

June 22, 1965

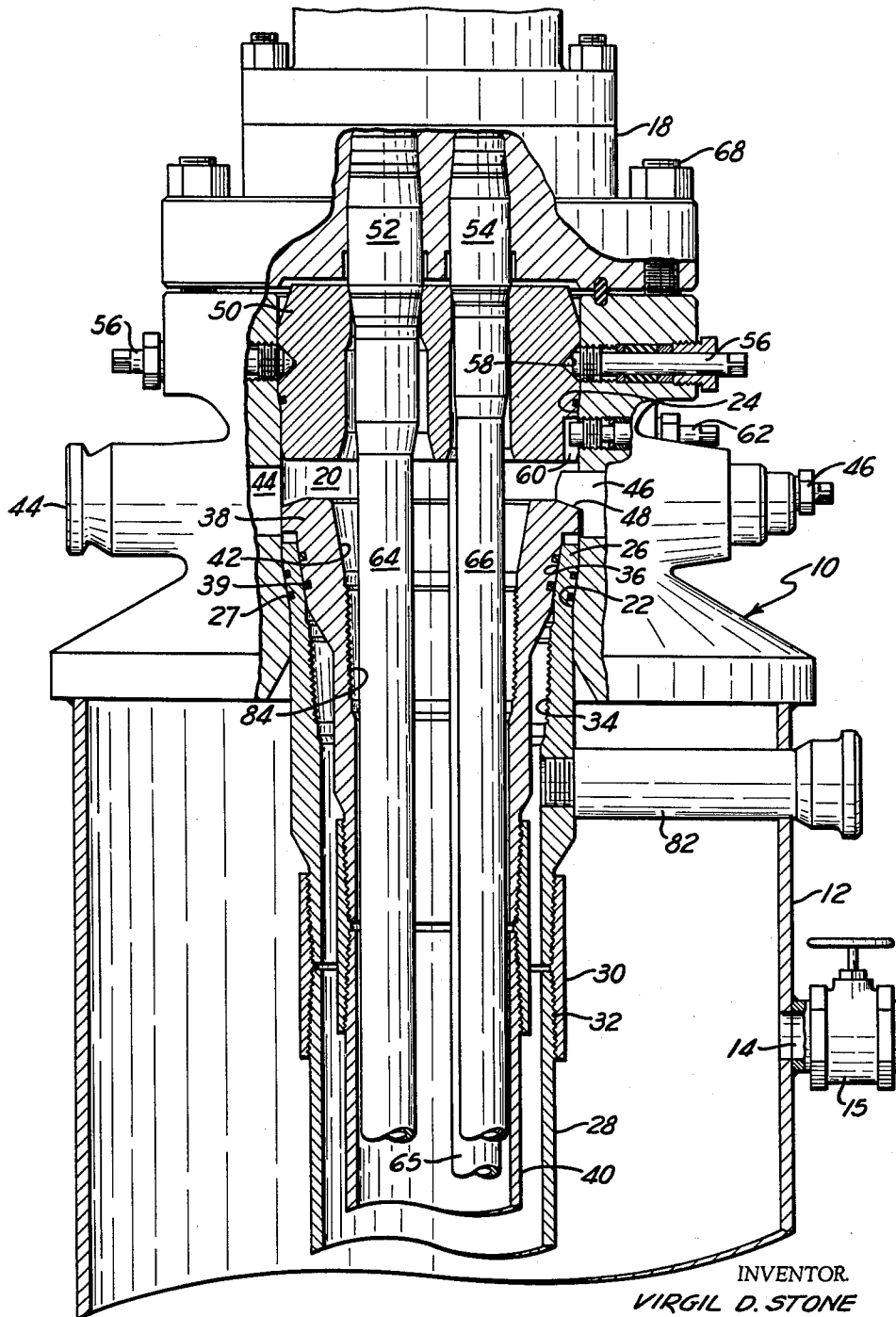
V. D. STONE

3,190,354

PROCESS OF DRILLING A WELL AND INSTALLING CASING

Original Filed March 28, 1960

2 Sheets-Sheet 1



104.
X105.
X108.

Fig. 1

BY

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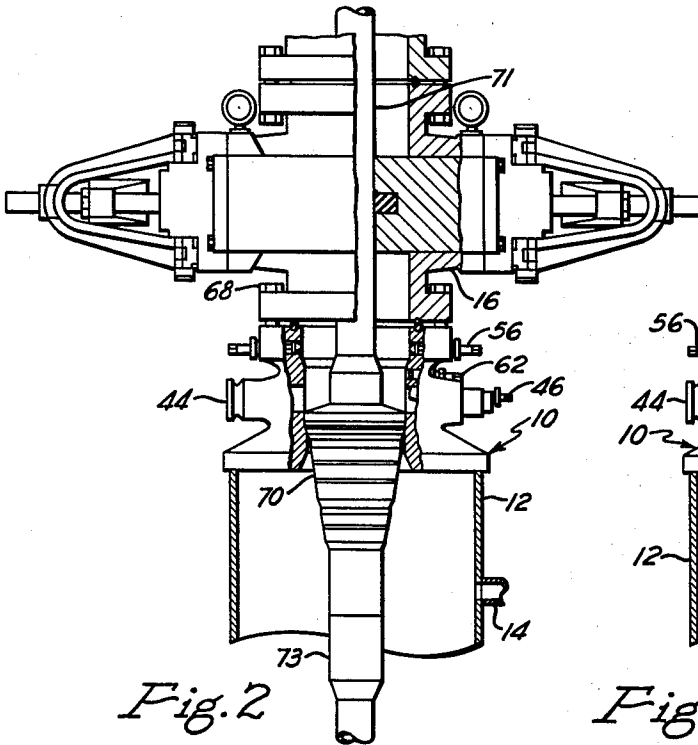


Fig. 2

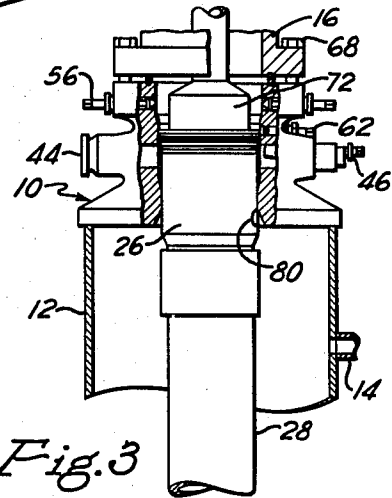


Fig. 3

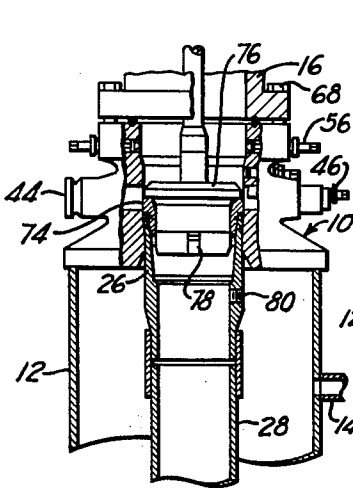


