Nov. 22, 1966 R. L. CRAIN ETAL 3,287,030

HANGER HAVING LOCKING AND SEALING MEANS

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FIG.1.

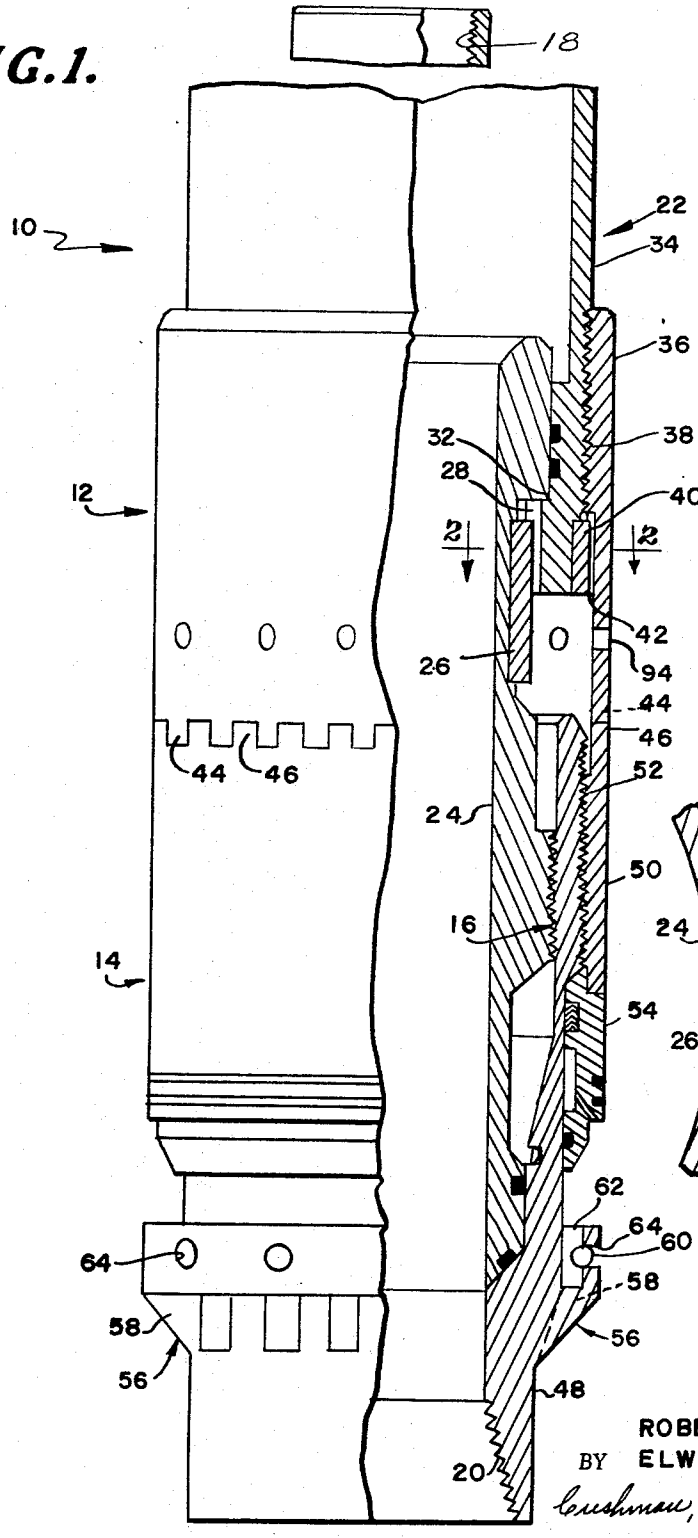


FIG.2.

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HANGER HAVING LOCKING AND SEALING MEANS

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FIG.3.

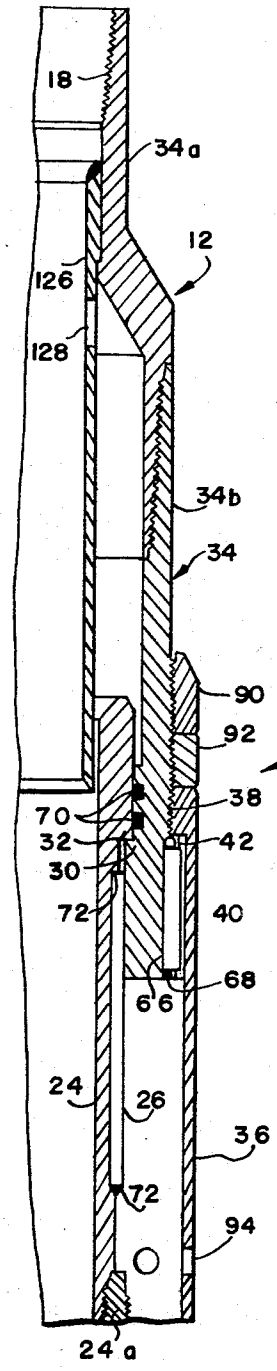
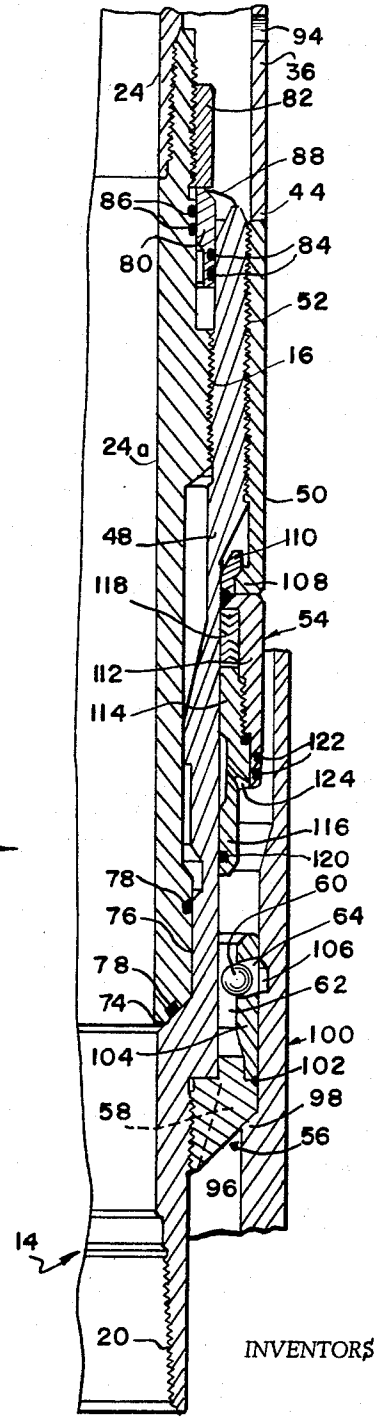


FIG.4.



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FIG.5.

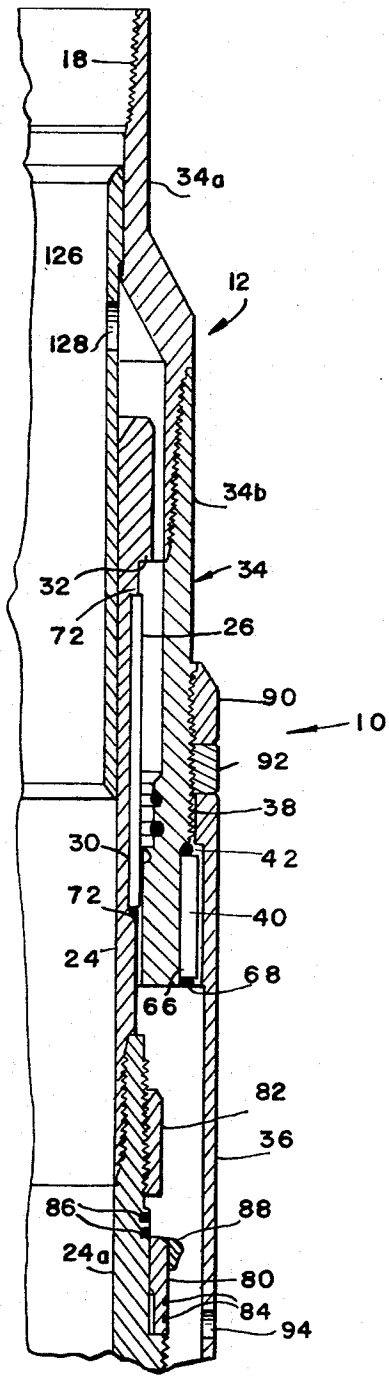
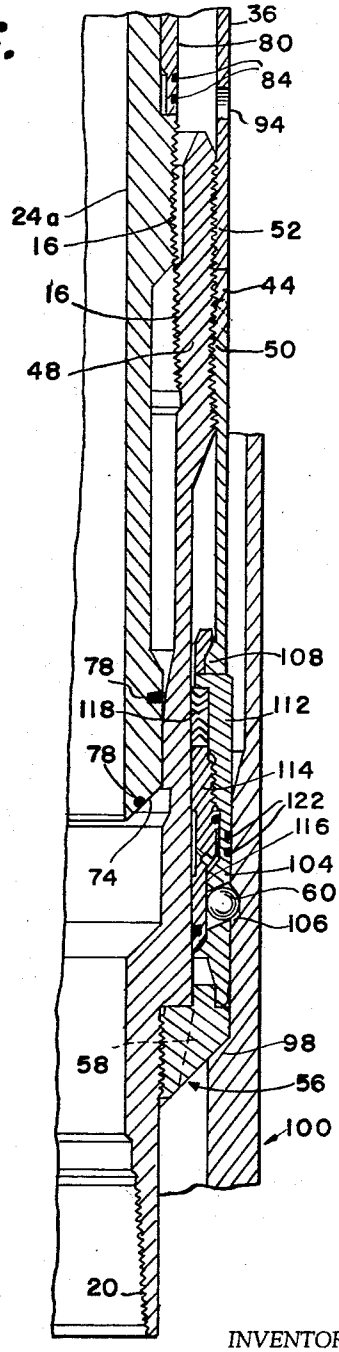


