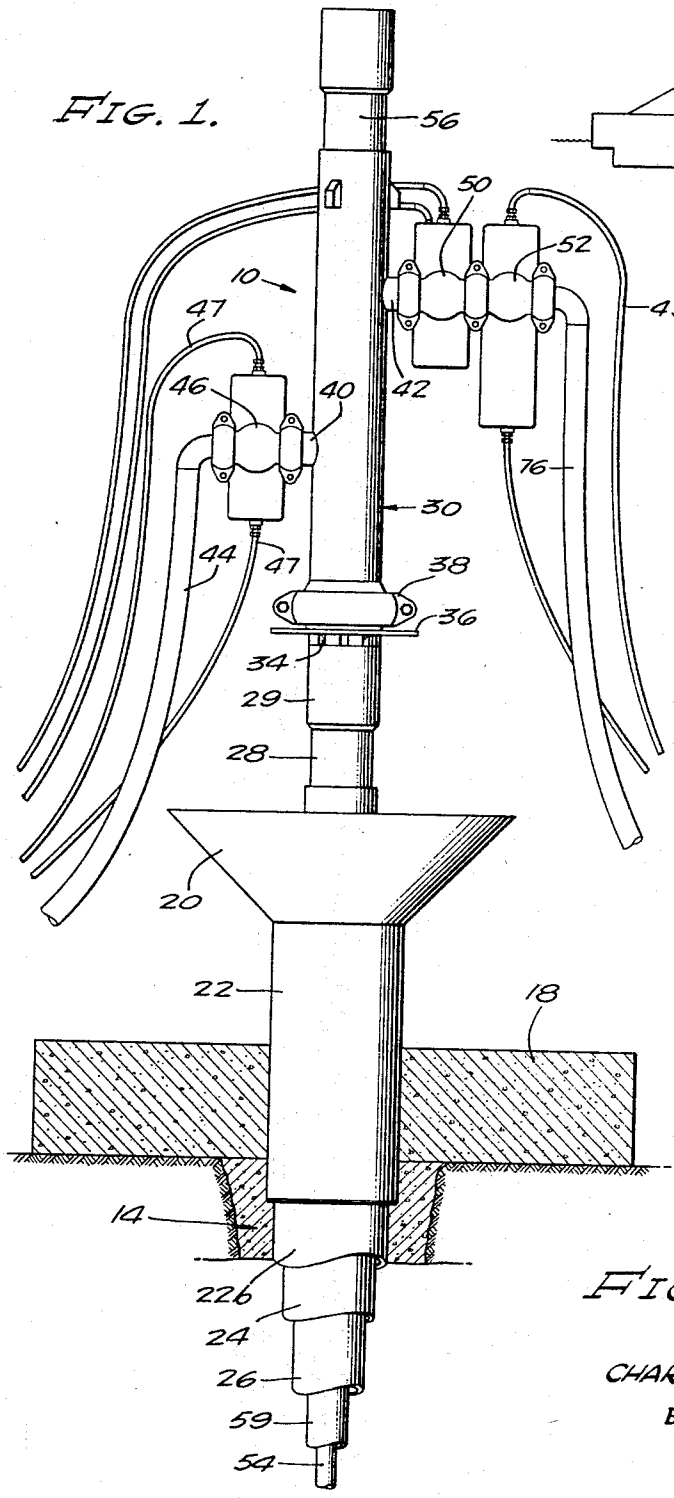
Oct. 18, 1966 C. E. WAKEFIELD, JR 3,279,536

SUBMARINE DRILLING AND PRODUCTION HEAD AND METHOD OF INSTALLING SAME

Filed April 3, 1961

4 Sheets-Sheet 1

FIG. 1.



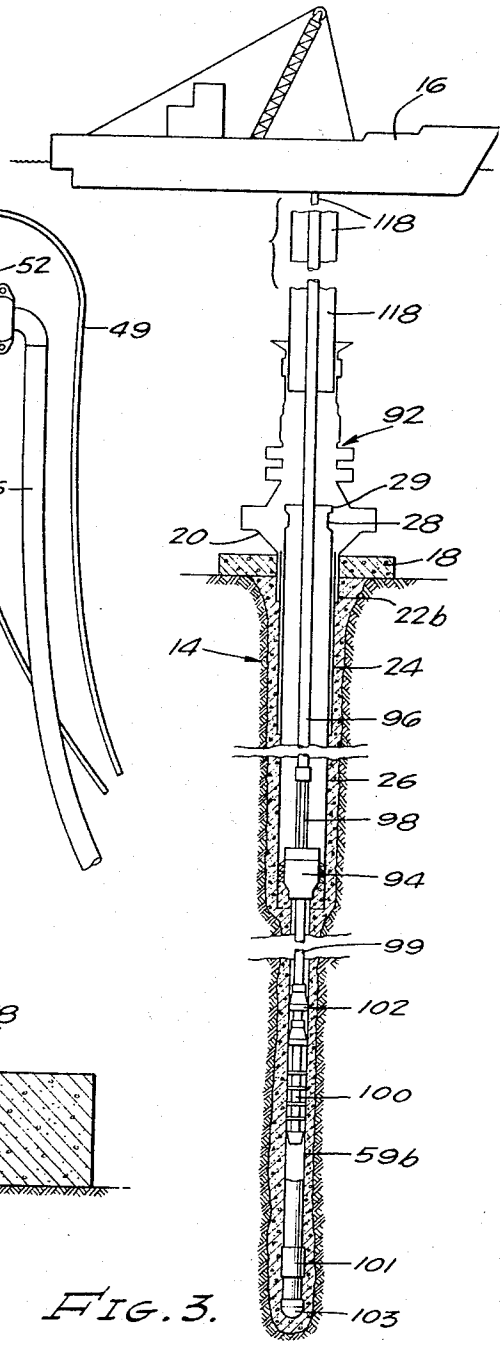


FIG. 3.