Fig. 4

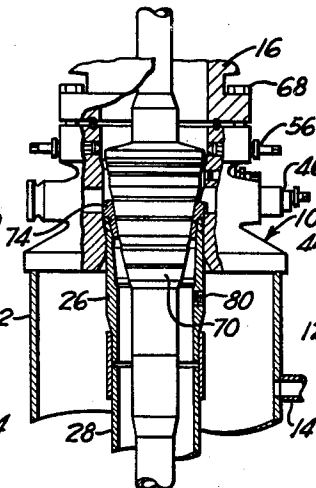


Fig. 5

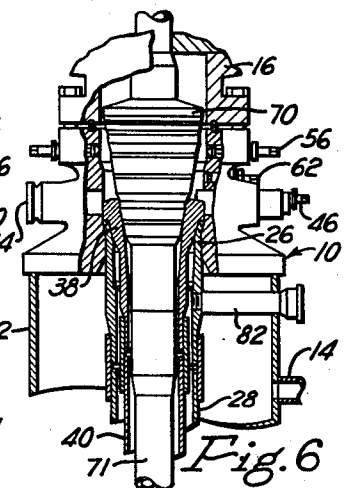


Fig. 6

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3,190,354

**PROCESS OF DRILLING A WELL AND
INSTALLING CASING**

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Original application Mar. 28, 1960, Ser. No. 17,847.

Divided and this application Dec. 27, 1962, Ser.

