

Aug. 12, 1958

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2,847,072

METHODS FOR DUAL COMPLETION OF OIL AND GAS WELLS

Filed June 15, 1953

2 Sheets-Sheet 1

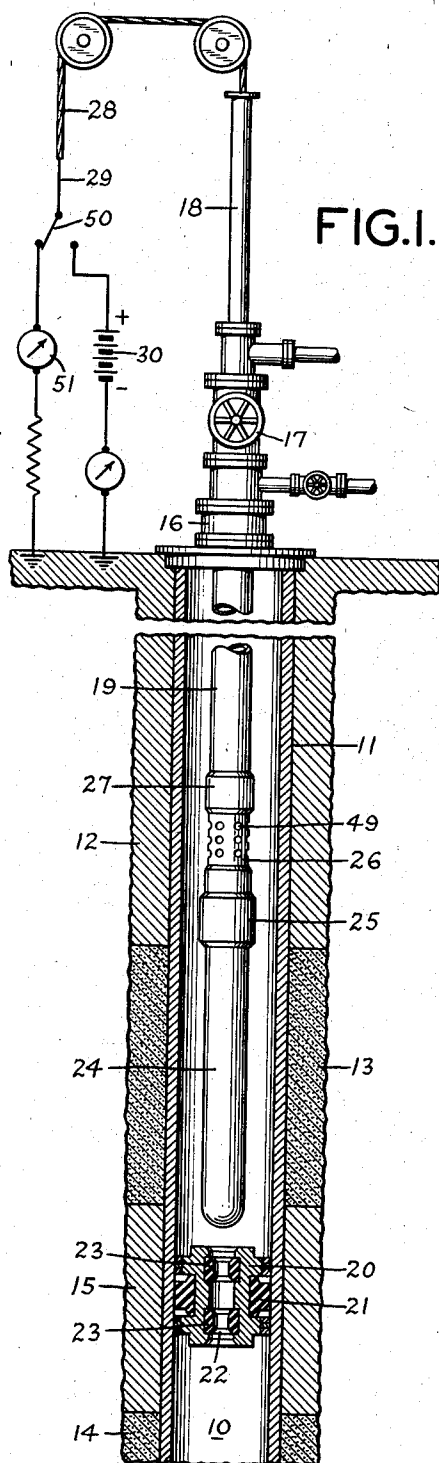
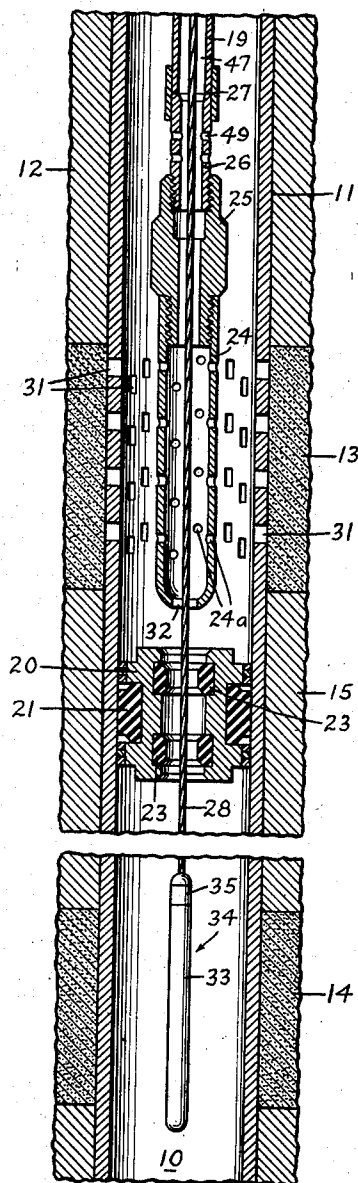


FIG. 2.



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FIG. 3.

