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3,022,822

METHOD OF MANIPULATING WELL TOOLS

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FIG. 1.

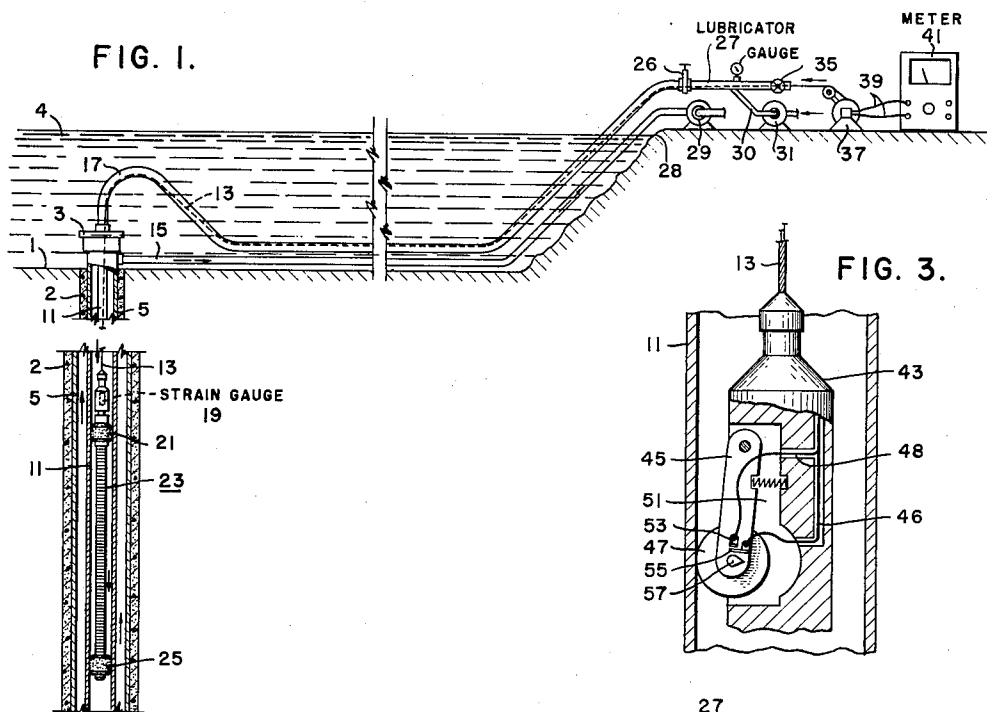


FIG. 3.

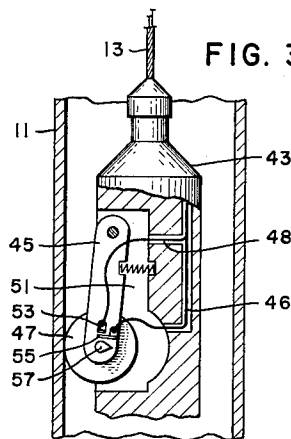
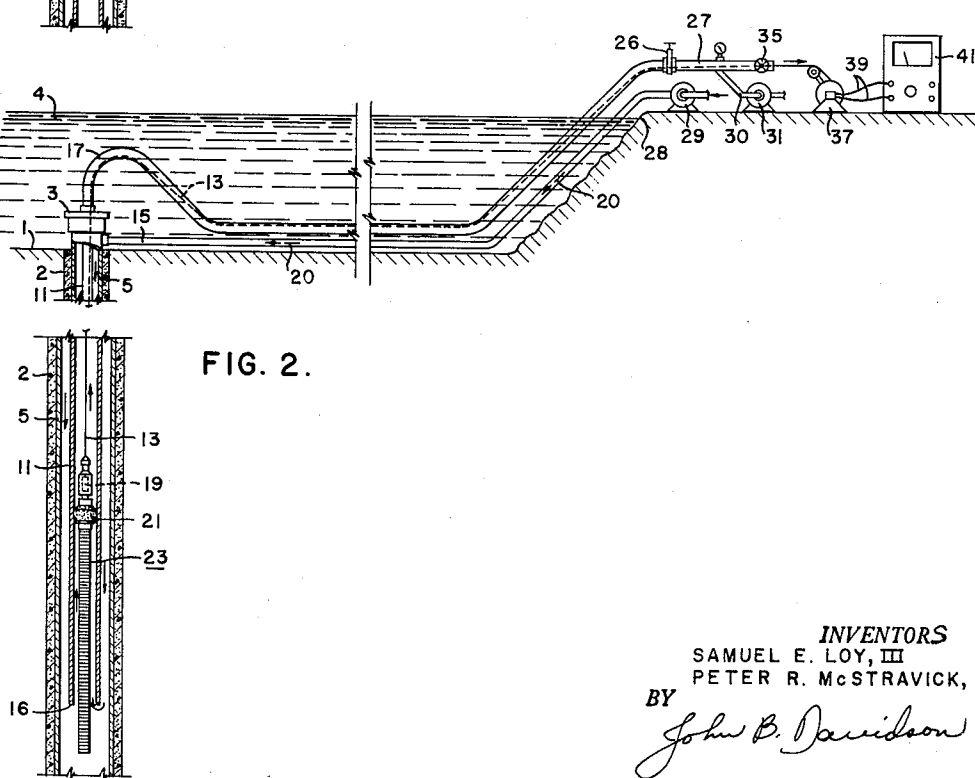