No. 247,580

3 Claims. (Cl. 166—21)

This application is a division of my copending application, Serial No. 17,847, filed March 28, 1960, assigned to the same assignee as the present application.

This invention relates to the drilling of wells for oil or gas and more particularly to a method of drilling a well using the wellhead assembly in which blowout preventers connected to the top of the wellhead assembly remain in place in operative condition throughout the drilling for hanging of successive strings of casing.

During the drilling of oil and gas wells, it is usually necessary to set several concentric strings of casing before the well drilled to its total depth. The usual procedure is to drill a hole to a depth slightly greater than that at which a string of casing is to be set, set a string of casing in the well, drill a hole of smaller diameter to a greater depth, set another string of casing, and repeat the process until the well is drilled to the desired total depth. The apparatus and processes usually used in the drilling of wells required the removal of blowout preventers after each string of casing was set and connections at the wellhead made for subsequent drilling. The time required for disconnecting and reconnecting blowout preventers between each stage of drilling in some instances constitutes an important part of the total time required for drilling and, hence, is responsible for a substantial part of the cost of drilling a well. Moreover, the removal of blowout preventers from the well between successive stages of drilling leaves a well without any means for closing it in if a surge of pressure should occur.

Danger from high pressure well fluids is particularly serious during the latter stages of the drilling of a well when the depth of the well is greatest. The larger size blowout preventers commercially available generally are not capable of withstanding high pressures, hence they offer little protection during the latter stages of drilling. In the well controls system conventionally used this caused no difficulty because of the practice of changing blowout preventers between successive drilling stages and the use of small blowout preventers capable of withstanding high pressure during the drilling at the greater depths. However, when the drilling operation is performed through the same blowout preventers from the time the conductor pipe is set, it is imperative that the blowout preventer be capable of withstanding pressures that may be encountered at any stage of the drilling. The practical effect of this requirement is that a blowout preventer of relatively small size must be used during all stages of the drilling operation.

It is important that the blowout preventers be in condition to function properly at all times during the drilling of the well. Proper operation of the blowout preventers can best be insured by providing means to test them periodically during the drilling of the well. It is further important that leakage be avoided between one string of casing and the next larger string of casing. To insure proper seals between successive strings of casing, it is desirable that means be provided to allow testing of the seals between an inner string of casing and the next outer string of casing before the inner string is cemented in place.

This invention resides in a method of drilling a well

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and setting a plurality of strings of casing therein in which a single blowout preventer can be used and kept on the casing head during the drilling and setting of the plurality of strings of casing. The method of this invention additionally contemplates the testing of the seals around the several casing hangers before the casing is cemented in the well. In the preferred embodiment of this invention, the drilling of the hole for the largest size of inner casing is accomplished by running a drill bit of the largest size that will pass through the blowout preventer and the casing head at the top of the well, and either simultaneously with or after drilling the hole with that bit, underreaming the hole to the size necessary to allow cementing of the largest inner string of casing.

In the drawings:

FIGURE 1 is an elevation view, partially in section, of the wellhead assembly of this invention after completion of the drilling and suspending casing and tubing within the well.

FIGURE 2 is a diagrammatic view showing, in elevation and partially in vertical section, the wellhead assembly, before drilling for the first inner string of casing, with a blowout preventer connected to the upper end of the casing head. The wellhead assembly is illustrated with the test hanger used for testing the blowout preventer and the seals in place.

FIGURE 3 is a diagrammatic elevation, partially in vertical section, illustrating the wellhead assembly as the first inner string of casing is being run into the well.

FIGURE 4 is an elevation, partially in vertical section, of the wellhead illustrating the installation of a bowl protector in the casing hanger for the first inner string of casing.

FIGURE 5 is an elevation view, partially in vertical section, of the wellhead with the test hanger in place for testing the seals between the casing hanger for the first inner string of casing and the landing surface of the casing head and between the bowl protector and the casing hanger.

FIGURE 6 is an elevation view, partially in vertical section, of the casing head with two inner strings of casing suspended from the landing surface and with the test hanger in place for testing the seals.

In the following description of this invention, the first or largest inner string of casing is referred to for convenience as the protector string and the next string of casing is referred to as the oil string. Those terms have no particular significance to the invention. They are merely terms used in the oil fields to identify inner strings of casing.