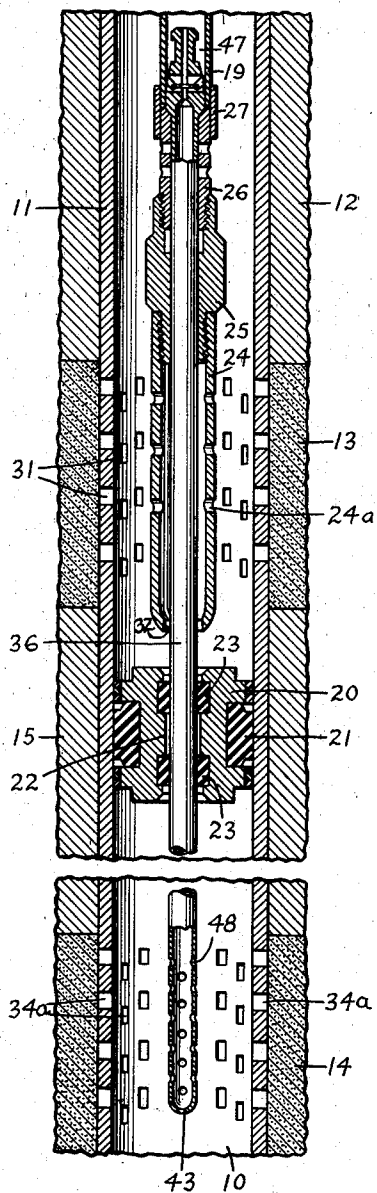
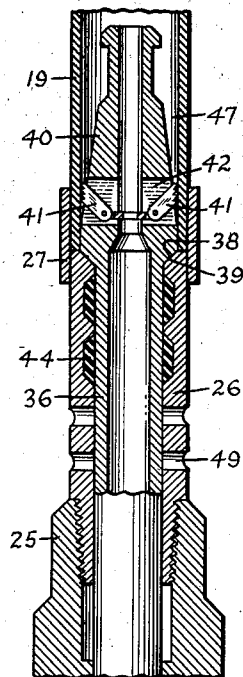


FIG.4.



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METHODS FOR DUAL COMPLETION OF OIL
AND GAS WELLS

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Application June 15, 1953, Serial No. 361,583

2 Claims. (Cl. 166-46)

The present invention relates to methods and means enabling fluids such as oil and gas to be produced simultaneously and separately from two vertically spaced productive formations traversed by a bore hole, a technique that will be referred to herein as "dual well completion."

It has become common field practice to employ the novel well completion methods and apparatus disclosed in copending application Serial No. 209,598, filed February 6, 1951, by H. S. Robertson for "Method and Apparatus for Perforating Well Casing and the Like," and described in an article entitled "A Method of Perforating Casing Below Tubing," by M. P. Lebourg and G. R. Hodgson, at page 303, vol. 195 (1952), Petroleum Transactions, AIME. In accordance with the principles set forth therein, a well is completed by placing production equipment at the surface and setting tubing in the well prior to perforating. However, in many oil fields, it is desirable to produce two different formations simultaneously to provide savings in pipe and drilling costs. The producing formations are often at different pressures, and one may produce gas, the other oil. The two formations, under these conditions, must of necessity be produced separately. It is also desirable to obtain such production simultaneously through the tubing and through the space between the casing and the tubing.

Accordingly, it is an object of the present invention to provide novel methods and apparatus for dual well completion.

Another object of the invention is to provide for separate and simultaneous production from two vertically spaced formations traversed by a bore hole.

A further object of the invention is to provide for separate and simultaneous production from two vertically spaced formations traversed by a cased bore hole, such production being through tubing and through the space between the tubing and casing.

These and other objects of the invention are accomplished by setting a production packer in the well casing between the two formations to be produced. The production equipment is placed at the surface and tubing set in the well with the lower end thereof at a position above the upper productive formation. The upper and lower formations are then respectively perforated, as, for example, by perforating apparatus of the type described in my copending application Serial No. 362,214, filed June 17, 1953, for "Method and Apparatus for Detonating Explosive Devices in Bore Holes," and/or by apparatus described in the aforementioned Robertson application, leaving the tubing end open. A tubing extension that passes through the production packer is connected to the tubing, thereby establishing fluid communication between the lower formation and the tubing. The two formations are effectively separated by the production packer after the tubing extension has been passed therethrough. The lower formation may then be produced through the tubing extension and tubing, and separately but simultaneously the upper formation may be produced through the space between the casing and the tubing.