FIG.6.



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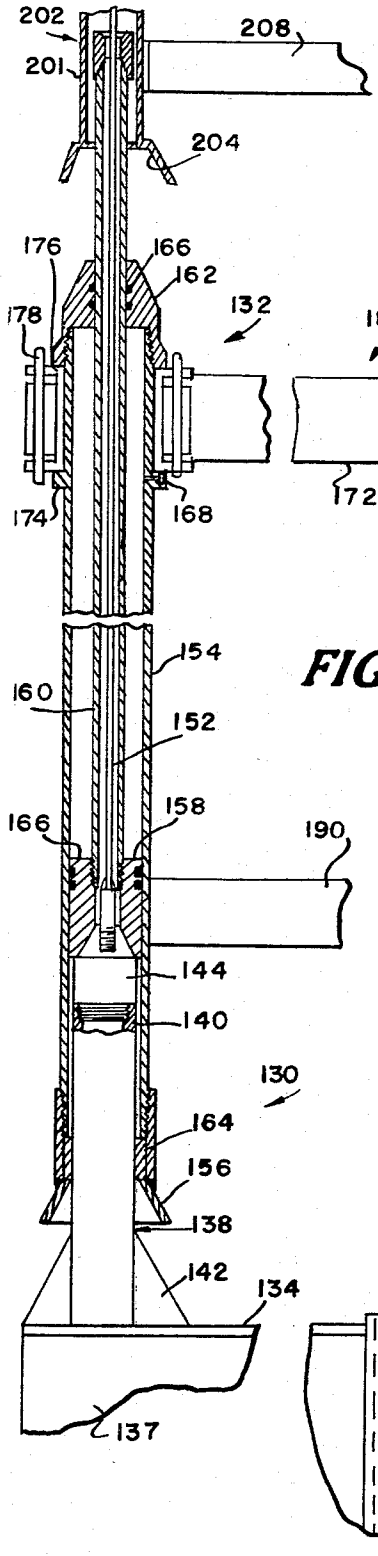


FIG. 7.

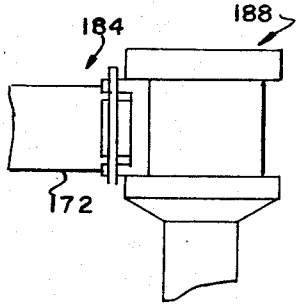
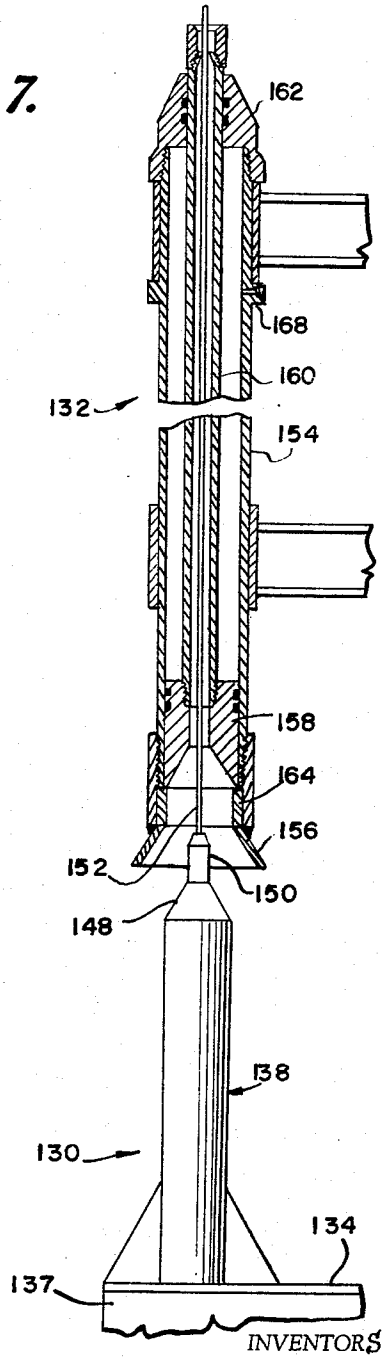


FIG. 8.



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FIG.9.

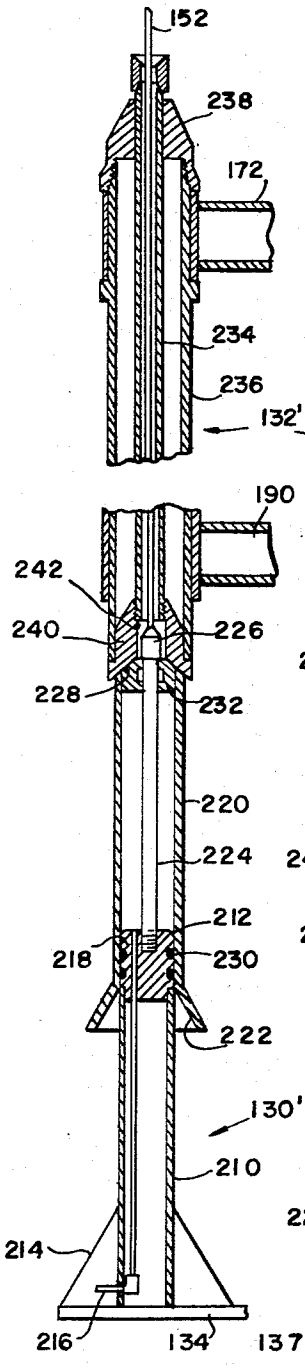


FIG.10.

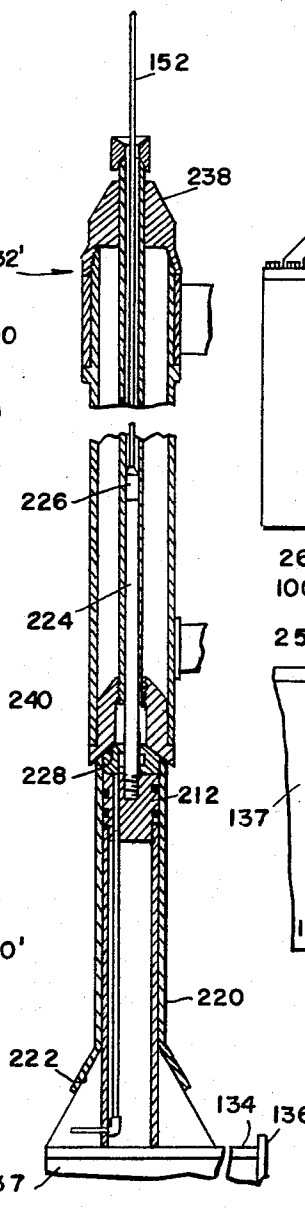
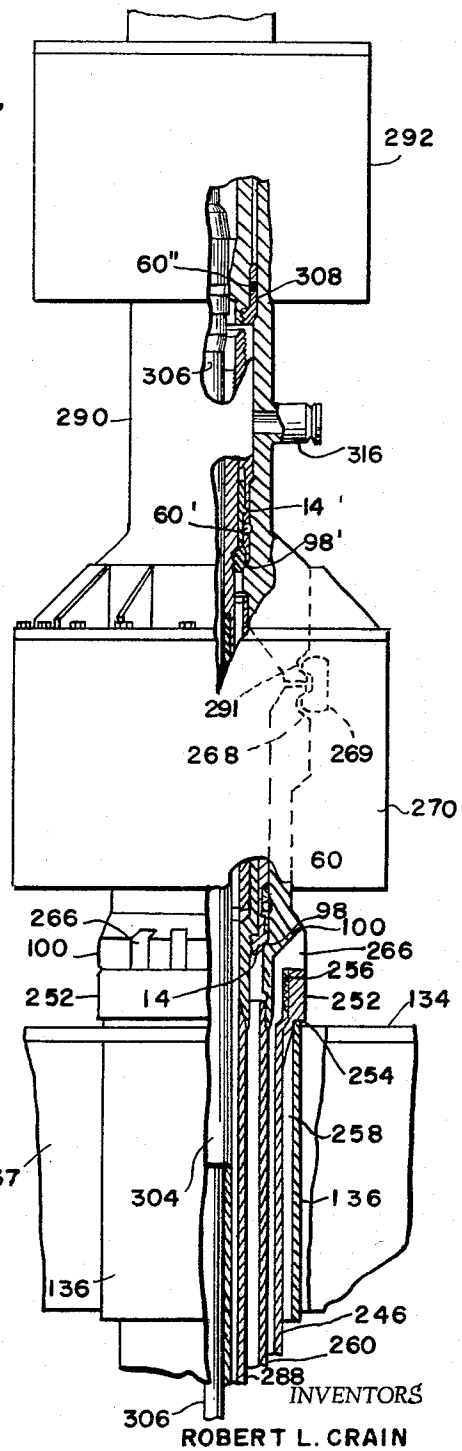


FIG.16.



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HANGER HAVING LOCKING AND SEALING MEANS

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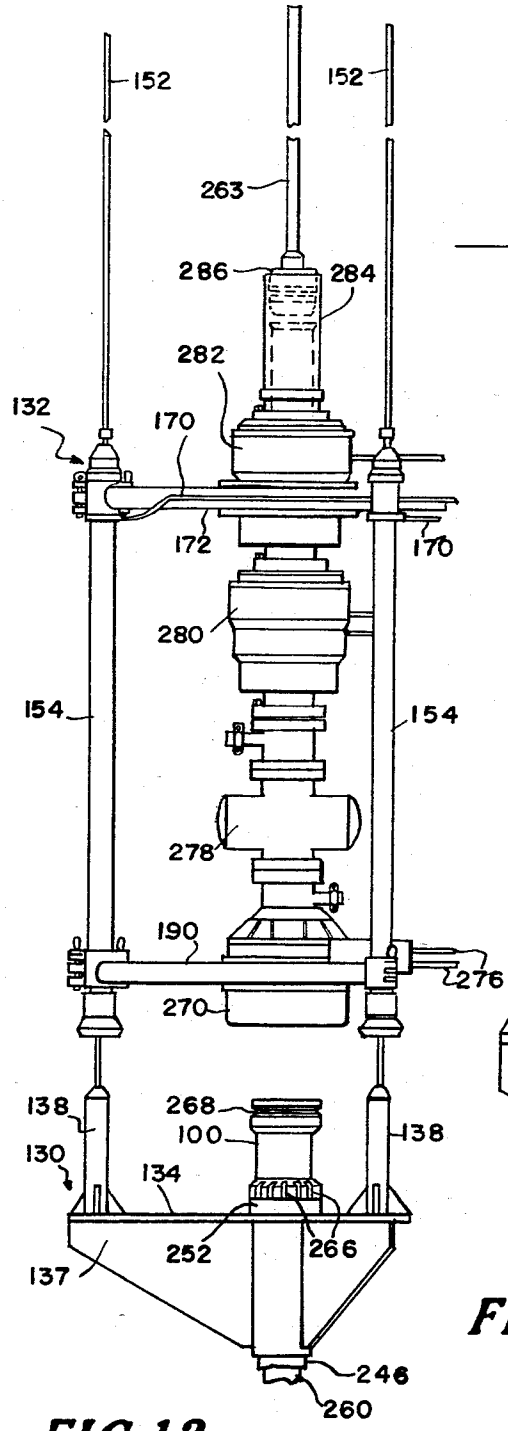


FIG.12.

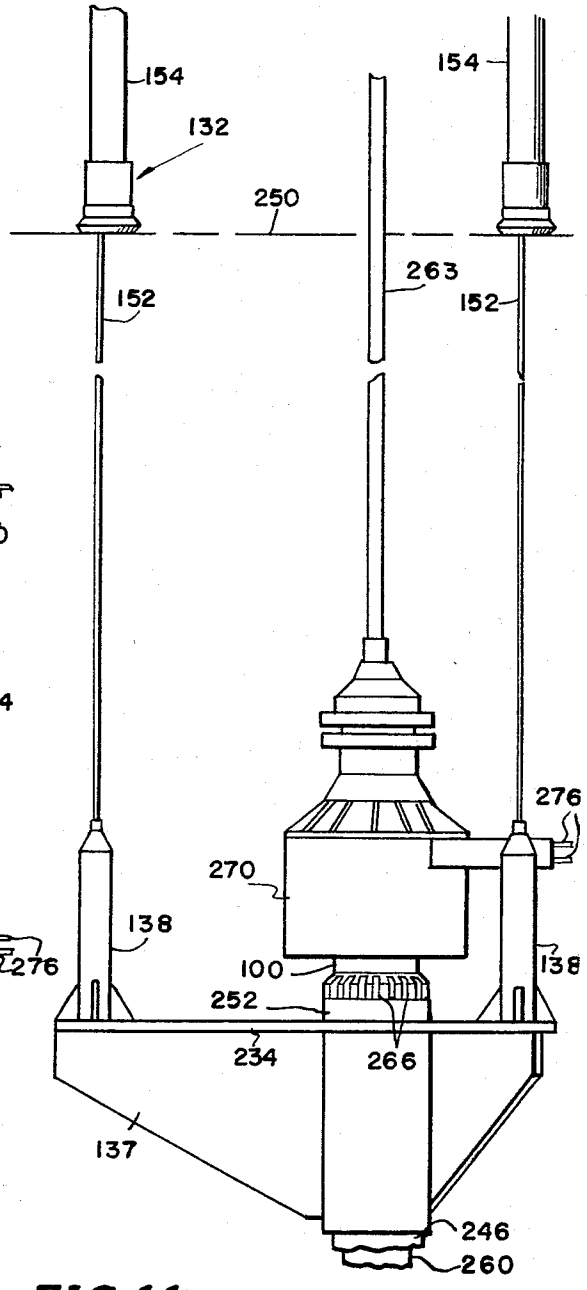


FIG.11.

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HANGER HAVING LOCKING AND SEALING MEANS

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FIG.14.

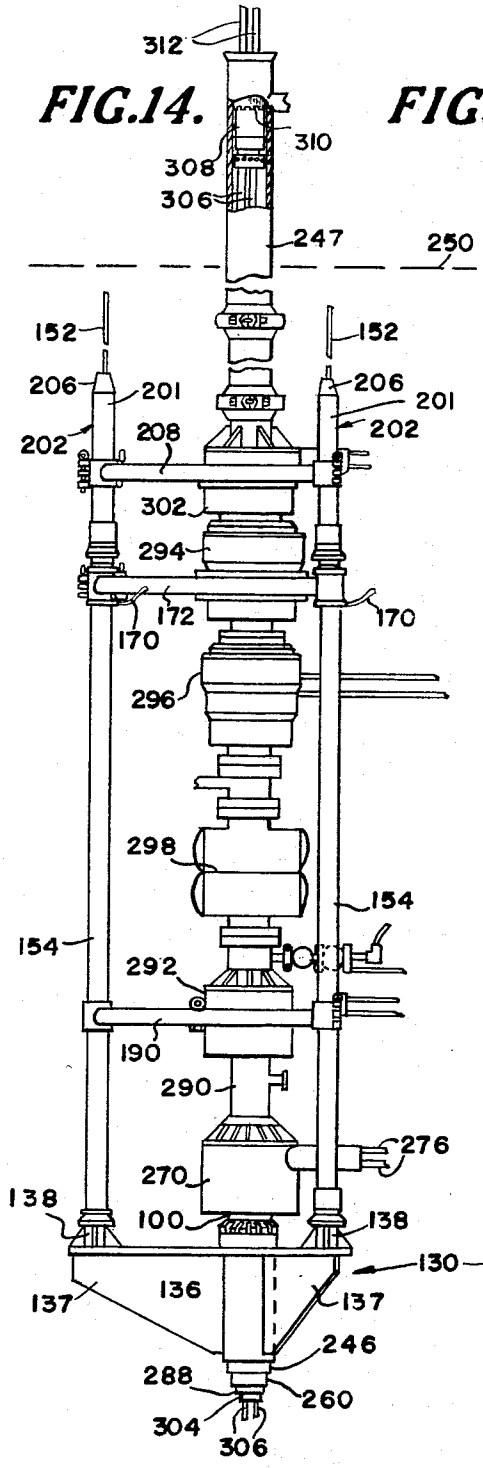
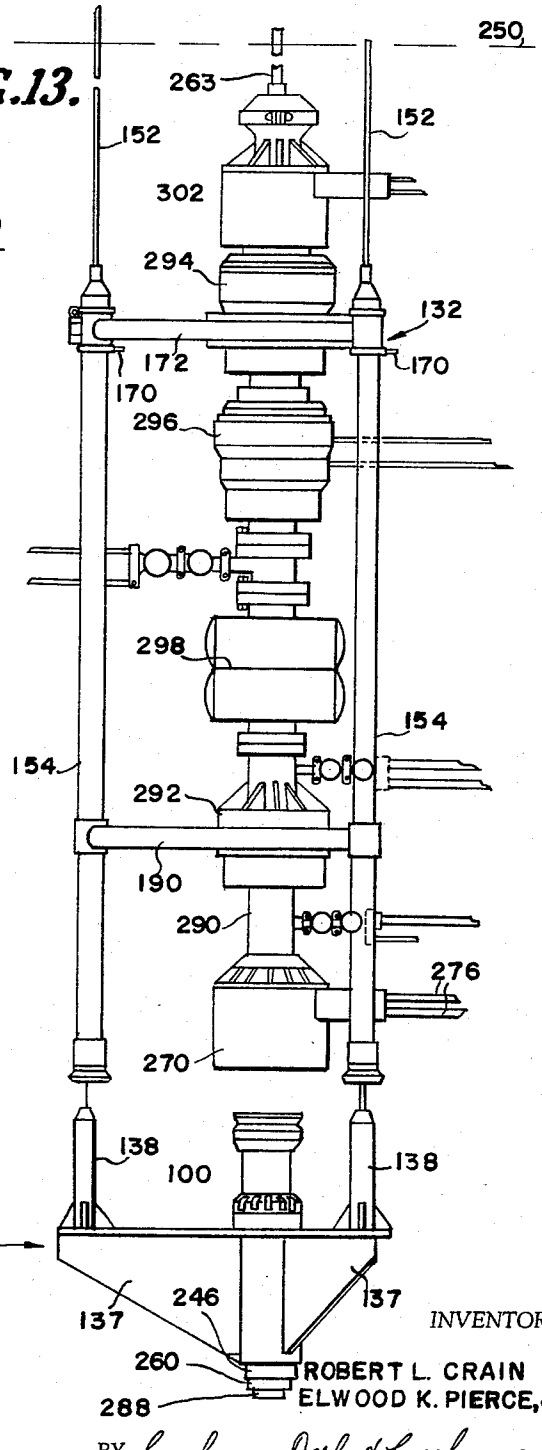


FIG.13.



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HANGER HAVING LOCKING AND SEALING MEANS

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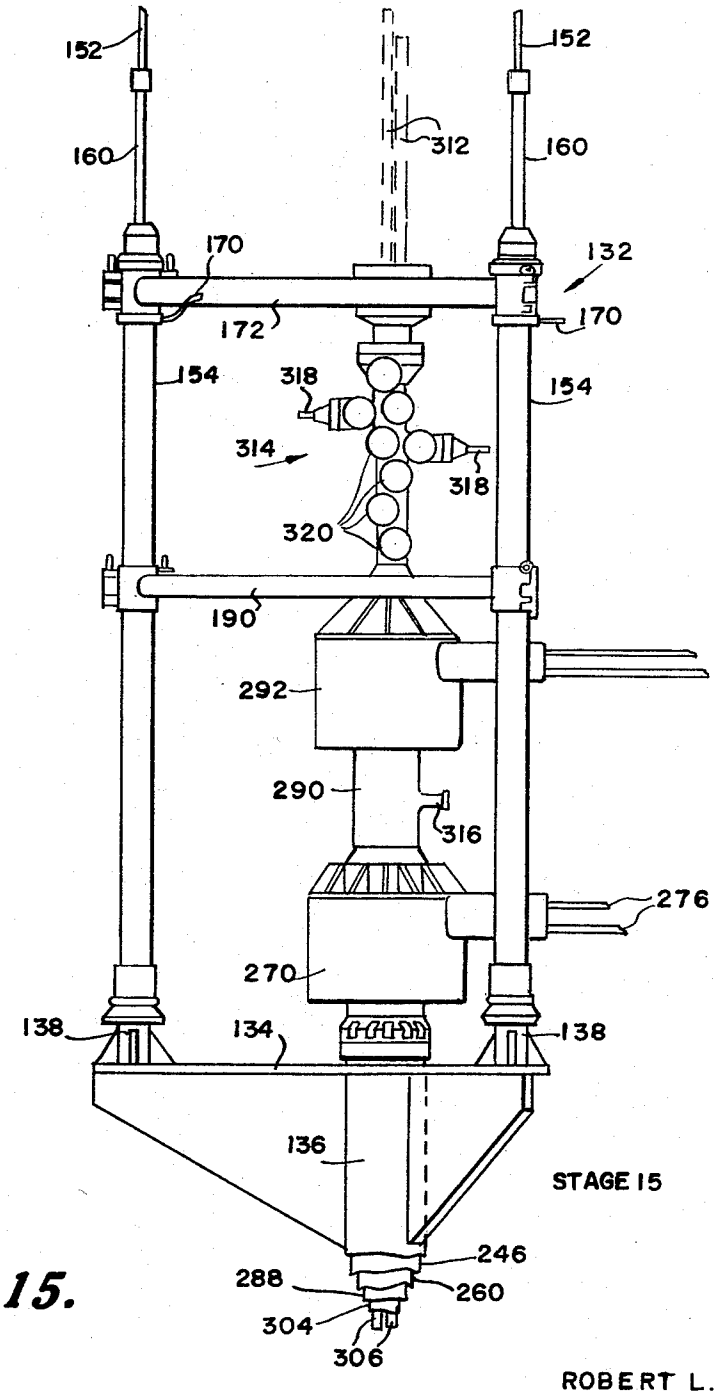


FIG. 15.

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United States Patent Office

3,287,030

Patented Nov. 22, 1966

3,287,030

HANGER HAVING LOCKING AND SEALING MEANS

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Filed Jan. 9, 1963, Ser. No. 250,262

6 Claims. (Cl. 285—18)

This invention relates to methods and apparatus for drilling and completing oil and gas wells and in particular to the hanging of casing and tubing strings and the installation of control equipment, casing heads and tubing heads during the construction of submerged wells.

It is one of the objects of the present invention to provide a novel hanger for a casing string or a tubing string and a novel setting tool which in combination with the hanger permits rapid and effective landing of the string, locking and sealing of the hanger to the bowl of its casing or tubing head and release of the tool from the hanger.

It is a further object of the invention to provide a hanger and tool assembly of the above type in which the tool subassembly is releasably connectable to the hanger subassembly and is adapted to coact therewith to land the hanger, to lock the hanger in the bowl of its head and to then disconnect itself from the hanger.

It is a further object to provide a hanger and tool assembly of the above type in which the hanger subassembly retains on its periphery a plurality of laterally movable latching elements and means for moving the elements outwardly into a recess in the bowl of a casing head or tubing head, the moving means being actuable by rotation of the tool subassembly.

It is yet another object to provide a hanger and tool assembly of the above type in which the tool subassembly includes a body member and a sleeve member which is rotatable by the body member and longitudinally movable with respect thereto and wherein the sleeve threadedly engages the hanger subassembly and is releasable therefrom by rotation of the tool assembly.

These and other objects and advantages will become apparent from reading the following brief and detailed descriptions taken with the drawings in which:

FIGURE 1 is a simplified elevational view, partly in section, of a tool and hanger assembly embodying the principles of the present invention;

FIGURE 2 is a sectional view on the line 2—2 of FIGURE 1 illustrating the manner in which the sleeve portion of the tool subassembly cooperates with the body portion of the tool assembly;

FIGURE 3 is a fragmentary elevational sectional view of the upper portion of a practical form of the tool and hanger assembly of FIGURE 1;

FIGURE 4 is a fragmentary elevational view of the lower portion of the device of FIGURE 3;

FIGURES 5 and 6 are views similar to FIGURES 3 and 4 showing the hanger subassembly locked to its seat and the tool subassembly disconnected from the hanger subassembly;

FIGURE 7 is a fragmentary elevational view, partially in section, of a hydraulic guide system embodying the principles of the present invention and showing the frame carrying member about to engage an upstanding post;

FIGURE 8 is a view of the apparatus of FIGURE 7 with the elements in engagement;

FIGURES 9 and 10 are views similar to FIGURES 7 and 8 of a modification of the hydraulic guide system of those figures; and

FIGURES 11–16 are elevational views illustrating some of the stages in the construction and completion of a submerged well using the equipment illustrated in FIGURES 1–8.

A tool and hanger assembly embodying the principles of the present invention is shown in simplified form in FIGURES 1 and 2 wherein, for the purposes of simplicity of illustration, some details have been omitted and the proportions have been modified so as to show an entire assembly in a single view. Detailed views of an actual assembly are shown in FIGURES 3–6.

The simplified tool and hanger assembly **10** of FIGURE 1 includes a tool subassembly **12** and a hanger subassembly **14** which are threadedly interconnected by left hand threads **16**. The upper and lower ends of the assembly **10** are interiorly threaded at **18** and **20**, respectively, so as to be connectable to the lower end of a drill pipe or the like at **18** and to the upper end of a casing string at **20**.

The primary elements of the tool subassembly **12** are a hollow cylindrical body **22** and an inner concentric sleeve **24** which extends out of the lower end of the body **22** and which is provided intermediate its ends with exterior circumferential threads forming part of the connection **16**. The sleeve **24** is keyed near its upper end to the inner circumference of the body **22** so as to be rotatable with the body **22** and at the same time be axially movable relative to the body **22**. As shown, a plurality of circumferentially spaced radial keys **26** are secured to the outer circumference of the sleeve **24** above the connection **16** and complementary keyways **28** are provided in the inner circumference of the body **22**. Axial movement of the sleeve **24** in a downward movement relative to the body **22** is limited by engagement of an inwardly extending shoulder **30** on the body **22** with a complementary shoulder **32** on the sleeve **24** near its upper end.

As shown, the body **22** of the tool subassembly **12** is constructed of two primary portions **34** and **36** which are threadedly interconnected at **38**. The outer circumference of the upper portion **34** is provided with a plurality of radial keys **40** which fit into complementary keyways **42** in the inner circumference of the lower portion **36**. The lower end of portion **36** is provided with a plurality of axially extending spaced teeth **44** which intermesh with complementary teeth **46** on the upper end of the hanger subassembly **14**.

The hanger subassembly includes, as primary elements, a cylindrical hanger body **48** adapted to seat in the bowl of a casing head an outer concentric sleeve **50** threaded thereto with right hand threads **52** and an outer ring **54** longitudinally slidable on the hanger body **48** below the hanger sleeve **50**. The exterior of the hanger body **48** is provided with an inwardly and downwardly tapered seat portion **56** which, as shown in the embodiment described, includes a plurality of circumferentially spaced, radial flutes **58**. According to the invention the hanger body **48** carries a plurality of latching balls **60** on its periphery. In the embodiment described the balls **60** reside in an annulus **62** which is formed by the upper portions of the flutes **58** and are movable through lateral channels **64**.

Briefly, the operation of the tool and hanger assembly **10** in landing a string of casing is as follows. The assembly **10** is threaded at **20** onto the upper end of the last section of the string of casing which is to be landed in a casing head. The upper end of the assembly is threaded at **18** onto the lower end of a drill pipe. By means of a derrick the drill pipe is lowered so as to lower the casing string in the well to a point at which the seat **56** on the hanger subassembly **14** rests in the bowl of its casing head. The drill pipe is then rotated clockwise as viewed from the top. The body **22** of the tool subassembly **12** rotates with the drill pipe and effects rotation of the tool sleeve **24** through key and keyway **26**, **28** and of the hanger sleeve **50** through the intermeshing teeth **44**, **46**.

Since the threads at **16** are left hand and at **52** are right

hand, the clockwise rotation of the tool sleeve **24** and the hanger sleeve **50** tends to move the former upwardly and the latter downwardly with respect to the hanger body **48**. Downward movement of the hanger sleeve **50** forces the ring **54** downwardly into the annulus **62** thus forcing the balls **60** outwardly into an annular groove in the casing head (not shown). Rotation of the elements also causes the tool sleeve **24** to disengage the hanger body **48** along the threads **16**, the number of turns to accomplish this or the locking of the balls depending on the number of threads at **16** and **52**. The entire tool subassembly **12** may then be removed by raising the drill pipe while the hanger subassembly **14** remains locked in the casing head.

Referring to FIGURES 3–6 there is shown therein a detailed practical construction for the simplified tool and hanger assembly **10** of FIGURES 1 and 2. Like numerals in FIGURES 3–5 and in later figures are used to designate the same or corresponding elements which are shown in FIGURES 1 and 2. The subassemblies **12** and **14** in FIGURES 3 and 4 are shown in the same relative position as those in FIGURE 1. In FIGURES 5 and 6 the tool subassembly **12** has been rotated in a right hand direction to set the balls **60** and to disconnect the threads **16** between the subassemblies **12** and **14**.

As shown in FIGURE 3 the cylindrical body of the tool subassembly **12** may be constructed of several pieces threadedly connected at their ends. In the construction illustrated the upper portion **34** of the body consists of two coaxial parts **34***a* and **34***b* which are threadedly interconnected. The part **34** is of somewhat larger diameter so that the inner concentric sleeve **24** may move upwardly without obstruction. The upper end of the part **34***a* is provided with the internal threads **18** by which the entire assembly may be connected to the lower end of a drill pipe or the like. The lower end of the part **34***b* is provided with the inner annular shoulder **30** having the vertical keyways **28** therein. The vertical keys **40** extending outwardly from the lower end of part **34***b* are set into slots **66** and are welded in place as at **68**. A pair of vertically spaced annular seals **70** is provided above the shoulder **30** for sealing with the upper periphery of the sleeve **24**.

The sleeve **24** is provided with vertical slots below the shoulder **32** into which the outwardly extending keys **26** are welded as at **72**. The lower portion **24***a* of the sleeve (FIGURE 4) terminates in a depending annular seating portion having an outer surface **74** whcih is tapered downwardly and inwardly and a vertical surface **76** each of which is provided with an annular sealing element **78**.

Above the seating portion the sleeve portion **24***a* is provided with an outer ring **80** which is vertically movable between the upper extremity of the threads **16** and a fixed collar **82**. The outer surface of the ring **80** intermediate its ends is provided with two spaced annular sealing elements **84** which are engageable with the hanger body **48** and the sleeve portion is provided with two spaced sealing elements **86** which are engageable with the ring **80**. A relatively large annular sealing element **88** such as a molded rubber element is secured to the upper periphery of the ring and extends outwardly therefrom for engagement with the top of the hanger body **48** in the FIGURE 3 position of the sleeve **24**.

The lower portion **36** of the tool subassembly **12** is threaded to the exterior of the part **34***b* at **38** immediately below two fixed collars **90**, **92** and extends downwardly to terminate in the axially extending teeth **44**. The inner vertical keyways **42** cooperating with the keys **40** on the tool body **34** are provided immediately below the threads **38**, and below the keyways **42** are a plurality of circumferentially spaced, radial circulating ports **94**.

The hanger body **48**, as seen in FIGURE 4, consists of three basic parts which have been secured together. Above the threads **20**, by which a casing string may be attached, the annular, radially extending seat portion **56** is threaded onto the body proper **48** and welded as at **96**. The seat portion is a ring-like element having the radially extending spaced flutes **58** formed integrally therewith and tapered downwardly and inwardly to form a seating surface engageable with a complementary tapered seat **98** on the interior of a structure **100**, such as a casing head, from which the hanger is to be suspended. To the top of the seat portion **56** is welded as at **102** an upstanding flange **104** which is spaced from the body **48** to form the ball-retaining annulus **62**. The balls **60**, as described above, are movable through the lateral passages **64** into a circumferential recess **106** in the suspending structure **100**.

The hanger sleeve **50** which is threaded to the hanger body at **52** terminates at its lower end in a small inwardly extending flange **108** which slidably engages under a flanged ring **110**. The ring **110** is welded to the top of another ring element **112** which in turn is threaded over a ball-setting member **114** having depending annular portion **116** which is insertable into the ball-retaining annulus **62**. The elements **110**, **112** and **114** correspond to the element **54** in FIGURE 1 and are vertically slidable as a unit on the outside of the hanger body **48**, seals **118** and **120** being provided therebetween to prevent leakage. The exterior of the element **112** is provided with annular seals **122** for engagement with the suspending structure **100** and the element **116** is provided with a test port **124**.

The hanger and tool assembly **10** is also provided with a fixed inner guide sleeve **126** secured near its upper end to the tool body **34** and extending downwardly to below the upper end of the movable tool sleeve **24**. Circulation ports **128** are provided radially through the sleeve near its upper end.

Referring now to FIGURES 7 and 8 there is shown therein an embodiment of a hydraulic guide apparatus for accurately controlling the movement of well head equipment when in close proximity to the well head. The apparatus comprises basically two subassemblies: a guide base **130** which is fixed and a telescoping section **132** which carries the equipment and which is movable with respect to the first.

As shown, the fixed guide base **130** includes a generally triangular, flat support plate **134** (see also FIGURES 11–15) having a central aperture therethrough in which is secured a sleeve member **136** which may be a short length of large diameter casing. Three vertical radially extending reinforcing plates **137** are secured as by welding to the sleeve **136** and to the lower surface of the support plate **134**. An upstanding, cylindrical guide post **138** is fixed to the support plate **134** near each apex thereof. As shown, each guide post **138** includes a hollow cylindrical portion **140** having external stop members **142** at the base thereof which are tapered downwardly and outwardly. The top of the cylinder **140** is closed with a threaded plug **144** which is tapered upwardly and inwardly at its upper end **148**. An upstanding pin **150** is threaded axially into the top of the plug **144** and is secured to a guide cable **152** which extends to the surface of the water when the guide base **130** is in its operative position.

The movable, telescoping section **132** includes three cylinders **154** each of which has a flared lower end **156** adapted to seat on the stop members **142**. Within each cylinder **154** is a piston **158** having an axial bore therethrough which is contoured at its lower end to seat on the tapered upper end **148** of the associated guide post **138**. A tubular piston rod **160** through which the guide cable **152** passes is secured to the upper end of the piston **158** and extends upwardly through a cap **162** which closes the upper end of the cylinder **154**. Downward movement of piston **158** within the cylinder **154** is limited by an annular stop **164**. Suitable seals **166** are provided between the piston and cylinder and between the piston rod and cap. The cylinder **154** is provided with a fitting **168** which is

suitably tapped for receiving a hydraulic pressure line **170** (FIGURE 12).

In order to support equipment which is to be carried by the guide system three horizontal crossheads **172** are associated with the cylinders **154**. As seen in FIGURE 8 a wide annular groove is formed near the top of each cylinder **154** between the cap **162** and a flange **174**. A split sleeve **176** having its halves secured together by a vertical pin **178** resides in the groove and is secured to one end of a crosshead **172** by a pin arrangement indicated at **180**. The other end of the crosshead is pinned to one of the other cylinders **154** in a like manner. Intermediate its ends each crosshead **172** is provided with a pin arrangement **184** which cooperates with a complementary structure secured to the equipment **188** which is thereby supported by the crossheads **172**. A set of lower crossheads **190** similar to the crossheads **172** is secured to the cylinders **154** by pin arrangements **192** and to the equipment by pin arrangements **186**. The split sleeve portions of these lower crossheads **190** are vertically adjustable on the cylinders **154**.

If necessary or desired, an auxiliary guide section **202** may be provided in the form of relatively hollow posts **201** the bores of which are tapered at their lower ends **204** to mate with the caps **162** of the cylinders **154**. The upper ends **206** (FIGURE 14) of the posts are tapered upwardly and inwardly so as to receive another similar post if desired. Each set of posts **202** is provided with crossheads **208** which, like the crossheads **190**, are vertically adjustable.

Referring to FIGURES 9 and 10 there is shown a modified hydraulic guide system in which the piston is incorporated into the fixed guide base **130'** rather than into the telescoping section **132'** as in the previously described embodiment. As shown the triangular support plate **134**, the sleeve **136**, and the reinforcing plates **137** are identical with those already described. Fixed to the plate **134** near each apex is an upstanding cylinder **210** having its upper end closed with a fixed piston **212** and having downwardly and outwardly tapered stops **214** at its lower end. A hydraulic pressure line **216** passes through the wall of the fixed cylinder **210** and connects with an eccentric vertical passage **218** in the piston **212**.

Vertically slidable over the piston **212** and fixed cylinder **210** is a movable cylinder **220** which has an outwardly flared lower end **222** adapted to seat on the stops **214**. A fixed, axial piston rod **224** is secured at its lower end to the top of the piston and extends upwardly through the movable cylinder **220** where it terminates in a knob **226** which serves as a stop to limit upward movement of the cylinder **220**. A guide cable **152** is secured to the knob **226** and extends upwardly to the surface. The upper end **228** of the cylinder **220** is tapered inwardly and upwardly to form a seat for the equipment-carrying portion of the guide system. Leakage into or out of the chamber defined by the piston **212** and the cylinder **220** is prevented by seals **230** in the periphery of the piston and a seal **232** in the top of the cylinder **220**.

The equipment-supporting portion of the guide system of FIGURES 9 and 10 consists basically of three hollow posts which carry crossheads and which are adapted to seat on the upper end of the cylinders **220**. As shown, each post is constructed of an inner and an outer concentric tube, **234** and **236** respectively. The upper end of the inner tube **234** passes through an upwardly and inwardly tapered cap **238** which is secured to the outer tube **236** and which provides a seat for additional supporting structure (not shown) identical to parts **202**, **204**, **206** and **208** in FIGURES 7 and 8. The lower end of the inner tube **234** is connected to a plug **240** which has a bore **242** of sufficient diameter to receive the piston rod **224**.

Each outer tube **236** is connected to equipment-supporting crossheads **172** and **190** in the same manner as the cylinder **154**. The actual connections between the tube **236** and the crosshead sleeves are illustrated schematically in FIGURES 9 and 10.

Specific example of use and operation of the apparatus

FIGURES 11–16 illustrate the use and operation of the above-described equipment in the construction and completion of a submerged oil well. In the particular procedure illustrated the well is drilled through a large diameter conductor pipe **246**, for example a 20 inch O.D. pipe, which is driven into a submerged bottom **248** from a floating or fixed platform at the surface. First, the guide base **130** of FIGURES 7 and 8 with its guide lines **152** attached is supported at about platform level which is illustrated at **250** in the drawings. The first section of conductor casing **246** with a conventional drive shoe (not shown) secured to its lower end is then lowered through the sleeve **136** of the guide base **130** and additional sections of conductor casing are joined in sequence, as by welding, to complete the conductor pipe **246**. When the shoe reaches the bottom **248** and the casing **246** is supported, the guide base **130** is lowered to the bottom by means of the guide cables **152**. As seen in FIGURE 16, the upper end of the last section of conductor casing **246** is provided with a head **252** defining a downwardly facing exterior shoulder **254** and coarse interior threads **256** for forming a releasable connection. Immediately below the head **252** the casing **246** is provided with vertically and radially extending centering guides **258**. The casing **246** is then driven into the bottom **248** in a conventional manner until the shoulder **254** rests on top of the sleeve **136** and the support plate **134**, the guides **258** having engaged the bore of the sleeve **136** during the last few feet of travel. As the casing **246** is driven, additional sections of casing are added by means of releasable couplings. After the casing **246** has been driven, the hole for the first string of casing to be suspended is drilled in conventional manner from the surface through the releasably connected sections and through the casing **246**, the former serving as the mud riser **247** (FIGURE 14).

When the hole has been completed, the lower end of the mud riser **247** is unscrewed from the threads **256** in the head **252** and is withdrawn to the surface. The lower end of a string of casing **260**, for example a 16 inch O.D. casing, is then attached to the crossheads **190** of the guide structure **132** at the surface, and the guide structure **132** is lowered by suitable lowering cables along the guide cables **152** to guide the lower end of the casing **260** into the conductor casing **246**. The telescoping guide structure **132** is then released from the casing **260** and raised to the surface.

As the casing **260** is run, a casing head **100** (see FIGURE 11 and also FIGURES 4, 6 and 16) for the next next string of casing is threaded onto the upper end of the last section of the casing **260**. The upper end of the casing head **100** is releasably connected to the lower end of a drill pipe **263** by means of a remotely operated coupling **270**. The casing head **100** and the casing **260** are then lowered by means of the drill pipe **263** until the head **100** rests on the head **252**, as seen in FIGURE 11. The lower portion of the casing head **100** is provided with circumferentially spaced, radial flutes **266** which communicate with the annulus between casings **246** and **260**. The upper portion of the casing head **100** has an external circumferential groove **268** (FIGURES 12 and 16) therein for engagement with a clamping element **269** in the coupling **270**. Intermediate its ends the head **100** is provided with the inner, downwardly sloping seat **98** (see also FIGURES 3–6) for receiving the hanger for the next string of casing, and above the seat **98** there is provided the circumferential recess **106** for receiving the locking balls **60** associated with the next-installed hanger.

The remotely controlled coupling **270** and other remotely controlled couplings **292** and **302** to be referred to later are preferably of the general type disclosed in

copending application Serial No. 128,174, Watts et al., filed July 31, 1961. It will be appreciated, however, that other types of couplings may be used if desired. It will be understood also that the various items of control equipment and other well completion equipment referred to herein may be interconnected by means of couplings of the type disclosed in Patent No. 2,766,829 rather than by means of the flange and bolt connections illustrated schematically in FIGURES 11–14.

When the casing head **100** has been landed on the head **252**, circulation may be established down through the casing **260** and up the annulus between it and the outer conductor casing **246**. The casing **260** is then cemented in place by pumping cement down casing **260** until the returns come out through the flutes **266**.

The coupling **270** is then released by operating its control lines **276** from the surface and is withdrawn by the drill pipe **263**. Blowout preventers are then assembled at the surface and are connected to the telescoping guide section **132** for lowering to the casing head **100**. As seen in FIGURE 12, three blowout preventers **278, 280** and **282** are connected to the top of the coupling **270**. The lower blowout preventer **278** may be of the blind ram type and the other two may be of the Hydril type, but any combination of blowout preventers and/or master drilling valves may be used, as known in the art and referred to herein. The upper preventers **282** and the coupling **270** are connected to the crossheads **172** and **190**, respectively, of the telescoping guide section **132**. The drill pipe **263** is releasably secured to the top of the upper preventer **282** by means of a conventional extension nipple **284** and a threaded adapter **286**, and the entire assembly is lowered by means of the drill pipe **263** along the guide cables **152** to a point at which the guide cylinders **154** engage the tops of the fixed guide posts **138**. FIGURE 12 shows the assembly just before the cylinders **154** engage the posts **138**.

The pistons **158** which are in the position shown in FIGURE 7 then assume the load of the blowout preventers **278, 280** and **282** and the last few feet of travel is controlled from the surface by gradually releasing hydraulic fluid from the cylinders **154** through the lines **170**. This operation transfers the preventer load from the drilling platform or barge to the foundation on the submerged bottom, eliminating the effect on the preventers of wave action and giving positive and acurate control at this critical moment. When it has been determined that coupling **270** is in contact, the controls for the same are actuated at the surface to join the preventer assembly to the casing head **100**.

When the preventer assembly has been connected, the drill pipe **263**, adaptor **286** and nipple **284** are disconnected and withdrawn. The mud riser **247** with another blowout preventer (not shown), for example, of the Regan type, at its lower end are lowered and connected to the upper blowout preventer **282**. Conveniently, the preventer at the lower end of the mud riser is connected at the water surface to the crossheads **208** of an auxiliary guide section such as is shown in FIGURE 8 so that the guide cables **152** assure proper alignment of the mud riser assembly with the upper blowout preventer **282**. When connection has been effected drilling for the next string of casing is performed through the mud riser assembly and the blowout preventers **282, 280** and **278**.

After a hole has been drilled using the drill pipe **263** and conventional procedures, the drill pipe **263** is withdrawn and the running of the next string of casing **288** is begun in a conventional manner. At the water surface the tool and hanger assembly **10** of FIGURES 1–6 is connected by means of the threads **20** to the top of the last section of the casing **288** and to the lower end of a string of landing casing (not shown) by means of the threads **18**. The landing casing is then lowered through the mud riser **247** until the exterior shoulder **56** on the hanger subassembly **14** engages the inner seat **98** on the casing head **100**. Ordinarily centralizers will be used during this step. Preferably, also, a long guide tube will be provided just below the assembly **10** so as to prevent hanging up on sharp shoulders that may be in the mud riser, the blowout preventers or the head **100**.

While the casing **288** is suspended from the drill pipe by means of the tool and hanger assembly **10** (see FIGURES 1–6) the load is transmitted from the casing **288** through the hanger body **48** across the left hand threads **16** to the inner hanger sleeve **24, 24***a*. From the hanger sleeve the load is transferred to the body **34** of the tool subassembly **12** by means of the complementary shoulders **30, 32** and thence to the landing casing through the threads **18**.

When the landing casing is lowered so as to set the shoulder **56** of the hanger body **48** on the seat **98**, the load of the landing casing will be transmitted through the threads **18** to the body **34** of the tool subassembly **12** and thence through the threads **38** to body portion **36**. From body portion **36** the load is transmitted through the teeth **44, 46** to the hanger sleeve **50** then through the threads **52** to the hanger body **48** and finally to the seat **98**.

In this position circulation can be established down through the casing **288**, up through the annulus between casings **288** and **260**, through the flutes **58**, past the balls **60** and into the mud riser back to the surface. In a similar manner the casing **288** is cemented by pumping cement down the landing casing. As described before, right hand rotation of the body portions **34** and **36** of the tool subassembly **12** causes the tool sleeve **24** to move upwardly and the hanger sleeve **50** to move downwardly as a result of the torque applied to these parts and as a result of the left hand and right hand threads at **16** and **52**, respectively. As will be understood the number and pitch of the threads at **16** and **52** will determine the relative magnitudes of movements. In the particular construction described the following sequence occurs.

Six revolutions raise the tool sleeve **24** to a position at which it no longer engages the seals **70**. Circulation may then be established down the drill pipe **263** through the guide sleeve **126**, past the seals **70** and out the ports **94** in tool body portion **36**. Sixteen revolutions disengage the left hand threads at **16** between the tool subassembly **12** and the hanger subassembly **14** so that, if desired, the former may be withdrawn to the surface.

Referring to FIGURE 6 at 18 revolutions the hanger sleeve **50** will have descended a distance sufficient to force the tip **116** of the ring **114** into engagement with the balls **60**. It is, of course, necessary to lower the landing casing during this operation in order to maintain the teeth **44, 46** in contact.

At 22 revolutions the balls **60** will have been forced through their channels **64** into the annular recess **106** in the casing head **100** thus locking the hanger body **48** in the latter. At the same time the sealing elements **122** will begin to engage a slightly tapered seat in the head **100** immediately above recess **106**. Twenty-seven revolutions complete the operation by engaging the lower edge of the ring **112** with the upper edge of element **104** which serves as a stop. The landing casing and the tool subassembly **12** are then withdrawn in preparation for further drilling.

With the particular casing program being described it is desirable to retain the pressure in the next-installed string of casing and the tubing within a single head of a high pressure rating. To accomplish this the blowout preventers **278, 280** and **282** and the Regan blowout preventer (not shown) should be removed and replaced with another set and at the same time attach the required head. The Regan preventer is retrieved by disconnecting it from the upper preventer **282** and stripping it along with the auxiliary guide structure over the drill pipe **263** by means of the mud riser. The coupling **270** is then released and the blowout preventer assembly which is con-

nected to the telescoping guide section **132** is raised a short distance by applying hydraulic pressure to the cylinders **154** through the lines **170** from a suitable controlled source at the surface. The drill pipe, which is still connected to the upper preventer **282**, is then raised by the draw works to assume the load and bring the preventer assembly and the telescoping guide section **132** to the surface.

FIGURE 13 illustrates the next stage in the construction of the well. As seen therein and in FIGURE 16 a casing and tubing head **290**, constructed as an integral unit and having an external circumferential groove **291** at its lower end has been connected to the upper end of the coupling **270**. Another remotely controlled coupling **292** connects the upper end of the head **290** to the lower end of another blowout preventer assembly. The latter includes two Hydril type blowout preventers **294** and **296** of a Cameron blowout preventer **398**, the upper section of which contains dual rams for two strings of tubing. The upper preventer **294** has been connected to the lower end of the drill pipe **263** by means of another remotely controlled coupling **302**, and the entire preventer assembly has been secured to the telescoping guide section **132** by means of the crossheads **172** and **190**. The drill pipe **263** is then lowered carrying with it the preventer assembly and the guide section **132** which slides along the guide cables **152**. FIGURE 13 shows guide section **13** about to engage the posts **138**. As before, when the pistons **158** in the cylinders **154** engage the upstanding posts **138** the load is transferred to the later and the remainder of the travel is hydraulically controlled. When the preventer assembly is properly seated, operation of the lower coupling **270** completes the connection. The upper coupling **302** is released and is withdrawn to the surface by the drill pipe **263**.

The coupling **302** is then removed from the drill pipe **263** and, as shown in FIGURE 14, is attached to the lower end of the mud riser **247**. The crossheads **208** of the auxiliary guide section **202** are secured to the coupling **302** and the assembly is lowered to the upper preventer **294** where connection is made by remote operation of the coupling **302**. Drilling is continued through the mud riser **247** and through the equipment installed on the casing **260** until sufficient depth has been reached to run the next string of casing **304**.

The casing **304**, for example 7 inch O.D. casing, is run in the same manner as was the casing **288**, that is, with a tool and a hanger **14'** (FIGURE 16) like those of FIGURES 1–6. Again, centralizers and a long guide tube are used to protect the hanger subassembly from damage while it is being lowered into position and to keep the hanger subassembly centered while it is entering the seating and sealing section of the head **290**. The cementing of the casing **304** is carried out with its hanger subassembly **14'** resting on a seat **98'** within the head **290**, the returns passing through the flutes at the base of the hanger subassembly. The head is also provided with an inner annular recess above the seat for receiving locking balls **60'** which are analogous to the balls **60** in the head **100**. The same procedure is followed for setting and sealing the hanger subassembly as used when setting and sealing the casing **288**.

When all of the conventional testing and bottom hole work has been completed, the tubing is run. Hydraulically set packers are used and the tubing is run simultaneously. A pack-off assembly may be placed at the top of the mud riser for partial protection if desired. As seen in FIGURE 14, a tubing hanger subassembly **308** adapted to suspend the strings of tubing **306** on two internal seats and having an outer parent seat is used. The hanger **308** may be generally of the type disclosed in Patent Nos. 3,052,301 and 3,001,803 modified to the extent of having locking balls **60''**, an actuating ring analogous to the ring **54** and an outer rotatable sleeve analogous to the sleeve **34**, **36**. The upper end of the rotatable sleeve is provided with axial teeth **310** for engagement with complementary teeth on a rotatable tool assembly (not shown).

After the hanger **308** has been placed on the tubing **306**, two strings of landing tubing **312** are threaded into the top of the hanger **308** and the assembly is lowered through the mud riser **247** and blowout preventer assembly as seen in FIGURE 14 until the parent seat on the hanger **308** engages the complementary seat **98''** (FIGURE 16) in the tubing head **290**. Preferably, tubing control valves, such as Otis valves, are included in the tubing for control after the preventers have been removed. The landing tubing **312** is then unscrewed from the hanger **308** and withdrawn. The hanger **308** is then locked in place by lowering a tool subassembly (not shown) through the mud riser by means of the drill pipe **263** and rotating the same. The tool subassembly has downwardly extending teeth thereon which mesh with the teeth **310** so that rotation of the drill pipe and tool assembly effect rotation of the sleeve of the latter and thereby force the locking balls into an annular recess in the head **290**. The tool is then withdrawn to the surface.

After the tubing **306** has been set the mud riser is released from the top of the blowout preventer assembly and withdrawn. The drill pipe **263** is then lowered and connected to the top of the preventer assembly. The coupling **292** at the lower end of the preventer assembly is released and the cylinders **154** of the telescopic guide section **132** are pressurized to raise the preventer assembly from the casing head **100**. The load is then transferred to the drill pipe **263** which is hoisted to the surface carrying with it the preventer assembly, the guide section **132** and the auxiliary guide section.

Next a Christmas tree **314** with the coupling **292** as the lowermost element is assembled at the surface and the telescoping guide system **132** attached as seen in FIGURE 16. The Christmas tree assembly **314** is then lowered along the guide cables **152** by means of the two strings of landing tubing **312**. As before, the load is transmitted to the fixed guide posts **138** when the pistons **158** engage the same and the last few feet of travel is hydraulically controlled from the surface. Preferably, the Christmas tree **314** is so arranged on the crossheads **172** and **190** that swiveling action may take place between the guide system and the tree. This freedom to rotate will allow the tree to align itself with the hangers when the upper section of the tree engages the parent hanger. When the final contact position is reached the coupling **292** is tightened to complete the connection. The tubing control valves may then be retrieved with a wire line from the surface passing through one of the strings of landing tubing **312**. A conventional packing operation is then performed using the landing tubing **312** to service the well. After the well has been cleaned the valves **320** on the Christmas tree are closed and the well arranged for production in conventional manner. The returns from the casing **304** are controlled through a side outlet **316** and production from the tubing **306** is controlled through outlets **318** in the Christmas tree.

It will be appreciated also that the detailed descriptions of the hanger and tool assembly **10** and the guide system **130**, **132** illustrate the principles of these devices and that modification may be made thereto without departing from the scope of the invention. The details of the described procedures and apparatus are not intended to be limiting except as they appear in the appended claims.

What is claimed is:

1. A hanger and tool for use in suspending a string of tubing or casing in a well structure comprising: a hanger body having an axial bore and an exterior tapered surface intermediate its ends for engaging a complementary surface in the well structure; at least one laterally movable locking element carried by said hanger body for engagement with a recess within the well structure; first thread

means on the upper inner extremity of said hanger body; second thread means of opposite rotation from said first thread means on the upper outer extremity of said hanger body; hanger sleeve means engaging said second thread means and including means engageable with said locking element to move the same laterally; a tool body having a bore coaxial with the bore of said hanger body; a tool sleeve connected to said tool body for rotation therewith and for independent longitudinal movement, the lower end of said tool sleeve threadedly engaging said first thread means; and complementary tooth and socket means on the opposed ends of said hanger sleeve and said tool body whereby rotation of said tool body rotates said tool sleeve and said hanger sleeve and whereby said tool sleeve moves upwardly to disengage from said hanger body and said hanger sleeve moves downwardly to actuate said locking element.

2. A hanger and tool assembly for use in suspending a string of casing in a well comprising:

a hanger subassembly including an annular hanger body having an exterior downwardly and inwardly tapered seating surface for engaging a complementary surface within the well, thread means on the inner surface of said hanger body, a laterally movable latch element carried by said hanger body above said seating surface, said latch element being movable between a retracted position and an extended position in which its outer edge projects laterally outwardly of said seating surface, an annular latch control member threaded onto said hanger body and movable axially when rotated into and out of engagement with said latch element, the threads between said hanger body and said latch control member and the thread means on the inner surface of said hanger being of opposite hand;

an annular tool subassembly including a first sleeve, thread means on the lower end of said first sleeve in engagement with said thread means on said hanger body whereby said subassemblies may be disconnected from each other, a second sleeve surrounding said first sleeve and axially movable with respect thereto, said second sleeve having a lower end portion adapted when rotated to effect rotation of said latch control member; means associated with said first and second sleeves for limiting relative axial movement between them to a predetermined amount whereby said first and second sleeves may be withdrawn upwardly as a unit away from said hanger subassembly after said first sleeve has been rotated in a direction to disconnect said inner sleeve from said hanger body.

3. Apparatus as in claim **2** wherein said first and second sleeves of said tool subassembly are carried on the lower end of an annular body, said annular body including means disposed above said sleeves for rigidly connecting said annular body to the lower end of a running-in pipe, said inner sleeve being rotatable with and axially movable relative to said annular body, and said outer sleeve being fixed relative to said annular body.

4. Apparatus as in claim **2** wherein said annular latch control member has a lower end portion engageable with said latch element and wherein said control member carries a circumferential sealing element at a location above and radially outwardly of said lower end portion.

5. A well head assembly comprising: a tubular supporting head having an internal upwardly facing seat for receiving a hanger, an internal recess for receiving a latch member and an annular surface for engagement by an annular sealing element;

a tubular hanger having an external downwardly facing shoulder resting on said seat in said head, said hanger defining with said head an upper annular space above said seat and a lower annular space below said seat;

a movable latch member carried by said hanger, said latch member being movable from a first position free of said head to a latching position within said recess in said head;

a movable, circumferential sealing element carried by said hanger, said sealing element being movable from a first position free of said head to a sealing position in sealing engagement with said annular surface in said head;

means defining at least one vertical passage connecting said upper and lower annular spaces; and

means for suspending said hanger from the lower end of a running-in pipe and for effecting latching movement of said latch member and sealing movement of said sealing element after said hanger shoulder has been lowered into engagement with said seat, said means including an annular tool device concentric with said hanger, said tool device including connecting means for connecting said tool device to the lower end of a running-in pipe, thread means disposed below said first connecting means and engaged with the complementary threads on said hanger, and an actuating element operable upon rotation of said tool device in a direction to disconnect the latter from said hanger for moving said latch member and said sealing element into their latching and sealing positions.

6. Apparatus as in claim **5** wherein said tool device includes an annular body, an inner sleeve carried by said body and an outer sleeve carried by said body, said outer sleeve being fixed with respect to said annular body and having a lower end portion defining said actuating element, said inner sleeve being rotatable with and axially movable relative to said annular body and having a circumferential portion defining said thread means whereby rotation of said body in a direction to disconnect said thread means from said hanger causes said inner sleeve to move upwardly relative to said hanger, said inner sleeve having a second circumferential portion which seals against said body in one axial position of said inner sleeve and defines a passage between said body and said inner sleeve in a higher axial position of the latter.

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