Referring to FIGURE 1 of the drawings, a casing head indicated generally by reference numeral 10 is shown welded to the upper end of conductor pipe 12. The conductor pipe 12 is set in accordance with the usual practice and may be either driven in place or set in a previously drilled hole depending upon the conditions encountered at the particular well site. The conductor pipe 12 is provided with a vent line 14 equipped with a valve 15 for use in cementing the protector string of casing. The casing head 10 tapers from the bottom towards the top and is studded at its upper end for connection with a blowout preventer 16, as shown in FIGURE 2 of the drawings, or upon completion of the well with a tubing bonnet 18 as illustrated in FIGURE 1.

The casing head 10 has a central opening 20 extending vertically through it. The walls of the central opening are substantially vertical but slope downwardly and inwardly slightly near the lower end of the casing head to form a lower landing surface 22. A similar downwardly and inwardly sloping portion of the walls of the central opening 20 is provided near the upper end of the casing

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head 10 to form an upper landing surface 24. Landing surfaces 22 and 24 are substantially vertical but open upwardly to allow downward movement of casing and parent hangers onto the landing surfaces in the manner hereinafter described. The diameter of the central opening 20 is larger at the upper landing surface 24 than at the lower landing surface 22 to allow a casing hanger adapted to seat on the lower landing surface to pass downwardly into engagement with that landing surface.

It is desirable that the diameter of the central opening 20 be as small as possible to reduce the total force of well fluids that might be exerted against the blowout preventer 16 to a minimum, and to reduce the size of the blowout preventer required. It is desirable that the maximum opening of the blowout preventer be slightly larger than the diameter of the protector string of casing to allow insertion of that casing and its attendant hanger through the blowout preventer.

Suspended from a first casing hanger 26 seated in the landing surface 22 is a string of protector casing 28. The casing hanger 26 is generally referred to as a boll weevil hanger which is run into the well integral with the protector casing 28. As shown in FIGURE 1, a collar 30 connects the protector casing 28 and casing hanger 26 by means of threads 32. The casing hanger 26 is internally threaded at 34 near its upper end to receive the threads of a landing nipple 72 (FIGURE 3) on which the protector casing 28 and hanger 26 are run into the well and landed on landing surface 22. Casing hanger 26 has an upwardly facing inner bowl surface 36 adapted to receive an oil casing hanger 38 from which a string of oil casing 40 is suspended. Hanger 38 like hanger 26 is internally threaded near its upper end to receive a landing nipple on which the hanger 38 and oil string 40 are run into the well. Hanger 38 is provided with an upwardly opening inner surface 42 against which a test hanger is adapted to seat to allow testing of the blowout preventer and seals between the two casing hangers in the manner hereinafter described. Casing hangers 26 and 38 are provided with rings of packing 27 and 39, respectively, in their outer surface for sealing against the landing surface 22 and bowl 36.

An oil string vent 44 extends through the casing head 10 and communicates with the central opening 20 above the landing surface 22. Suitable pipe and valve means, not shown in the drawings, are connected to vent 44 for control of flow of fluids through the vent into or out of casing head 10. A plurality of hold-down wedges 46 having sloping lower surfaces 48 adapted to engage the upper surface of the hanger 38 are movable inwardly through the wall of the casing head 10 by suitable screw threads to engage the upper end of the hanger 38. The hold-down wedges serve to adjust the position of the hangers 26 and 38 against the lower landing surface 22 and the inner bowl 36, respectively, and cause a tight seal between those two surfaces as well as to hold the hangers firmly in place and prevent their movement in the event that they should be subjected to high pressures from the well.

Seated on the upper landing surface 24 in the casing head 10 is a parent hanger 50 adapted to receive tubing hangers such as 52 and 54. The parent hanger 50 is held firmly in position by means of a plurality of hold-down screws 56 extending through the walls of the casing head 10 and engaging a groove 58 around the periphery of the parent hanger 50. A slot 60 in the outer surface of the parent hanger 50 near its lower end receives a parent hanger guide 62 fix the angular position of the parent hanger 50 in the casing head 10. Tubing hangers 52 and 54 are provided with rings of packing material near their upper and lower ends which seal against the tubing bonnet 18 and parent hanger 50, respectively. In this manner, any pressure exerted by fluids within tubing strings 64, 65, and 66 suspended from tubing hangers 52 and 54 and a third tubing hanger not shown in FIG-

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URE 1 is transmitted to the Christmas tree assembly at the wellhead and is not applied against the casing head 10.

The assembly of the apparatus illustrated in FIGURE 1 is accomplished in the following manner. After welding the casing head 10 to the conductor pipe 12 and connection of the blowout preventer to the upper end of the casing head, a test hanger 70 provided with a series of seating surfaces and rings of packing material on its outer surface is run into the casing head 10 on drill pipe 71 and landed upon the lower landing surface 22, as illustrated in FIGURE 2. Hydraulic pressure is then applied against the upper surface of the test hanger 70 through the oil string vent 44 with the rams of the blowout preventer 16 closed against the drill pipe 71 and the blowout preventer and the wellhead assembly pressure tested. After completion of the pressure tests, the test hanger 70 is withdrawn from the well. Test hanger 70 has an opening communicating with the bore of drill pipe 71 through which hydraulic pressure may be applied to test the strings of casing. A tail pipe 73 may extend from the lower end of the test hanger.

Drill pipe with a bit attached to its lower end is then run through the blowout preventer 16 and the casing head 10. Circulation of drilling mud down through the drill pipe and drill bit up through the annulus surrounding the drill pipe is established in the conventional manner and drilling of the hole within the conductor pipe is commenced. The drilling is continued to a depth slightly greater than the depth at which the protector casing is to be set. In order to provide space for the sheath of cement around the protector casing the hole is underreamed while drilling to form a hole of larger diameter than the maximum opening through the blowout preventer 16 and casing head 10. The use of an underreamer to enlarge the hole for the protector pipe allows use of a blowout preventer of minimum size and capable of withstanding high pressures even though the hole necessary for the protector casing must be larger than the maximum opening of the blowout preventer and the central opening 20 of the casing head 10. For example, in a typical installation using this invention, the conductor pipe 12 is 20 inches to 30 inches in diameter and the protector casing is a 10¾ inch casing. By means of this invention, a 12 inch blowout preventer having a maximum opening of 13¾ inches, which allows collars on the casing and the casing hanger 28 to pass through it, can be used. In this invention, the hole for the protector casing 28 is underreamed to 15 inches in diameter while drilling or prior to running the protector casing into the hole. A drill bit which can be run through the 12 inch blowout preventer and then expanded to make a fifteen inch hole also can be used.

The protector casing 28 connected to the lower end of the casing hanger 26 is run into the hole on a landing mandrel 72, which may be a joint of protector casing, or as illustrated in FIGURE 3, a special nipple. After landing the casing hanger 26 on the landing surface 22 of the casing head 10 the landing mandrel 72 is unscrewed from the hanger 28 and removed from the hole. A bowl protector 74, illustrated in FIGURE 4 of the drawings, is run into the hole on a bowl protector retriever 76 and seated in the inner bowl 36 of the casing hanger 26. Bowl retriever 76 is provided with lugs 78 on its outer surface adapted to slide through grooves in the lower inner surface of the bowl protector 74. The retriever is rotated relative to the bowl protector after the lugs 78 have passed through the grooves to move the lugs 78 out of alignment with the grooves and to a position for engagement with the bottom grooves and to a position for engagement with the bottom surface of bowl protector 74. After the bowl protector is lowered into position the bowl protector retriever 76 is rotated to bring the lugs 78 into alignment with the grooves and the bowl protector retriever is withdrawn upwardly through the blowout preventer. Bowl protector 74 has a machined

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inner surface adapted to receive and form a seal with one of the outer surfaces of test hanger 70.

The hold-down wedges 46 are then moved inwardly to engage the upper end of the bowl protector 74 and force it downwardly against the inner bowl 36 of the casing hanger 26. The hold-down wedges 46 provide means for the slight adjustment of the position of the bowl protector 74 to form a tight seal between the bowl protector and the casing hanger 26 and between the casing hanger 26 and the landing surface 22.

Referring to FIGURE 5, after the bowl protector has been placed in position the test hanger 70 is run into the casing head 10 and landed on the inner surface of the bowl protector 74. The rams of the blowout preventer 16 are brought into contact with the drill pipe one which the test hanger is supported. Liquid under pressure is then introduced into the casing head 10 through the oil casing vent 44, and the blowout preventer and the seals between the casing hanger 26 and landing surface 22 and between the bowl protector 74 and bowl 36 of casing 26 are tested. If the test shows no leaks in the seals the protector casing 28 is then cemented in place in the conventional manner by circulating cement down through the protector casing 28 and up through the annulus surrounding the protector casing 28 and out through the surface pipe vent 14. While waiting for the cement to harden a plug 80 in the hanger 26 is removed by means of a suitable tool through an opening cut in the conductor pipe 12. A protector pipe vent 82 is then inserted through the opening in the conductor pipe 12 and screwed into the opening in the casing hanger 26 from which the plug 80 was removed.

After the cement around the protector casing hardens, drilling is resumed and continued to the depth desired for the oil string of casing. Drilling mud is circulated down through the drill pipe and drill bit and up through the annulus between the drill pipe and the protector casing in the usual manner during the drilling. After completion of the drilling, the bowl protector retriever is lowered through the blowout preventer into the casing head 10. The hold-down wedges 46 are moved out of engagement with the bowl protector and the bowl protector is removed from its position in the bowl 36 of casing hanger 26. The oil string 40 connected to casing hanger 38 is then run into the hole on a suitable landing nipple connected to the casing hanger 38 by means of threads 84. After landing the casing hanger 38 in the bowl 36 of hanger 26 the landing nipple is unscrewed and withdrawn from the well. The hold-down wedges are then moved inwardly to engage the upper surface of casing hanger 38 in the manner illustrated in FIGURE 6 of the drawing. The test hanger 70 is run into the well to the position illustrated in FIGURE 6 of the drawing to close the central opening of casing hanger 38, and the seals within the casing hanger and the blowout preventer are again tested. If the seals do not leak oil, string 40 is then cemented in accordance with conventional practice. Returns of liquid displaced from the hole during the cementing of oil string 40 are discharged through protector casing vent 82.

If it is desired to extend an open hole below the lower end of the oil string 40 drilling can be resumed after the cement surrounding oil casing 40 has hardened and the procedure described above repeated. In the apparatus illustrated in the drawings, no further drilling is performed after setting the oil string 40. With the blowout preventer 16 remaining in place on the upper end of the casing head 10, the parent hanger 50 is lowered into the upper landing seat 24 and held in that position by the hold-down screws 56. Tubing is then run into the well through the parent hanger 50 in accordance with the conventional practice.

The apparatus herein described provides a simple well-head assembly of great strength and rigidity. The use of casing hangers of successively smaller outside dimen-

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sions for hanging successive strings of casing allows the opening at the upper end of the casing head to be only slightly larger than the largest inner string of casing. The opening of the oil casing vent into the casing head above the level of the landing surface allows complete pressure testing of the seals between casing strings before each of the inner strings of casing is set.

I claim:

1. A method of drilling and setting casing below the lower end of conductor pipe of a well while maintaining a blowout preventer secured to the well continuously during the drilling and the setting of casing, comprising securing a casing head to the upper end of the conductor pipe, securing a blowout preventer to the upper end of the casing head, running a drill having a diameter slightly less than the diameter of the opening in the blowout preventer downwardly through the blowout preventer and casing head and drilling a borehole to the desired depth below the lower end of the conductor pipe, underreaming the borehole below the lower end of the conductor pipe to the bottom of the borehole, running protector casing downwardly through the blowout preventer and suspending the protector casing from a protector casing hanger seated on a landing surface in the lower end of the casing head, said protector casing hanger having an upwardly facing landing surface, closing the upper end of the protector casing hanger and the blowout preventer, introducing a liquid under pressure into the casing head above the protector casing to test the seal between the protector casing hanger and the landing surface, after the testing shows a tight seal between the protector casing hanger and the landing surface displacing cement down through the protector casing to cement the protector casing in the well, running a drill downwardly through the blowout preventer and the protector casing to drill a borehole below the lower end of the protector casing, running oil casing downwardly through the blowout preventer and the protector casing and suspending said oil casing from an oil casing hanger seated in the upwardly facing landing surface of the protector casing hanger, closing the upper end of the oil casing hanger, closing the blowout preventer, introducing a liquid under pressure into the casing above the end of the oil casing hanger to test the seal between the oil casing hanger and the protector casing hanger, after the testing shows a tight seal between the oil casing hanger and the protector casing hanger displacing cement downwardly through the oil casing to cement the oil casing in place, running a tubing string downwardly through the blowout preventer and the oil casing hanger, and hanging the tubing string from a landing surface in the upper end of the oil casing hanger.

2. A method of drilling a borehole below the lower end of conductor pipe and setting casing therein while maintaining a blowout preventer secured to the well continuously during the drilling and the setting of the casing comprising securing to the upper end of the conductor pipe a casing head having a lower landing surface, an upper landing surface of larger diameter than the lower landing surface spaced above the lower landing surface, and an opening into the casing head between the upper and lower landing surface, securing a blowout preventer to the upper end of the casing head; running a drill having a diameter slightly less than the diameter of the blowout preventer downwardly through the blowout preventer and the casing head and drilling a borehole to the desired depth below the lower end of the conductor pipe; underreaming the borehole below the lower end of the conductor pipe to the bottom thereof; running protector casing having a diameter slightly less than the opening in the blowout preventer downwardly through the blowout preventer and suspending the protector casing from a protector casing hanger seated on the lower landing surface of the casing head; closing the upper end of the protector casing and the blowout preventer; introducing a liquid into the casing head above the protector casing hanger to test the seal between

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the protector casing hanger and the lower landing surface; after obtaining a tight seal between the protector casing hanger and the lower landing surface cementing the protector casing; running a drill bit downwardly through the blowout preventer and protector casing and drilling a hole below the lower end of the protector casing; running a second string of pipe downwardly through the protector casing and suspending said second string on a second hanger seated on the upper landing surface; and securing said second hanger against upward movement from the upper landing surface.

3. A method of drilling a borehole below the lower end of conductor pipe and setting casing therein while maintaining a blowout preventer secured to the well continuously during the drilling and setting of the casing comprising securing to the upper end of the conductor pipe a casing head having an upper bore extending downwardly therein from the top thereof, a lower bore of smaller diameter than the upper bore extending downwardly in the housing structure from the upper bore, an annular upwardly facing surface at the lower end of each of said bores, and a radial outlet extending through the casing head between the upwardly casing surfaces; securing a blowout preventer to the upper end of the casing head; running a drill having a diameter slightly less than the internal diameter of the blowout preventer downwardly through the blowout preventer and casing head and drilling a borehole to the desired depth below the lower end of the conductor pipe; underreaming the borehole below the lower end of the conductor pipe to a diameter larger than the opening in the blowout preventer, running protector casing having a diameter slightly less than the opening to the blowout preventer downwardly through the blowout preventer and suspending the protector casing from a protector casing hanger supported on the lower annular upwardly facing surface of the casing head; closing the blowout preven-

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ter and the upper end of the protector casing; introducing a liquid into the casing head through the radial outlet and increasing the pressure on said liquid to test the seal between the outer surface of the protector casing hanger and the casing head; after obtaining a tight seal between the protector casing hanger and the casing head, cementing the protector casing; running a drill bit downwardly through the blowout preventer and protector casing and drilling a hole below the lower end of the protector casing; running a string of oil casing downwardly through the protector casing and suspending the string of oil casing on the oil casing hanger supported on the protector casing hanger; closing the blowout preventer and the upper end of the oil casing hanger; introducing a liquid through the radial outlet and increasing the pressure thereon to test the seals around the outer surface of the oil casing hanger; wedging the oil casing hanger downwardly against the protector casing hanger, after obtaining a tight seal around the outer surface of the oil casing hanger, cementing the string of oil casing; running a string of tubing downwardly through the blowout preventer and the oil casing; and suspending the tubing in a tubing hanger supported on the upper annular upwardly facing surface.

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BENJAMIN HERSH, *Primary Examiner.*

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,190,354

June 22, 1965

Virgil D. Stone

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, line 22, after "well" insert -- is --; column 3, line 68, after "62" insert -- to --; column 4, lines 68 and 69, strike out "for engagement with the bottom grooves and to a position"; column 5, line 16, for "one" read -- on --; line 23, strike out "through"; column 6, line 33, for "a" read -- to --; column 7, line 23, for "casing" read -- facing --; line 32, for "to" read -- in --; column 8, line 12, for "the", first occurrence, read -- an --.

Signed and sealed this 16th day of November 1965.

(SEAL)

Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents