Sept. 12, 1967 E. K. PIERCE, JR 3,341,227

CASING HANGER

Filed Feb. 4, 1964 3 Sheets-Sheet 1

Fig. 1.

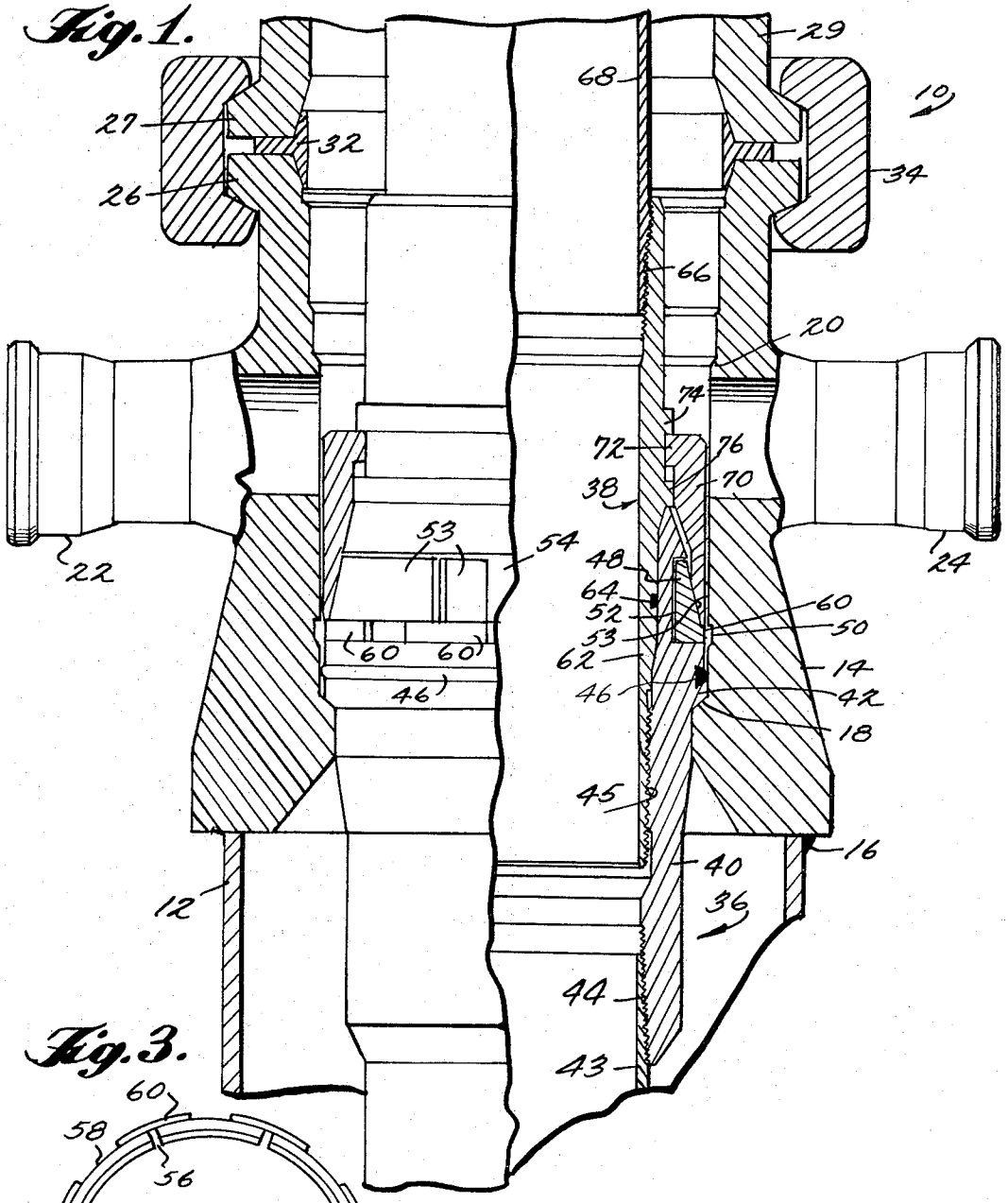

Fig. 3.

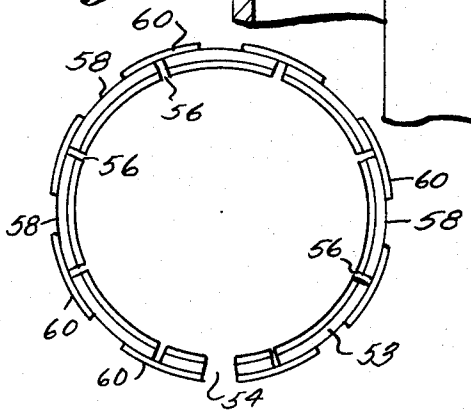

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Fig. 2.

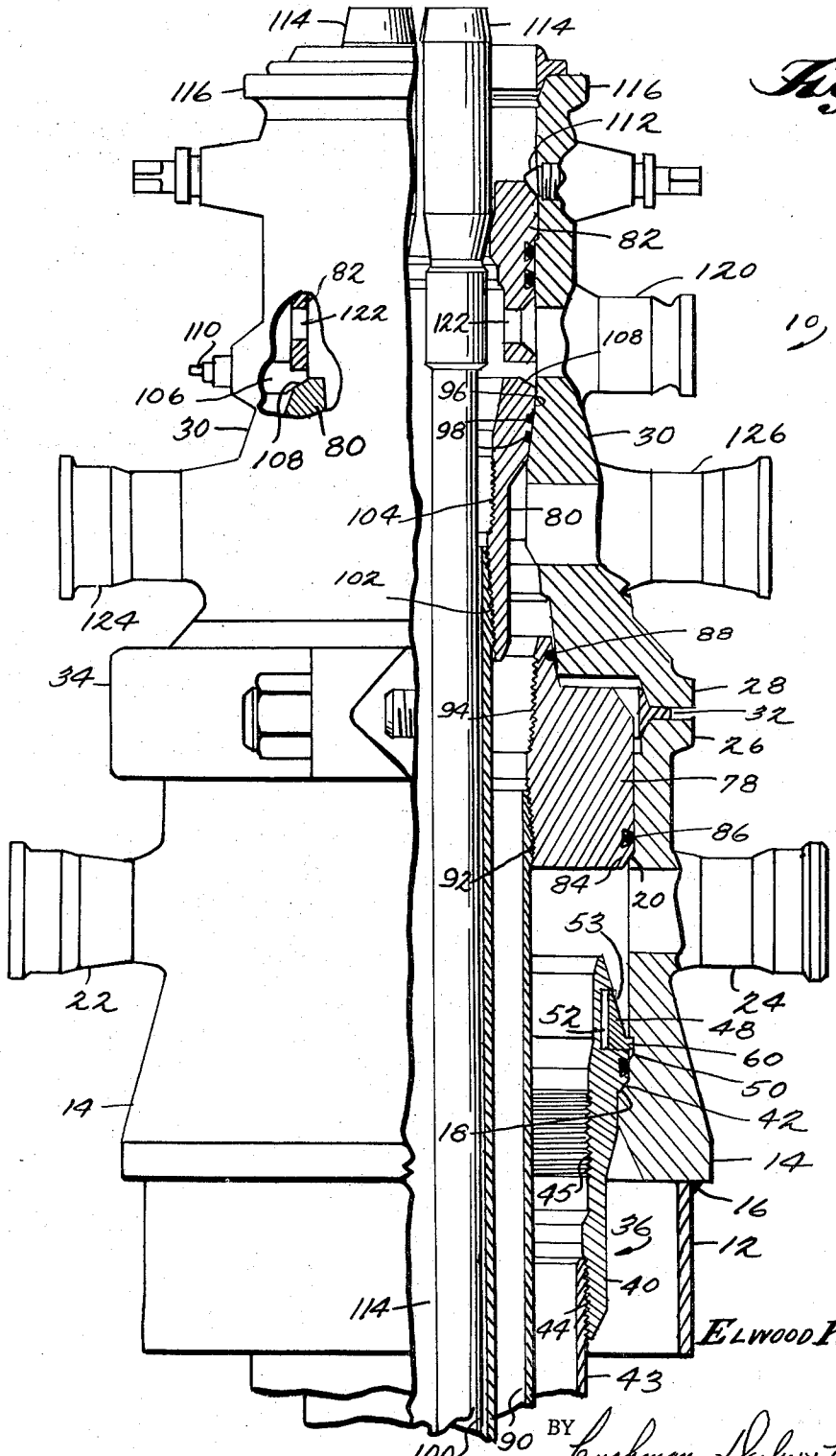

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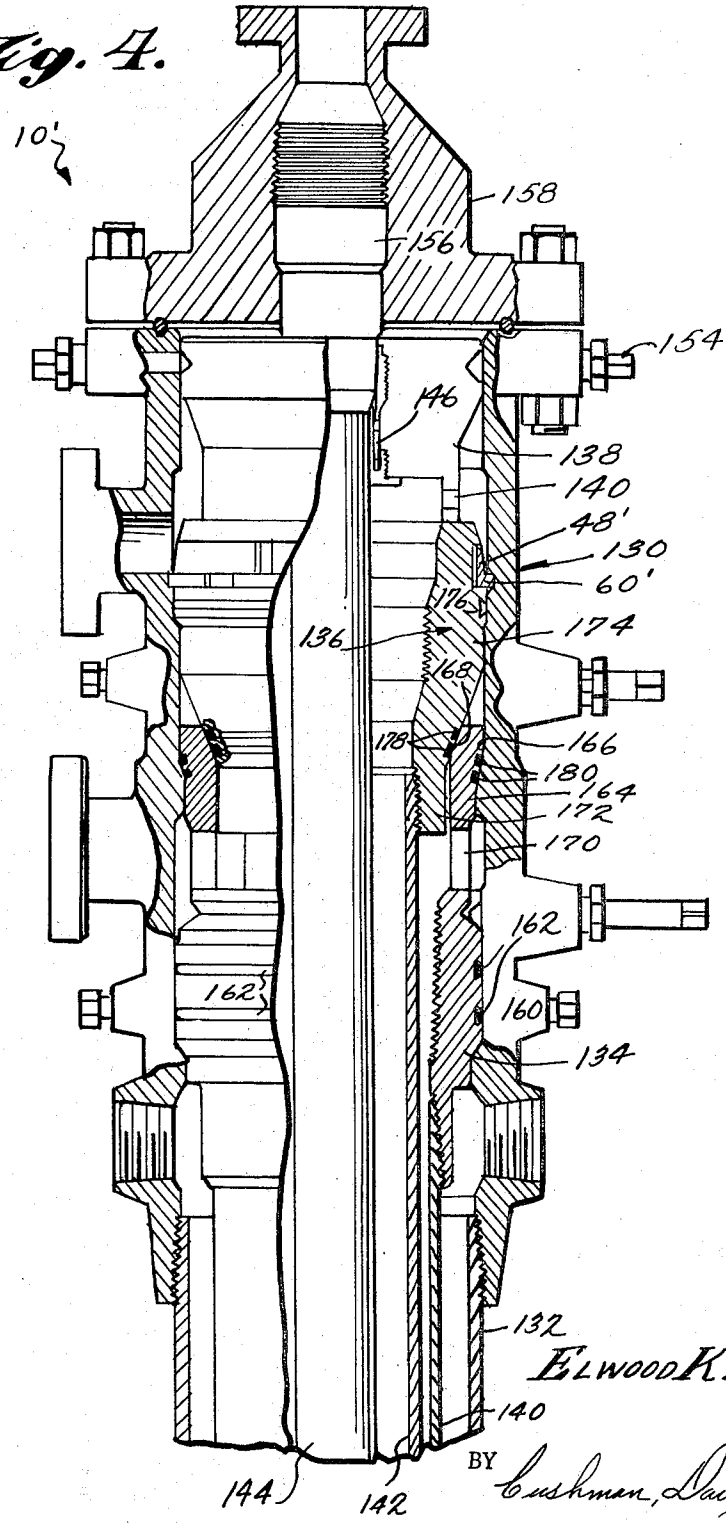
Fig. 4.



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United States Patent Office 3,341,227
Patented Sept. 12, 1967

3,341,227

CASING HANGER

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Filed Feb. 4, 1964, Ser. No. 342,440
6 Claims. (Cl. 285—39)

This invention relates to apparatus for use in constructing oil and gas wells and in particular to the construction and use of hangers and related equipment for suspending casing strings and tubing strings in a well head.

