Nov. 15, 1966 R. D. JOHNSTONE ETAL 3,285,337

WELL DRILLING METHOD

Original Filed July 10, 1961 6 Sheets-Sheet 1

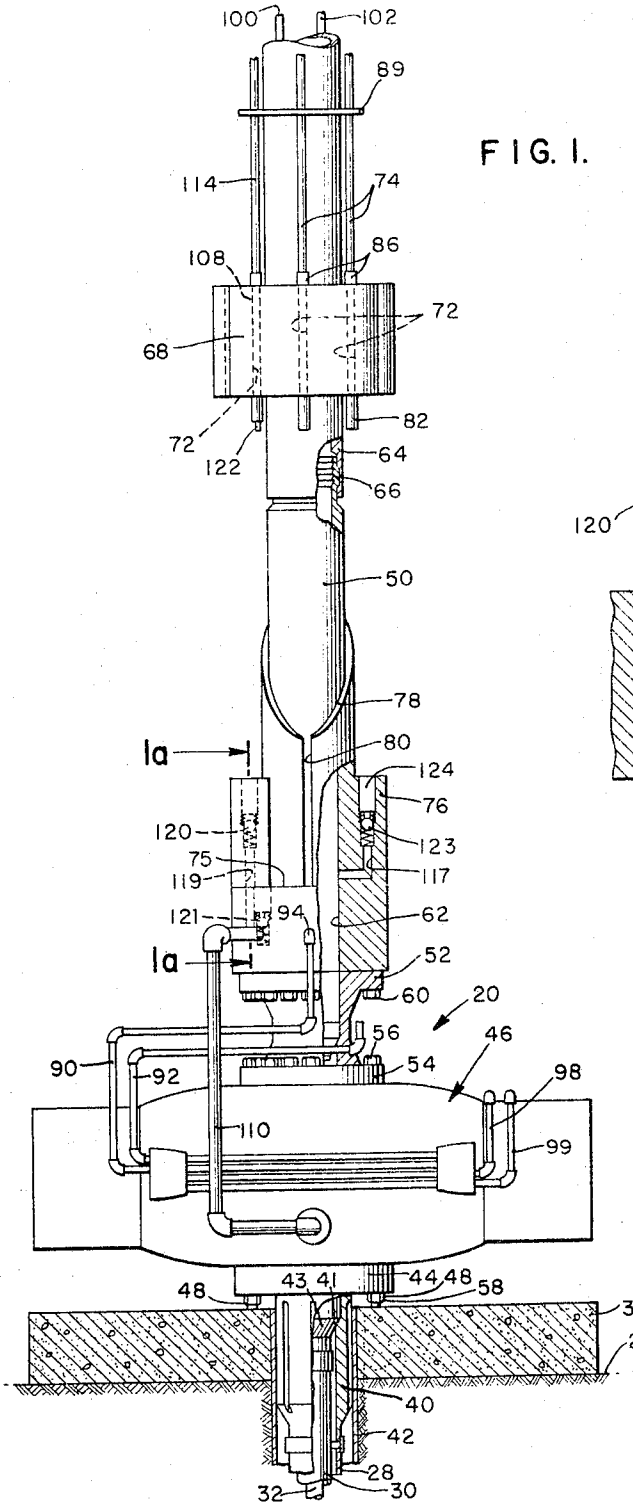


FIG. 1.

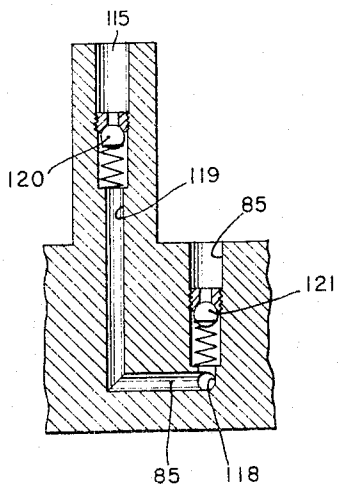


FIG. 1a.

INVENTORS.
ROBERT D. JOHNSTONE
DAVID C. KOFAHL

BY Donald W Canady

ATTORNEY

WELL DRILLING METHOD

Original Filed July 10, 1961 6 Sheets-Sheet 2

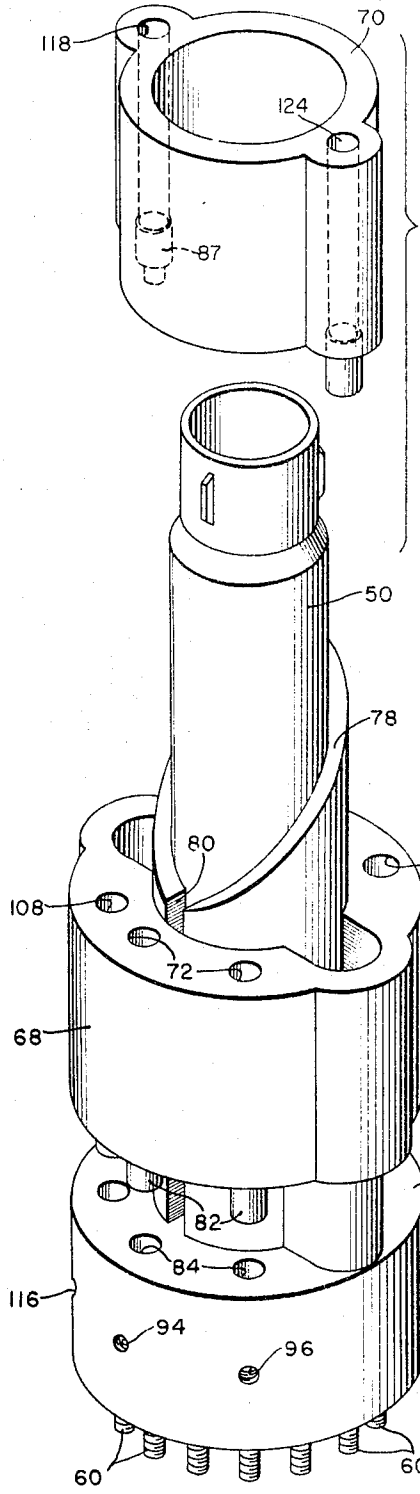


FIG. 2.