INVENTOR.
CHARLES E. WAKEFIELD, JR.
BY

ATTORNEY

Oct. 18, 1966 C. E. WAKEFIELD, JR 3,279,536

SUBMARINE DRILLING AND PRODUCTION HEAD AND METHOD OF INSTALLING SAME

Filed April 3, 1961

4 Sheets-Sheet 2

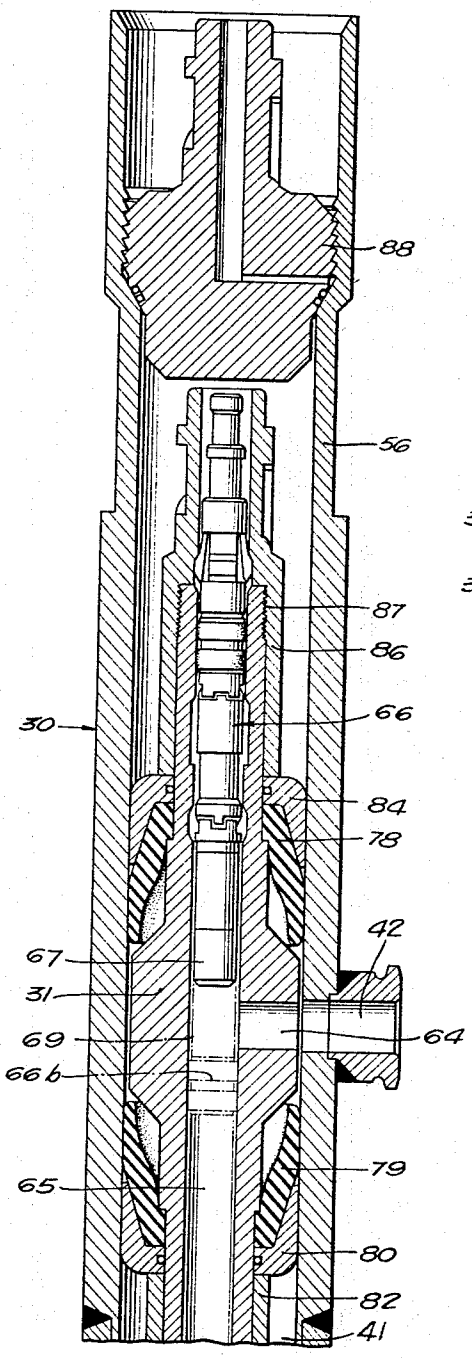


FIG. 2a.

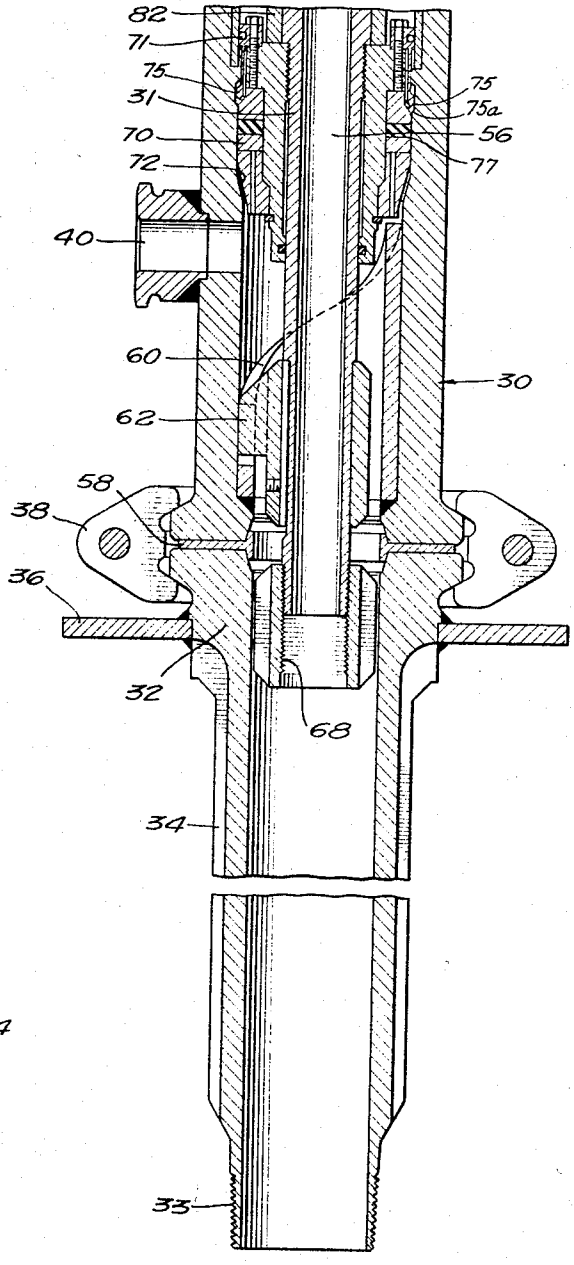


FIG. 2b.

INVENTOR.
CHARLES E. WAKEFIELD, JR.

