May 1, 1962 C. B. CORLEY, JR., ETAL 3,032,109

GUN PERFORATING APPARATUS FOR WELLS

Filed Oct. 12, 1959 2 Sheets-Sheet 1

FIG. 1.

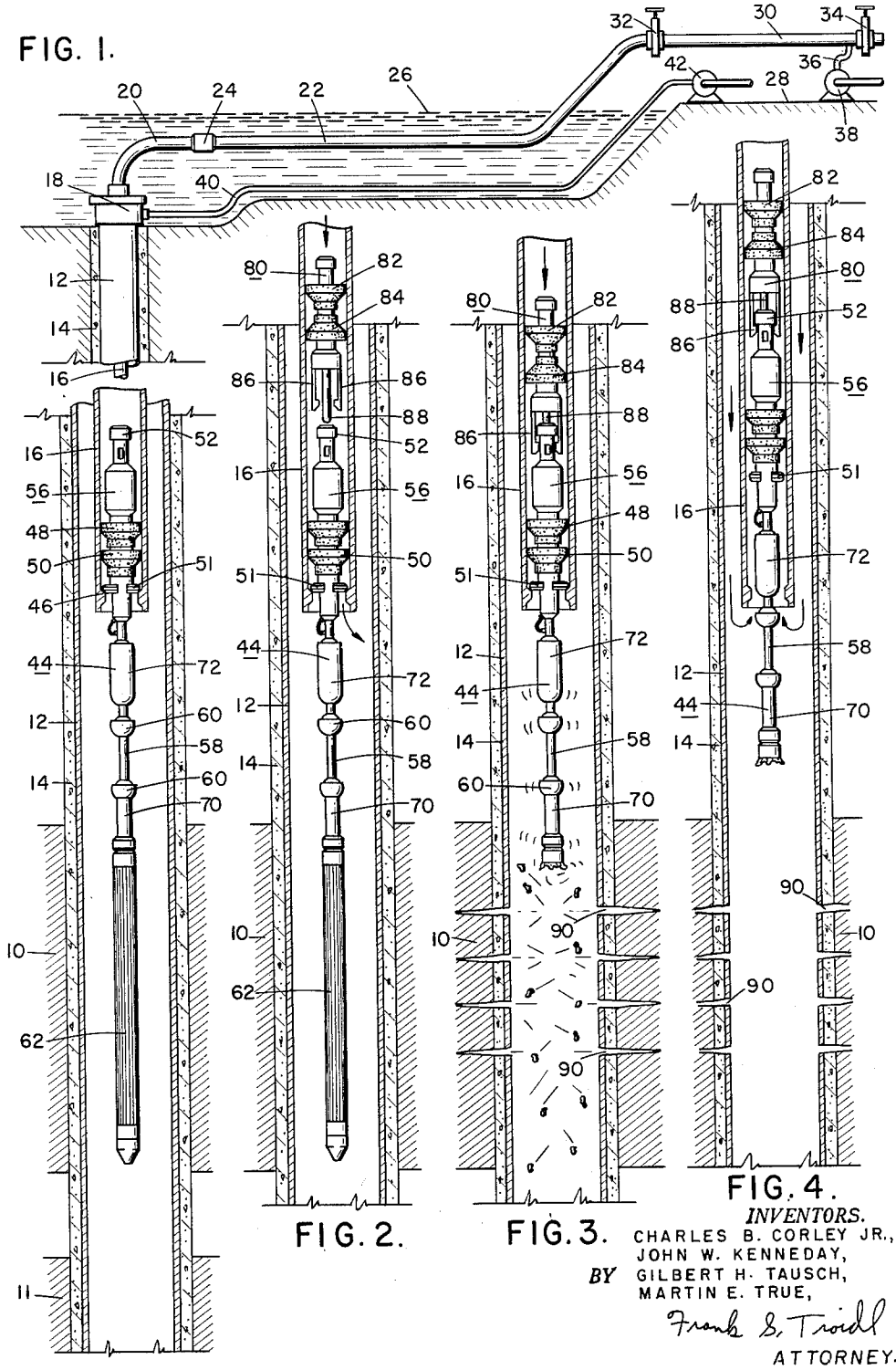

FIG. 2.

FIG. 3.

FIG. 4.