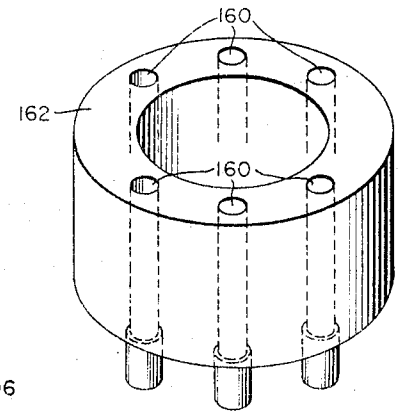


FIG. 3.

INVENTORS.
ROBERT D. JOHNSTONE
DAVID C. KOFAHL
BY
Donald W Canady
ATTORNEY

WELL DRILLING METHOD

Original Filed July 10, 1961 6 Sheets-Sheet 3

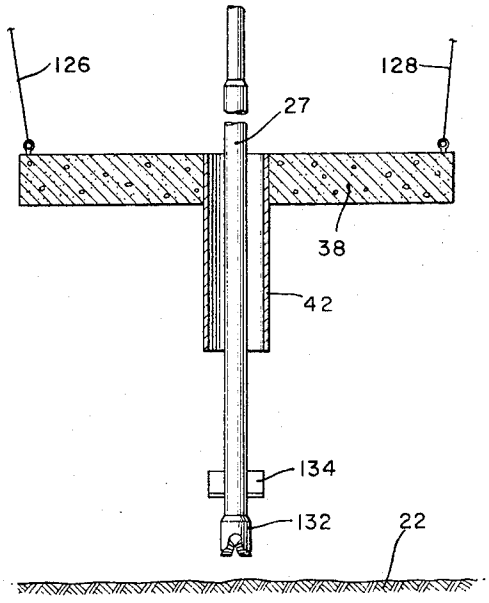


FIG. 4.

FIG. 5.

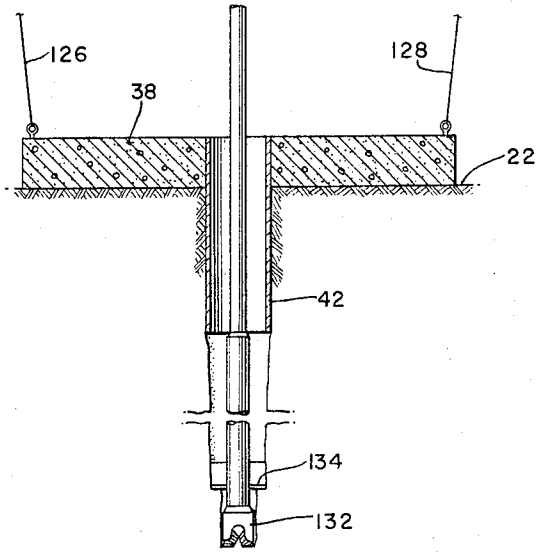
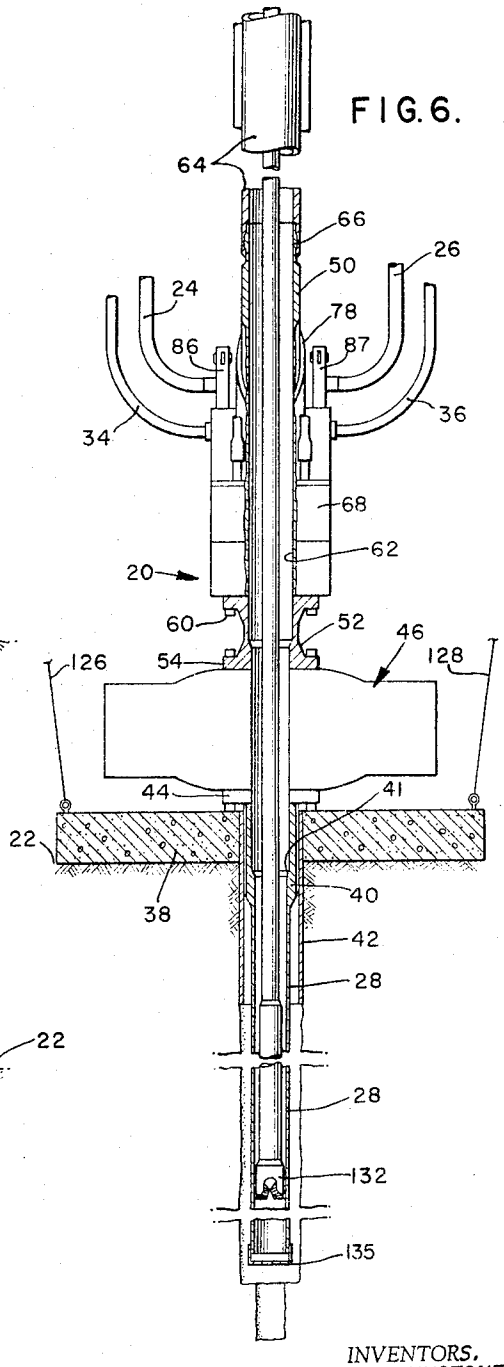


FIG. 6.



INVENTORS,
ROBERT D. JOHNSTONE
DAVID C. KOFAHL
BY
Donald W Canady
ATTORNEY.

Nov. 15, 1966 R. D. JOHNSTONE ETAL 3,285,337

WELL DRILLING METHOD

Original Filed July 10, 1961 6 Sheets-Sheet 4

FIG. 7.

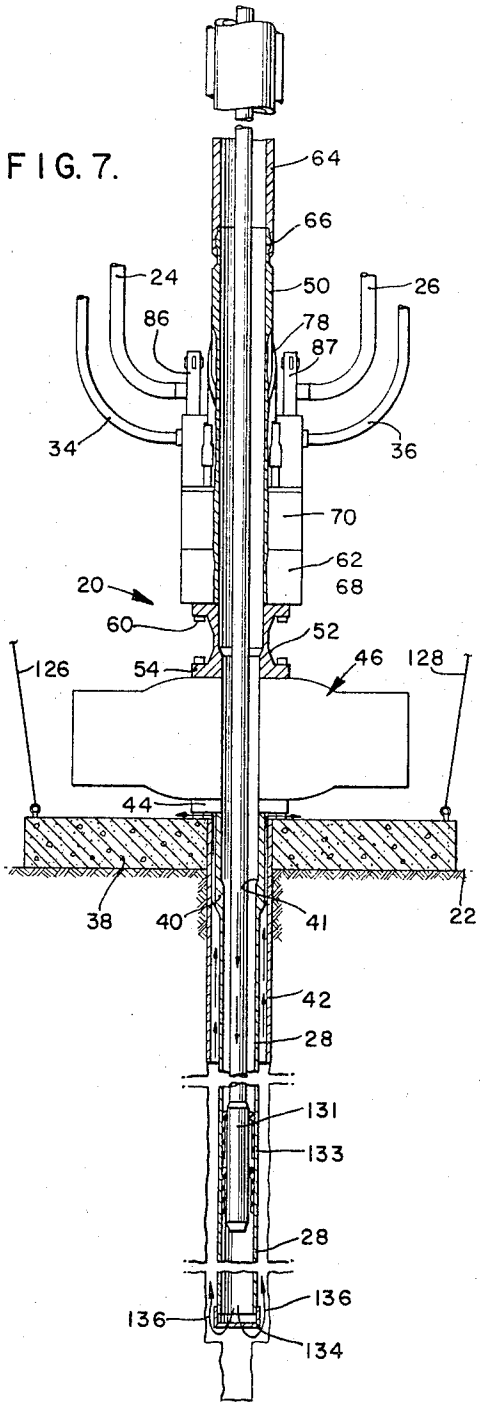
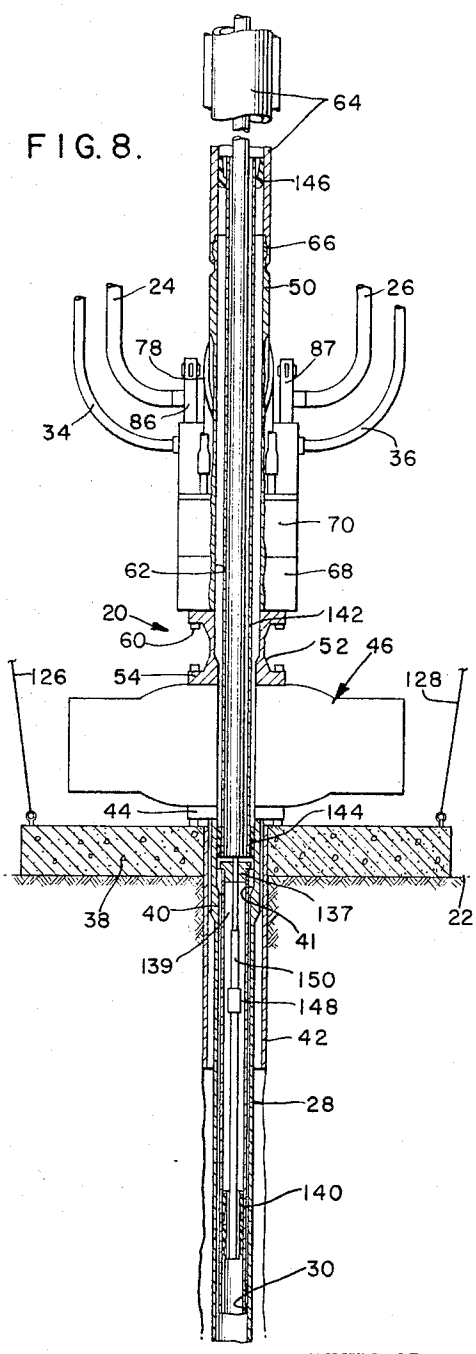


FIG. 8.



INVENTORS.
ROBERT D. JOHNSTONE
DAVID C. KOFAHL

BY Donald W Canady

ATTORNEY.

Nov. 15, 1966 R. D. JOHNSTONE ETAL 3,285,337

WELL DRILLING METHOD

Original Filed July 10, 1961 6 Sheets-Sheet 5

FIG. 9.

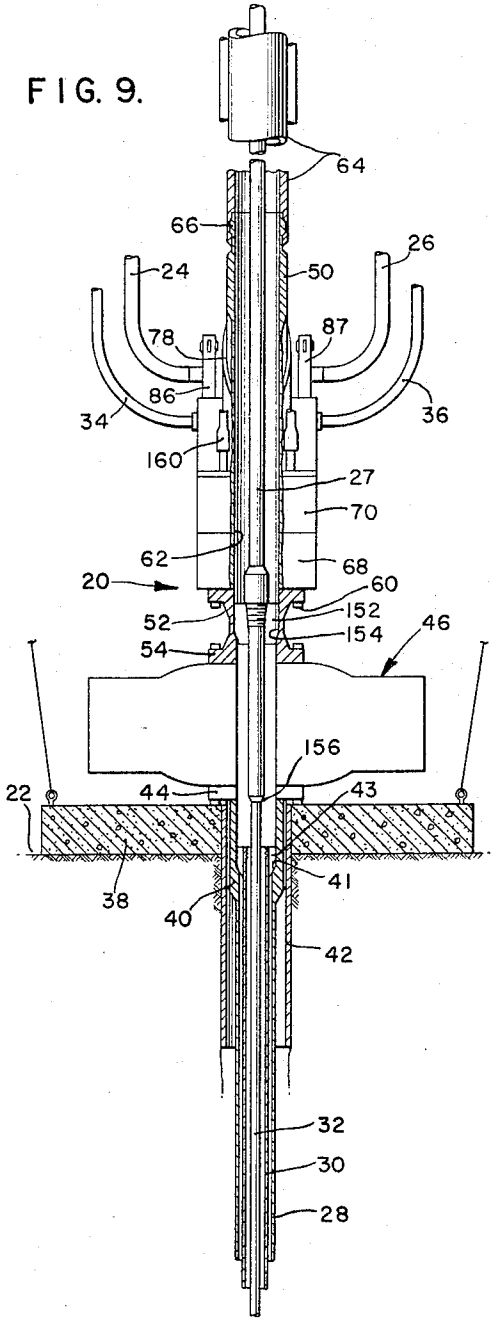
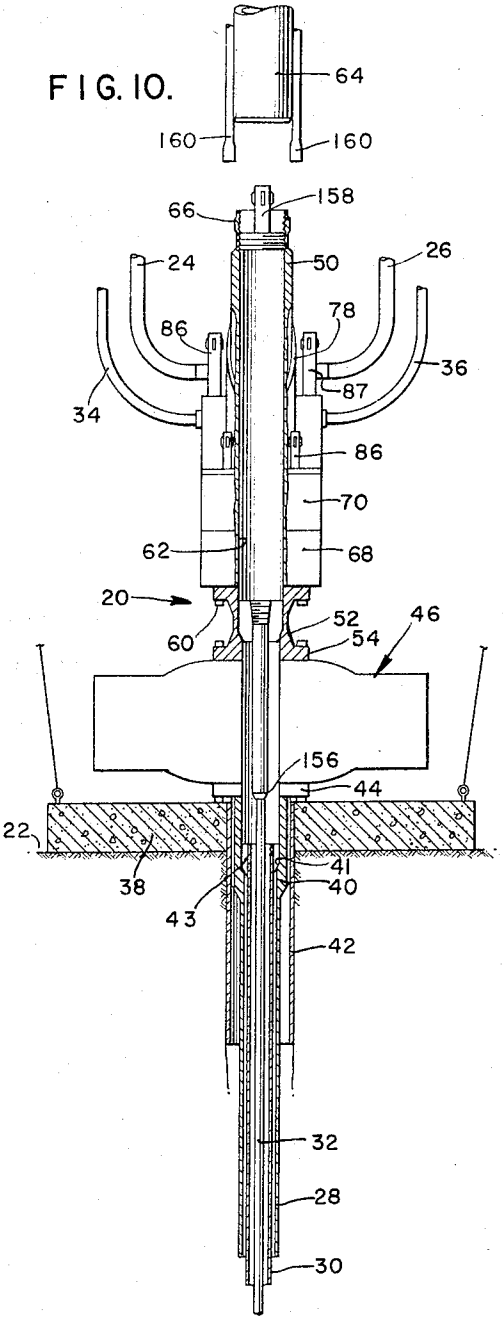


FIG. 10.



INVENTORS.
ROBERT D. JOHNSTONE
DAVID C. KOFAHL

BY Donald W Canady

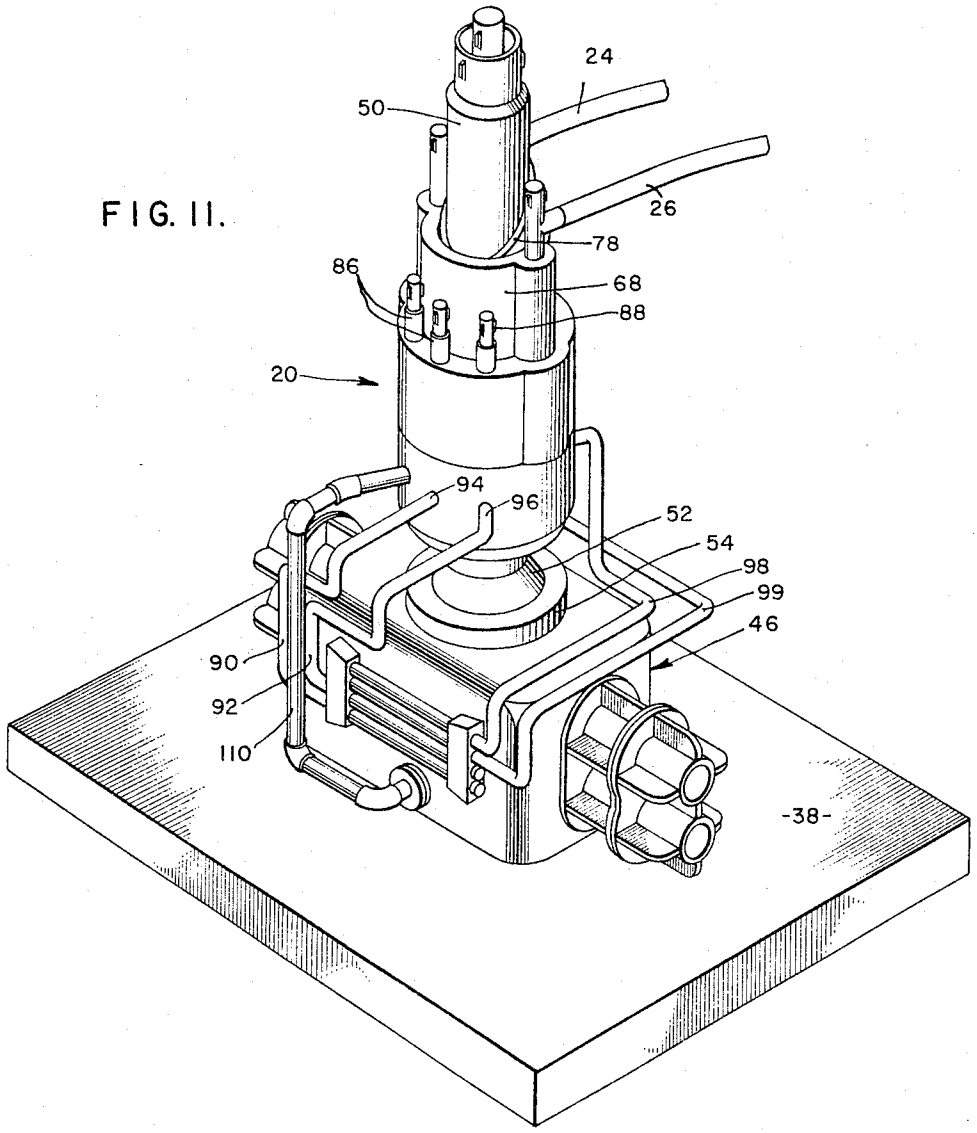
ATTORNEY.

