

Feb. 21, 1967

C. C. BROWN ET AL

3,305,015

TUBING HEAD APPARATUS AND METHOD

Filed Sept. 20, 1963

3 Sheets-Sheet 1

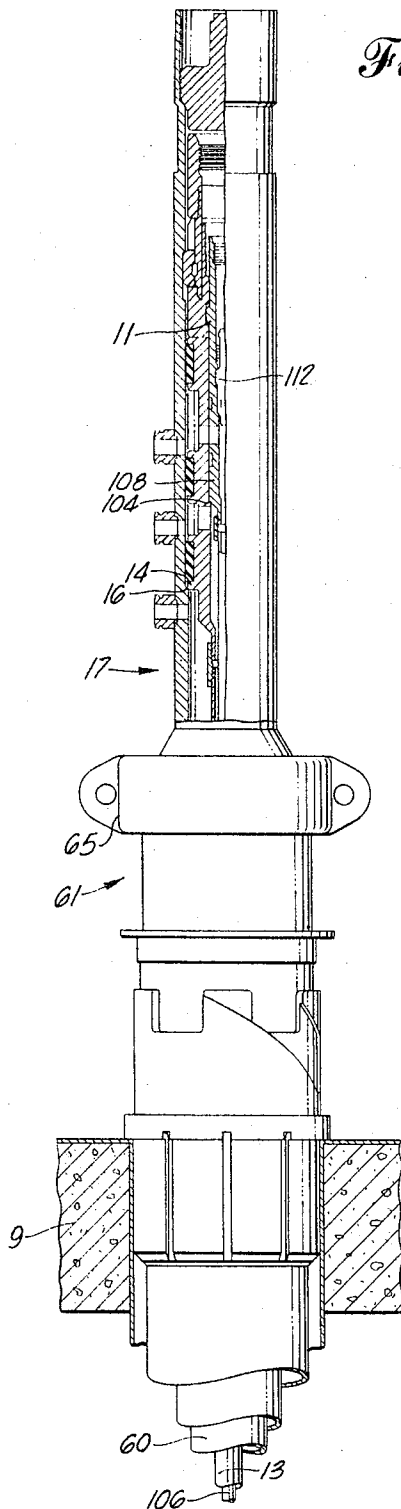


Fig. 1.

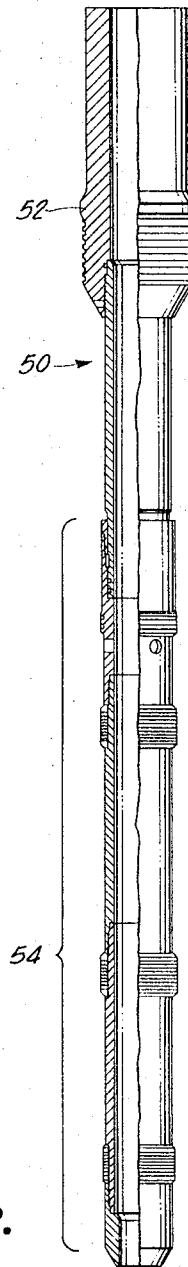


Fig. 2.

Inventors
C. C. BROWN
C. E. WAKEFIELD, JR.

by *Donald W. Canady*
Attorney

Feb. 21, 1967

C. C. BROWN ET AL

3,305,015

TUBING HEAD APPARATUS AND METHOD

Filed Sept. 20, 1963

3 Sheets-Sheet 2

Fig. 3 a.

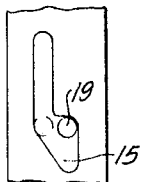


Fig. 3.