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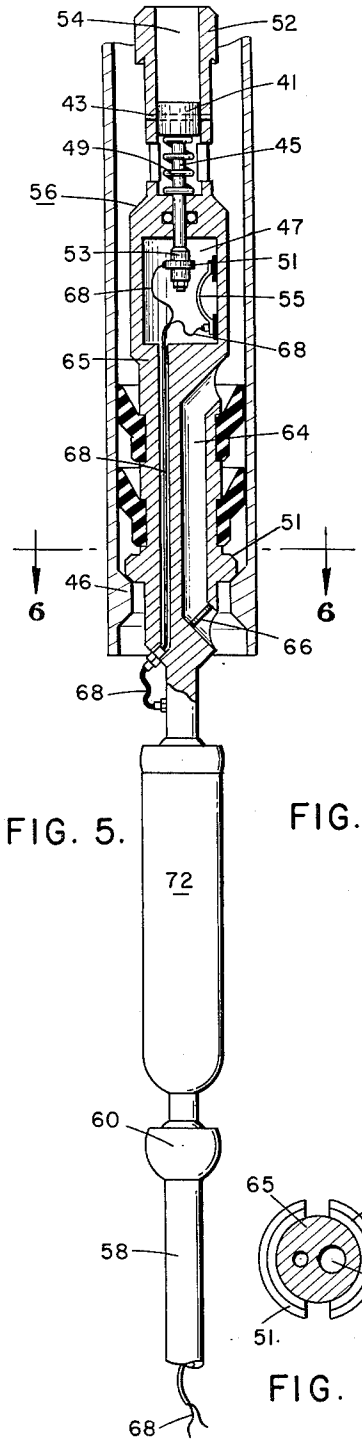

FIG. 5.

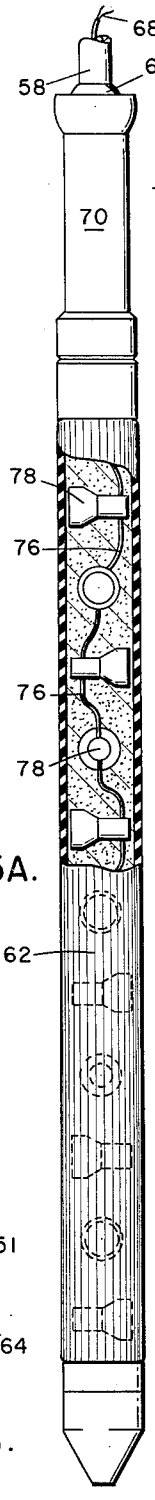

FIG. 5A.

FIG. 6.

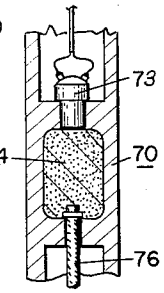

FIG. 7.

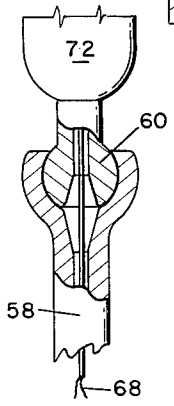

FIG. 8.

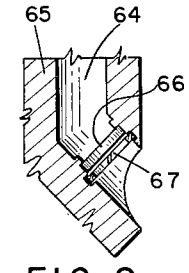

FIG. 9.

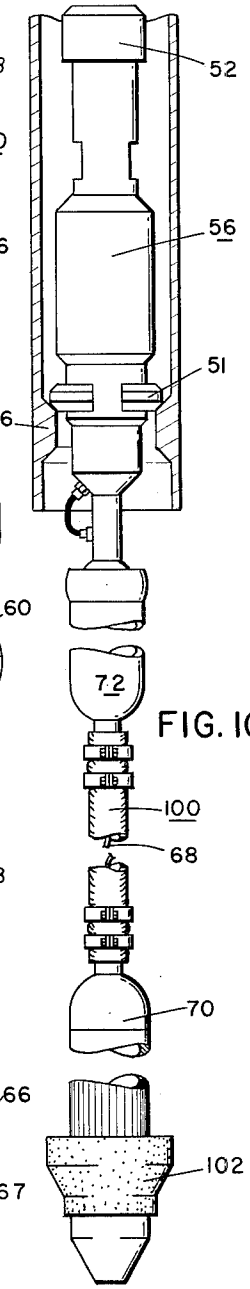

FIG. 10.

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3,032,109

GUN PERFORATING APPARATUS FOR WELLS

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1 Claim. (Cl. 166—55.4)

This invention relates to oil and gas wells. More particularly, this invention relates to methods for perforating a cased well.

For certain operations in oil and gas wells, it is often desirable to eliminate the need for a wireline. For example, when a well is located offshore, it is extremely desirable that the various tools which are put into the well and located in the tubing be so placed without requiring the use of a wireline. It is very difficult to lower tools into a well by means of gravity or by wireline when the well is located offshore. The tubing extends from the shoreline to the offshore location and often has many bends or curves through which the tools must be passed.

After the tool, such as a perforating tool, has been placed into the offshore well and the perforating operations completed, it then becomes necessary to remove that portion of the perforating tool which remains extending from the lower portion of the production tubing. Here again, if wireline operated devices are used to remove this portion, undue friction occurs, interfering with the efficient operation of the removal procedure. These wireline tools are only with difficulty forced through the bends in the piping leading from the onshore location to the offshore well.

The method to be described herein is a new and improved method for perforating a cased well having production tubing arranged in the well with its lower extremity at a point above the area to be perforated. In performing this method, a wireline or pulling tool having a wireline connected thereto is never required.

Briefly described, the method comprises first pumping a perforating member down the well through the production tubing to seat the upper portion of the perforating member in the lower end of the production tubing. Thus, the gun portion of the perforating member extends from the lower portion of the production tubing to a point adjacent the area to be perforated. The upper portion of the perforating member contains a firing switch. After the perforating member has been properly placed, a firing member is then pumped down the well through the production tubing to engage the upper portion of the perforating member and close the firing switch. The desired area is thus perforated. Finally, reverse circulation is applied to remove the firing member and that portion of the perforating member remaining attached to the firing member.

The invention as well as its many advantages will be further understood by reference to the following detailed description and drawings in which:

FIG. 1 is an elevational view showing a well located offshore with the perforating member located in position within the bottom portion of the production tubing;

FIG. 2 is an elevational view showing the firing member being pumped through the production tubing to engage the perforating member and fire the perforating gun;

FIG. 3 is an elevational view showing the firing member engaging the fishing neck of the perforating member;

FIG. 4 is an elevational view showing the removal of the firing member and the remaining portion of the perforating member by reverse circulation;

FIG. 5 is a view, partly in elevation and partly in section, showing the firing switch assembly, in detail;

FIG. 5A is a continuation of FIG. 5;

FIG. 6 is a cross-sectional view taken along lines 6—6 of FIG. 5;

FIG. 7 is a sectional view of the firing chamber;

FIG. 8 is a view, partly in elevation and partly in section, of the knuckle joints;

FIG. 9 is an enlarged sectional view of the fluid bypass and rupture disk shown in FIG. 5; and

FIG. 10 is an elevational view showing a second embodiment of perforating member suitable for use in carrying out our new method.

Referring to FIG. 1, a borehole is shown penetrating the earth and traversing subsurface formations **10** and **11**. The borehole includes the usual casing **12** which is cemented to the sides of the borehole by means of cement **14**.

Production tubing **16** extends into the well and terminates at a point above the formation **10**. The production tubing **16** extends through a wellhead **18** and connects with a short radius bend pipe **20**. The short radius bend pipe **20** is coupled to a laterally extending conduit **22** by means of a coupling member **24**. The well, short radius bend pipe **20**, and laterally extending pipe **22** are all below the water line **26**.

Pipe **22** extends to a remote location, such as a central production platform or to the shore **28**. A lubricator **30** is connected to the pipe **22**. Valves **32** and **34** are provided at the extremities of lubricator **30**.

Extending from the lubricator **30** is a conduit **36**. Fluid may be pumped into the lubricator **30**, laterally extending pipe **22**, bend **20**, and production tubing **16** by means of pump **38**.

A second laterally extending pipe **40** is connected to the wellhead **18** and extends to a pump **42** located on the shore **28**.

FIGS. 1 to 9 show a perforating member **44** which is pumped from the lubricator **30** through the laterally extending pipe **22**, short radius bend pipe **20**, and production tubing **16** until it rests upon a no-go shoulder **46** provided adjacent the lower end of the production tubing **16**. The perforating member **44** includes in the upper portion thereof swab cups **48** and **50** which are used to pump the tool into the well. A fishing neck **52** is provided at the upper extremity of the perforating member **44**. Also provided on member **44**, below the cup **50**, is a no-go ring **51**.

A normally open firing switch mechanism **56** is provided in the perforating member **44**. The details of the firing switch mechanism are shown in FIG. 5. A small piston member **41** is shear pinned by shear pin **43** extending from the sides forming bore **54** and through piston **41**. The piston shaft **45** extends from the piston member **41** to a point within chamber **47** and is biased upwardly by compression spring **49** disposed about shaft **45**. Electrical contact **51** is mounted on shaft **45** adjacent the lower extremity thereof and insulated from shaft **45** by insulator **53**. A second electrical contact **55** is mounted to a side of chamber **47**. The firing mechanism may be fired by a member to be subsequently pumped down the tubing **16** and having an elongated probe portion which will extend into the bore **54** to break the shear pin and move contact **51** into engagement with contact **55**.