BY

ATTORNEY

Oct. 18, 1966 C. E. WAKEFIELD, JR 3,279,536

SUBMARINE DRILLING AND PRODUCTION HEAD AND METHOD OF INSTALLING SAME

Filed April 3, 1961 4 Sheets-Sheet 3

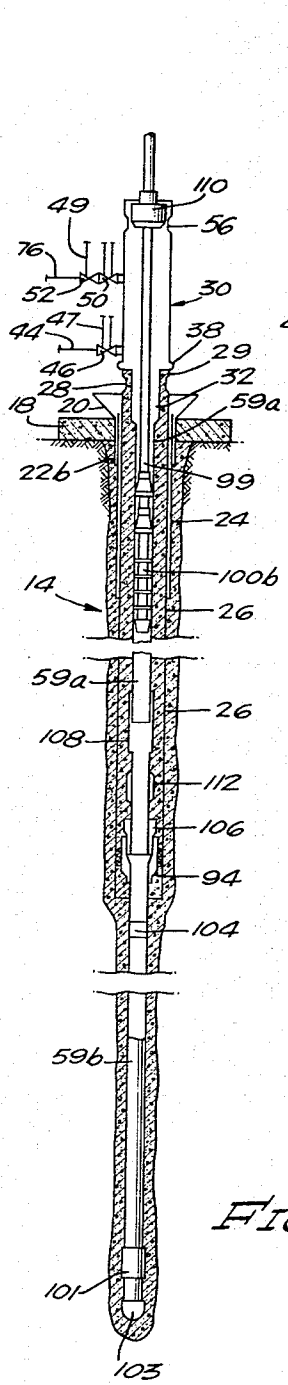


FIG. 5.

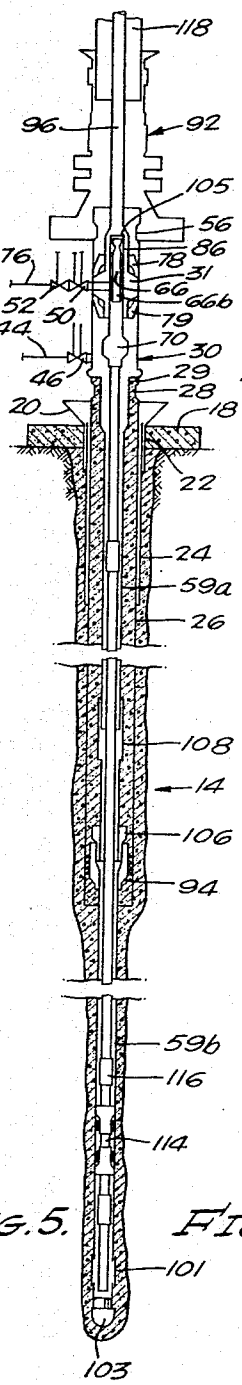


FIG. 6.

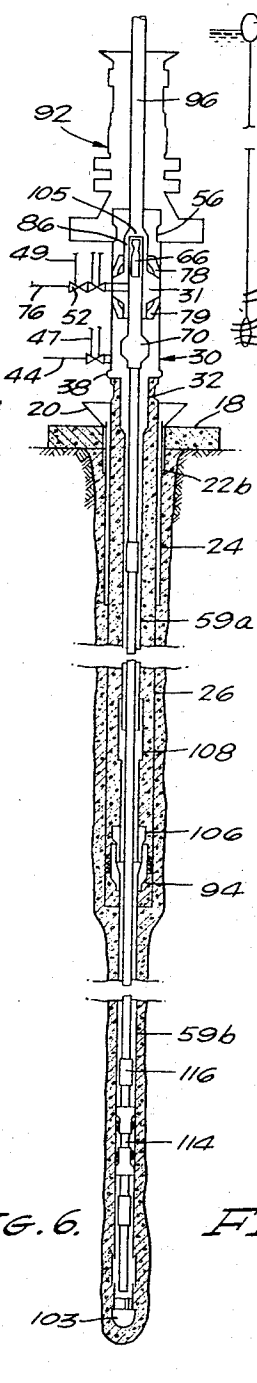


FIG. 7.

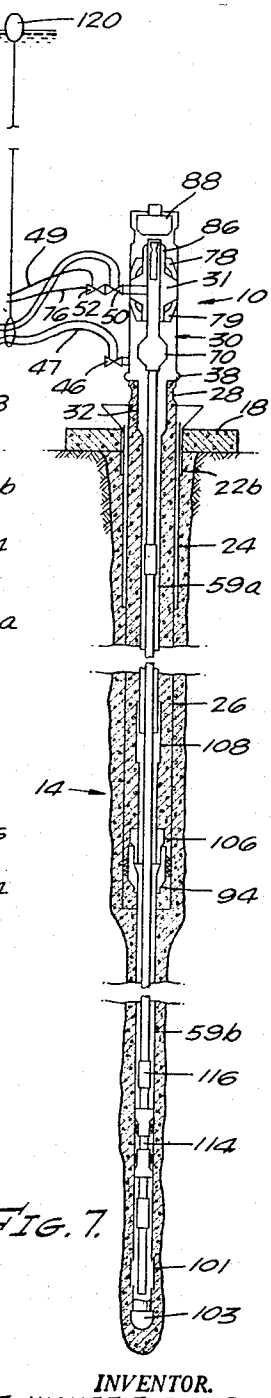


FIG. 4.

