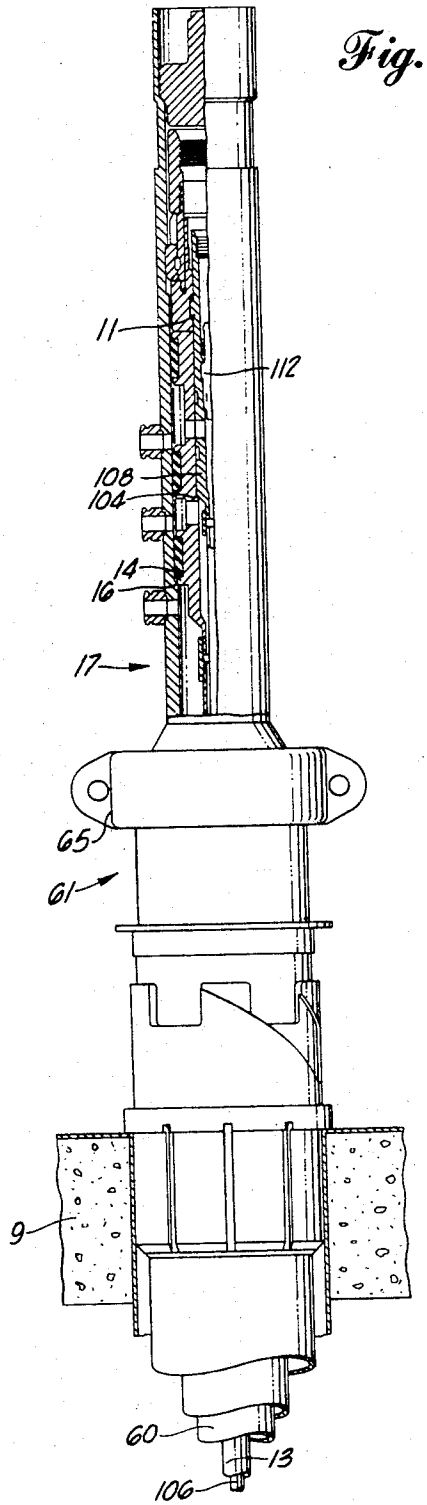
Jan. 3, 1967 C. C. BROWN ET AL 3,295,600

UNDERWATER PRODUCTION METHOD

Original Filed Sept. 20, 1963 3 Sheets-Sheet 1

Fig. 1.



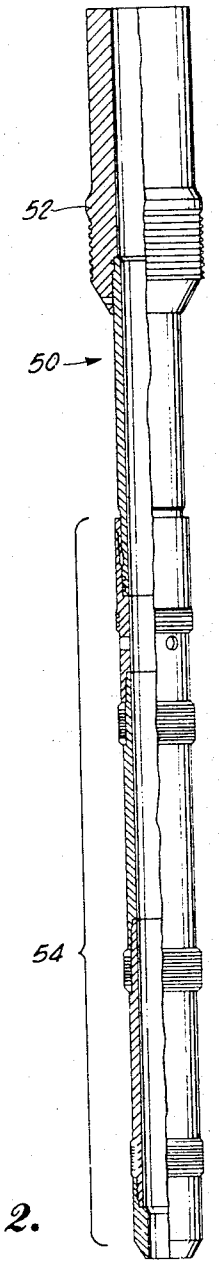


Fig. 2.

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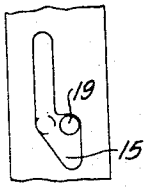
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UNDERWATER PRODUCTION METHOD

Original Filed Sept. 20, 1963 3 Sheets-Sheet 2

Fig. 3a.



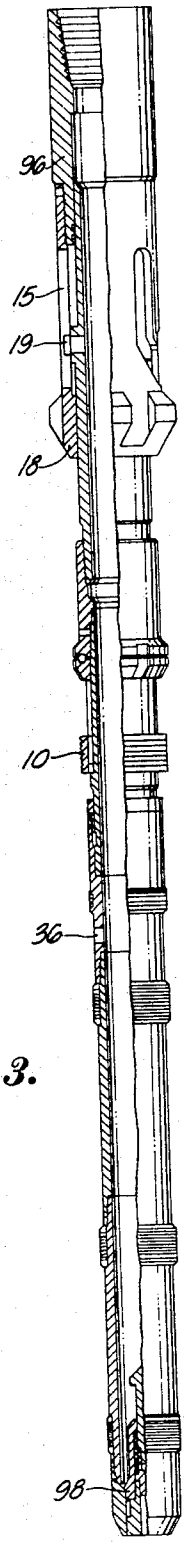


Fig. 3.

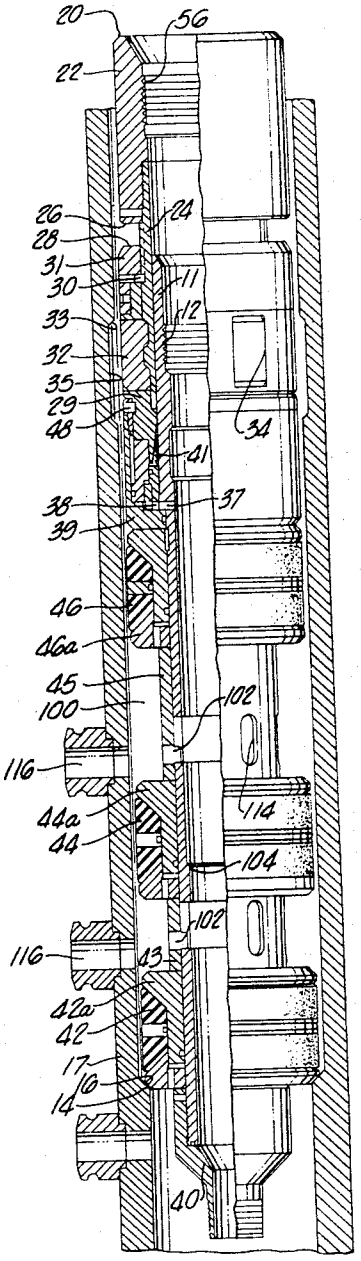


Fig. 4.

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UNDERWATER PRODUCTION METHOD

Original Filed Sept. 20, 1963 3 Sheets-Sheet 3

Fig. 5.

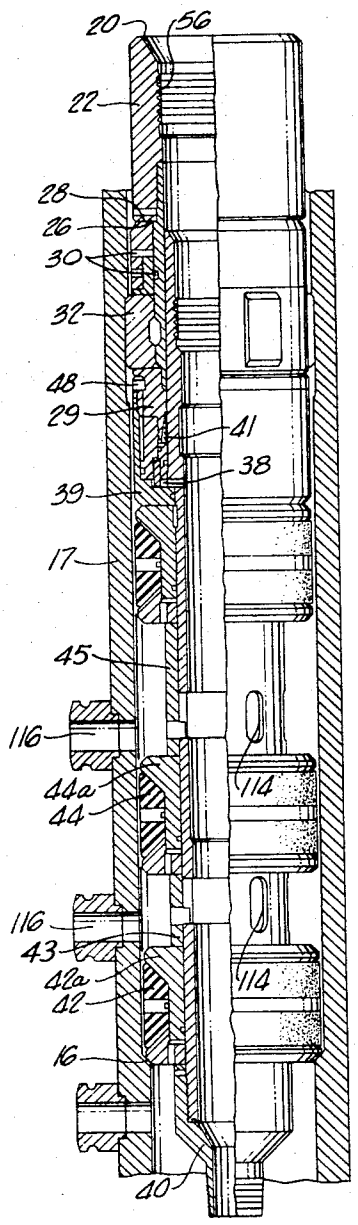
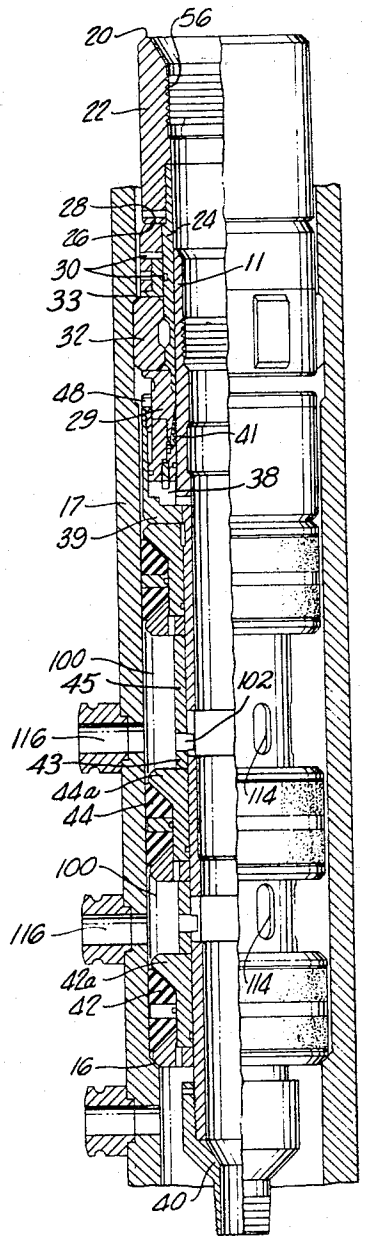


Fig. 6.



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United States Patent Office 3,295,600 Patented Jan. 3, 1967

3,295,600

UNDERWATER PRODUCTION METHOD

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Original application Sept. 20, 1963, Ser. No. 310,203. Divided and this application Oct. 22, 1965, Ser. No. 501,057

2 Claims. (Cl. 166—.5)

The present application is a divisional application of Serial No. 310,203 filed September 20, 1963, and relates to the underwater production of oil and gas. More particularly, the present invention relates to an improved method for installing underwater production head apparatus remotely at an underwater location.

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 by 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, some prior proposals for underwater production heads such as that described in copending application of C. E. Wakefield, Jr., Serial No. 100,411 filed April 3, 1961, require registry with 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 system 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 system wherein the openings of the tubing hanger mandrel communicate with the side openings of the tubing head without the use of an orientation cam.

It is a further object of our present invention to provide a tubing hanger system 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 system 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 the 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. 3*a* 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. 3*a*, 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 **42***a*, **44***a*, **46***a* and the entire tubing hanger mandrel assembly from cyl-

inder **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 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.

Slips **41** 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. 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 **42***a*, **44***a*, and **46***a*, 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.

We claim:

1. A method for completing a well in a formation underlying a body of water from a structure over said well, the steps comprising:

installing a tubing head in said well adjacent said formation,

installing production tubing on a tubing hanger mandrel at said structure,

lowering said tubing and tubing hanger mandrel from said structure into said well,

landing said tubing hanger mandrel on a shoulder in said tubing head,

mechanically locking said tubing hanger mandrel in a recess in said tubing head, and

extruding packing in the annulus between said tubing hanger mandrel and said tubing head by hydraulically moving piston means associated with said tubing hanger mandrel between said recess and said shoulder.

2. The method of claim **1** including the step of sealing said annulus with said packing about a transversely disposed tubing flow passage extending through a side outlet of said tubing hanger mandrel and an adjacent side outlet in said tubing head.

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