The portion of the perforating member **44** which extends below the lower end of the production tubing **16** includes a spacer member **58** which is connected into the assembly by knuckle joints such as **60**. The length of the spacer member **58** and the provision of knuckle joints **60** permit the tool to pass through the bends and joints in the tubing system such as the short radius bend

20. The length and number of the knuckle jointed members 58 is predetermined to locate the gun portion 62 of the perforating member in the desired area to be perforated, which in FIG. 1 is shown to be the producing formation 10. The gun portion 62 is made of a resilient material, such as rubber. If it is desirable to perforate the lower formation 11, it is obvious that a plurality of spacer members 58 would be required. The proper length has been previously determined by methods well known to those skilled in the art.

A fluid by-pass port 64 extends through the mandrel 65. A shear disk 66 is mounted across the by-pass port 64 and kept in place by slip ring 67 (see FIG. 9).

Electrical conductors 68 extend from the firing mechanism 56 through the mandrel 65 and the knuckle jointed members 60 to the firing chamber 70. A plurality of batteries in battery section 72 provide an electrical current through conductors 68 when the switch assembly 56 is actuated. Conductors 68 have their lower ends connected to a firing means such as blasting cap 73 (see FIG. 7). When current is fed to firing cap 73, the powder 74 in firing chamber 70 is ignited which, in turn, ignites prima cord 76 leading to a plurality of shaped charges 78. Thus, when the firing mechanism is actuated, the shaped charges 78 in the gun portion 62 will be fired to perforate the casing 12, cement 14, and formation 10.

After the perforating member 44 has been properly located, the firing member is then pumped down the well through the production tubing 16. As shown in FIG. 2, the firing member 80 includes an upwardly facing swab 82 and a downwardly facing swab 84. Included as a portion of the firing member 80 are latching members 86 and a firing pin 88. The firing pin 88 is centrally located on the bottom of the firing member 80.

Prior to the pumping of the firing member 80 down the production tubing 16, an increased pressure is applied against the disk 66 to expel the disk from by-pass 64, thus providing a fluid by-pass which permits the retrieving tool to be pumped down the well into position.

FIG. 3 shows the engagement of the firing member 80 with the fishing neck 52 of the perforating member 44. The firing pin 88 has contacted the piston member 41 to fire the shaped charges 78 through the casing 12, cement 14, and into the subsurface formation 10 to provide perforations 90. Subsequent production from formation 10 will flow oil and gases through the perforations 90, the production tubing 16, bend 20, and laterally extending pipe 22 to the shoreline.

Reverse circulation is then applied to the well by pumping fluid, by means of pump 42 (see FIG. 1), through laterally extending pipe 40, the annulus between the production tubing 16 and casing 12, and then up the inside of production tubing 16, short radius bend 20, and laterally extending pipe 22. By this means, the firing member 80 and the remaining portion of the perforating member 44 are removed to the onshore location.

FIG. 10 shows a second embodiment of perforating member which can be used in carrying out our new method. Referring to FIG. 10, a flexible connection 100 interconnects the battery section 72 and the firing chamber 70. Electrical conductors 68 extend from switch assembly 56, through the flexible connection 100 to firing chamber 70. An upwardly facing cup 102 is used to pump the tool into the well.

In operation, the perforating member is first pumped down the production tubing and located in its proper position. Then the disk 66 is ruptured and the firing member 80 is pumped down the production tubing to close the contacts 51 and 55 to perforate the subsurface formation. The reverse circulation is applied to remove the firing member 80 and the portion of the perforating member which remains after the perforations have been made.

We claim:

A system for use in perforating a cased well having production tubing arranged in the well with the lower extremity of the production tubing at a point above the area to be perforated and the production tubing also having internal landing means comprising: a perforating member having a fishing neck and shaped charges positioned therein; said perforating member being provided with packing and engaging means so that when direct circulation is started, the perforating member is pumped down the production tubing and located in the production tubing by the engagement of said engaging means with said internal landing means; a normally open firing switch mechanism located in said perforating member; and a separate and disconnected firing member having packing means shaped so that the firing member will move in the same direction as the direction of fluid flow, said firing member having means for closing the normally open firing switch mechanism in the perforating member and latching means for engaging the fishing neck of the perforating member so that after the perforating member is located in the production tubing, the firing member is pumped down the tubing to close the firing switch mechanism to perforate the desired area and engage the fishing neck of the perforating member, and then reverse circulation initiated to remove the firing member and that portion of the perforating member remaining attached to the firing member.

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