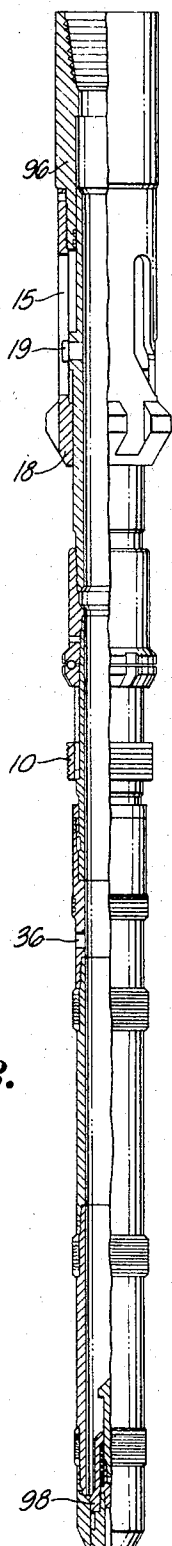
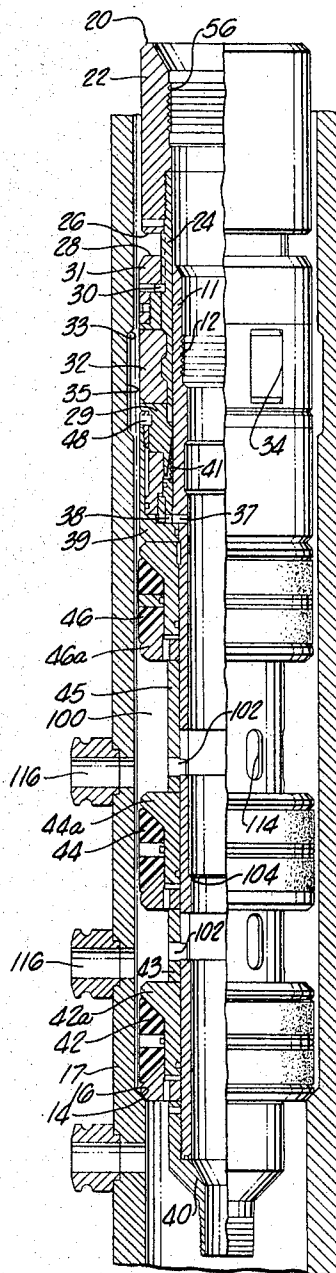


Fig. 4.



Inventors
C. C. BROWN
C. E. WAKEFIELD, JR.
by *Donald W. Canady*
Attorney

Feb. 21, 1967

C. C. BROWN ET AL

3,305,015

TUBING HEAD APPARATUS AND METHOD

Filed Sept. 20, 1963

3 Sheets-Sheet 3

Fig. 5.

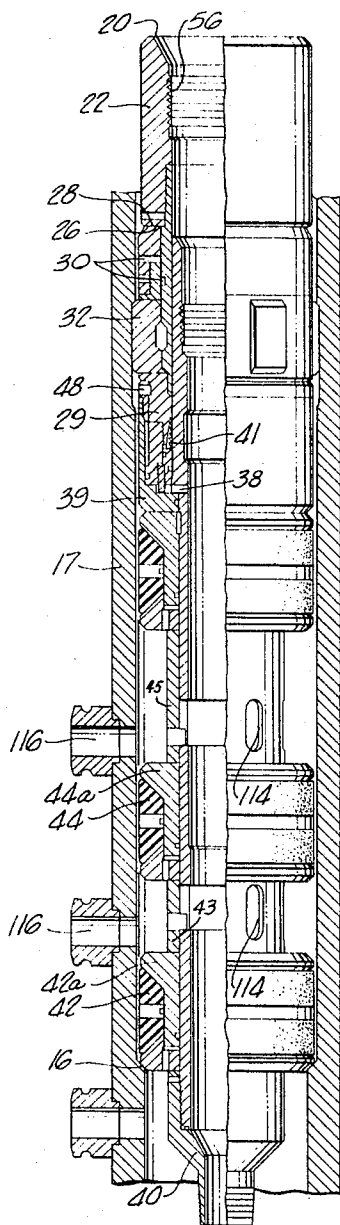
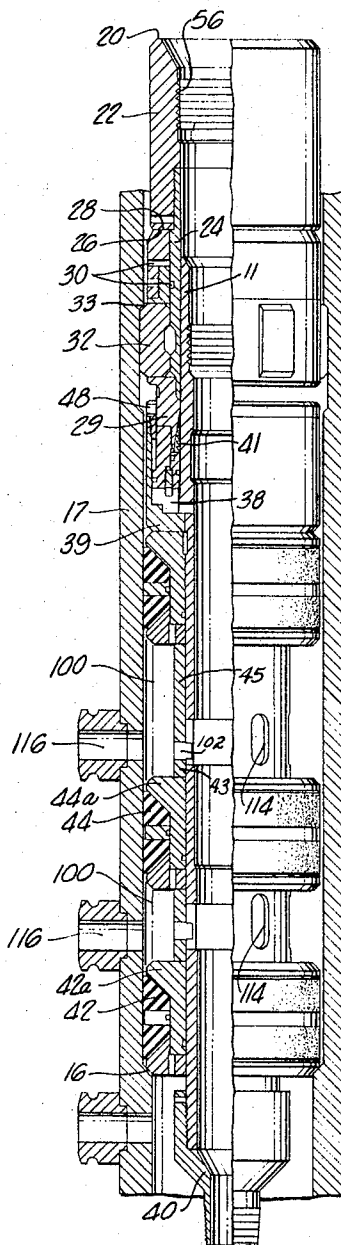