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These and further objects and advantages of the invention will be more fully understood when the following description is read in conjunction with the accompanying drawings, in which:

Fig. 1 is a view in partial cross-section of a typical oil or gas well in which the first stages of operations in accordance with the invention are under way;

Fig. 2 is a cross-section view of the well shown in Fig. 1, in which the lower producing zone is about to be perforated;

Fig. 3 is a cross-sectional view of the well, after the tubing extension is in place; and

Fig. 4 is a detailed view in cross-section of a portion of the tubing extension.

Describing the invention in detail, in Fig. 1, a bore hole 10 lined with a casing 11 traverses earth formations 12-15, inclusive, the formations 13 and 14 being shown as potentially productive and separated by the formation 15. The upper end of the bore hole 10 is fitted with a well completion assembly 16, a conventional Christmas tree 17 and a lubricator 18.

Set in the casing 11 opposite the formation 15 is a production packer 20 which separates the formations 13 and 14. Formed in the packer 20 is an opening 22 passing vertically therethrough and provided with conventional sealing means 23 therein. The packer 20 is also provided with conventional outer sealing means 21.

Suspended from the well completion assembly 16 is a string of tubing 19 with an open lower end 47 (Fig. 2). A well casing perforating apparatus 24 is connected by a head member 25 and a perforated seating nipple 26 to the tube end 47, a collar 27 securing the nipple 26 to the tubing 19. Perforations 49 are formed in the nipple 26 which are useful for replacing drilling mud with a lighter fluid in the well prior to perforation casing 11, as is more fully described in my aforementioned copending application Serial No. 362,214. As illustrated in detail in Fig. 4, the nipple 26 is provided with sealing inserts 44 and a seating shoulder 39 for cooperating with a tubing extension 36, to be more fully described hereinafter.

The perforating apparatus 24 is preferably a shaped explosive charge perforating device constructed in accordance with the disclosure in my above-mentioned copending application. Thus, the perforating apparatus 24 is adapted to be detonated by a detonating device lowered through the tubing 19 by a cable 28 carrying an insulated conductor 29. For simplicity, the detonating device has not been shown. A switch 50 is provided to connect the conductor 29 selectively to an indicator 51 which may be a sensitive galvanometer and to a source of electrical energy 30 for detonating the perforating apparatus 24. Upon firing the latter, not only is the casing 11 perforated, but also a hole 32 is formed in the lower end of the housing for the perforating apparatus 24, which hole is of sufficient diameter to accommodate the tubing extension 36, as shown in Fig. 3.

As shown in detail in Figs. 3 and 4, the tubing extension 36 preferably has perforations 48 formed in the lower end 43 thereof, although the lower end 43 could also be formed of screening or be open ended. The extension 36 is adapted to be lowered into position through the tubing 19, as described in greater detail hereinafter, and it has a flanged edge 38 which is adapted to seat on a shoulder 39 formed in the nipple 26. Above the flange 38 is formed a fishing head 40, by means of which the tubing extension 36 may be readily removed from the well. Suitable means, such as a plurality of latches 41, are provided to prevent the tubing extension 36 from being forced upwardly in the tubing 19 under the pressure of the fluid in casing 11, in normal operation.

In a typical operation, it will be assumed that the well casing 11 has been set, and that the production packer 20, the perforating apparatus 24 and the nipple 26 are in position, as shown in Fig. 1. Further, the cable conductor 29 is connected to suitable means suspended on the cable 28 for detonating the charges in the perforating apparatus 24. Also, the heavy drilling mud formerly in the well has been depleted and replaced, if at all, by lighter liquid.

With the perforating apparatus 24 positioned adjacent productive formation 13, as shown, the switch 50 is operated to connect the conductor 29 to the battery 30 resulting in the detonation of the charges in the perforating apparatus 24 and in the formation in the lower end of the latter of an opening 32, as described in my aforementioned copending application Serial No. 362,214. The explosive jets generated by the charges in the perforating apparatus 24 penetrate the casing 11 forming perforations 31 therein communicating with formation 13 (Fig. 2). If the formation 13 contains oil or gas under a high pressure, care must now be observed in manipulating the surface controls on the Christmas tree 17 to prevent the well from blowing out since the heavy drilling mud has been removed.

The cable 28 is then brought out of the well and the head member 35 thereon is secured to well casing perforating apparatus 34 (Fig. 2) which is preferably of the expendable, shaped charge type disclosed in the aforementioned Robertson application and may include the modifications described in copending application Serial No. 322,017, filed November 22, 1952, by G. R. Hodgson, for "Expendable Shaped Explosive Charge Well Casing Perforating Apparatus," and in application Serial No. 322,070, filed November 22, 1952, by J. M. Bricaud for "Bore Hole Detecting Circuit and Bore Hole Firing Circuit Utilizing a Common Transmission Channel," now U. S. Patent 2,732,518 issued January 24, 1956. The circuit disclosed in the latter application includes a casing collar locator which may be of the type shown in Fagan Patent No. 2,558,427. This apparatus is inserted into the lubricator 18 and lowered into the well by the cable 28 through the tubing 19, the hole 32 in the bottom of the housing for the perforating apparatus 24 and the packer 20 to a position adjacent the formation 14.

During the lowering of the perforating apparatus in the well, the switch 50 is in the position to connect the conductor 29 to the indicator 51 which then receives signals from a casing collar locator in the head 35, enabling the perforating apparatus 34 to be positioned accurately adjacent the formation 14 (Fig. 2). The perforating apparatus 34 is then brought to rest and the switch 50 is moved to the position in which the source 30 is connected to the conductor 29. This detonates the charges in the perforating apparatus 34 producing perforations 34a (Fig. 3) in the casing adjacent the formation 14. The nonexpended head member 35 may next be raised through the packer 20, the opening 32 in the perforating apparatus 34 and the tubing 19 and removed from the lubricator 18 (Fig. 1).

The foregoing operations being completed, the tubing extension 36 is passed through the tubing 19 until the flanged edge 38 thereof is seated on the shoulder 39 (Fig. 4) within the nipple 26 and the lower perforated end is adjacent the formation 14. As shown in Fig. 3, this provides a fluid path from the formation 14 through the tubing extension 36 and the tubing 19 to the surface of the well. Meanwhile, another fluid path is provided from the formation 13 through the space between the casing 11 and the tubing extension 36 and tubing 19 to the surface of the earth. The sealing means 23 prevent the

passage of fluid from the formation 14 to the interior of the casing 11 above the packer 20 and the sealing means 44 prevent fluid from the formation 13 from entering the tubing 19. Therefore, separate and simultaneous production from both of the formations 13 and 14 is possible without regard to pressure differentials between the formations or the character of the formations, since one may produce oil and the other gas.

Accordingly, the invention provides for obtaining oil and/or gas production separately and simultaneously from two vertically spaced productive formations traversed by a well. Other advantages gained by use of the invention include the prevention of plugging of the perforations with mud and the reduction of blowout possibilities since the casing is perforated after removal of all mud and setting of production tubing.

It should be understood that the embodiments described and illustrated herein are illustrative only. For example, various other casing collar locators equivalent to that disclosed in the aforementioned Fagan patent may be incorporated in the system within the scope of the invention. Numerous other modifications of the invention will suggest themselves so that the specific embodiments described and shown herein are not to be construed as limiting the scope of the appended claims.

I claim:

1. A method for completing a well having a casing set therein traversing a plurality of vertically spaced formations of interest and containing a column of drilling fluid, comprising the initial steps of setting apertured packer means in said casing between two of said formations, installing production control equipment at the well head, permanently setting tubing in said casing to a position adjacent the upper of said two formations, and replacing the drilling fluid with a lighter fluid, and thereafter the subsequent steps of perforating said casing and said upper and lower formations above and below said packer means, then lowering tubing extension means within said tubing to extend from the lower end of the tubing and through the aperture in said packer means in sealing engagement therewith to said lower formation, and thereafter separately producing said formations.

2. A method for completing a well having a casing set therein traversing a plurality of vertically spaced formations of interest and containing a column of drilling fluid, comprising the initial steps of setting apertured packer means in said casing between two of said formations, installing production control equipment at the well head, permanently setting tubing in said casing to a position adjacent the upper of said two formations, and replacing the drilling fluid with a lighter fluid, and thereafter the subsequent steps of perforating said casing and said upper formation above said packer means, perforating said casing and the lower of said two formations below said packer means, then lowering tubing extension means within said tubing to extend from the lower end of the tubing and through the aperture in said packer means in sealing engagement therewith to said lower formation, and thereafter separately producing said formations.

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