **10** by such a tool and a drill string (not shown) to which it can be attached.



The locking dogs **16** serves to lock the packoff **10** in its housing against upward movement, the packoff body **12** being landed on a shoulder or other stop means **62** that prevents further downward movement of the device. Inner and outer annular resilient packing members **64** and **66**, respectively, which can be single units as shown or a plurality of units, provide a pressure tight seal between the packoff, an inner casing string **68**, and the outer housing **56**, respectively.

As illustrated in FIGURES 4–6, the cross-sectional configuration of the packoffs correspond to the configurations of the various housings into which they are set, and with the various well tools that they might support or that might support them. For example, they can be shaped like the two packoffs **70** and **72**, shown best in FIGURE 4, which are designed for use in a unitized wellhead such as that described in the aforementioned Todd application. As is readily apparent, the packoff **70** seals the annulus **74** between the unitized wellhead **78** and the first inner casing string **76**, which could be the protection string, and the packoff **72** seals the annulus **80** between the wellhead **78** and the next inner casing string **82**, which could then be the oil string. This sealing is effected through inner and outer packings diagrammatically illustrated at **84**, it being understood that these packings **84** can be singular or plural, and of other configurations, all as desired.

In order to be able to monitor the pressure in the annuli **74**, **80**, and **85**, the latter being located between the second inner casing or oil string and the production tubing **86**, lateral ports **88**, **89** and **90** are provided in the wellhead **78**, and similar ports **91** (indicated by dotted lines) and **92** in the packoffs **70**, **72**, respectively. The ports **91**, **92** in the packoffs **70**, **72** do not have to be coaxial with the ports **89**, **90** in the unitized wellhead **78**, since the wellhead is provided with annular grooves **94**, **95** that extend circumferentially and thus permit continuous fluid circulation between the ports **90**, **92** and **89**, **91**, regardless of orientation of the packoffs **70**, **72**. Another circumferential groove **96** in the packoffs **72** cooperates with the groove **95** to provide a larger passageway between the ports **90**, **92** to accommodate fluids that might flow into or out of the annulus **85**. Although they are not shown, conventional pressure or fluid conducting lines are attached to the outer ends of the ports **88**, **89**, **90** before the wellhead **78** is run.

As is shown best in FIGURE 4, both packoffs **70**, **72** comprise bodies, mandrels, and locking dogs which cooperate with each other just as do their counterparts in the packoff **10**. In packoff **70**, the body **98** has a lower shoulder **100** which serves to support the packoff in the wellhead **78** when it is landed on the wellhead's radially inward projecting seat **102**, and an upper radially inward projecting surface **104** which provides a stop and seat for the mandrel **106**. Except for a lower portion **108** that extends radially inward, thus providing a seat **110** upon which a well tool can be landed if desired, the mandrel **106** is shaped identically to the mandrel **14** in the packoff **10**, having ears **112** that cooperate with upper and lower annular grooves **114**, **116**, respectively, in the body **98**, and a camming surface **118** and a locking surface **120** that activate the locking dogs **122**, all in a manner analogous to the packoff **10**.

The body **124** of packoff **72** has a lower portion **126** shaped to accommodate the annular space between the wellhead **78** and the casing **82**, to provide a seat **128** for the production tubing hanger **130**, and to provide a sealing surface **126***a* for a seal **129** on the hanger **130**. However, the upper portion **132** of the body **124** is identical to the corresponding portion of the body **98** of the packoff **70**. The mandrel **134** and the locking dogs **136** are shaped identically to their counterparts **106**, **122**, respectively, of packoff **70**, so that the procedure for locking the

packoff **72** into the wellhead **78** is the same as that for locking packoff **70** in this wellhead.

For purposes of illustrating the method of completing an OBS well according to this invention, attention is directed to FIGURES 4–7 of the drawings. As a brief background preparatory to describing this method, after the well is drilled and cased with OBS equipment, the conductor pipe and all of the casing risers between the ocean floor and the surface are removed and, using a J-latch running tool T (FIG. 7), a temporary abandonment cap **138** attached to a landing sub **140** is connected to a landing adapter **142** that has been left on the end of the oil string **82**, a back pressure valve **144** is set in the cap **138**, a temporary abandonment cover **146** is installed over the cap **138**, and a corrosion cover **148** is then installed with a remotely controllable coupling (not shown) to the top of the conductor pipe (not shown) that extends into the ocean floor. As is evident from FIGURE 7, landing adapter **150** on the protection string **76** and landing adapter **152** on the intermediate string (not shown) are left in place when the well is abandoned. In the usual manner, each of the landing adapters **142**, **150**, and **152** have a pair of acme threads, one right-hand and the other left-hand, so that right-hand rotation breaks the connection between the adapters and the risers (not shown), and makes up the tie-back subs **154**, **156** and **158** (FIG. 6) into these adapters **142**, **150**, and **152**, respectively.