INVENTOR.
CHARLES E. WAKEFIELD, JR.
BY

ATTORNEY

Oct. 18, 1966 C. E. WAKEFIELD, JR 3,279,536

SUBMARINE DRILLING AND PRODUCTION HEAD AND METHOD OF INSTALLING SAME

Filed April 3, 1961 4 Sheets-Sheet 4

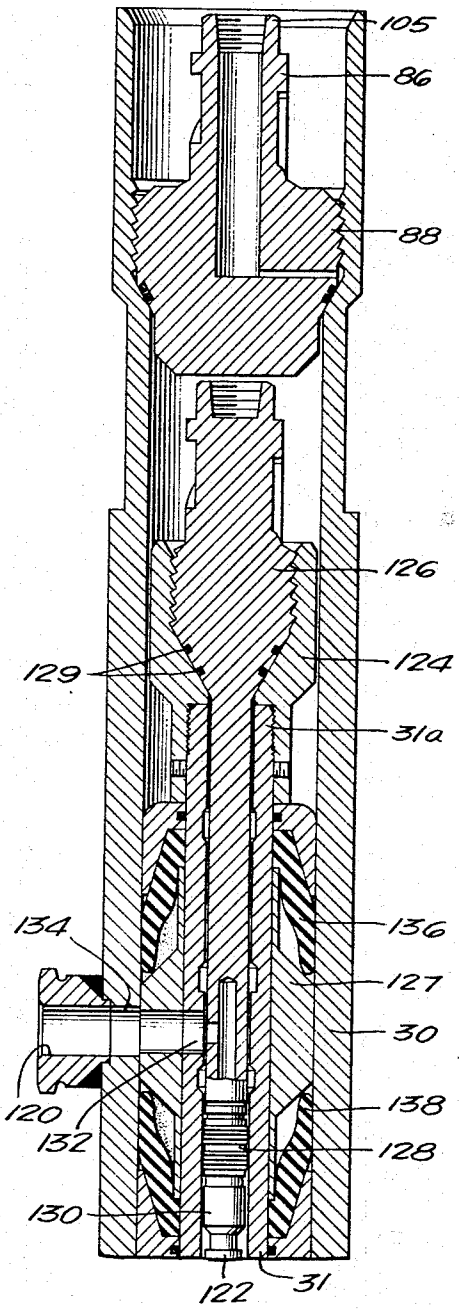


FIG. 8a.

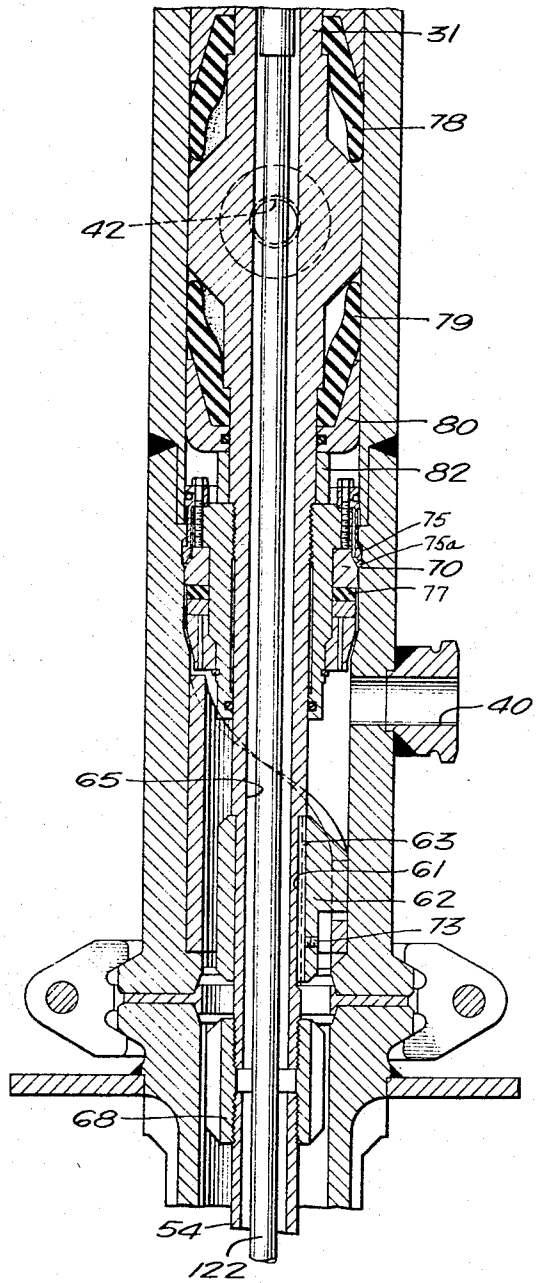


FIG. 8b.

INVENTOR.
CHARLES E. WAKEFIELD, JR.
BY Donald W Canady
ATTORNEY

United States Patent Office

3,279,536

Patented Oct. 18, 1966

3,279,536

SUBMARINE DRILLING AND PRODUCTION HEAD AND METHOD OF INSTALLING SAME

Charles E. Wakefield, Jr., Bakersfield, Calif., assignor to Richfield Oil Corporation, Los Angeles, Calif., a corporation of Delaware

Filed Apr. 3, 1961, Ser. No. 100,411
18 Claims. (Cl. 166—.5)

The present invention is a continuation-in-part of my copending application Serial No. 36,215, filed June 15, 1960, now abandoned, and relates to the production of petroleum from a formation underlying a body of water, more particularly relating to a device for controlling flow of oil and gas from a well underlying a body of water and a method for landing an underwater production head at the ocean floor.

When drilling into and producing from a stratum containing oil and gas under high pressure, a device known as a Christmas tree is normally utilized to control flow of oil and gas from the well during the period of natural flow. The Christmas tree comprises an assemblage of valves including generally, a master valve, one or more wing valves, and such flow constricting and gauging devices as may be required in a particular well. The outer casing is normally cemented into the well with the casing spool, the tubing head, the casing head, and the various Christmas tree components connected to the outer casing by bolting flanged fittings thereto. This, of course, requires working access to the well head during installation.