FIG. 2.



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METHOD OF MANIPULATING WELL TOOLS

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3 Claims. (Cl. 166—4)

This invention is directed to a method for manipulating well tools in wells having an underwater wellhead, and more particularly to a method for manipulating well tools in a well having substantially horizontal flow lines connecting the casing and tubing of a cased and tubed well to a remote operating location.

The present invention is concerned with the manipulating of tools in wells such as are described in U.S. Patent No. 2,810,440, J. W. Kenneday et al. In connection with the invention, substantially horizontal flow lines are used to interconnect the tubing and casing of a tubed and cased well to a remote operating location, which may be located on dry land. It is necessary to send well tools horizontally through the flow line and down the tubing string of the well. This may be done by pumping the well tool down the well on the end of a flexible, elongated line, such as a wireline, which is played out as the tool moves horizontally through the flow line and downwardly through the tubing. The tool may be retracted from the well by reversing the pressure differential across the tool by placing the flow line connected to the casing under fluid pressure with respect to the flow line connected to the tubing. Should the stress in the wireline become too great, the line will break and considerable difficulty will be experienced in retrieving the tool from the flow line and the tubing. Likewise, when the tool is being retracted from the well, the pressure applied to the casing may be so great that the tool will overrun the wireline to seriously impede the retrieving operation. In accordance with the teachings of the invention, electrical signals are produced at the tool which are indicative of the stress in the line between the operating location and the tool. The signals are transmitted to the earth's surface and the hydraulic pressure in the flow line is adjusted to maintain the stress in the wireline below a first given stress while the tool is going down the well, and greater than a second given stress while the tool is being retrieved from the well.

The present invention will be further described with reference to the drawing, wherein:

FIGS. 1 and 2 are schematic showings of a well drilled at an underwater location illustrating two steps in the method of the present invention; and

FIG. 3 is a sectional view of apparatus used for producing electrical signals indicative of the strain in the wireline.

With reference now to FIGS. 1 and 2 of the drawing in which identical numerals will be employed to designate identical components, numeral 2 designates a well drilled from the water bottom 1 of a body of water 4 at a substantial distance from the shoreline 28. Arranged in the well bore 2 is a casing string 5 which is cemented in place in the well bore; the casing string 5 extends substantially to the depth of the well. Arranged in the casing 5 and coextending therewith from the earth's surface is a tubing string 11 having its lower open end 16 disposed at a level above a hydrocarbon productive zone.