With the foregoing brief background, the method for completing the well now will be described. First the corrosion cover **148** is removed and a unitized wellhead, such as **78**, to which has been attached a casing extension or nipple **160** and tie-back sub **158**, is landed on the intermediate string **162** by making up the tie-back sub **158** into the landing adapter **152**. At this time, blow-out preventer equipment (not shown) and risers are installed to give total protection during the following completion procedure. The abandonment cover **146**, the back pressure valve **144**, and the abandonment cap assembly **138** and **140** are then removed in that order.

The protection string **76** (FIG. 6) is then extended into the wellhead **78** by an extension **164** that is connected to tie-back sub **156** which makes up into landing adapter **150** by right-hand rotation, and packoff **70** is then run and set between the wellhead **78** and the extended protection string **76**. At this time, the annulus **74** between the wellhead **78** and the string **76** can be pressure tested via the ports **89**, **91** to determine if a tight seal has been established by the packoff **70**.

The oil string **82** then is extended into the wellhead **78** with extension **166** and tie-back sub **154** that is made up into landing adapter **142**. Packoff **72** is run and set between the wellhead **78** and the extended oil string **82**, and pressure tested via ports **90**, **92** to assure that annulus **80** is sealed off.

The tubing string **86** with the tubing hanger **130** are run and landed on the seat **128**, and a back pressure valve (not shown) is then run and set in the tubing hanger **130**. The tubing hanger hold-down **168**, having a body **170** like the upper portions of the bodies of the packoffs **70**, **72**, a mandrel **172** identical to the mandrels **106**, **134** and locking dogs **174** also identical to the dogs **122**, **136**, is run and set into the wellhead **78** using the same J-type running tool (not shown) and technique employed with the packoffs **70**, **72**, the hold-down **168** landing on an annular hold-down ring **176** that transmits the holding force from the hold-down **168** to the tubing hanger **130**, securing it in place. A Christmas tree **178**, such as that disclosed in the Lebeaux et al. U.S. Patent No. 3,050,126, containing a tubing hanger stinger **182**, is landed on the wellhead **78** and then fastened to it by hydraulic or other remotely controlled couplings diagrammatically illustrated at **180**, completing the well.

It is to be understood that although the foregoing description and the drawings show somewhat specific types of well equipment, such as the subs, adapters, unitized head, Christmas tree, etc., the inventive method can of course be carried out with other tools and equipment that perform or function in the same manner. Thus, the inventive method is of broad scope in that it does not depend upon use of precisely the same equipment disclosed herein.

As is evident from the foregoing, the method of this invention can be carried out entirely by remote control from the surface of the water. However, it should be understood that if for some reason diver assistance is desirable, such assistance can be employed within the spirit of the invention. For example, the Christmas tree could be mounted on the wellhead with conventional clamp-type connections or with conventional flanges, and these connections made by a diver. Therefore, the invention encompasses both techniques.

Although the best mode contemplated for carrying out the present invention has been herein shown and described, it will be apparent that modification and variation may be made without departing from what is regarded to be the subject matter of the invention as set forth in the appended claims.

Having completed a detailed description of the invention so that those skilled in the art could practice the same, I claim:

**1.** A method for completing an underwater well by remote control from a surface location, said well having been drilled and cased with ocean-bottom suspension equipment, comprising the following steps:

(a) running and landing a wellhead onto an outer casing string of the well at a subsurface location,

(b) extending the first inner casing string adjacent said outer string into said wellhead,

(c) sealing off the annulus between the said wellhead and the said first inner casing string,

(d) repeating steps (b) and (c) on all remaining inner casing strings, in consecutive order from the outermost to the innermost,

(e) running and landing at least one production tubing string into the said wellhead, and

(f) coupling a Christmas tree to the said wellhead and tubing string,

the performance of each of said steps (a), (b), (c), (d), and (e) being diver unaided and with mechanical means controlled remotely from a surface location.

**2.** The method of claim **1** wherein the performance of step (f) is diver-unaided.

**3.** The method of claim **1** wherein the said well has been temporarily abandoned prior to beginning step (a).

**4.** The method of claim **1** wherein the said well is newly drilled and cased.

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U.S. Cl. X.R.

175—7