

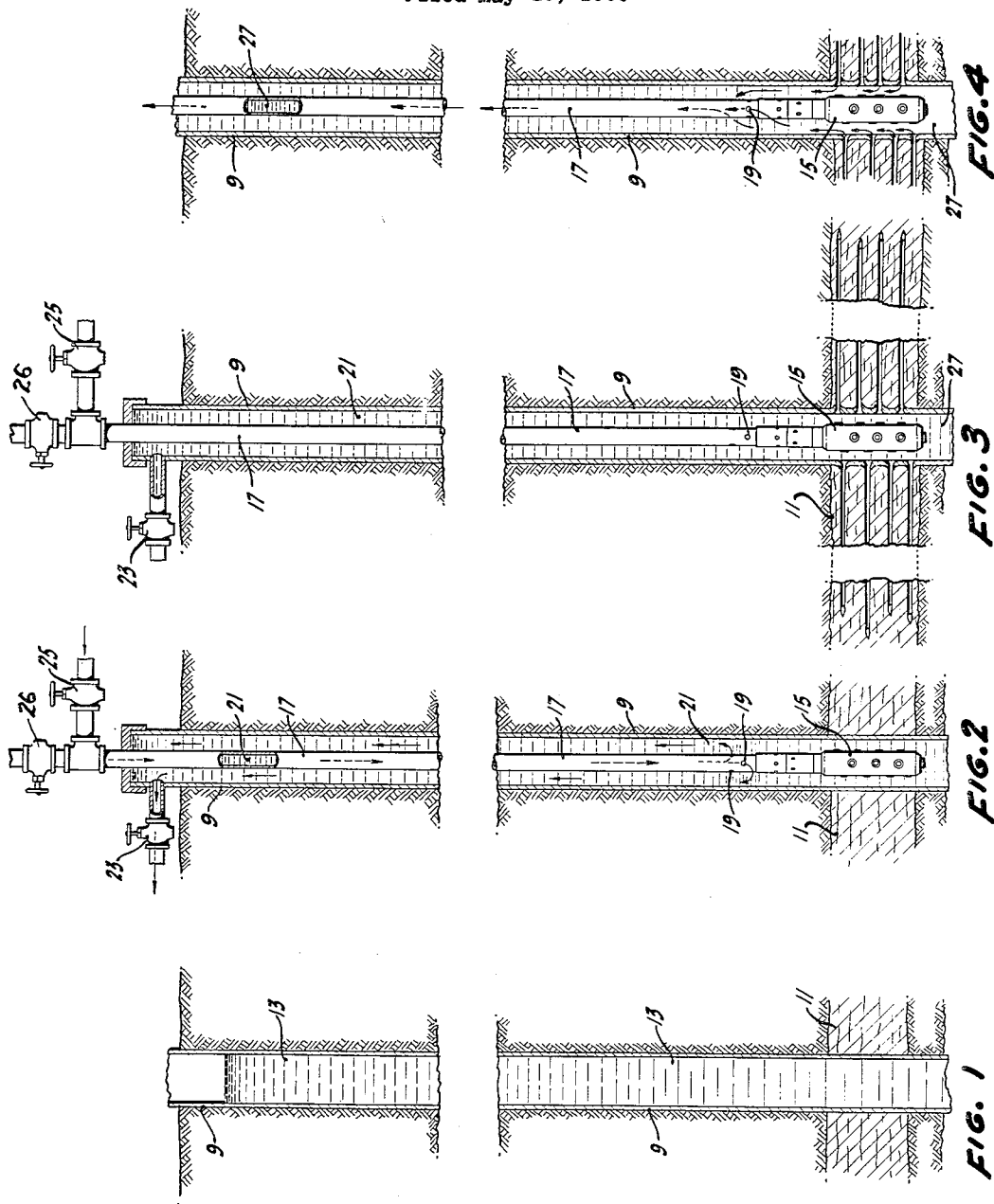
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W. B. TAYLOR

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METHOD OF COMPLETING OIL WELLS

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WILLIAM B. TAYLOR
INVENTOR.

BY

Mellin and Hanscom
ATTORNEYS

1

2,745,495

METHOD OF COMPLETING OIL WELLS

William B. Taylor, Houston, Tex., assignor, by mesne assignments, to Johnston Testers, Inc., Houston, Tex., a corporation of Texas

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2 Claims. (Cl. 166—35)

This invention relates to methods of completing oil wells.