Fig. 6.



Inventors
C. C. BROWN
C. E. WAKEFIELD, JR.

by *Donald W. Canady*
Attorney

1

2

3,305,015

TUBING HEAD APPARATUS AND METHOD
Cicero C. Brown, Houston, Tex., and Charles E. Wakefield, Jr., Bakersfield, Calif., assignors to Atlantic Richfield Company, a corporation of Pennsylvania
Filed Sept. 20, 1963, Ser. No. 310,203
9 Claims. (Cl. 166—6)

The present invention relates to the underwater production of oil and gas, and more particularly relates to an improvement in underwater production head apparatus which can be remotely installed at an underwater location, and the method for such installation.

Underwater well heads heretofore known which may be remotely installed on the ocean floor, have been installed by first running the casing and thereafter hanging the tubing inside a tubing head on a donut type hanger with several packing elements separating the various annuli. When the packing elements employed are of the packer cup type, they are not set for sealed annulus until fluid pressure is exerted thereon.

The automatic latching type tubing hanger is designed to be locked to the tubing head by well zone pressure but is not positively mechanically locked until such time as a head plug can be set in the tubing head above the tubing hanger mandrel. Prior to the setting of the head plug, it is possible that the tubing hanger may not be properly actuated by zone pressure, in which case the tubing could be blown out of the hole. At present, there is no method of determining whether the tubing hanger is locked down in such devices since the tubing hanger seating area is inside the production head.

In addition, prior proposals for underwater production heads such as that described in copending application of C. E. Wakefield, Jr., Ser. No. 100,411, filed Apr. 13, 1961, now Patent No. 3,279,536, require an orientation cam to register the annulus openings in the tubing hanger mandrel with the corresponding annulus openings in the tubing head.

It is therefore an object of our present invention to provide an underwater production head apparatus wherein movement of the tubing hanger mandrel relative to the tubing head is prevented in either direction when the tubing hanger mandrel is landed therein.

It is also an object of our present invention to provide an underwater production head wherein the openings of the tubing hanger mandrel register with the side openings of the tubing head without the use of an orientation cam for registry.

It is a further object of our present invention to provide a tubing hanger apparatus wherein the tubing is mechanically locked against vertical movement within the tubing head independent of the well zone pressure.

It is also an object of our present invention to provide a tubing hanger apparatus wherein the packing elements are positively set independent of the fluid pressure exerted thereon.

Other objects and a more complete understanding of our present invention may be had by reference to the following specification taken in conjunction with the appended claims and the drawings.

According to the teaching of the present invention, a tubing hanger mandrel is mechanically locked against vertical movement relative to the tubing head with transversely movable dogs which lock into a shouldered groove in the tubing head, and packing elements are positively set to seal between the tubing hanger mandrel and the tubing head. An orientation cam is not necessary with the present remotely installed production head apparatus, since there is an annular space in the tubing hanger mandrel adjacent each side outlet in the mandrel, which outlets are adjacent the corresponding side outlets of the tubing head.

In the drawings:

FIG. 1 shows in cross-sectional view an assembled well head in accordance with the present invention.

FIG. 2 shows in cross section the tool used to retrieve tubing hanger shown in FIG. 4.

FIG. 3 shows in partial cross section the tubing hanger setting tool utilized to lock down the tubing hanger and set the packers shown in FIG. 4.

FIG. 3a shows an enlarged view of a J slot safety device used on the casing hanger setting tool.

FIG. 4 shows in partial cross-sectional elevation the tubing hanger mandrel within the tubing head.

FIG. 5 shows the tubing hanger mandrel of FIG. 4 locked relative to the tubing head.

FIG. 6 shows the tubing hanger mandrel of FIG. 4 with the packing elements in set position.

With reference to the drawings, a production head is shown in FIG. 1 mounted on the ocean floor on a conventional landing base 9. The production head consists essentially of a casing head 61 and a tubing head 17. The casing 60 is run and set in the casing head, after which the tubing hanger mandrel 11 is run, mechanically locked in position, and the packers thereafter hydraulically set with a tool 96 designed for this purpose and shown in FIG. 3.

Preparatory to landing the tubing hanger mandrel 11 in the tubing head 17, as shown in FIG. 4, the tubing hanger setting tool 96, shown in FIG. 3, is inserted into the tubing hanger mandrel 11 on a drill pipe (not shown) and connected thereto by turning the setting tool to the left with the drill pipe so that the sliding nut 10 engages the tubing hanger mandrel at threaded section 12.

The tubing hanger mandrel 11, with production tubing 13 threaded to the lower end thereof, is lowered into the production head 17 until the shoulder 14 in the tubing hanger mandrel lands on the shoulder 16 of the production mandrel 17, as shown in FIG. 1. A J slot 15, shown in FIG. 3a, is provided on the setting tool as a safety device to prevent unintentional shearing of the shear pin 30. Pin 19 prevents downward movement of the hammer 18 of the setting tool shown in FIG. 3. Thus, the drill pipe must be rotated approximately one-eighth turn to the left, as shown in phantom line in FIG. 3a, to move the J slot in a position to permit downward movement of hammer 18.

Hammer 18 abuts the shoulder 20 of the top sub 22 of the tubing hanger mandrel 11 to drive the top sub 22 and sleeve 24 downward until the lower shoulder 26 of the top sub abuts shoulder 28 of the mandrel body 29. As the sleeve 24 is driven down around the mandrel 11, pin 30 shears and the latching dog 32 is driven outward by sleeve 24 into window 34 (the position shown in FIG. 5) where it locks in circumferentially spaced slots 35 of the production mandrel 17. Thus, the tubing hanger is positively locked into position.

A pressure fluid is then passed down the drill pipe (not shown) and through the hole 36 of the setting tool 96, hole 37 of the tubing hanger mandrel 11, and into the chamber 38 of the tubing hanger mandrel. The pressure exerted by this fluid forces the cylinder 39 downward towards the shoulder 16, thus hydraulically compressing packers 42, 44, and 46, as shown in FIG. 6. The hydraulic fluid used to hydraulically set the tubing hanger packers is trapped in the setting tool 96 by inserting plug 98 therein. As the cylinder 39 moves downward towards 16, the pin 48 shears and seal mandrels 42a, 44a, 46a and the entire tubing hanger mandrel assembly from cylinder 39 to nipple 40, along with spacer rings 43 and 45, are moved downwardly against the shoulder 16 of the tubing head 17, thus extruding packer rubbers 42, 44, and 46 as the lower shoulder 14 engages shoulder 16 of the tubing head to form seals with the inner surface

3

of the tubing head 17 around the side outlets 114 and 116 of the tubing hanger mandrel and the tubing head, respectively. The term "extrude" as used herein means that the packer or sealing element, e.g. packers 42, 44, and 46, is mechanically compressed to form a fluid-tight seal between two members, e.g. the tubing hanger mandrel and the tubing or production head.

Lock slips 41 are operatively positioned in a slip bowl of mandrel body 29 to prevent return of the cylinder 39 and mandrel 11 relative to the mandrel body 29 when the hydraulic pressure on cylinder 39 is released, thus maintaining the packers in "set" position. Upward movement of the cylinder 39 (and mandrel 11 to which it is affixed) relative to the body 29 causes the slips to bite into mandrel 11, thus preventing further upward movement of the mandrel 11 and the cylinder 39. The slips permit the packers to be compressed between the shoulders 33 and 16 of the tubing head.

When the packers are set, the drill pipe (not shown) may be rotated to the right to release the setting tool 96 from the tubing hanger mandrel 17 after which the drill pipe and the setting tool may be pulled from the hole.

Due to the gaps 100 between the seal mandrels 42a, 44a, and 46a, sufficient space is provided between the spacer rings 43 and 45 and the production mandrel 17 at the openings in the tubing hanger mandrel to obviate the need for registering adjacent openings of the two mandrels, as with an orientation cam. Alignment pins 102 prevent rotation of the spacer rings 43 and 45.

The tubing hanger can be removed from the production mandrel by running the retrieving tool 50 shown in FIG. 2 into the tubing hanger mandrel and threadably engaging the top sub 52 of the tool with the tubing hanger mandrel top sub 22 at threaded portion 56 by turning the drill pipe to the right. A spline connection between sleeve 24 and top cap 31 prevents rotation of sleeve 24 as the releasing tool is threaded into top sub 22. A stinger portion 54 may be coupled to the retrieving tool 50 when it is desired to pack off the side outlets of the tubing hanger mandrel when it is above the blowout preventers as it is being pulled. The drill pipe is then pulled upward so that sleeve 24 is pulled from behind dogs 32 allowing them to retract into the position shown in FIG. 4, after which the entire tubing hanger may then be pulled from the production mandrel 17 on the drill pipe.

A macaroni string 106 and macaroni hanger 108 (FIG. 1) may be landed and locked in the tubing hanger mandrel on shoulder 104 in a manner similar to that which the tubing hanger mandrel is landed within the production mandrel. A macaroni hanger plug 112 closes off the top of the macaroni string and has a check valve therein through which fluid may be pumped to kill the well.

Although our invention has been described with a certain degree of particularity, the scope of our invention is not limited to the details set forth, but is of the full breadth of the appended claims.

I claim:

1. An underwater tubing head apparatus for controlling the flow of oil and gas from a well drilled in a formation underlying a body of water, comprising in combination:

- a first tubular member having a side outlet,
- a second tubular member having a side outlet adjacent the side outlet of said first tubular member, said second tubular member being disposed within said first tubular member and of a configuration to form an annulus between said first and second tubular members,

means independent of well pressure for mechanically locking said second tubular member to said first tubular member,

4

means for sealing said annulus about said outlet, and means for hydraulically extruding said sealing means in said annulus.

2. An underwater tubing head apparatus for controlling the flow of oil and gas from a well drilled in a formation underlying a body of water, comprising in combination:

- a first tubular member having a side outlet,
- a second tubular member having a side outlet adjacent the side outlet of said first tubular member, said second tubular member being disposed within said first tubular member and of a configuration to form an annulus between said first and second tubular members,

means independent of well pressure for mechanically locking said second tubular member to said first tubular member,

packer means for sealing said annulus about said side openings,

movable means associated with said second tubular member for extruding said packers in said annulus, and

said movable means including piston means and means for exerting fluid pressure on said piston means to extrude said packers.

3. An underwater tubing head apparatus for controlling the flow of oil and gas from a well drilled in a formation underlying a body of water, comprising in combination:

- a first tubular member having a side outlet,
- a second tubular member having a side outlet adjacent the side outlet of said first tubular member, said second tubular member being disposed within said first tubular member and of a configuration to form an annulus between said first and second tubular members,

means independent of well pressure for mechanically locking said second tubular member to said first tubular member,

packing means for sealing about said side outlets in said annulus, and

means movable downwardly for extruding said packing in said annulus,

slip means for holding said movable means down in said extruding position.

4. In a tubing hanger locking and packer apparatus used with a tubing head having a side outlet and a shoulder below said side outlet and an inner mandrel having a side outlet adjacent said side outlet of said tubing head and to which tubing string is connected, and wherein packing means are used for sealing the annulus between said mandrel and said tubing head about said side outlets, the improvement comprising:

a locking member associated with said mandrel and transversely movable with respect thereto,

a slot in said tubing head adjacent said locking member of said mandrel and adapted to receive said locking member and thereby prevent longitudinal movement of said mandrel relative to said tubing head, and

means slidable with respect to said mandrel for moving said locking member outwardly into said tubing head slot,

packing means for sealing about said side outlets in said annulus,

means movable downwardly with respect to said locking member against said shoulder for extruding said packing in said annulus, and

means for holding said movable means down in said extruding position.

5. In a tubing hanger locking and packing apparatus used with a tubing head having a side outlet and an inner mandrel having a side outlet adjacent said side outlet of said tubing head and to which tubing string is connected, and wherein packer means are used for sealing

the annulus between said mandrel and said tubing head about said side outlets, the improvement comprising:

- a locking member adapted for mechanically locking said mandrel against longitudinal movement relative to said tubing head,
- means associated with said mandrel for moving said locking member transversely into locking position between said tubing head and said mandrel,
- means longitudinally movable with respect to said tubing head for extruding packing between said mandrel and said tubing head,
- means in said tubing head for limiting longitudinal movement of said movable extrusion means relative to said tubing head, and
- means for holding said longitudinally movable means in said packing extruding position.

6. In a tubing hanger locking and packing apparatus used with a tubing head having a side outlet and an inner mandrel having a side outlet adjacent said side outlet of said tubing head and to which tubing string is connected, and wherein packing means are used for sealing the annulus between said mandrel and said tubing head about said side outlets, the improvement comprising:

- a locking member adapted for locking said mandrel against longitudinal movement relative to said tubing head,
- means associated with said mandrel for mechanically moving said locking member transversely into locking position between said tubing head and said mandrel,
- means longitudinally movable with respect to said tubing head for extruding said packer between said mandrel and said tubing head,
- means in said tubing head for limiting movement of said movable extrusion means relative to said tubing head,
- and means for hydraulically actuating said movable means against said tubing head limit means whereby said packer is extruded between said mandrel and said tubing head as said movable means are moved with respect to said tubing head.

7. An underwater tubing head apparatus for controlling the flow of oil and gas from a well drilled in a formation underlying a body of water, comprising in combination:

- a first tubular member having a side outlet,
- a second tubular member having a side outlet adjacent the side outlet of said first tubular member, said second tubular member being disposed within said first tubular member and of a configuration to form an annulus between said first and second tubular members,
- means independent of well pressure for mechanically locking said second tubular member against vertical movement of said second tubular member relative to said first tubular member,
- packing means for sealing said annulus about said outlet,
- movable means associated with said second tubular member for extruding said packing means in said annulus to set said packers, and

means for holding said movable means in said packing setting position.

8. An underwater tubing head apparatus for controlling the flow of oil and gas from a well drilled in a formation underlying a body of water, comprising in combination:

- a first tubular member having a side outlet and shoulder means below said side outlet,
- a second tubular member having a side outlet adjacent the side outlet of said first tubular member, said second tubular member being supported within said first tubular member on said shoulder means and of a configuration to form an annulus between said first and second tubular members,
- means for locking said second tubular member against upward movement relative to said first tubular member in a recess in said first tubular member,
- packer means for sealing about said side outlets in said annulus, and
- means associated with said second tubular member movable against said recess and said shoulder means for extruding said packer means in said annulus.

9. An underwater tubing head apparatus for controlling the flow of oil and gas from a well drilled in a formation underlying a body of water, comprising in combination:

- a first tubular member having a side outlet and shoulder means therein,
- a second tubular member having a side outlet adjacent the side outlet of said first tubular member, said second tubular member being disposed within said first tubular member and of a configuration to form an annulus between said first and second tubular members,
- means for locking said second tubular member into a locking recess in said first tubular member,
- packer means for sealing about said side outlets in said annulus,
- piston means associated with said second tubular member movable with fluid pressure between said shoulder means and said recess for extruding packing in said annulus, and
- means for holding said piston means in said packing extruding position.

References Cited by the Examiner

UNITED STATES PATENTS

2,188,589	1/1940	Armentrout	166—47
2,475,429	7/1949	Humason	166—88
2,546,638	3/1951	Humason	166—88
2,598,512	4/1952	Cypher	166—47
3,054,449	9/1962	Schramm et al.	166—.5
3,090,438	5/1963	Raulins	166—89
3,143,172	8/1964	Wakefield	166—.5
3,154,148	10/1964	Peterson	166—88
3,209,829	10/1965	Haerber	166—89

CHARLES E. O'CONNELL, *Primary Examiner*.

R. E. FAVREAU, J. A. LEPPINK, *Assistant Examiners*.