Nov. 15, 1966 R. D. JOHNSTONE ETAL 3,285,337

WELL DRILLING METHOD

Original Filed July 10, 1961 6 Sheets-Sheet 6

FIG. 11.



INVENTORS.
ROBERT D. JOHNSTONE
DAVID C. KOFAHL

BY Donald W Canady

ATTORNEY.

United States Patent Office 3,285,337 Patented Nov. 15, 1966

3,285,337

WELL DRILLING METHOD

Robert D. Johnstone, Anchorage, Alaska, and David C. Kofahl, Bakersfield, Calif., assignors to Richfield Oil Corporation, Los Angeles, Calif., a corporation of Delaware

Original application July 10, 1961, Ser. No. 122,919, now Patent No. 3,219,117, dated Nov. 23, 1965. Divided and this application Oct. 21, 1965, Ser. No. 499,908
4 Claims. (Cl. 166—.5)

This application is a divisional application of Serial No. 122,919, filed July 10, 1961, now Patent No. 3,219,117, issued November 23, 1965.

The present invention relates to the drilling and production of pertoleum from a formation underlying a body of water and, more particularly, relates to a method for installing such drilling and production apparatus at the submarine formation without the use of divers.

When drilling into and producing from a formation containing oil and gas under high pressure, blowout prevention equipment is conventionally used in the drilling operation and a flanged wellhead assembly with a christmas tree is normally utilized to control the production of oil and gas from the well during the period of natural flow. The drilling apparatus including the drilling head and the blowout prevention equipment is normally installed on a marine platform located on the surface of the water over the well bore. More recently the drilling head including the blowout prevention equipment has been mounted on the ocean floor in relatively shallow water accessible to divers. The production apparatus including generally a flanged wellhead assembly and a christmas tree valve arrangement is normally installed for offshore production on a drilling platform at the surface of the body of water. This assembly includes generally a casing which is normally cemented into the well, a casing spool, a tubing head, a casing head, and the various christmas tree components which include generally, a master valve, one or more wing valves, and such flow-constricting and gauging devices as may be required in a particular well. This conventional equipment is unsuitable to the production of oil wells in deep water due to the excessive diving operations involved in flanging the various wellhead and christmas tree components together. Such equipment would obviously be impossible to install at depths greater than diving operations can be conducted. This marine production equipment so limited to relatively shallow water usage necessarily constitutes an obstacle to navigation and to aesthetic beauty. Because of this distraction from the natural beauty of the offshore areas and the obstruction of navigation, petroleum drilling and production operations are prohibited in certain areas which are geologically favorable to the production of petroleum.

It is therefore an object of our present invention to provide a novel method for producing petroleum from wells underlying relatively deep bodies of water and for installing a drilling and production head at the surface without the use of divers.

It is also an object of our present invention to provide a method for installing and using a combination drilling and production head which can be installed remotely at an underwater formation from the surface of the body of water.

It is also an object of our present invention to provide a method for drilling a well bore into a formation underlying a body of water whereby the drilling head control lines can be replaced without utilizing a diver.

Other objects and a fuller understanding of our invention may be had by reference to the following specification and claims taken in conjunction with the accompanying drawings in which:

FIG. 1 is an elevational view partially in section of our underwater production and drilling head, positioned at the submarine formation over the well bore;

FIG. 1*a* is a section taken on 1*a*—1*a* showing the kill line-annulus outlet connector;

FIG. 2 shows the drilling and production mandrel with the drilling block and production block as utilized in one embodiment of my invention;

FIG. 3 shows a combination of drilling and production head utilized in the present invention in place of the separate drilling block and production blocks shown in FIG. 2;

FIGS. 4 through 10 show the several steps involved in installing and using the drilling and production head of the present invention at a well drilled in a formation underlying a body of water;

FIG. 4 shows an elevational view of the manner in which the drilling base may be lowered to the formation;

FIG. 5 shows an elevational view of the manner in which the surface hole is drilled;

FIG. 6 shows an elevational view of the manner in which the surface pipe is run into the well bore with the drilling and production head;

FIG. 7 shows an elevational view of the method utilized for cementing the surface pipe into the well;

FIG. 8 shows an elevational view of the manner in which the water string is run and cemented into the hole;

FIG. 9 shows an elevational view of the manner in which the tubing string is run and hung from the wellhead;

FIG. 10 illustrates in cross-sectional elevation, the manner in which the riser pipe and drilling control lines are removed from the wellhead installation;

FIG. 11 shows in schematic form, the wellhead equipment during the production period.

With reference to the drawings, an embodiment of the invention is illustrated in FIGS. 1 and 11, where an assembled wellhead designated generally as **20**, which wellhead is adapated for remote installation at the floor **22** and the operation thereof controlled from the surface of the body of water during the drilling stage through control lines **74** connected to the drilling head and during the production stage through flow control lines **34** and **36**. The wellhead as shown in FIGS. 6 through 10 is installed by lowering the wellhead attached to the surface casing to the floor and subsequently running the water string **30** and tubing string **32** into the well bore by remote means from the surface of the body of water. After the well is drilled and completed, the wellhead is plugged off and the casing riser is disconnected from the wellhead and raised to the surface after which the production of the well through flow lines **24** and **26** is controlled remotely through flow control lines **34** and **36**.

Referring now more particularly to the drawings, FIG. 1 shows the wellhead partially assembled at the ocean floor **22** and positioned at the well bore opening with a surface casing **28** extending therein through the landing base **38**. A water string landing mandrel **40** extends through the landing base **38** and into the conductor pipe **42** and has a flanged head portion **44** to which conventional blowout prevention equipment **46** having fluid operated control means may be connected, as with bolts **48**. A drilling and production mandrel **50** is connected to the blowout preventer **46** by bolting to a flanged drilling and production head spool **52** which, in turn, is bolted to the blowout preventer at the lower flanged spool portion **54**. The blowout preventer preferably has threaded bolts **56** and **58** connected to its upper and lower extrem-

ities for connecting the wellhead assemblies. The drilling and production mandrel is equipped with similar bolts **60** at its lower extremity for securing the same to the wellhead spool. A central bore **62** extends through the drilling and production mandrel **50**, the head spool **52**, the blowout preventer equipment **46** and the water string landing mandrel **40**, through which bore drilling and production equipment are passed into the well.

The drilling and production mandrel is connected at its upper end to the casing riser pipe **64** with a safety joint **66**. Drilling mud is returned to the vessel with a pitcher nipple (not shown) through the casing riser **64**, or a rotating drilling head may be used with a hose provided for mud returns, in which case a casing riser is not needed. A drilling block **68** is lowered over the riser pipe **64** as shown in FIGS. 1 and 2 into the position shown in FIG. 6 to removably connect the blowout preventer control hoses **74** with the mandrel **50**. The drilling block **68** has several vertical holes **72** therein, with which control hoses **74** communicate for connection to the blowout preventer **46**. The drilling block **68** is lowered over the casing riser **64** and the drilling and production mandrel **50** to rest on the surface **75** of the drilling and production mandrel **50** and is guided into position thereon with an orientation cam **78** which engages an internal lug (not shown) in the drilling block **68**. The drilling block is guided down orientation keyway **80** into fixed position on the drilling and production mandrel **50** so that the sealing plugs **82** of the drilling block fit into the holes **84** (FIG. 2) of the drilling and production mandrel. The vertical holes **72** of the drilling block are equipped with tubular pipe connectors **86** as best viewed in FIG. 11. These connectors are secured to the drilling block **68** as by threading therein. The control hoses **74** extend into the connectors **86**. The connectors **86** have external locking lugs **88** near the upper ends thereof so that the drilling block may be removed from the drilling and production mandrel by gripping the connectors **86** at the lugs **88** with a barrel-type joint connector of the type shown at **160** (FIG. 10) with which the drilling block may be lifted to the surface vessel. Thus, the control hoses **74** may be replaced by lifting the drilling block to the drilling vessel and replacing the hoses as required. A spacer plate **89** having holes for the control hoses **74** may be fitted on the riser pipe to equally space the control hoses above drilling block and thus prevent the entanglement of the hoses.

The blowout preventer control lines **90** and **92** connect with openings **94** and **96** (FIG. 2), respectively, in the drilling and production mandrel which in turn communicate with the receptacles **84** into which the sealing plugs **82** fit, thus completing the connection between the blowout preventer control hoses **74** from the vessel to the blowout preventer through control lines **90** and **92**. The sealing plugs **82** may be any type of protuberance, e..g, fingers, etc., however, we prefer to use sealing plugs. The blowout preventer control lines **98** and **99** connect to the control hoses **100** and **102** in a similar manner on the opposite side of the drilling and production head assembly through hole **106** (and another hole therein, not shown) in the drilling block. The drilling block is provided with an additional hole **108** which serves the dual function of a kill line channel into the casing annulus during the drilling stage and an annulus channel to the annulus flow line **24** during the production period.

The annulus (between the tubing and water string) communicates with the annulus pipe **110** through the blowout preventer **46** and pipe **110** is connected to the drilling and production mandrel **50** through passageway **116** (FIG. 2) which has a "Y" therein, as shown in FIG. 10, which leads to passageway **119** and the annulus flow line **24** (see FIG. 11) or through opening **118** to opening **85** and the kill line **114** through hole **108** in the drilling block.

A spring-loaded check valve **121** (shown in FIG. 1*a*) is positioned in the passageway **85** in such a position that when the drilling block **68** is placed on the drilling and production mandrel **50** (as shown in FIG. 11) the lower end plug **122** depresses the check valve **121** to permit flow from the kill line **114** through the annulus. Thus, during the drilling stage if it is desired to kill the well, a heavy weighting mud may be pumped down kill line **114** and into the annulus through pipe **110**. A second spring-loaded check valve **120** is positioned in passageway **119** so that when the production block **70** is lowered onto mandrel **50** with sealing plug **87** positioned in the shoulder opening **118**, the valve **120** is depressed and flow permitted through the annulus flow line **24**. Plugs **87** and **122** are designed with tip portions **87***a* and **122***a* to actuate valves **120** and **121**, respectively. During the production stage, oil may be produced in the annulus through the annulus pipe **110** through the shoulder opening **118** in the drilling and production mandrel **50** by lowering the production block **70** onto the mandrel **50** whereby plug **87** seats in the shoulder opening **115** and depressing the valve **120**. A check valve **123** is also positioned in the passageway **117** extending through the shoulder on the opposite side of the production block and through which the tubing **32** communicates with the tubing outlet hose **26**. Thus, when the production block is not positioned on or is removed from the drilling and production mandrel **50**, the check valves **120** and **123** prevent fluid flow through the shoulder openings **118** and **124**.

The drilling block **68** and the production block **70** may be secured to the drilling and production mandrel **50** with a conventional tubing insert latch-down spring (not shown) or the blocks may be held down by their own weight. The pipe connectors **86** and **87** are threaded into the passageways **118** and **124** in the production block and have side connections for flow control line hoses. Flow control hose **24** is attached to pipe connector **86** to receive the annulus flow. In a similar manner, connector **87** transmits the tubing flow through tubing flow control line **26**. The drilling block preferably has fail-safe valves internally thereof with control hoses **34** and **36** connected to such valves for hydraulic control.

Although we have shown the production block and drilling block as two blocks, the function served by each block can be performed by a single production and drilling block as shown in FIG. 3 by providing six holes **160** in the block **162**, four for blowout preventer control hoses, one for the annulus flow line and a sixth hole for the tubing flow line. The hole for the annulus flow line could alternately be used for the kill line, or vice versa. When separate production and drilling blocks are used the drilling block may be employed without the production block, although the drilling may be conducted with the production block in place. Similarly, the well can be produced with or without the drilling block.

The drilling and production head shown in FIG. 1 can be installed at the submarine formation by remote control from the drilling vessel as shown in FIGS. 4 through 11. The drilling base **38** is lowered to the submarine formation on a pair of cables **126** and **128** with the drill string extending through an aperture in the drilling base which aperture is provided with a conductor pipe **130** so that a bore hole can be started by operating the drill string through the drilling base and conductor pipe before the lower end of the conductor pipe reaches the ocean floor. A conventional pilot bit **132** is provided at the lower extremity of the drill column on a drill collar, and a hole opening device such as a three-blade wall scraper **134** may be used to enlarge the hole for placement of the conductor pipe and the surface pipe. When the well bore has been deepened sufficiently to receive the conductor pipe **42**, the drilling base having the conductor pipe affixed thereto is lowered to the formation as shown in FIG. 5.

The well is then deepened sufficiently to run the surface casing. The surface casing with the drilling and

production head attached thereto as shown in FIG. 6 is loweerd to the formation over the drill pipe with the drill pipe extending into the well bore. The wellhead, generally designated as **20**, connected to the water string landing mandrel **40** which has threaded thereon the surface pipe **28**, is lowered from the vessel on the riser pipe **64** which releasably engages the drilling and production mandrel **50** through a safety joint **66**.

After the surface pipe and the drilling and production heads are made up at the surface of the body of water and lowered as a unit to the well, the drill pipe is retracted to the surface through the riser pipe **64** and a conventional cement tool **131** attached to the lower end thereof, for example, a cement tool, using a double-down swab, e.g., **133** to prevent cement from entering the annulus between the drill pipe and the surface pipe when the surface pipe is cemented into the formation. Cement is pumped down through the drill pipe and out through a guide shoe **135** located at the bottom of the surface pipe, until the cement returns up through the splined portion of the water string landing mandrel **40** and out onto the floor as indicated by the arrows **136** at FIG. 7. Cement tool **131** and the double-down swab **133** are then circulated clean and retracted to the surface where they are removed and the water string landing equipment attached to the drill pipe.

A water string hanger **43** such as a conventional Burns fluted hanger or adapter with the water casing hung therefrom is then lowered into the surface pipe and seated (as shown in FIG. 8) on a shoulder **41** provided in the water string landing mandrel **40**. Cement is then pumped down through the drill pipe to cement the water string within the surface pipe. Preferably, a double-down swab **140** is used to prevent cement from returning through the drill pipe-water string annulus. Cement rising in the annulus between the surface pipe and the water string passes through the fluted aera in the Burns fluted hanger **43** and up through a bypass pipe **142** which is temporarily welded to the drill pipe to prevent cement from contacting the blowout prevention equipment and the drilling and production blocks and mandrel. A liner hanger releasing tool **137** is threaded into the fluted hanger **43** to prevent cement from passing down into the annulus **139** between the tubing or drill pipe and the water string. The cement flow is confined to the annulus between the bypass pipe and the drill pipe by packer cups **144** and **146** provided on the bypass sub as shown in FIG. 8. A reverse circulating sub **148** is provided in the drill pipe or tubing **150** so that after the water string is cemented in place the bypass pipe can be circulated clean and any cement in the bypass pipe washed out without going to the bottom of the hole. The reversed circulating sub has a hollow bolt through it and a heavy bar is dropped down the pipe **150** to break the bolt off, thus leaving a passageway to the annulus through the bolt holes. After cementing, the water string and circulating clean, the cementing tools and double-down swabs, etc., are brought to the vessel and the bypass pipe **142** removed from the drill pipe.

The production tubing **32** is then run into the well through the water string and hung on an automatic tubing hangar **152**, which is supported within the tubing hanger spool **52** on a tapered shoulder section **154** provided therein. The production tubing **32** is lowered into the well on drill pipe with a suitable release tool **156**, so that after the tubing is hung the drill pipe **27** can be released from the tubing and returned to the surface.

A mandrel plug **158** is threaded into the upper end of the mandrel **50** and the riser pipe **64** disconnected from the drilling and production mandrel plug **158** by releasing the safety joint **66**. The riser pipe and blowout preventer control lines are then removed from the drilling and production mandrel by disconnecting the barrel connectors **160** from the lugged pipe connectors **86** on the drilling block. The flow lines **24** and **26** and the flow line control valve hoses **34** and **36** are then run to a pumping station or to an onshore pumping installation by running these hoses along the ocean floor. The cables **126** and **128** used to lower the landing base may be used to attach a buoy for marking the locating of the producing wellhead after the drililng and production tools are removed to the surface of the water.

Although the present invention has been described in its preferred form with a certain degree of particularity, it should be understood that this disclosure has been made only by way of example and that numerous changes in the details of the method and the combination and arrangement of parts may be made without departing from the spirit and scope of the invention as hereinafter claimed.

We claim:

1. In a method for completing a well drilled into a formation underlying a body of water from a vessel floating on said body of water wherein an apertured landing base is positioned over said well, the steps comprising:

connecting at said vessel, a surface pipe, casing landing mandrel, blowout preventer, drilling and production mandrel, and casing riser, said connected assemblage having a central bore extending therethrough,

lowering said connected assemblage from said vessel to said formation on said casing riser over a drill string extending into said well whereby said surface pipe extends into said well and the remainder of said assemblage rests on said landing base,

cementing said surface pipe into said formation,

lowering and guiding a water shut-off casing through said central bore of said assemblage into said surface pipe whereby said casing is landed on said landing mandrel,

attaching a bypass pipe to a section of said drill string whereby a bypass annulus is provided between said drill string and said assemblage above said water casing,

cementing said water casing into said surface pipe and said formation,

circulating said bypass annulus clean, and

guiding a tubing string into said water casing and hanging said tubing string in said drilling and production mandrel, whereby said tubing communicates with an outlet in said drilling and production head.

2. In a method for completing a well drilled into a formation underlying a body of water from a vessel floating on said body of water wherein an apertured landing base is positioned over said well, the steps comprising:

connecting at said vessel, a surface pipe, casing landing mandrel, blowout preventer, drilling and production mandrel, and casing riser, said connected assemblage having a central bore extending therethrough,

lowering said connected assemblage from said vessel to said formation on said casing riser over a drill string extending into said well whereby said surface pipe extends into said well and the remainder of said assemblage rests on said landing base,

cementing said surface pipe into said formation,

lowering and guiding a water shutoff casing through said central bore of said assemblage into said surface pipe whereby said casing is landed in said landing mandrel,

attaching a bypass pipe to a section of said drill string whereby a bypass annulus is provided between said drill string and said assemblage above said water casing,

positioning packer cups near the upper and lower ends of said bypass pipe to thereby restrict annulus flow to said bypass annulus,

cementing said water casing into said pipe and said formation, circulating said bypass annulus clean,

removing said bypass pipe and said packer cups, and

guiding a tubing string into said water casing and hanging said tubing string in said drilling and production mandrel, whereby said tubing communicates with an outlet in said drilling and production head.

3. In a method for producing oil and gas from a formation underlying a body of water from a vessel floating on said body of water, the steps comprising:

lowering a drilling base and drilling tools from said vessel to said formation, said drilling base having an aperture therein through which said drilling tools extend,

operating said drilling tools through said drilling base to drill a surface hole in said formation through said drilling base,

connecting at said vessel, a surface pipe, casing landing mandrel, blowout preventer, drilling and production mandrel, and casing riser, said connected assemblage having a central bore extending therethrough,

lowering said connected asesmblage from said vessel to said formation on said casing riser over a drill string extending into said well whereby said surface pipe extends into said well and the remainder of said assemblage rests on said landing base,

cementing said surface pipe into said formation,

lowering and guiding a water shutoff casing through said central bore of said assemblage into said surface pipe whereby said casing is landed on said landing mandrel,

attaching a bypass pipe to a section of said drill string whereby a bypass annulus is provided between said drill string and said assemblage above said water casing,

cementing said water casing into said surface pipe and said formation,

circulating said bypass annulus clean,

guiding a tubing string into said water casing and hanging said tubing string in said drilling and production mandrel, whereby said tubing communicates with an outlet in said drilling and production head.

4. In a method for producing oil and gas from a formation underlying a body of water from a vessel floating on said body of water, the steps comprising:

lowering a drilling base with drilling tools extending through an aperture thereof, said drilling base aperture having a conductor pipe extending therethrough and fixed thereto,

operating said drilling tools through said drilling base aperture and conductor pipe while said driling base is suspended above said formation to drill a hole in said formation to receive said conductor pipe,

lowering said drilling base to said formation whereby said conductor pipe extends into said hole drilled in said formation,

operating said drilling tools to deepen said well bore,

connecting at said vessel, a surface pipe, casing landing mandrel, blowout preventer, drilling and production mandrel, and casing riser, said connected assemblage having a central bore extending therethrough,

lowering said connected assemblage from said vessel to said formation on said casing riser over a drill string extending into said well whereby said surface pipe extends into said well and the remainder of said assemblage rests on said landing base,

cementing said surface pipe into said formation,

lowering and guiding a water shutoff casing through said central bore of said asesmblage into said surface pipe whereby said casing is landed on said landing mandrel,

attaching a bypass pipe to a section of said drill string whereby a bypass annulus is provided between said drill string and said assemblage above said water casing,

cementing said water casing into said surface pipe and said formation,

circulating said bypass annulus clean,

guiding a tubing string into said water casing and hanging said tubing string in said drilling and production mandrel, whereby said tubing communicates with an outlet in said drilling and production head.

References Cited by the Examiner

UNITED STATES PATENTS

3,137,348	6/1964	Ahlstone et al.	166—.6
3,159,218	12/1964	Wilde	166—.6
3,163,220	12/1964	Haeber et al.	166—.6
3,186,486	6/1965	Rhodes et al.	166—.5

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

R. E. FAVREAU, *Assistant Examiner.*