The tubing string 11 and the casing string 5 are suspended from a wellhead 3 at the water bottom 1. A flow line or pipe 17 is connected to the well-head 3 so as to be in fluid communication with the tubing string 11. Similarly, a second flow line 15 is connected to the wellhead so as to be in fluid communication with the annulus be-

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tween the casing string and the tubing string. Flow line 17 has a short radius bend at the wellhead end thereof which may be of any desired degree. Both flow lines 15 and 17 extend substantially horizontally to a remote location which may be on dry land at the shore 28. The flow line 17 is provided with a lubricator 27 and a blowout preventer 35. Lubricator 27 is provided with a valve 26. Connected to the lubricator 27 by a laterally extending conduit 30 is a pump 31 which connects to a fluid source, not shown. Flow line 15 also is provided with a pump 29 which also is connected to the fluid source. The fluid source may be drilling mud, oil, fresh or salt water, or may be a suitable treating agent of the types well known to the art.

Shown in FIG. 1 in the running-in position is a well tool 23 which is shown as being a tubular extension member. The tool 23 is connected to the remote operating location by means of an electrical signal producing device, here shown as a strain gauge 19, and by an elongated wireline 13. The line 13 may be a logging cable or a stranded line, as desired, and may have one or more electrical conductors associated therewith. The wireline is wound or spooled on a reel or drum 37 having associated therewith apparatus for measuring the length of line run through and retracted from the lubricator. Suitable apparatus for this purpose is described in the "Composite Catalog of Oil Field Equipment and Services," 1958-1959 edition, pages 2272 and 2273. The electrical leads associated with the line extend through the wireline reel and line measuring apparatus 37 to electrical leads 39 connected to a suitable meter or electrical measuring equipment 41. The electrical equipment 41 may be a pulse counting device or a current measuring device, as will become apparent from the following discussion.

Suitable landing nipples may be included at the lower end 16 of the tubing for the purpose of landing tubing extension and other apparatus, if such is so desired. The tool to be run into the well may have suitable cup packer or packers 21 and expandable plug 25 associated therewith to facilitate pumping the tool into and out of the tubing string 11 and flow line 17. Tool 23 is shown as being a tubing extension, but it is to be understood that a perforating gun, logging sonde, fishing tool or other suitable tools may be used in connection with the invention.

The strain gauge 19 may be an apparatus such as is shown in U.S. Patent No. 2,589,599, J. A. Bond et al. Other suitable strain gauges may be used as desired. The function of the strain gauge is to produce electrical signals indicative of the stress in wireline 13, preferably at or near well tool 23.

The well tool 23 is run into the flow line through the blowout preventers 35 and lubricator 27. When the well tool 23 is pumped through the flow line, the friction between the wireline 13 and the flow line 17 will increase as the well tool 23 moves further and further away from the operating location. If a strain gauge were used to measure the stress in the wireline 13 at the operating location, the stress so measured would not be truly indicative of the stress in the line down the well or in the flow line 17. The fluid pressure placed on the flow line 17 is varied in accordance with the electrical indications produced by the strain gauge 19 and transmitted back to the remote location so that the signals do not exceed a predetermined magnitude indicative of a predetermined stress in the line as the well tool gets further and further away from the operating location. When it is desired to retract the tool from the well, pump 31 is shut off and pump 29 is started up. The direction of fluid circulation will be as indicated by arrows 20 (FIG. 2). The well tool will start up the tubing string. Manifestly, unless the correct tension is maintained in the line, either the line will

break or the well tool will overrun the wireline 13. Therefore, the electrical signals produced by the strain gauge 19 are kept greater than a predetermined magnitude while the tool is being run out of the well. As the tool proceeds up the tubing string 11 and out the flow line 17, the pressure exerted on flow line 15 by pump 29 may be gradually reduced.

In FIG. 3 there is shown another apparatus for producing electrical signals indicative of the strain in the line. The apparatus is shown as being disposed in tubing string 11 suspended from wireline 13. The apparatus comprises a suitable body member 43 connecting wireline 13 to the tool (not shown). A roller member 47 is connected to one end of a pivoted arm 45 which is affixed to the body member 43 so as to pivot thereon in recess 51. A movable electrical contact 55 and a fixed electrical contact 53 are disposed relative to a cam 57 driven by roller member 47 so that the electrical contacts are closed with each revolution of the roller 47. The arm 45 is spring-biased so that the wheel or roller member 47 is in engagement with the tubing string 11. Electrical connections 46 and 48 from the contact members 53 and 55 are electrically connected to meter 41 through the cable 13. A source of electrical energy (not shown) is included in the meter 41 in the usual manner for ohmmeters so that an electrical pulse is produced on each closure of contact members 53, 55 and is indicated by the meter. The function of the apparatus of FIG. 3 is to produce pulses indicative of the distance traversed by the well tool 23 as the well tool passes through the flow line 17 and the tubing string 11. Manifestly, as the roller member or wheel 47 rotates, an electrical pulse will be produced every time it passes through a unit length of the flow line 17 and tubing string 11. The pulses may be counted by the electrical measuring apparatus 41 so as to provide an accurate indication of the actual distance that the tool has travelled going into or out of the well. By applying the well known relationship

$$\frac{F}{A} = Y \frac{\Delta L}{L}$$

the stress in the line may be readily determined. The quantity "L" may be determined from the readings provided by the wireline reel and line measuring apparatus 37, the quantity "ΔL" may be determined from the difference between line length as determined from the apparatus 37 and the line length as determined from electrical signals produced by electrical measuring apparatus 41. The quantity "Y" is Young's modulus of elasticity for the particular cable used in connection with the apparatus and may be readily determined. This apparatus will provide an indication of the average stress in the line between the operating location and the well tool. Manifestly, the maximum stress indicated in this manner must be less than that indicated by means of a strain gauge at the well tool while the tool is being run into the well and while it is being withdrawn from the well. However, the readings obtained with the apparatus of FIG. 3 will make it possible to manipulate the well tool in and out of the well without breaking the line and without overrunning the line during the time that the tool is being retrieved from the tubing string.

The invention is not necessarily to be restricted to the specific structural details or arrangement of parts herein set forth, as various modifications thereof may be effected without departing from the spirit and scope of the invention.

The nature and objects of the invention having been

completely described and illustrated, what we wish to claim as new and useful and to secure by Letters Patent is:

1. In a well in the earth having a casing extending substantially the depth of the well, having a tubing string arranged in said casing with a lower open end extending to a predetermined level, and having first and second substantially horizontal flow lines extending from said tubing string and said casing, respectively, to a remote operating location with the first horizontal flow line having a section of short radius connected to the tubing string, the method comprising: hydraulically pumping a well tool at the end of a flexible line into the first horizontal flow line and down the tubing string; sensing the stress in the flexible line at the tool, and producing electrical signals indicative of the stress sensed in the flexible line; transmitting the electrical signals to the operating location; varying the hydraulic pressure applied to the first horizontal flow line to maintain the stress in the flexible line below a predetermined stress in accordance with the electrical signals received at the remote operating location while pumping the tool through the first flow line and down the tubing string; reversing fluid pressure on the tool by hydraulically pressurizing the casing through the second flow line; and maintaining the stress in the flexible line between the operating location and the tool above a predetermined stress while said tool is moving up the tubing string and out the first flow line.

2. In a well in the earth having a casing extending substantially the depth of the well, having a tubing string arranged in said casing with a lower open end extending to a predetermined level, and having first and second substantially horizontal flow lines extending from said tubing string and said casing, respectively, to a remote operating location with the first horizontal flow line having a section of short radius connected to the tubing string, the improvement comprising: a well tool adapted to be connected to a wireline; annular packer means connected to said tool and in sliding engagement with the inner surfaces of said first flow line and said tubing string adapted to permit said well tool to be pumped into and out of said flow line; variable pressure pump means connected to said first and second flow lines for selectively pressurizing said first and second flow lines to move said tool into and out of said first flow line and the tubing string; a flexible, elongated line connected to said tool and extending into the first flow line and tubing string; means operatively associated with said flexible line at the remote operating location for reeling said flexible line; first electrical means operatively associated with the flexible line for measuring the strain in the flexible line between the remote operating location and the tool, and for producing electrical signals correlatable to said strain; conductor means associated with said first electrical means and said flexible line for conducting the electrical signals to the remote operating location; and second electrical means associated with said first electrical means to measure said electrical signals.

3. Apparatus as defined in claim 2 wherein the first electrical means is a strain gauge.

References Cited in the file of this patent

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2,589,599	Bond et al.	Mar. 18, 1952
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