A running tool, packing assembly and casing hanger body are run together into a wellhead, the running tool being releasably connected to the hanger body, with the packing assembly held above and free from packed-off relation to the hanger body by a retention member engaging a torque sleeve slidably splined to the running tool body. Release of the running tool from the hanger body allows the retention member to release from the torque sleeve, which is shifted downwardly by a spring to position the packing assembly actuating and retaining sleeve for threaded engagement with the hanger body. The transmission of rotation and torque from the running tool body through the torque sleeve to the actuating and retaining sleeve threads the latter downwardly along the hanger body to packoff the packing assembly between the hanger body and wellhead.

15 Claims, 11 Drawing Figures
CASING HANGER AND PACKOFF APPARATUS

The present invention relates to well apparatus, and more particularly to underwater apparatus for running a casing string in the well bore, cementing the casing string in place, and sealing the region between a casing hanger body and the surrounding wellhead disposed at the upper end of the well bore.

In the drilling of oil and gas wells at an underwater location, a casing string is run into a well bore, the casing string being supported by a hanger body resting on a companion seat in its surrounding wellhead. The casing string is cemented in place, and a suitable packing or seal assembly actuated to pack off the annular region between the hanger body and wellhead. Apparatus for performing the above method is illustrated in a number of U.S. patents, including applicant's U.S. Pat. Nos. 3,468,558, 3,468,559, 3,489,436 and 3,492,026. In such apparatus, the casing hanger body and packing assembly are lowered into position at the same time on a running tool, the packing assembly sealing the region between the hanger body and wellhead following completion of the cementing operation.

In the present invention, the casing hanger body and packing assembly are lowered into position within the wellhead at the same time through use of a running string secured to a running tool releasably connected to the hanger body and to a packing assembly. The packing assembly is not connected initially to the hanger body, but is supported by the hanger body through the agency of a retention member and an actuating member responsive to movement of the running tool. After the hanger body lands within the wellhead, the running tool is released from the hanger body, such release also releasing the retention member, permitting the packing assembly and actuating member to move downwardly to enable the packing assembly to be connected to the hanger body. Movement of the running tool then effects downward shifting of the packing assembly along the hanger body into the annular seal region between the exterior of the hanger body and surrounding wellhead, and places the packing portion of the assembly in a condition packing off the annular seal region.

More specifically, the connection between the hanger body and packing assembly is a threaded one, rotation of the running tool being transmitted through the actuating member to rotate the upper portion of the packing assembly and thread the latter downwardly along the hanger body to effect the packoff of the annular seal region.

With further respect to the invention, the actuating member is releasably secured to the packing assembly, enabling the actuating member to be released, after the packoff has been effected, so that the running tool, actuating member, and retention member can be removed simultaneously by the running string attached to the running tool.

This invention possesses many other advantages, and has other purposes which may be made more clearly apparent from a consideration of a form in which it may be embodied. This form is shown in the drawings accompanying and forming part of the present specification. It will now be described in detail, for the purpose of illustrating the general principles of the invention; but it is to be understood that such detailed description is not to be taken in a limiting sense.

Referring to the drawings:
seat 25 disposed above a lock ring groove 26 between the upper and lower seats when the running tool body has been unthreaded from the hanger body, with its male 17 disposed adjacent to the uppermost female thread 18 of the hanger body, as disclosed in FIGS. 7, 8 and 9.

The body 14 has a landing ring 30 threadedly secured thereto, which has a tapered surface 31 adapted to rest upon the companion seat 32 in the wellhead housing H, in order that the hanger body can support a string of well casing M threadedly secured thereto and extending downwardly into the well bore A. A split lock ring 33 is disposed in a peripheral groove 34 in the hanger body, resting upon the upper end of the landing ring 30. This lock ring is initially in a contracted position, but is adapted to be expanded outwardly into an opposed circumferential lock groove 35 in the wellhead housing, to prevent upward movement of the casing string M and the hanger body 14 with respect to the wellhead housing.

Circumferentially spaced, longitudinal flow passages or grooves 36 are provided in the lower portion of the hanger body 14 to permit circulating fluid and cement slurry to flow upwardly through the interior of the landing ring and into the annulus 37 between the hanger body and wellhead housing H. The lower portion 37a of this annulus is defined between an external peripheral sealing surface 38 on the hanger body above the flow passages 36 and an opposed internal cylindrical sealing surface 39 in the wellhead housing. A suitable packing assembly 100 is movable into the annular space 37a to be sealed against the opposed external and internal surfaces 38, 39 and to also engage the lock ring 33 and expand it outwardly into the lock groove 35, as described below.

The running tool 15a also includes a torque ring or sleeve 40 slidable along its exterior, there being a slidable spline type of connection 41 between the running tool body 15 and the torque sleeve. As specifically illustrated in one or more circumferentially spaced longitudinally extending torque keys 42 are suitably secured to the running tool body 15, such key or keys extending within companion longitudinal grooves 43 in the upper portion of the torque sleeve (FIG. 3). A helical compression spring 44 surrounds the running tool body, its lower end bearing against the upper end of the torque sleeve 40, and its upper end bearing against an annular spring seat 45 prevented from moving upwardly along the running tool body by a split contractible retainer ring 46 fitting within a companion external groove 47 in the upper end of the running tool body 15. A split contractible stop ring 48 is also mounted in a peripheral groove 49 of the running tool body immediately above the torque keys 42, to limit the extent of upward movement of the torque sleeve along the running tool body 15 when the sleeve 40 is shifted upwardly for the purpose of compressing the helical spring 44.

By virtue of the spline interconnection 41 between the running tool body and the torque sleeve, the latter can be rotated upon rotation of the running tool body by the tubular running string 16. Such rotation and torque is transmittable to an actuating sleeve 50 surrounding the lower reduced diameter portion 51 of the torque sleeve. A plurality of circumferentially spaced drive keys 52 are suitably secured, as by welding, to the torque sleeve, these keys fitting within companion slots 53 in the upper end of the actuating sleeve 50 (FIG. 10). A thrust shoulder 54 on the torque sleeve engages the upper end of the actuating sleeve 50. The two sleeves are held in their assembled position by one or a plurality of shear screws or pins 55 threadedly within the actuating sleeve and received within companion bores 56 of the torque sleeve (FIG. 11). The actuating sleeve 50 has a right-hand internal thread 57 adapted to mesh with a companion external right-hand thread 58 on the upper portion of the hanger body 14.

The packing assembly 100 is carried by the actuating sleeve. As illustrated, such assembly includes an upper supporting ring 59, the upper portion of which encompasses a reduced diameter lower portion 60 of the actuating sleeve 50. A swivel connection is provided between the upper support ring and actuating sleeve. As disclosed, such swivel connection includes a swivel ring 61 mounted in an external groove 62 in the lower portion of the actuating sleeve 50, this ring also being received within an opposed internal groove 63 in the upper support ring. With the actuating sleeve and upper ring 59 swivelingly connected together, the upper end of the supporting ring engages a thrust bearing ring 64, which, in turn, bears against a downwardly facing shoulder 65 of the actuating sleeve. A similar thrust bearing ring 66 engages the lower end of the actuating sleeve 50 and an opposed upwardly extending shoulder 67 on the upper support ring. As described hereinbelow, the actuating sleeve 50 can rotate without its rotation being transmitted to the upper supporting ring 59. The latter, however, cannot move longitudinally with respect to the actuating sleeve.

The packing assembly further includes an elastomer packing sleeve 68, the upper end of which is connected to the lower portion of the upper supporting ring 59, and the lower end of which is connected to a lower abutment ring 69. The specific construction of the packing assembly per se forms no part of the present invention. However, as specifically illustrated, the connections are provided by dovetails 70 on the upper and lower ends of the packing sleeve received within companion dovetail grooves 71 in the upper supporting ring and lower abutment ring. These rings also have metallic lip seals 72 facing toward each other and encompassing the upper and lower portions of the elastomer packing sleeve 68.

It will be noted that the packing assembly 100 with the actuating sleeve 50 are spaced laterally outwardly from the periphery of the running tool body 15 to a substantial extent, providing an annular space 73 of large area communicating with the annular space 37 between the wellhead housing H and the casing hanger body 14. This annular space 73 communicates with a plurality of circumferentially spaced longitudinally extending circulation grooves 74 provided in the exterior of the torque sleeve 40, these grooves opening into the annular space 75 between the running tool body 15 and the wellhead above the torque sleeve, which, in turn, communicates with the annular space 76 surrounding the tubular running string 16, which extends through the blowout preventer stack F and the marine riser D to the rig R mounted on the drilling vessel.

When the running tool 15a is threadedly connected to the casing hanger body 14, the torque sleeve 40, actuating sleeve 50, and packing assembly 100 are held in an elevated position with respect to the running tool body 15 and with respect to the casing hanger body 14, with the spring 44 in its compressed state, by an annular retention member 77 surrounding the running tool
body. The lower end of the member 77 bears against an upper shoulder 78 on the casing hanger body 14, its upper end bearing against a lower shoulder 79 of the torque sleeve 40. Following disconnection of the running tool body 15 from the casing hanger body 14, this retention member is released to permit the torque sleeve 40 to be moved downwardly by the compressed spring 44, for the purpose of shifting the packing assembly 100 into the annular space 37a between the hanger body and wellhead housing H, and to place the internal thread 57 of the actuating sleeve 50 into a position for threaded connection with the external thread 58 on the upper portion of the casing hanger body 14.

As specifically disclosed, the retention member 77 is in the form of an elongate collet sleeve having a circumferentially continuous lower portion 80 of relatively short extent and a plurality of elongate spring-like arms 81 integral with the lower portion and terminating in upper fingers 82 extending laterally inwardly. The arms and fingers may be formed by providing longitudinal slots 83 in the collet sleeve (FIG. 4). As shown, a lower flange 84 on the collet sleeve engages the upper shoulder 78 on the casing hanger body. When the left-hand threaded connection 17, 18 exists between the running tool body 15 and the casing hanger body 14, the fingers 82 engage the periphery of the running tool body 15, underlying the torque sleeve shoulder 79. The intervention of the collet sleeve 77 prevents the spring 44 from expanding, and retains the torque sleeve 40, actuating sleeve 50 and the packing assembly 100 in the upper position illustrated in FIGS. 2 and 6, in which the packing assembly 100 is disposed above the upper end of the casing hanger body 14.

Upon rotation of the running tool body 15 with respect to the casing hanger body 14, the running tool body threads upwardly along the casing hanger body, the helical spring elongating while holding the collet sleeve 77 in its lower position in engagement with the hanger body 14, until the running tool body has shifted upwardly to an extent in which an external peripheral groove 85 in the body is located opposite the fingers 82, such fingers then snapping laterally inwardly within this groove, the effective external diameter of the fingers decreasing for release from the shoulder 79 permitting the spring 44 to expand and shift the torque sleeve 40, actuating sleeve 50, and packing assembly 100 downwardly of the running tool body 14.

Following full disconnection of the running tool body 15 from the casing hanger body, the running tool body can be lowered by the running string 16 until its lowermost thread turn 17a engages the uppermost thread turn 18a of the casing hanger body, the lowermost thread turn 57a of the actuating sleeve 50 engaging the uppermost thread turn 58a on the exterior of the casing hanger body 14, the slideable splined relation 41 between the running tool body 15 and torque ring or sleeve 40 still being maintained (FIG. 7). Rotation of the running string 16 and running tool body 15 is then transmitted through the spline connection 41 to the torque sleeve 40, and through its key connection 52, 53 to the actuating sleeve 50, causing the latter to thread downwardly along the external threads 58 of the casing hanger body to shift the packing assembly 100 downwardly within the opposed circumferential seal surfaces 39, 38 of the wellhead housing H and the casing hanger body 14, until the lower abutment ring 69 moves within the lock ring 33 and expands it outwardly into the wellhead housing groove 35, the lower abutment ring coming to rest against a shoulder 87 on the casing hanger body. Continued application of torques through rotation of the running string 16, running tool body 15, torque sleeve 40 and actuating sleeve 50 will then move the upper supporting ring 59 toward the lower abutment ring 69, shortening the elastomer packing sleeve 68 and firmly sealing it against the opposed sealing surfaces 38, 39 in leakproof relation. The imposition of yet additional torque to the actuating sleeve 59 will cause the elastomer packing to expand the opposed circumferential metal lips 72 against the opposed sealing surfaces 38, 39, so that combined elastomer and metallic seals are provided between the packing assembly and the opposed surfaces (FIGS. 8, 9).

In the use of the apparatus, a string of well casing M is to be run into the well bore A and is to be supported from the wellhead housing H previously located in place at the ocean floor K. The casing string is lowered from the rig R through the marine riser D, blowout preventers F and wellhead H and into the well bore. The casing hanger body 14 is then threadedly secured to the upper end of the uppermost casing string stand, and the running tool 15a, torque sleeve 40, actuating sleeve 50, packing assembly 100 and retention member or collet sleeve 77 are then appropriately assembled with respect to the casing hanger body, the parts then being in the relative positions illustrated in FIG. 2, with the running tool fully threadedly connected to the casing hanger body 14, and with the collet sleeve 77 holding the torque sleeve, actuating sleeve and packing assembly in their upper position with respect to the casing hanger body. The running string 16 is secured to the upper end of the running tool body 15 and the entire assembly lowered through the marine riser D, until the casing hanger body 30 engages its companion seat in the wellhead, as disclosed in FIGS. 2 and 6. At this time, it is to be noted that the lower seal rings 23 on the running tool body sealingly engage the lower cylindrical seat 24 of the casing hanger body, preventing flow of fluid between these two bodies.

Circulation can then be established down through the running string 16, the running tool body passage 200 and the casing string M, with the returns flowing upwardly through the annulus surrounding the casing string, up through the hanger body grooves 36 into the annular space 37 between the casing hanger body and wellhead, the flow then proceeding through the interior 73 of the packing assembly 100 and actuating sleeve 50, and through the circulation grooves 74 in the torque sleeve to the annular space 76 thereof. After the circulation of fluid has properly conditioned the well bore, an appropriate charge of cement slurry is pumped down through the running string, running tool body passage 200 and casing string for discharge into the annulus surrounding the casing string and for upward movement toward the casing hanger body 14.

After the desired amount of cement slurry has been displaced behind the casing string M, the running string 16 is rotated to the right to correspondingly rotate the running tool body 15 and effect its upward threading with respect to the casing hanger body 14, until the running tool body is completely unthreaded from the hanger tool body. As described above, such upward movement of the running tool body occurs with respect to the collet sleeve 77 to place the internal groove 85 of the running tool body opposite the fingers 82, which
spring inwardly therewithin, to free the upward holding or retention force on the torque sleeve 40, actuating sleeve 50 and packing assembly 100, allowing the spring 44 to expand and shift the torque sleeve, actuating sleeve and packing assembly downwardly along the running tool body 15. Reloewing of the running string 16 and running tool body 15 until the lowestmost thread 17a on the running tool body engages the uppermost thread 18a of the hanger body places the parts in the position disclosed in FIG. 7, in which the packing assembly 100 is partly within the seal region 37a between the casing hanger body and the wellhead.

The running string 16 and running tool body 15 are now rotated to effect rotation, through the spline connection 41, of the torque sleeve 40, and rotation of the actuating sleeve 50 through the key and key slot interconnection 52, 53, which threads the actuating sleeve 50 downwardly along the casing hanger body 14, to shift the lock ring 33 outwardly into the wellhead lock groove 35, and to effect compression and outward expansion of the packing element 68 and the metallic lip seals 72 against the external periphery 38 of the casing hanger body and the internal periphery 39 of the wellhead. Appropriate torque can be imposed on the running tool body 15 to the torque sleeve 40, this same torque being transmitted to the actuating sleeve 50, to force the actuating sleeve to thread downwardly along the hanger body 14 and produce a leakproof seal between the hanger body and the wellhead H. Rotation of the actuating sleeve 50 does not produce rotation of the packing assembly 100 because of the swivel connection 61–63, the downward force between the actuating sleeve and the upper supporting ring 59 being transmitted through the rings 64, 66 made of bearing material (FIGS. 8, 9).

A blowout preventer F can now be closed around the tubular running string 16 and pressure applied to the fluid in the annulus surrounding the tubular running string, to test the efficacy of the annular seal. It will be noted that during the circulation and cementing operation the lower seal rings 23 provide the seal against the lower seat 24 and between the running tool body 15 and the casing hanger body 14 to prevent leakage therebetween. When the running tool body has been released from the casing hanger body, and with its threads 17 then being supported upon the uppermost thread 18a of the casing hanger body, as disclosed in FIG. 7, several of the seal rings 23 are sealing off against the upper cylindrical seat 25 of the casing hanger body. As a result, pressure can be imposed upon the fluid in the annular space around the tubular running string 16 and around the apparatus to ascertain whether leakage has occurred. If the packing assembly 100 gives evidence of leakage, additional torque can be imposed through the tubular running string 16, running tool body 15 and torque sleeve 40 to the actuating sleeve 50 to further compress the packing element 68 and expand the metallic lip seals 72 outwardly against the opposed hanger body and wellhead sealing surfaces 38, 39.

In the event there is no leakage, the running tool 15a and the parts surrounding it can be released by taking an upward strain on the running string and running tool body, the upper right-hand thread 17 engaging the lower end of the collet sleeve 77, the flange 84 of the latter then engaging the lower end of the torque sleeve 40, urging the latter upwardly to shear the pin or pins 55. Continued upward movement of the running string 16, running tool body 15, retention sleeve 77, and the torque sleeve 40 then results in such parts moving as a unit upwardly with the running string to the drilling rig R, leaving the actuating sleeve 50 threaded to the casing hanger body 14, causing it to act as a member retaining the packed-off packing assembly 100 in its sealed relation to the casing hanger body 14 and wellhead H.

1 claim:

1. Hanger apparatus for supporting a tubular string extending into a wellbore from a surrounding wellhead comprising a hanger body adapted to be located in the wellhead and having a sealing surface; a running tool connectible to a running string; means releasably connecting said hanger body to said running tool to enable said hanger body to be lowered into the wellhead; packing means; means for supporting said packing means from said hanger body and above said sealing surface while said hanger body is connected to said running tool; means for releasing said supporting means upon release of said releasable connecting means to discontinue support of said packing means from said hanger body and allow said packing means to move downwardly of said hanger body towards said sealing surface; and means for actuating said packing means to effect its sealing engagement with said sealing surface.

2. Hanger apparatus as defined in claim 1; said releasable connecting means comprising a threaded connection between said running tool and hanger body.

3. Hanger apparatus as defined in claim 1; said supporting means including a first sleeve engaging said hanger body, a second sleeve supported by said first sleeve, said running tool engaging said first sleeve to hold said first sleeve in position supporting said second sleeve, means releasably connecting said second sleeve to said packing means; said means for releasing said supporting means including means on said running tool enabling said first sleeve to be shifted from its position supporting said second sleeve.

4. Hanger apparatus as defined in claim 1; said supporting means including a first sleeve engaging said hanger body, a second sleeve supported by said first sleeve, said running tool engaging said first sleeve to hold said first sleeve in position supporting said second sleeve, means releasably connecting said second sleeve to said packing means; said means for releasing said supporting means including means on said running tool enabling said first sleeve to be shifted from its position supporting said second sleeve; said actuating means including means on said running tool for shifting said second sleeve.

5. Hanger apparatus as defined in claim 1; said supporting means including a first sleeve engaging said hanger body, a second sleeve supported by said first sleeve, said running tool engaging said first sleeve to hold said first sleeve in position supporting said second sleeve, means releasably connecting said second sleeve to said packing means; said means for releasing said supporting means including means on said running tool enabling said first sleeve to be shifted from its position supporting said second sleeve; said actuating means including a torque transmitting connection between said running tool and second sleeve.

6. Hanger apparatus as defined in claim 1; said supporting means including a first sleeve engaging said hanger body, a second sleeve supported by said first
sleeve, said running tool engaging said first sleeve to hold said first sleeve in position supporting said second sleeve, means releasably connecting said second sleeve to said packing means; said means for releasing said packing means including means on said running tool enabling said first sleeve to be shifted from its position supporting said second sleeve; said actuating means including a torque transmitting connection between said running tool and second sleeve and a threaded connection between said packing means and hanger body.

7. Hanger apparatus for supporting a tubular string extending into a wellbore from a surrounding wellhead: comprising a hanger body adapted to be located in the wellhead and having a sealing surface; a running tool connectible to a running string; means releasably connecting said hanger body to said running tool to enable said hanger body to be lowered into the wellhead; packing means; a lower sleeve supported by said hanger body; an upper sleeve initially supported by said lower sleeve; means providing a releasable connection between said upper sleeve and packing means; coengaging means on said running tool and lower sleeve holding said lower sleeve in its position supporting said upper sleeve; releasing means on said running tool enabling said lower sleeve to move from its position supporting said upper sleeve; and operating means for effecting sealing engagement of said packing sleeve with said sealing surface including means for effecting movement of said upper sleeve and packing means downwardly relative to said running tool and hanger body.

8. Hanger apparatus as defined in claim 7; said operating means including spring means on said running tool engaging said upper sleeve.

9. Hanger apparatus as defined in claim 7; said operating means comprising a torque transmitting connection between said running tool and upper sleeve, and a threaded connection between said packing means and hanger body.

10. Hanger apparatus as defined in claim 7; said operating means comprising a torque transmitting connection between said running tool and upper sleeve, a torque transmitting connection between said upper sleeve and packing means, and a threaded connection between said packing means and hanger body.

12. Hanger apparatus as defined in claim 7; said operating means comprising a torque transmitting connection between said running tool and upper sleeve, a torque transmitting connection between said upper sleeve and packing means, and a threaded connection between said packing means and hanger body.

13. Hanger apparatus as defined in claim 7; said lower sleeve being a collet sleeve having a finger portion at its upper end engaging said upper sleeve; said releasing means comprising a groove in said running tool into which said finger portion can shift upward movement of said running tool relative to said lower sleeve.

14. Hanger apparatus as defined in claim 7; said lower sleeve being a collet sleeve having a finger portion at its upper end engaging said upper sleeve; said releasing means comprising a groove in said running tool into which said finger portion can shift upward movement of said running tool relative to said lower sleeve; said operating means comprising a torque transmitting connection between said running tool and upper sleeve, a torque transmitting connection between said upper sleeve and packing means, and a threaded connection between said packing means and hanger body.

15. Hanger apparatus as defined in claim 7; said lower sleeve being a collet sleeve having a finger portion at its upper end engaging said upper sleeve; said releasing means comprising a groove in said running tool into which said finger portion can shift upward movement of said running tool relative to said lower sleeve; said operating means comprising a torque transmitting connection between said running tool and upper sleeve, a torque transmitting connection between said upper sleeve and packing means, and a threaded connection between said packing means and hanger body; and spring means on said running tool engaging said upper sleeve to urge said upper sleeve and packing means relatively downwardly of said running tool.

* * * * *
PATENT NO.: 3,871,449
DATED: March 18, 1975
INVENTOR(S): ARTHUR G. AHLSTONE

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 3, line 4: after "male" insert --thread--.

Signed and sealed this 15th day of July 1975.

(S Seal)
Attest:
RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks