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METHOD FOR PERFORATING A WELL

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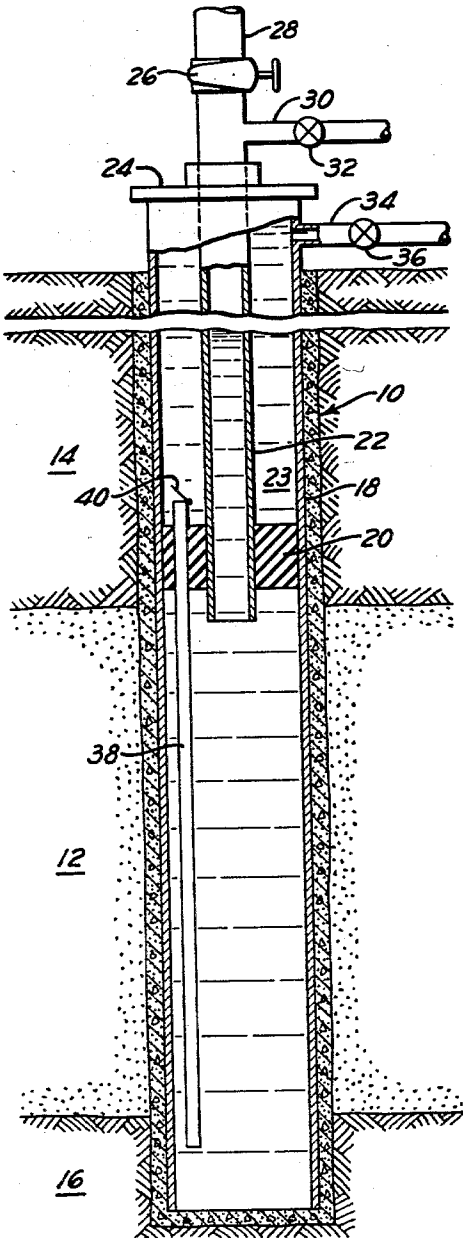


Fig. 1

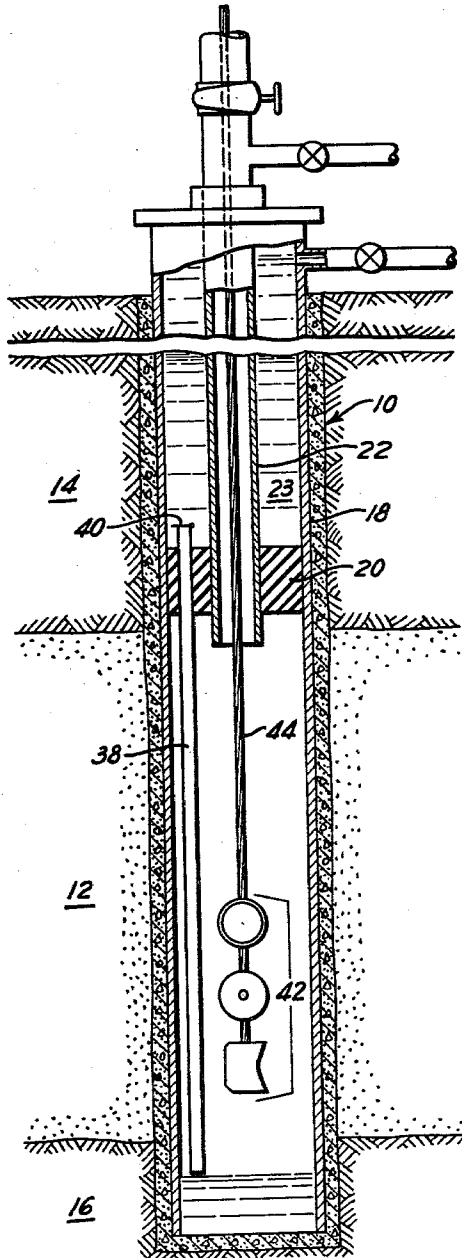


Fig. 2

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METHOD FOR PERFORATING A WELL

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This invention relates to oil and gas wells, and more particularly to a method for use in the perforation of casing set in such wells.

Most oil and gas wells are drilled by the rotary drilling method in which a drilling mud is circulated down the well through a string of drill pipe and upwardly from the bottom of the well through the annulus between the drill pipe and the borehole wall. When the well has been drilled to the desired depth, the drill pipe is pulled from the well leaving the well full of drilling mud. It is the usual practice to set steel casing in the well through the production zone of the well. The setting of the casing is accomplished by lowering the casing into the well to locate its lower end at the desired depth and pumping a slurry of cement downwardly through the casing. The cement displaces the drilling mud downwardly in the casing, around the lower end of the casing, and up through the annulus between the casing and the borehole wall. The slurry of cement is followed by suitable liquid such as water or drilling mud to displace the cement to the desired location between the outer surface of the casing and the borehole wall. Any excess of cement slurry that may remain in the casing after the cement has been placed is circulated from the bottom of the casing with a nonsetting liquid; hence at the end of the setting of casing, the casing is filled with a liquid such as water or drilling mud.

After casing has been set through an oil- or gas-bearing formation, it is usually perforated through the production zone by means of guns or shaped charges which create holes extending through the casing and the surrounding sheath of cement and into the adjacent oil- or gas-bearing formation. Liquid present in the casing at the time of perforating may flow through the perforations into the oil- or gas-bearing formation and diminish its permeability to oil or gas.

This invention resides in a method for use in the perforation of casing of a well in which liquid is displaced from the casing in communication with the perforations to a level below the level of the perforations whereby the liquid cannot flow from the casing into the formation through the perforations cut in the casing. In a preferred form of this invention, liquid displaced from the casing communicating with the perforations is held in the casing above the perforated section of the casing. If formation fluids entering the well through the perforations cause excessive pressure and danger of a blowout, the well can be killed quickly by discharging the liquids into the perforated section of the casing.

In the drawings:

FIGURE 1 is a diagrammatic view, partially in vertical section, illustrating a well equipped for displacement of liquids from the interval of the casing adjacent on oil- or gas-bearing formation during an early stage of the displacement of the liquid; and

FIGURE 2 is a diagrammatic view also partially in vertical section showing the well after displacement of liquid from the casing and ready for perforation of the casing.

Referring to FIGURE 1 of the drawings, a well indicated generally by reference numeral 10 extends downwardly through an oil- or gas-bearing formation 12 between a cap rock 14 and base rock 16. Casing 18 is set

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through the formation 12 and cemented in place by any conventional cementing procedure. A packer 20 is run into the well on tubing 22 and is set at approximately the upper boundary of formation 12 to close the annulus 23 between tubing 22 and casing 18.

The upper end of the casing 18 is closed by a suitable cap 24 through which tubing 22 passes. A valve 26 is connected to the upper end of tubing 22. Extending upwardly from valve 26 is a lubricator 28, the lower end of which is shown in FIGURES 1 and 2, for running a wire line into the well, as hereinafter described. A gas supply line 30 equipped with a valve 32 opens into tubing 22 below valve 26. Directly below cap 24 is an outlet line 34 from the casing 18. A valve 36 in outlet line 34 allows control of flow through the outlet line.

Packer 20, which preferably is of a type which can be released by manipulation of tubing 22, is assembled at the wellhead with a dip tube 38 extending through the packer below the lower end thereof for a distance adequate to locate the lower end of the dip tube 38 below the lower end of tubing 22 and also below the level of the perforations to be made in the casing adjacent the formation 12. At the upper end of dip tube 38 is an upwardly opening flapper valve 40 which allows flow of fluids upwardly through the dip tube 38 but prevents downward flow through the dip tube. While it is preferred to run the packer 20 into the well on the lower end of tubing 22 to avoid a separate trip into the well, packer 20 can be set in place in the well and thereafter tubing 22 and dip tube 38 lowered through the packer to the desired position.

In the operation of the apparatus illustrated in FIGURE 1, valve 26 is closed and valves 32 and 36 are opened. A gas, such as nitrogen, is delivered through supply line 30 into the upper end of tubing 22 to displace liquid in tubing 22 downwardly into the casing 18 below the packer 20, and then upwardly through dip tube 38 and annulus 23 to the wellhead where the liquid is discharged from the well. Displacement of gas into the tubing 22 is continued until the liquid level in casing 18 below the packer 20 reaches the lower end of the dip tube 38. The arrival of the liquid level at the lower end of the tube 38 will be indicated at the wellhead by the flow of gas through outlet line 34. Displacement of gas into the upper end of tubing 22 is then discontinued. Flow of liquid from the annulus 23 back into the liquid-free casing below the level of the packer 20 is prevented by flapper valve 40.

With the well under the pressure of the gas used to displace liquid into the annulus 23, perforating means 42, which may be guns or shaped charges, are dropped from lubricator 28 into the upper end of tubing 22 and lowered into position below the lower end of tubing 22 and above the lower end of the dip tube 38 on the wire line 44. The perforating means 30 are then set off to cut perforations through the casing and surrounding cement sheath. Because liquid has been removed from the tubing 22 and the casing communicating with the perforations to a level below the perforations, liquid cannot flow through the perforations into the formation and damage the formation.

After the perforations have been made, wire line 44 is withdrawn from the well and the gas pressure within the well is gradually reduced by means of valve 32 to initiate production from formation 12 through the perforations. As important advantage of the process of this invention is that pressure within the tubing 22 can be gradually reduced to initiate flow from formation 12 without the necessity of swabbing tubing 22. Because tubing 22 is run into the well to the position it will occupy during operation of the well, a rig is not needed at the well after the tubing 22 is run into the well.

If the formation 12 should be under a very high pressure and any danger of the well blowing out should be encountered, the well can be readily killed by dumping the liquid in annulus 23 into the casing 18 below packer 20. Delivery of liquid from the annulus 23 to the casing below the packer 20 can be accomplished by unseating the packer, or by pulling the tubing 22 from the packer 20.

I claim:

1. In a method of completing a well for the production of hydrocarbons from a hydrocarbon-bearing formation penetrated by the well, said well having casing substantially filled with liquid set through the hydrocarbon-bearing formation, the improvement comprising setting a packer within the casing above the level of the desired perforations, running tubing downwardly from the wellhead into the well and through the packer, suspending a dip tube from the packer, said dip tube having a one-way valve therein preventing flow downwardly therethrough and extending from the annulus between the tubing and casing above the packer downwardly through the packer to a level below the lower end of the tubing, injecting gas into the upper end of the tubing to displace liquid therein downwardly to the lower end of the dip tube and upwardly through the dip tube into the annulus above the packer, maintaining liquid in the annulus above the packer, running perforating means through the tubing to a level between the lower end of the tubing and the lower end of the dip tube, and setting off the perforating means to perforate the casing.

2. In a method of completing a well for the production of hydrocarbons from a hydrocarbon-bearing formation penetrated by the well, said well having casing substantially filled with liquid set through the hydrocarbon-bearing formation, the improvement comprising setting a packer within the casing above the level of the desired perforations, suspending tubing in the well extending downwardly from the wellhead through the packer, suspending a dip tube from the packer, said dip tube having a one-way valve therein preventing flow downwardly therethrough and extending from the annulus above the packer between the tubing and casing downwardly through the packer to a level below the upper boundary of the hydrocarbon-bearing formation and below the lower end of the tubing, injecting gas into the upper end of the tubing under pressure to displace liquid therein downwardly to the lower end of the dip tube and upwardly through the dip tube into the annulus above the packer, maintaining liquid in the annulus above the packer, running perforating means through the tubing to a level in the interval of the hydrocarbon-bearing formation between the lower end of the tubing and the lower end of the dip tube while maintaining pressure on the gas in the tubing, setting off the perforating means to perforate the casing, and gradually releasing gas from the upper end of the tubing to cause formation fluids to flow through the perforations into the casing.

3. In a method of completing a well for the production

of hydrocarbons from a hydrocarbon-bearing formation penetrated by the well, said well having casing substantially filled with liquid set through the hydrocarbon-bearing formation, the improvement comprising assembling a packer on the lower end of a tubing string, said packer having a dip tube extending therethrough, said dip tube having a one-way valve at the upper end thereof permitting upward flow therethrough and having its lower end extending below the lower end of the tubing, running the packer in the well on the lower end of the tubing, setting the packer in the casing adjacent the hydrocarbon-bearing formation, injecting gas under pressure into the upper end of the tubing to displace liquid downwardly from the tubing to the lower end of the dip tube and upwardly through the dip tube into the annulus between the tubing and casing above the packer, maintaining liquid in said annulus above the packer, running perforating means downwardly through the tubing to a level between the lower end of the tubing and the lower end of the dip tube while maintaining pressure on the gas in the tubing, setting off the perforating means to perforate the casing, and thereafter releasing gas from the upper end of the tubing whereby formation fluids flow into the well.

4. In a method of perforating a well having casing filled with liquid set to a depth below the desired level of the perforations, the improvement comprising running tubing into the well to a depth less than the depth of the desired perforations, setting a packer in the well around the lower end of the tubing at a depth less than the depth of the desired perforations to close the annulus between the tubing and casing, suspending a dip tube in the well from the packer to a depth greater than the depth of the desired perforations, said dip tube opening above the packer into the annulus between the tubing and casing, injecting a gas into the upper end of the tubing to displace liquid in the well below the packer downwardly to the lower end of the casing and upwardly through the dip tube to displace the liquid in the casing, between the packer and the lower end of the dip tube into the annulus surrounding the tubing above the packer, maintaining liquid in the annulus surrounding the tubing above the packer lowering perforating means through the tubing to the level of the desired perforations, and setting off the perforating means.

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