The conventional method of completing an oil well by gun perforating comprises lowering a perforating gun on the lower end of a string of tubing, or a cable, into a cased well bore which is partly or entirely filled with mud fluid, into registry with a selected production formation penetrated by the cased well bore, firing the gun to penetrate the casing and the production formation surrounding the casing, then removing the perforating gun and the lowering means, either tubing or cable, from the well, and if desired lowering a packer on the lower end of a string of tubing into the well to a position where the packer is above the place of perforation of the casing. At this time the mud fluid is replaced by circulating either oil or water downwardly through the tubing, outwardly either through the lower end of the tubing or through fluid passages located in a short section of tubing extending below the packer, and upwardly through the annular space between the tubing and the casing. After replacing the mud fluid, with either oil or water, the packer is sealingly engaged with the inside wall of the casing thus closing the annular space between the tubing and casing and leaving only a passageway upwardly through the tubing for the flow of fluid from the production formation.

This conventional method is time consuming because of the two separate operations required. First, the operation of lowering, shooting, and removing the perforating gun from the cased well bore; and, secondly, the operation of lowering the packer into the well. The time interval involved, usually several hours, has been proven to be detrimental to the future production of the well. Thus, after perforating the casing the hydrostatic pressure in the cased well bore forces drilling mud through the perforations and into the oil bearing formation, thereby forcing the oil away from the well bore and also blocking off some of the perforations, thus reducing the number of effective perforations.

It is a main object of the present invention to provide a method of completing an oil well which not only reduces the equipment required but also substantially reduces the time necessary for completing the well.

A more particular object of the present invention is to provide a method of completing an oil well wherein a perforating gun is lowered into a well on the lower end of a string of tubing, which tubing is retained in the well after the gun is fired and utilized as the production string of the well.

A further particular object of the present invention is to provide a method of completing an oil well, wherein the selected production formation has been penetrated by a cased well bore in which the mud fluid is retained, comprising lowering a perforating gun into the well on the lower end of a string of tubing to a position in registry with the production formation, the string of tubing having a fluid passage communicating between the interior

2

of the string and the cased bore at a point above and adjacent the gun, thereafter circulating oil downwardly through the tubing, outwardly through the passage and then upwardly through the space between the tubing and casing to replace the mud fluid with oil by such circulation, thereafter closing the space between the tubing and casing at the surface, and thereafter firing the perforating gun to perforate the casing and the surrounding production formation. The tubing is left open at the time the perforating gun is fired, to serve both as a pressure relief and to permit observation of effects of the explosion. Thereafter, the formation fluid from the production formation is permitted to flow upwardly through the tubing to the surface by leaving the tubing at least partially open at the surface.

A still further object of the present invention is to provide a method, as described immediately above, wherein the steps are carried out one after another in close timed sequence so as to constitute one overall operation.

Various other objects of the present invention will be apparent from the following description taken in connection with the accompanying drawings wherein:

Fig. 1 is a diagrammatic sectional view showing a cased well bore containing mud fluid and depicting the well bore prior to the commencement of the method of the present invention.

Fig. 2 is a view similar to Fig. 1, but showing a perforating gun as having been lowered into the well bore into registry with a selected production formation, and showing oil as being circulated downwardly through the tubing outwardly therefrom and upwardly between the tubing and the casing to replace the mud fluid with oil.

Fig. 3 is a view similar to Fig. 2, but showing the space between the tubing and the casing as having been closed and the perforating gun as having been fired to penetrate the casing and the production formation surrounding the casing, the tubing being open at the outlet.

Fig. 4 is a view similar to Fig. 3, but showing the tubing as having been partially opened to permit controlled flow of formation fluid from the production formation upwardly through the tubing to the surface.

In describing the method of the present invention, it will be assumed that the well bore has been entirely cased in, this being the conventional condition of a well at the time that the well is to be completed. However, sometimes the well bore is not entirely cased, and occasionally selected production formation itself is not cased, the well being completed in this condition. It is standard practice, however, to case a well bore at the surface regardless of the condition of the remainder of the well bore. Since the method of the present invention may be readily employed to complete a well regardless of the condition of the well bore, the invention is not intended to be limited to completing wells wherein the selected production formation is cased in.

Referring to Fig. 1, there is disclosed, diagrammatically, an oil well bore cased in by casing 9, the cased bore penetrating a production formation 11. The casing is partially or entirely filled with mud fluid 13 retained therein after the penetration of the production zone to prevent collapse of the casing and also to maintain control over any high pressure fluid having access to the well bore.

In practicing the method of the present invention, the first step comprises lowering a perforating gun 15 into the well on the lower end of a string of tubing 17. Above but adjacent gun 15, the tubing is provided with one or more passages 19 communicating between the interior of the tubing and the space between the tubing and casing 9.