In off-shore production methods heretofore known the production head has been located at the surface of the water on a platform where workmen can easily flange-up a well head and Christmas tree. In deeper water, however, such platforms are obviously impractical and it has been proposed to locate the production head on the floor of the body of water. Installing a conventional Christmas tree on bottom, however, which has been done in some areas, necessarily requires costly diving operations.

It is therefore an object of my invention to provide a novel form of production head for controlling the flow of oil and gas from a well drilled in a formation underlying a body of water and also to provide a method for installing such production head beneath the water surface.

It is also an object of my present invention to provide a submarine production head for installation on the ocean floor at relatively deep depths. It is also an object of my present invention to provide a submarine production head which can be installed remotely from a floating vessel.

It is a further object of my present invention to provide a submarine production head for controlling flow of oil and gas from a location remote from the production head.

It is a further object of my present invention to provide a submarine production head through which drilling operations may be conducted.

Other objects and a fuller understanding of the invention may be had by referring to the following description and the appended claims taken in conjunction with the accompanying drawings, in which:

FIGURE 1 is an elevation of my underwater production head showing its position relative to the well and submarine drilling base.

FIGURES 2*a* and 2*b* are divided longitudinal sectional views of the assembled production head showing the outer

production mandrel and the inner tubing hanger mandrel assembly.

FIGURES 3 through 7 show the steps of the method for installing the production head in a well drilled into a formation underlying a body of water.

FIGURE 3 is a side elevation in diagrammatic form showing the manner in which the inner casing is hung preparatory to landing the assembled production mandrel.

FIGURE 4 is a side elevation in diagrammatic form showing the production mandrel positioned on the surface casing landing mandrel just above the landing base.

FIGURE 5 is a diagrammatic side elevation showing the equipment used to run the tubing into the well.

FIGURE 6 is a diagrammatic side elevation illustrating the means used to plug the production mandrel preparatory to bringing the well in.

FIGURE 7 is a diagrammatic side elevation view showing the benthonic well in production.

FIGURES 8*a* and 8*b* are divided longitudinal sectional views of a modification of the production head shown in FIGURES 2*a* and 2*b* employing a second string of tubing with an additional side outlet communicating therewith.

With reference to the drawings, the invention is illustrated as being embodied in an underwater production head **10** which is adapted to be operated remotely either from a land base or a nearby off-shore structure through control lines. The production head **10** serves the purpose of controlling the flow of gas and oil from the well **14** which function is normally performed by a Christmas tree and well head in land based operations. The assembled production head **10** is installed from a drilling barge **16** so that it can subsequently be remotely controlled from land at the completion of the drilling operation when the top opening is plugged off above the tubing outlet.

In another embodiment of my invention the bore of the production head assembly shown in FIGURE 2 is enlarged to permit drilling operations and the passage of casing therethrough thus obviating the need for separate installation of the production head at the conclusion of the drilling operation.

Referring now to FIGURE 1 a landing base **18** with a funnel member **20** and a sleeve **22** which guide drilling tools and various well equipment through the landing base is positioned on the ocean floor at the well opening. The lower portion **22***b* of the sleeve **22** is affixed to sleeve **22** in such a manner that the joint forms a seat on which the conductor pipe **24** rests as shown in copending application Serial No. 19,722, of William D. Leake, filed April 4, 1960. A surface pipe **26** is equipped with external lugs (not shown) which supports the surface pipe within the conductor pipe **24**. The surface pipe **26** is provided at its upper extremity with a landing mandrel **29** onto which the blowout prevention equipment is latched during the drilling operation.

The production head **10** includes a production mandrel **30** which is clamped together in two pieces, the lower portion **32** of which may be provided with splines **34** and cemented into the surface pipe. The production mandrel **10** functions as one piece and can be constructed as one unit, however, as a prevention measure I prefer to divide the outer mandrel into two pieces as shown to facilitate removal of upper part of the mandrel should the need arise after the lower portion **32** has been cemented into the surface pipe. A sealing member **58** is positioned between the production mandrel and the lower splined portion **32**. Portion **32** is equipped with a baffle **36** beneath

the clamps **38** which serves to protect the clamps from cement returns. The production mandrel has a latching neck **56** near its upper end onto which the blowout prevention equipment may be latched while the tubing **54** is being run into the well.

The production mandrel **30** is provided with a casing outlet **40** and a tubing outlet **42** through which latter outlet the flow of oil and gas from the well **14** is controlled. A casing flow line **44** is provided at the outlet **40** and a casing valve **46** is positioned at the outlet **40** and hydraulically actuated through fluid control lines **47**. The casing outlet may be used initially to circulate drilling fluid from the well, however it is normally closed during the period of natural flow. Valve **46** preferably is a conventional non-lubricated plug valve equipped with a conventional hydraulic actuator.

The tubing outlet **42** is equipped with a hydraulically actuated control valve **50** similar to casing valve **46**, and a second spring loaded safety valve **52** held open with hydraulic pressure, which together control the flow of gas and oil from the well through the flow tube **54**.

The production head **10** has an outer or production mandrel **30** and an inner or tubing hanger mandrel **31** as shown in detail in FIGURES 2*a* and 2*b*.

Water shut-off casing **59** is threaded to the lower end of the production mandrel **30** at **33** and the production tubing **54** is threaded into the lower end of the tubing hanger mandrel at **68**. An orientation cam **60** inside the production mandrel **30** is adapted to receive orientation lug **62** on the tubing hanger mandrel **31** only in such a manner that the side opening **64** in the tubing hanger mandrel **31** registers with the tubing outlet **42** in the production mandrel **30**. In FIGURE 2*b*, the orientation cam **60** and the lug **62** have been rotated 180° for the ease of illustration. As best viewed in FIG. 8*b*, orientation lug **62** has an internal keyway **63** which is aligned with keyway **61** provided in the tubing hanger mandrel **31**. A key held in place by set screw **73** is fitted in the aligned keyways **63** and **61** to prevent the orientation lug **62** from rotating relative to the tubing hanger mandrel **31**.

The tubing hanger mandrel bore **65** is plugged above the side outlet **64** with any suitable means which can be inserted remotely, such as the Otis type "S" packing mandrel assembly **66** which can be fitted into sealing position on a wire line. The cap **67** of packer assembly **66** can be removed from a second packer **66***b* added to the packer assembly on an extension **69** to seal off tubing outlet **64**.

Tubing **54** is threaded into a coupling member **68** which in turn is threaded to the lower end of the tubing hanger mandrel **31**. The tubing and the tubing hanger mandrel are supported within the production mandrel with a suitable tubing hanger member such as the automatic tubing hanger **70**, on internal tapered portion **72** of the production mandrel. The automatic tubing hanger **70** hangs the tubing in the production head automatically without the use of manually tightened ring nuts or locking screws. The hanger, supporting the tubing string, seats on a tapered bowl **72** in the tubing head and is locked against upward movement by spring dogs **75**. As the hanger **70** enters the production mandrel **30**, the spring dogs **75** surrounding the upper part of the hanger are retracted and the hanger slides down until, as shown in FIGS. 2*b* and 8*b*, the dogs spring automatically into the groove or shoulder **75***a* provided in the production mandrel. Downhole pressure from below the tubing hanger actuates or locks the automatic tubing hanger by moving the packing unit **77** upward which, in turn, locks the spring dogs securely into groove **75***a*.

During production, oil and gas flows through tubing **54** and up through tubing hanger mandrel bore **65**, out the registering tubing outlets **64** and **42** through the hydraulically controlled valves **50** and **52** and thence through flow line **76** to storage tanks. Packer cups **78** and **79** which may advantageously be of the self sealing or pressure energized type, seal against leakage between the production mandrel and the tubing hanger mandrel at their tubing outlets. The tubing hanger seals **71** are the primary seals between the tubing and the casing against upward flow through the casing annulus **41** above casing outlet **40**. Packer cup **79** also serves as a secondary seal behind primary seals **71**, to restrict flow between the tubing and casing to the casing outlet **40**. Packer cup **79** is supported by a thimble **80** which is supported on the automatic tubing hanger **70** by a sleeve **82**. Packer thimble **84** is supported in place by the safety joint part **86** which is threaded to the tubing hanger mandrel at **87**.

A variation of the production head is shown assembled in FIGURES 8*a* and 8*b*. In this modification a macaroni string **122** is supported within the tubing hanger mandrel **31**. A tubing hanger mandrel adaptor **124** is threaded to the upper end of the tubing hanger mandrel **31** and has a macaroni hanger **126** threaded therein on which the inner or macaroni string of tubing **122** is hung with a coupling member **130**. Packing member **128** seals off flow between tubing **122** and the tubing hanger mandrel above the tubing outlet **42**, and sealing elements **129** serve as secondary seals. The upper end of the macaroni hanger **126** is socketed similar to the upper end of the head plug **88** and the safety joint **86** so that the tubing hanger mandrel or the macaroni string **122** can be removed on a socket coupling (not shown) attached to the drill string. The upper end **31***a* of the tubing hanger mandrel is provided with an additional outlet **132** which communicates with outlet **134** in the production mandrel, thus providing communication between the macaroni tubing **122** and the outlet **120**. As an example of the second recovery techniques for which this macaroni tubing may be employed, gas may be injected into the outlet **120** and through the macaroni tubing to effect a gas lift.

Packers **136** and **138** (FIG. 8a) are provided above and below the macaroni outlet **120** to seal between the production mandrel **30** and the upper portion **127** of the tubing hanger mandrel. In FIGURE 8*b* the tubing outlet **42** is shown in phantom since in this modification outlet **42** would not be in the same plane with the casing outlet **40** and macaroni outlet **120**. In the modification shown in FIGURES 8*a* and 8*b* the production head apparatus below the tubing outlet **42** would be essentially the same as in the production head described above.

In operation the production mandrel is first landed on the surface casing landing mandrel with a suitable landing sub, then the assembled tubing hanger mandrel with tubing connected thereto is lowered into place on the drill pipe with the socket end of a safety joint attached to the lower end thereof, after which the plug **66** is set on a wire line. A head plug **88** is then lowered on the socket end of the safety joint (not shown) and screwed into the production mandrel. The head plug **88** is designed to limit upward movement of the tubing hanger mandrel in the event of a blowout and serves as a secondary seal above packer cup **78** and plug **66**.

The underwater production head of the present invention is landed at the benthos well from a drilling vessel **16** such as is disclosed in detail in copending application Serial No. 19,722, of William D. Leake, filed April 4, 1960. With the blowout prevention equipment **92** latched to the latching neck **28** of the surface casing landing mandrel **29** the lower section of casing **59***b* is hung on a conventional casing hanger **94** which is lowered into the surface pipe on the drill pipe **96**, as shown in FIGURE 3. A suitable release tool **98** is used to release the drill pipe from the casing hanger.

A tubing tail **99** is run through the casing hanger and the lower section **59***b* of the casing is cemented up to the casing hanger. A flexible cement plug **100** is provided to divide the cement from the drilling mud and a down swab **102** prevents the cement from coming back up the casing. A float collar **101** and a float shoe **103** are provided in the conventional manner at the lower end of the casing

to prevent cement from coming back up the inside of the casing after displacement of the cement.

After the lower section of casing is cemented in the surface pipe the casing is sealed off internally with a bridge plug or a cement plug **104** and the blowout prevention equipment removed from the well head, as shown in FIGURE 4. The production mandrel **30** with the upper section of casing **59***a* threaded thereon is lowered into the surface pipe on the drill pipe with a landing sub **110**. A suitable casing splice **106** is provided to splice the lower section **59***b* of the casing to the upper section **59***a* of the casing. A flexible slip joint **108** may be provided in the casing between the upper and lower sections of casing.

In shallow drilling operation setting the casing in two parts may not be necessary and hence the entire casing can be hung from the production mandrel.

The tubing tail **99** is withdrawn to the barge to attach a second flexible plug **100***b* and then the upper section **59***a* of the casing is cemented through a stage cement collar **112**. Thus the casing and the splined lower portion **32** of the production mandrel are cemented into the surface pipe **26** and surface casing landing mandrel **29**. The baffle **36** prevents cement returns from contacting the clamp **38**. The surface pipe and conductor pipe were previously cemented into the well.

When the production head is used as a drilling head, the casing is hung from the inside of the enlarged production mandrel, for example, on a donut hanger, and the surface casing is threaded to the lower end of the production mandrel.

The blowout prevention equipment **92** is replaced on the production mandrel by latching the blowout prevention equipment to the latching neck **56** of the production mandrel. The casing riser **118** which was used in the drilling operation is then lowered and latched into the upper end of the blowout prevention equipment **92**. After the casing plug **104** is drilled out or retrieved, the tubing is hung on the tubing hanger mandrel and the tubing hanger mandrel lowered into the production mandrel, as shown in FIGURE 5. The socket end **105** of the safety joint is threaded to the drill pipe **96** and releasably latches the safety joint **86** of the tubing hanger mandrel to the drill pipe to lower the mandrel assembly into the well. The lower end of the tubing is provided with a special packer **114** which is a means of confining zone pressure. Above this packer a sliding side door **116** is provided for circulating mud out of the hole after the tubing is run into the casing.

Before the tubing hanger mandrel is lowered through the blowout prevention equipment, plug **66** with an extension **69** and second packer **66***b* which seals the bore of the tubing hanger mandrel below the tubing outlet, is lowered into the tubing hanger mandrel to seal off the tubing outlet of the tubing hanger mandrel until the mandrel is lowered through the blowout preventers and the tubing outlet put in communication with the tubing outlet valves **50** and **52**. After the tubing hanger mandrel **31** is lowered into place, however, the plug **66** is pulled up to the barge and the second packer **66***b* and extension **69** are removed and a cap **67** screwed into the plug **66** to seal off the tubing above the tubing outlet **64** and permit tubing flow through the outlet. A head plug **88** is then threaded into the production mandrel **30** with the socket end **105** of the safety joint attached to the drill pipe **96**. This plug **88** serves as a secondary seal above the packer cup **78** and also is a secondary seal to the plug **66** as well as a safety device to prevent the tubing hanger mandrel from blowing out of the hole.

At the conclusion of the drilling and cementing operations and after the well is brought in, the drill pipe and casing riser are withdrawn to the barge and the blowout prevention equipment retrieved. The production of fluid from the well is then controlled remotely from a shore control center or a control barge. Flow line **76** is connected to the fail-safe valve **52** and run on the ocean floor with the safety valve control line **49** to a tank (not shown). The casing outlet hose **44** and the remainder of the control lines are then blanked off and dropped on bottom. A buoy marker **120** is attached to the blanked off control lines and casing outlet hose as shown in FIGURE 7.

Although I have described my present invention with a certain degree of particularity in order to set forth the best mode of operation, it is to be understood that my invention is not to be limited to the details set forth but should be given the full scope of the appended claims.

I claim:

1. An underwater production head 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 of a smaller outside diameter than the internal diameter of said first tubular member,

said second tubular member having a side outlet in fluid communication with said outlet in said first tubular member,

said second tubular member so disposed within said first tubular member as to form an annulus between said first and said second tubular members,

means for supporting said second tubular member within said first tubular member,

means actuatable internally of said first tubular member for automatically locking said second tubular member against vertical movement relative to said first tubular member when said second tubular member is supported within said first tubular member by said supporting means, and

means for sealing said annulus above said first and second tubular member side outlets.

2. The apparatus of claim **1** including removable means for sealing said second tubular member internally above said side outlet of said second tubular member.

3. The apparatus of claim **1** including means for affixing said first tubular member to said well.

4. The apparatus of claim **1** wherein said annulus sealing means are pressure energized.

5. The apparatus of claim **1** wherein said first tubular member comprises an upper and lower section and including means for releasably connecting said sections, and means for securing said lower section of said first tubular member into said well.

6. The apparatus of claim **1** including orientation means for registering said side outlet of said second tubular member with said side outlet of said first tubular member.

7. The apparatus of claim **1** wherein said second tubular member is concentrically disposed within said first tubular member.

8. The apparatus of claim **1** including a third tubular member supported within said second tubular member, a second side outlet in said first tubular member and said second tubular member, said second side outlet of said second tubular member being in fluid communication with said second side outlet of said first tubular member, said third tubular member having an outlet communicating with said second side outlets of said first and said second tubular members.

9. The apparatus of claim **1** including removable means for sealing the bore below said side outlet of said second tubular member to prevent the flow of oil and gas through said second tubular member side outlet during installation of said second tubular member within said first tubular member.

10. The apparatus of claim **1** including a second means for sealing said annulus below said communicating side outlets, and

a second side outlet in said first tubular member below said second sealing means, said second side outlet

communicating with said annulus below said second sealing means.

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

a first tubular member having a side outlet,

a second tubular member of a smaller outside diameter than the internal diameter of said first tubular member,

said second tubular member having a side outlet in fluid communication with said outlet in said first tubular member,

said second tubular member being so disposed within said first tubular member as to form an annulus between said first and said second tubular members,

tubing hanger means positioned on said second tubular member below said outlet thereof,

said tubing hanger means being arranged and constructed to support said second tubular member within said first tubular member,

means actuatable internally of said first tubular member for automatically locking said second tubular member against vertical movement relative to said first tubular member when said second tubular member is supported within said first tubular member by said supporting means, and

means for sealing said annulus above said first and second tubular member side outlets.

12. An underwater drilling and production head for drilling a well in a formation underlying a body of water and subsequently controlling the flow of oil and gas for said well, comprising in combination:

a first tubular member having a side outlet,

means for affixing said first tubular member to said well,

means for connecting a surface casing to said first tubular member,

a second tubular member through which drilling tools may be operated,

said second tubular member being of a smaller outside diameter than the internal diameter of said first tubular member and said second tubular member having a side outlet in fluid communication with said side outlet of said first tubular member,

said second tubular member being so disposed within said first tubular member as to form an annulus between said first and said second tubular member,

said second tubular member having means for supporting tubing therefrom,

means for supporting said second tubular member within said first tubular member, and

means actuatable internally of said first tubular member for automatically locking said second tubular member against vertical movement relative to said first tubular member when said second tubular member is supported within said first tubular member by said supporting means.

13. An underwater production head 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 a shoulder therein,

a second tubular member disposed within said first tubular member,

said second tubular member having a side outlet in fluid communication with said side outlet of said first tubular member,

means for supporting said second tubular member within said first tubular member,

means actuatable internally of said first tubular member for automatically engaging said shoulder to lock said second tubular member against upward movement relative to said first tubular member when said second tubular member is supported within said first tubular member by said supporting means, and

means for sealing between said tubular members above said side outlets.

14. An underwater production head 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 a shoulder therein,

a second tubular member of a smaller outside diameter than the internal diameter of said first tubular member,

said second tubular member having a side outlet in fluid communication with said side outlet of said first tubular member,

said second tubular member being so disposed within said first tubular member as to form an annulus between said first tubular member and said second tubular member,

means for supporting said second tubular member within said first tubular member,

dog means associated with said second tubular member,

means internal of said first tubular member for moving said dog means into engagement with said shoulder automatically when said second tubular member is supported within said first tubular member by said supporting means, to thereby lock said second tubular member against upward movement relative to said first tubular member, and

means for sealing said annulus above said first and said second tubular member side outlets.

15. An underwater production head for controlling the flow of oil and gas from a well drilled in a formation underlying a body of water wherein a vessel is positioned over said well comprising in combination:

a production mandrel having a side outlet,

a tubing hanger mandrel of a smaller outside diameter than the internal diameter of said production mandrel,

said tubing hanger mandrel having a side outlet in fluid communication with said side outlet of said production mandrel,

said tubing hanger mandrel being so disposed within said production mandrel as to form an annulus between said production mandrel and tubing hanger mandrel,

means for remotely lowering said tubing hanger mandrel into locking position with said production mandrel from said vessel,

means for supporting said tubing hanger mandrel within said production mandrel, and

means for sealing said annulus above said side outlets of said production mandrel and said tubing hanger mandrel.

16. The apparatus of claim 15 including a second means for sealing said annulus below said communicating side outlets, and

a second side outlet in said production mandrel below said second sealing means, said second side outlet communicating with said annulus below said second sealing means.

17. An underwater production head 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 a shoulder therein,

a second tubular member disposed within said first tubular member, said second tubular member having a side outlet in fluid communication with said side outlet of said first tubular member,

means for supporting said second tubular member against vertical movement relative to said first tubular member, said means including locking means positioned internally of said first tubular member and automatically movable into locking position relative

to said shoulder as said second tubular member is lowered into operative position in said first tubular member.

18. An underwater production head 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 of a smaller outside diameter than the internal diameter of said first tubular member,

said second tubular member having a side outlet in fluid communication with said outlet in said first tubular member, said second tubular member so disposed within said first tubular member as to form an annulus between said first and said second tubular member,

means for supporting said second tubular member within said first tubular member,

means for locking said second tubular member in said first tubular member, said locking means including means responsive to pressure in said annulus below said locking means for locking said second tubular member relative to said first tubular member, and

means for sealing said annulus above said first and second tubular member side outlets.

References Cited by the Examiner

UNITED STATES PATENTS

1,836,419	12/1931	Wigle	166—89 X
1,923,448	8/1933	McCoy	166—46
2,077,480	4/1937	Humason	166—88
2,096,565	10/1937	Shaffer et al.	166—88
2,187,839	1/1940	Penick	166—89 X
2,469,772	5/1949	Johnson	166—89
2,623,467	12/1952	Andrew	166—95 X
2,808,229	10/1957	Bauer et al.	175—7
2,810,442	10/1957	Tausch	166—46 X
2,859,823	11/1958	Bauer	166—88
2,889,886	6/1959	Gould	166—89
2,906,500	9/1959	Knapp et al.	166—66.5 X
2,918,972	12/1959	Tubbs	166—88
2,970,646	2/1961	Knapp et al.	166—66.5 X
3,032,106	5/1962	Focht et al.	166—46
3,050,120	8/1962	McSpadden	166—86 X
3,065,792	11/1962	Andrew	166—46
3,130,785	4/1964	McCullough	166—46

FOREIGN PATENTS

336,323	10/1930	Great Britain.

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

R. E. FAVREAU, *Assistant Examiner.*