The present invention is related to the subject matter of application Serial No. 250,262 filed January 9, 1963, describing a casing hanger which is locked in place in its casing head by means of a plurality of locking balls which are carried in laterally extending passageways in the hanger. To lock the hanger in a supporting head the balls are forced outwardly into a groove in the inner surface of the head by means of a setting or landing tool which is releasably connected to the upper end of the hanger. The tool is designed so that upon rotation thereof, by means of a drill pipe or the like, it sets the locking balls and then releases itself from the hanger. The present invention is related to this general type of arrangement but differs therefrom in several respects, one of which is the use of an expandable locking ring in place of locking balls.

It is the primary object of the present invention to provide a novel hanger and setting tool therefor for use in landing casing strings and tubing strings in appropriate supporting heads and for locking the hanger to the head without employing the usual externally operated holdown screws or the like. The arrangement, in effecting hold-down of the hanger from within the head, is particularly advantageous in constructing well heads below water level or under other conditions where the well head is remote from workmen.

It is a further object to provide apparatus and procedures for landing a casing hanger or a tubing hanger in a supporting head and locking the hanger in place solely by operations conducted through blow-out preventers and other control equipment connected to the top of the head.

It is another object to provide a hanger and tool assembly which in combination with a drawworks permits rapid and effective landing of the hanger in a head, locking and sealing of the hanger to the interior of the head and release and withdrawal of the tool from the hanger.

It is still another object to provide a hanger and tool assembly of the above type in which the hanger carries on its periphery an expandable locking ring for engagement with a groove in the inner surface of the head and in which the tool carries a ring compressing member which is actuable by rotation of the tool to release the locking ring at the desired time.

The invention will be further understood from the following detailed description taken with the drawings in which:

FIGURE 1 is a fragmentary elevational view, partly broken away and partly in section, of a well head in an early stage of construction;

FIGURE 2 is an elevational view, partly broken away and partly in section, of the well head of FIGURE 1 in a later stage of construction;

FIGURE 3 is a top plan view of the locking ring used in constructing the well head of FIGURES 1 and 2; and

FIGURE 4 is an elevational view, partly broken away and partly in section, of another well head.

Referring to FIGURES 1 and 2 there is shown a well head **10** mounted on top of a vertical conductor pipe **12**,

for example a 26 inch casing, whose lower end has been driven or otherwise set into the ground. The invention is particularly advantageous under conditions where the well head **10** is remote from the drawworks as where the well head is below the surface of a body of water, but it is not limited to this type of arrangement.

In the construction illustrated the lowermost member of the well head **10** is a multiple-bowl casing head **14** which has been welded at **16** to the top of the conductor pipe **12**. The casing head **14** has a central bore having a lower annular seat **18** which is tapered downwardly and inwardly and a similar upper seat **20** of slightly greater diameter. Intermediate the seats **18** and **20** are two conventional flanged outlets **22** and **24** which communicate with the bore. The upper end of the head **14** terminates in an outwardly extending flange **26** which is connected to the lower flanged end **27** of control equipment **29** by means of a clamp **34** and sealing ring **32** of the type fully disclosed in Patent No. 2,766,829.

In FIGURE 1 a casing hanger **36** is shown being landed through the control equipment **29** on the lower seat **18** in the multiple-bowl casing head **14** by means of a setting tool **38**. The hanger **36** includes an annular body portion **40** which defines the bore of the hanger and an external tapered shoulder **42** adapted for engagement with the seat **18** in the head **14**. A string of casing **43**, for example 16 inch casing, is suspended from the lower end of the hanger body **40** by means of a threaded connection **44**, and the hanger itself is suspended from the lower end of the tool **38** by threads **45**. Immediately above the shoulder **42** is an annular groove carrying a sealing ring **46** which engages a vertical cylindrical surface on the bore of the head **14**.

According to the invention the hanger body **40** is provided with a resilient locking ring **48** which is adapted, when not restrained, to expand into a groove **50** in the bore of the head **14**. As shown in FIGURES 1 and 2 the ring **48** is carried in a groove **52** in the external surface of the hanger body **40** at a location above the shoulder **42**.

The ring **48** is machined from a closed steel ring and is then formed into a snap-type ring so that it may be slipped over the top of the hanger body **40**. A machining operation shapes the bore of the original closed ring to a smooth cylindrical surface and shapes the outer periphery of the upper portion to a frusto-conical shape **53** which tapers upwardly and inwardly. Below the tapered surface **53** there is machined an outwardly extending annular flange having parallel upper and lower flat surfaces extending transversely to the axis of the ring. In order to make the ring extensible and contractible a single vertical saw cut **54**, as shown in FIGURE 3, is made completely through the metal. Then a plurality of vertical cuts **56** are made in the wall of the bore deep enough to extend through the frustro-conical surface **53**, but not through the flange. Portions of the flange are then cut away at locations **58** between the cuts **56** so as to leave a plurality of arcuate flanges **60**. In its operative position the ring **48** is engaged along its upper and lower edges by the upper and lower walls of the groove **52**, but sufficient clearance is provided to allow the ring to expand and contract.

The setting tool **38** for use with the hanger **36** includes an annular body portion **62** defining a bore of about the same diameter as the bore of the casing string **43** and having an outside diameter which permits its insertion within the bore of the hanger body **40** for threaded engagement therewith at **45**. A sealing ring **64** is carried in an external groove in the tool body **62** above the connection **45** for engagement with the wall of the bore in the hanger body **40**. The upper end of the bore of the

tool body 62 is provided with threads 66 for connection with the lower end of a string of landing casing 68 or the like by means of which the tool 38, hanger 36 and casing string 43 can be lowered by a drawworks. The threads 66 are cut in the opposite direction from the threads at the connection 45 so that rotation of the pipe 68 in a direction to disengage the connection 45 will not disengage the connection at 66.

The tool 38 further includes a locking ring compressor in the form of a collar 70 which is carried externally on the tool body 62 above the connection 45. The upper end of the collar 70 has an inwardly extending flange 72 which is vertically slidable between upper and lower outwardly extending flanges 74 and 76 on the tool body 62. The lower portion of the collar 70 is spaced laterally from the tool body 40 thereby forming an annulus into which the upper end of the hanger body 40 and the locking ring 48 project. The inner surface of the collar 70 in this region is tapered upwardly and inwardly so as to be complementary to the exterior frusto-conical surface 53 on the locking ring 48.

The locations of the collar 70 and the flanges 74 and 76 are such that when the tool body 62 is fully threaded into the hanger body 40, the lower flange 76 serves as a stop which abuts the top of the hanger body 40. In this position the upper flange 74 assures that the collar 70 rides down on the locking ring 48 a sufficient distance to contract the ring 48 completely into the groove 52. When the hanger body 40 rests on the seat 18 rotation of the pipe 68 and the tool body 62 raises the collar 70 so that the lock ring 48 extends into the groove 50 to lock the hanger body 40 in place. Continued rotation releases the threaded connection 45 so that the pipe 68, tool body 62 and collar 70 may be withdrawn from the well head 10.

FIGURE 2 illustrates the well head 10 in a substantially completed state. The additional components include an intermediate casing hanger 78 within the casing head 14, the combined casing-tubing head 30, an upper casing hanger 80 within the head 30 and a parent tubing hanger 82 for dual strings of tubing also within the head 30. As will be understood from the above brief description of the operation of the tool body 62, the latter and its collar 70 are removed after the hanger 36 has been landed on the seat 18 in the head 14 so that further drilling and landing operations may be conducted through the head 14.

The external surface of the intermediate casing hanger 78 is provided with a downwardly and inwardly tapering annular shoulder 84 engaging the upper seat 20 in the head 14 and with a sealing ring 86 above the shoulder. The upper end of the hanger 78 terminates in an upwardly and inwardly tapered extension which carries a sealing ring 88 engaging a complementary surface on the bore of the casing tubing head 30. A string of casing 90, for example 10¾ inch casing, is threaded into the lower end of the bore of the hanger 78 at 92. The upper end of the bore is provided with threads 94 for connection with a pipe or the like employed for lowering the hanger 78 into place.

The uppermost casing hanger 80 has a downwardly and inwardly tapered exterior surface which rests on a complementary seat 96 in the bore of the casing-tubing head 30. A pair of sealing rings 98 carried in grooves in hanger 80 form a seal at this point. A casing string 100, such as 7 inch casing, is threaded into the lower end of the bore of the hanger 80 at 102. The upper end of the bore is provided with threads 104 for connection with a pipe or the like.

The tubing hanger 82 is supported within the casing-tubing head 30 on top of a plurality of circumferentially spaced, laterally extending wedges, one of which is shown at 106. The wedges 106 serve also as hold-down means for the casing hanger 80 by engaging an upwardly and inwardly tapered surface 108 on the top of the latter. Movement of each wedge into its operative position is achieved by means of a screw 110 which extends through the wall of the head 30. A complete description of the wedges 106 and their operating mechanisms and seals may be found in copending application Serial No. 260,372 filed Feb. 25, 1963. Two strings of tubing 114 are suspended from the tubing hanger 82 and extend through the upper end of the head 30 for connection with a flow control head (not shown).

The casing-tubing head 30 further includes a plurality of conventional hold-down screws 112 engaging the top of the tubing hanger 82 and an outwardly extending flange 116 at its upper end for receiving a clamp such as the clamp 34 shown in FIGURE 1. An upper set of flanged laterally extending outlets, one of which is illustrated at 120 are positioned opposite lateral ports 122 in the tubing hanger 82 for receiving flow of well fluids from the space between the tubing 114 and the casing string 100. A lower set of flanged outlets 124 and 126 receive flow from the annulus between the casing strings 90 and 100.

In operation, the tool 38 and the hanger 36 are first assembled at the surface by screwing the lower end of the tool body 62 into the bore of the hanger body 40 to nection is complete when the top of the hanger body 40 make up the connection 45. As indicated above, this conabuts the lower flange 76 on the tool body. The collar 70 will be moved toward the locking ring 48 by the upper flange 74 so as to engage the lower tapered surface of the collar with the complementary surface 53 on the ring 48. By the time the connection is complete the ring 48 will have been compressed in the groove 52 an amount sufficient to assure that the outwardly extending flanges 60 do not extend beyond the periphery of the hanger body 40.

When the casing string 43 has been partially lowered by a drawworks into a hole drilled through the multiple-bowl casing head 14 and the conductor casing 12 the lower end of the hanger body 40 is screwed over the end of the last section of the string to make up the connection 44 at the surface. Then a section of landing casing 68 is screwed into the upper end of the tool body at 62. The landing casing 68 is lowered, connecting additional sections as necessary, until the shoulder 42 on the hanger body 40 rests on the seat 18 in the casing head 14. The landing casing 68 is then rotated in a direction to unscrew the connection 45 between the hanger body 40 and the tool body 62. The hanger body 40 does not rotate because the weight of the casing string 42 is now carried at the seat 18, and the connection 66 does not unscrew because these threads are opposite to those at 45. As the tool body 62 moves upwardly during the disconnecting operation, the lower flange 76 thereon lifts the collar 70 so as to allow the locking ring 48 to expand and thereby move the flanges 60 into the groove 50 in the head 14.

It is a further feature of the tool and hanger assembly that the connection 45 is of sufficient length that it does not completely disengage until after the locking ring 48 has been allowed to expand. This arrangement allows an upward pull on the hanger body 40 by means of the landing casing 68 and drawworks in order to determine that the locking action has been effected. In addition, this feature permits the tool body 62 to be easily reconnected to the hangar body 40 in the event that it is desired to unlock and remove the hanger body 40.

It will be understood that the initial setting of the conductor casing 12, the attachment of the head 14 thereto and the drilling which precede the above-described landing and locking operation of the hanger body 40 and the subsequent cementing and drilling steps and the landing of the casings, 90 and 100 and the tubing 114 may be carried out by known procedures. In this connection reference is again made to copending application Ser. No. 250,262 wherein well completion procedures are described in detail for a well head system which embodies

a tool and hanger assembly employing locking balls. Further, it is contemplated that the principles involved in the present locking ring arrangement may be applied to a variety of well head systems, such as those disclosed in Patent Nos. 2,082,413, 2,117,444, 2,207,469, 2,620,880 and 2,624,413. It will be apparent that whenever the present invention is employed to lock a hanger in place, the tool and hanger assembly is lowered through appropriate control equipment mounted on top of the respective casing or tubing head and the locking operation is conducted through the control equipment from the surface, which in underwater operations may be quite remote from the well head. The arrangement is thereby advantageous in adapting a given hanger and head to remote operations because there is no need for externally operated hanger hold-down means. While the well head **10**, as shown, employs only one locking ring **48**, it will be understood that additional rings could be used in place of the wedges **106** and the hold-down screws **112**.

One type of different well head with which the locking ring of the invention can be employed is illustrated in FIGURE 4. The well head **10'** illustrated therein includes a unitary, compact casing-tubing head **130** of the type fully disclosed in the copending application of Pierce filed Jan. 3, 1964. As disclosed therein the head **130** is mounted on top of a conductor casing **132**, for example 13⅜ inch casing, and contains in ascending order a first casing hanger **134**, a second casing hanger **136** and a tubing hanger **138**. The lower casing hanger **134** is provided with a downwardly projecting interiorly threaded extension by which a first string of casing **140**, for example 9⅝ inch casing, is suspended. The upper casing hanger **136** has a lower interiorly threaded extension from which a second string of casing **142**, for example 7 inch casing, is suspended. The tubing hanger **138** suspends a single tubing string **144**, for example 3½ inch tubing, and is itself supported on top of the upper casing hanger **136**.

The tubing hanger **138** is of the stuffing box type in which an annular seal **146** grips the exterior of the tubing string **144**. An annular bottom extension on the tubing hanger **138** is spaced inwardly from the wall of the head **130** and is provided with a plurality of lateral ports **140** communicating with the annulus between the tubing **144** and the casing **142**. The upper portion of the head **130** is provided with an annular groove for receiving hold-down screws **154** which extend laterally through the head **130**. Above the top of the head **130** the tubing **144** connects with a threaded plug bushing **156** which is retained in a flanged cap member **158** bolted to the top of the head **130**. In practice, suitable valving and a production line will be connected to the top of the cap member **158** for receiving flow from the tubing **144**.

The lower hanger **134** is supported by the head **130** primarily along an exterior, downwardly facing tapered shoulder **160** which is located on a cylindrical center portion of the hanger **134** below a pair of spaced sealing rings **162** and which rests on a complementary seat within the head **130**. Integral with the center portion of the lower hanger **134** is an upwardly projecting annular extension **164** having an exterior sealing surface **166** which is tapered slightly inwardly and downwardly for engagement with a complementary seat within the head **130**. This seat has, of course, a minimum diameter of sufficient size to permit the body portion of the hanger **134** to pass by during the landing of the casing string **140**. The inner surface of the extension **164** is tapered inwardly and downwardly at **168** to a greater extent than the surface **166** so as to form a seat for the upper hanger **136**. A plurality of circulation ports **170** extends through the extension **164** below the tapered surfaces.

The upper hanger **136** includes, in addition to a lower extension **172**, an upper cylindrical portion **174** which engages the bore of the head **130** above the lower hanger **134**. Intermediate the extension **172** and the upper portion **174** the upper hanger **136** is provided with an exterior tapered surface which engages the seat **168** in the lower hanger **134**. Suitable sealing rings **176**, **178** and **180** are provided between the upper hanger portion **174** and the bore of the head **130** and at the seats **168** and **166**, respectively.

Above the seat the upper hanger carries a locking ring **48'** which is identical to the locking ring **48** described with reference to FIGURES 1–3. In the substantially completed assembly illustrated the ring **48'** is shown in its expanded condition in which its flanges **60'** engage the walls of a groove in the inner surface of the head **130**.

It will be understood, without specific description, that the upper hanger is landed and locked in position with the aid of a tool identical with that already described and by the same procedure.

Modifications of the invention will occur to those skilled in the art and it is therefore not intended that the described and illustrated details be limiting except as they appear in the appended claims.

What is claimed is:

1. A hanger and tool assembly for use in landing and suspending a string of pipe within a head comprising: a hanger body having a vertical inner bore and an exterior downwardly facing shoulder by which the hanger body may be suspended in the head; means for connecting said hanger body to the pipe to be suspended; a laterally deflectable and resilient locking ring carried in an annular groove in the exterior of said hanger body above said shoulder, said locking ring having an outwardly extending flange portion and a body portion above said flange portion, said locking ring when relaxed assuming an expanded position such that said flange portion projects radially beyond the circumference of said hanger body, said body portion having an exterior surface which is tapered upwardly and inwardly; a tool body threadedly connected to said hanger body; means for connecting said tool body to the lower end of a landing casing or the like; a locking ring compressor collar having an inner surface tapered downwardly and outwardly to engage said tapered surface on said locking ring; and means connecting said collar to said tool body whereby upward movement of said tool body occasioned by rotation of said tool body in a direction to unscrew said tool body from said hanger body raises said collar away from said locking ring to permit the latter to expand and whereby downward movement of said tool body occasioned by rotation of said tool body in a direction to screw said tool body on to said hanger body moves said collar toward said locking ring to compress the latter, said means for connecting said collar to said tool body including a pair of axially spaced apart radial projections on the outer surface of said tool body and a radially inwardly extending projection on said collar disposed between the radial projections on said tool body.

2. A hanger and tool assembly as in claim **1** wherein said tool body is an annular body having a threaded lower end portion fitting concentrically within the bore of said hanger body and defining the threaded connection between bodies and wherein said hanger body includes an upwardly facing surface which abuts the lower of said radial projections on said tool body when the latter has been threaded into said hanger body a sufficient distance to compress said locking ring with said collar.

3. In a well head construction the combination of a tubular supporting member having a vertical inner bore defining an upwardly facing seat; a hanger body having a vertical inner bore and a downwardly facing shoulder for engagement with said seat whereby said hanger body may be suspended in said supporting member, each said supporting member and said hanger body having a radial recess located above said shoulder and seat and having an open end facing into the bore in said supporting member, said open ends facing each other when said shoulder is in engagement with said seat; a locking element mounted in one of said recesses for lateral movement between first and second positions and being biased

toward said first position, said locking element having a laterally extending locking portion dimensioned to reside in the other of said recesses when said locking element is in said first position and to be free of said other recess when said locking element is in said second position, said locking element further including an upwardly facing cam surface located above said laterally extending portion; a tool body; a threaded connection releasably connecting said tool body to said hanger body; rotatable connecting means of opposite hand from said threaded connection for securing said tool body to the lower end of a landing casing or the like, whereby said connecting means maintains a connection between said tool body and the landing casing during rotation of the latter in a direction to unscrew said threaded connection between said tool body from said hanger body; a lock actuating element having a downwardly facing surface disposed in the bore of said tubular supporting member and externally of said hanger body and upon rotation of said tool body in a direction to tighten said threaded connection and disengageable upon rotation in a direction to loosen said thread connection; mounting means cooperating with said tool body and with said actuating element, said mounting means connecting said actuating element to said tool body for positive linear movement therewith in both directions, said threaded connection between said tool body and said hanger body being of such length that it remains connected when said actuating element disengages from said locking element upon rotation of said tool body in a direction to unscrew said threaded connection.

4. Apparatus as in claim 3 wherein said locking element is a deflectable resilient ring carried in a circumferential groove in the exterior of said hanger body, said ring having an outwardly extending flange which defines said laterally extending locking portion, said ring having a tapered body which defines said upwardly facing cam surface.

5. Apparatus as in claim 4 further including stop means for preventing further engagement of said threaded connection between said tool body and said hanger body after said locking element has been moved to its second position, said stop means including opposing stop surfaces on said tool body and said hanger body disposed so that the stop surface on said tool body moves into abutment with the stop surface on said hanger body as the length of said threaded connection increases.

6. A hanger assembly for supporting an inner pipe string in a head comprising: a hanger body having a vertical inner bore and an exterior downwardly facing shoulder by which the hanger assembly may be suspended in the head; a laterally deflectable and resilient locking ring carried in an annular groove in the exterior of said hanger body above said shoulder, the depth of the groove and the thickness of the ring being such that in the relaxed conditions of the ring its innermost portion will remain within the groove while its outermost portion will extend beyond the outermost portion of the hanger body whereby the outermost portion of the ring may be inserted into a groove in the inner surface of the head for locking the hanger assembly within the head, said outermost portion of said locking ring being defined by a laterally extending flange portion and wherein the periphery of said ring above said flange portion is tapered upwardly and inwardly for engagement with a vertically movable tool, said locking ring having one vertical cut extending through said tapered portion and said flange portion, said flange portion having a plurality of vertical cuts extending from the bore of the ring outwardly to said flange portion and said flange portion having a plurality of spaced vertical cuts extending from its periphery to said tapered portion, the outwardly and inwardly extending cuts being horizontally offset from each other.

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