The next step comprises forcing oil 21 downwardly through tubing 17, out through passages 19 and then

upwardly through the annular space between the tubing and the casing to replace mud fluid 13 with oil 21. The portion of tubing 17 below passages 19 is closed to the passage of fluid downwardly therethrough, so that oil forced downwardly through said tubing is directed outwardly through passages 19.

After the above step has been carried out, the space between the tubing and the casing is closed at the surface as by a valved connection 23. The tubing itself is provided at the surface with a valved connection 25, opening from one side of the tubing, and with a relief valve 26, opening directly from the top of the tubing. With the valve 26 open the perforating gun 15 is then fired to perforate the casing and the production formation surrounding the casing. Thereafter, the valve 26 is closed and the valve 25 is adjusted partially opened at 25 to permit formation fluid 27, produced by the penetrated production formation, to flow into passages 19, and then upwardly through the tubing to the surface, as indicated in Fig. 4. Thus, the entire operation of completing the well is accomplished by lowering a string of tubing into the well which serves to run in the perforating gun and thereafter functions as a production string. By this arrangement, the equipment necessary to complete a well is reduced over that equipment conventionally employed. Furthermore, the time required to complete the well is considerably and substantially reduced by eliminating the steps of removing and breaking a string of tubing and then making and running the tubing back into the well.

The steps comprising the method of the present invention are carried out one after another in close timed sequence so as to constitute one overall operation. The close timing of these perforating and producing operations, performed after the drilling mud has been replaced by either oil or water, give the very important advantage of flowing the formation oil through the perforations immediately after the perforating operation, thus preventing "mudding-off" the oil in the formation adjacent to the well bore and/or plugging the perforations with mud as has been done when using conventional completion procedures.

The specific structure of the perforating gun and of the firing means therefor forms no part of the present invention, and a detailed description thereof is therefore omitted herefrom. In general, the perforating gun employed may be of the electrically fired type, or the type fired by dropping a go-devil down the string of tubing, or any type that suits the desires of the operator. I have disclosed in my copending application, filed May 19, 1953, Serial No. 355,899, and entitled Firing Head, a device especially adapted for carrying out part of the method of the present invention, and reference may be had to that application for the details of construction.

Sometimes, a production formation is penetrated by a bore which is not cased at the level of the formation. However, in each instance, the well is cased at the surface. The only difference between completing such an uncased well by the method of the present invention and a well wherein the production formation is penetrated by a cased bore, is that in the former instance there is no casing to be perforated at the production formation when the perforating gun is fired. In that case, the projectiles serve only to penetrate and break up the formation surrounding the bore and thereby facilitate the flow of oil therefrom.

While I have shown the preferred form of my invention,

it is to be understood that various changes may be made in its construction by those skilled in the art without departing from the spirit of the invention as defined in the appended claims.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

1. The method of completing an oil well wherein a selected production formation has been penetrated by a cased well bore and in which the mud fluid is retained, comprising the following steps carried out one after another in close timed sequence so as to constitute one single overall operation, lowering a perforating gun into the mud fluid in the well attached to the lower end of a string of tubing to a position in registry with the selected production formation, the string of tubing having a fluid passage communicating between the interior of the string and the cased bore at a point above and adjacent the gun, introducing oil downwardly through the tubing, outwardly through the passage into contact with the mud fluid and upwardly through the space between the tubing and casing to replace the mud fluid with oil, closing the space between the tubing and the casing at the surface after the well bore has been cleansed of mud fluid, thereafter firing the perforating gun to perforate the casing and the surrounding production formation, while the tubing is open at the top of the well, and then regulating the flow of formation fluid from the production formation through the passage in the tubing and upwardly through the tubing to the surface by partially closing the tubing at the surface.

2. The method of completing an oil well wherein a selected production formation has been penetrated by a well bore uncased at the production formation but cased at the surface and in which the mud fluid is retained, comprising the following steps carried out one after another in close timed sequence so as to constitute one overall operation, lowering a perforating gun into the mud fluid in the well attached to the lower end of a string of tubing to a position in registry with the selected production formation, the string of tubing having a valve controlled opening above the surface and a fluid passage communicating between the interior of the string of tubing and the well bore at a point above and adjacent the gun, thereafter introducing oil downwardly through the tubing, outwardly through the passage into contact with the mud fluid and then upwardly through the space between the tubing and the walls of the well bore to replace the mud fluid with oil, closing the space between the tubing and the casing at the surface after the well bore has been cleansed of mud fluid, thereafter firing the perforating gun to perforate the production formation surrounding the gun while the tubing is open above the surface then regulating the flow of the formation fluid from the production formation through the passage in the tubing and upwardly through the tubing to the surface by at least partially closing the tubing at the surface.

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