

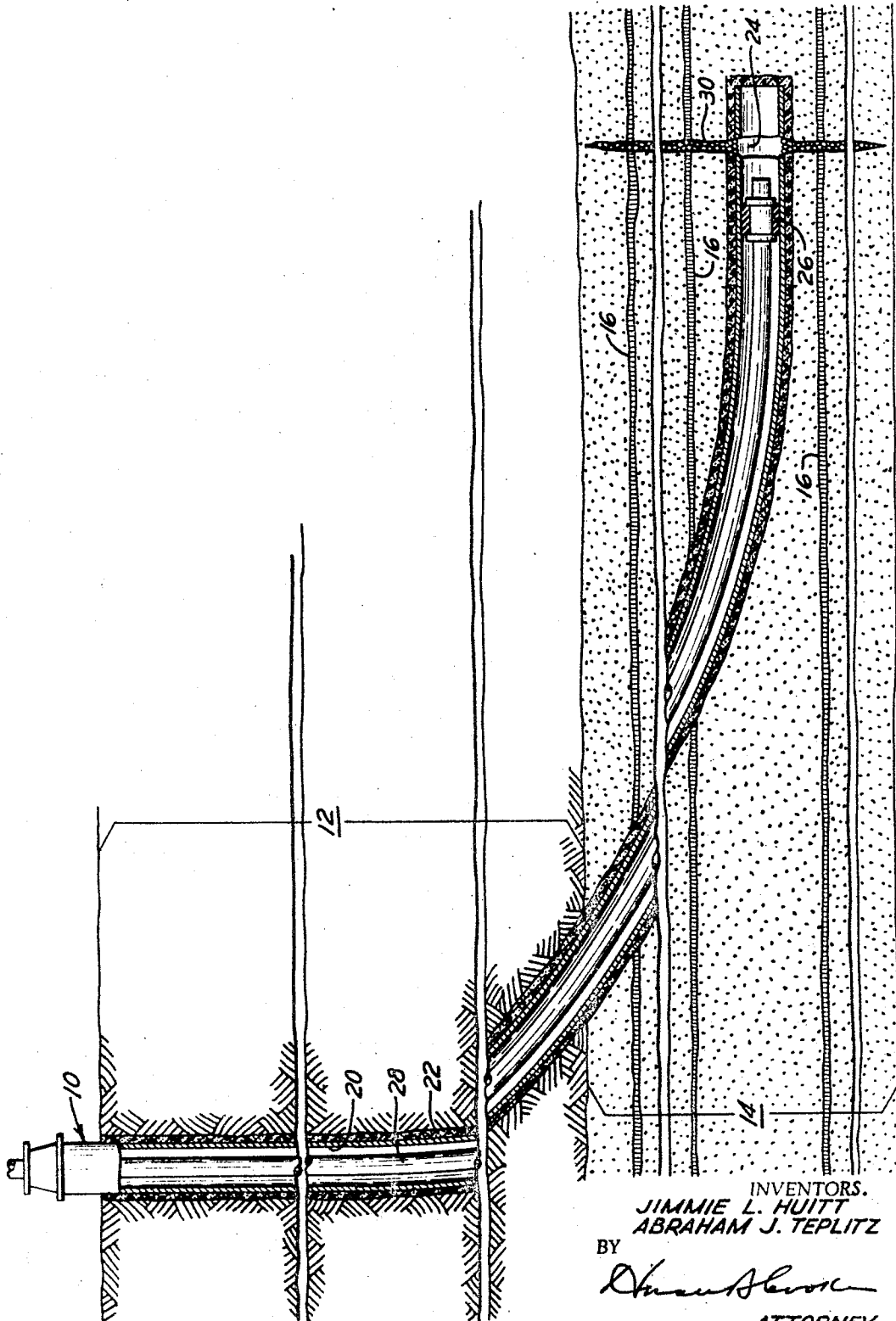
April 11, 1967

J. L. HUITT ET AL

3,313,348

PROCESS OF FORMING VERTICAL WELL BORE FRACTURES BY USE
OF CIRCUMFERENTIAL NOTCHING

Filed Dec. 27, 1963

INVENTORS.
JIMMIE L. HUITT
ABRAHAM J. TEPLITZ

BY

Shaul Shor

ATTORNEY.

1

3,313,348

PROCESS OF FORMING VERTICAL WELL BORE FRACTURES BY USE OF CIRCUMFERENTIAL NOTCHING

Jimmie L. Huitt, Glenshaw, and Abraham J. Teplitz, Penn Hills, Pa., assignors to Gulf Research & Development Company, Pittsburgh, Pa., a corporation of Delaware
Filed Dec. 27, 1963, Ser. No. 333,843

7 Claims. (Cl. 166—42)

This invention relates to a method of completing a well, and more particularly to a method of fracturing an underground oil- or gas-bearing formation to increase the rate of production therefrom.

The hydraulic fracturing process has been widely used to increase the productivity of wells by providing a channel of high fluid flow capacity extending for substantial distances from the wells into the surrounding oil- or gas-bearing formations. In the hydraulic fracturing process, a fracturing liquid is pumped down a well into contact with the underground formation which is to be fractured and the pressure on the liquid is increased to the breakdown pressure of the formation whereby a fracture extending from the well outwardly into the formation is created. Solid particles, designated as propping agents, are suspended in a liquid and displaced down the well and into the fracture behind the fracturing liquid to hold the fracture open during the production of fluids from the formation.

Ordinarily, the fractures are created along planes of weakness in the formation. Those planes are usually along the bedding planes of the formation, and are substantially horizontal or make a very small angle with the horizontal. Many oil-bearing formations have streaks of shale or other materials of low permeability extending through the formation at intervals. The low permeability streaks normally are parallel to the bedding planes and prevent or restrict flow through the formation in a direction perpendicular to the bedding planes.

Attempts have been made to create substantially vertical fractures which will cross the shale or other streaks of low permeability and allow flow into the fracture from substantially the entire thickness of the oil-bearing formation. One method that has been suggested for creating substantially vertical fractures is to seal the borehole wall through the interval of the formation to be fractured and then increase the hydraulic pressure within the borehole until breakdown occurs. Because the hydraulic pressure is applied only to the substantially vertical surfaces of the borehole wall, it is believed that a vertical fracture normally will occur. A disadvantage of that method is the high pressure required to break down the formation. Another method of creating a vertical fracture is to cut a vertical notch in the borehole wall along the axis of the well, and thereafter increase the hydraulic pressure in the well until fracturing occurs. The purpose of the vertical notch is to concentrate fracturing forces at the apex of the notch, and thereby fracture the formation rock at a low pressure.

Both of the methods described above for creating vertical fractures suffer a serious disadvantage resulting from the fracture extending along the length or axis of the well. Ordinarily casing is cemented in place through the oil-bearing formation and production into the well is through perforations or other openings in the casing. A vertical fracture extending along the axis of the wall may rupture the cement or separate the cement from the formation over a long interval and leave a long section of casing substantially unsupported through the oil bearing formation.

This invention resides in a method of creating fractures extending across bedding planes in a well by drilling

2

a borehole at an angle less than 45° with the horizontal through the formation to be fractured. Thereafter, a notch is cut in the borehole wall, or when casing is set through the oil-bearing formation through the casing and surrounding cement sheath substantially perpendicular to the well bore at the point of notching, a fracturing liquid is pumped down the well and the pressure on the liquid increased to create a fracture extending from the extremity of the notch.

The single figure of the drawing is a diagrammatic view, partially in vertical section, of a well having a fracture extending therefrom created by the method of this invention.

Referring to the drawing, a well indicated generally by reference numeral 10 is shown extending downwardly through overburden 12 into an oil-bearing formation 14. Well 10 is diverted from the vertical and is shown in the drawing with the lower end of the borehole extending substantially horizontally in the oil-bearing formation 14. A plurality of substantially horizontal impermeable streaks 16 extend through formation 14.

The diversion of the borehole of well 10 from vertical can be accomplished by any conventional means such as those used for drilling directional wells. One method of diverting the borehole from vertical is to set a cement plug in the borehole, place a whipstock oriented in the desired direction on the cement plug, and then resume drilling. The whipstock changes the direction of the drill bit in the desired direction. A plurality of whipstocks usually will be required to obtain the desired diversion of the borehole from vertical.

Drilling is continued until the borehole penetrates the oil-bearing formation 14 and extends at the desired angle in that formation. In the drawings, the borehole terminates in a substantially horizontal position in the oil-bearing formation. Diversion all of the way to horizontal is not necessary; the diversion of the borehole from vertical need only be such that the borehole makes an angle less than 45° with the horizontal. If the diversion of the borehole from vertical is less than 45°, for example at 20°, or less as is sometimes employed in directional drilling, a resultant fracture created in accordance with this invention may not cross the bedding planes at a great enough angle to continue the fracture across the bedding plane. The component of force perpendicular to the bedding planes when the diversion of the borehole is less than 45° from the vertical may be adequate to open the formation along the planes of weakness created by the bedding planes, and thereby change the direction of the fracture from the direction in which it was initiated.

As is shown in the drawing, casing 20 is run in well 10 through the oil-bearing formation 14 and is set in place by conventional cementing procedures which form a cement sheath 22 surrounding the casing. Ordinarily, casing 20 is run into the well with centralizers positioned along its length to insure a continuous cement sheath extending all of the way around the casing.

A circular notch 24 is cut through the casing 20 near its lower end. The notch 24 extends through the cement sheath 22, and preferably cuts a notch in the oil-bearing formation to create a plane of weakness substantially perpendicular to the casing 20 at the location of the notch. Notch 24 can be cut by any of a variety of means. A casing milling tool can be run in to ream an opening extending completely around the casing at the desired location and followed by a tool designed to cut a notch through the cement and into the surrounding formation. Another method of cutting the desired notch is by means of a shaped charge which may be either a single charge designed to cut a continuous notch around the casing or a plurality of charges designed to cut a plurality of openings

3

in a plane perpendicular to the length of the casing. A notch can also be cut by positioning a nozzle at the desired location in the well and discharging an abrasive slurry from the nozzle as the nozzle is rotated.

After the notch 24 has been cut through the casing, cement sheath, and into the formation, tubing 28 and packer 26 are run into the well and the packer 26 is set in the casing above the notch 24. Tubing 28 provides a conduit for the delivery of fracturing fluid to the space in the well below the packer.

After the packer has been set, a fracture is created extending from the outer edge of the notch 24 into the formation 14. In a preferred method of creating the fracture, a liquid capable of penetrating the formation, for example, a dilute aqueous solution of hydrochloric acid is pumped down tubing string 28 and into the notch 24. The penetrating liquid is followed by a low penetrating liquid containing a fluid-loss additive to reduce the flow of the liquid into the formation. The pressure on the low penetrating liquid is increased to the breakdown pressure of the formation to create a fracture, and sufficient low penetrating liquid is displaced down the well to extend the fracture for the desired distance into the oil-bearing formation 14. It is desirable that the fracture extend across the streaks of low permeability. In the drawing, the fracture is shown extending substantially to the boundary between the oil-bearing formation 14 and overburden 12. The low penetrating liquid is followed with a liquid, which may contain an additive to increase its viscosity, having a propping agent suspended therein which is displaced down the well and outwardly into the fracture 30. The well is then shut in for a period, and after pressure in the fracture 30 decreases to that of the formation, the pressure in the well is reduced and the well is placed on production by conventional means. For example, a pump, not shown, may be anchored in tubing 28 near its lower end to lift fluid from oil-bearing formation 14 from the well. The method described herein for creating the fracture after the notch has been formed is merely a preferred method. This invention is not limited to any specific method of creating a fracture extending from a well at right angles to the axis of the well at the point of fracture initiation.

This invention provides a method of creating a fracture extending radially from the well bore and across substantially horizontal impermeable streaks in an oil- or gas-bearing formation. Fluids from the formation can drain into the formation over substantially the entire thickness of the formation. The fracture created by this invention extends substantially perpendicular to the axis of the well at the location of the fracture and leaves the well substantially unaffected and undamaged except at the point of entry of the fluids from the fracture into the well.

We claim:

1. A method for increasing the capacity of a well for recovery of oil from an underground oil-bearing formation comprising drilling a well, deviating the borehole of the well from the vertical whereby at least a portion of the borehole of the well extends through the oil-bearing formation at an angle of at least 45° with the vertical,

4

cutting a notch extending from the borehole of the well into the oil-bearing formation at substantially right angles to the borehole of the well, said notch being located at a position in the well where the borehole of the well makes an angle of at least 45° with the vertical, displacing a fluid under pressure into the well and increasing the pressure on said fluid to create a single fracture extending from said notch substantially perpendicularly to said borehole, and depositing a propping agent in the fracture.

2. A method as set forth in claim 1 in which the notch is cut in the formation by underreaming.

3. A method as set forth in claim 1 in which the notch is cut in the formation by means of an explosive.

4. A method as set forth in claim 1 in which the notch is cut by means of an abrasive slurry.

5. A method for increasing the capacity of a well for production of oil from an underground oil-bearing formation comprising drilling the borehole of a well into said formation, at least a portion of the borehole of the well in the interval of said formation making an angle of at least 45° with the vertical, setting casing in the well into the oil-bearing formation, cutting an opening through said casing to expose the formation adjacent the well in a plane substantially perpendicular to the axis of the well, displacing a liquid down the well and into the formation at the opening in the casing, increasing the pressure on the liquid to create a single fracture from said well at the opening in the casing substantially perpendicular to said casing, and depositing a propping agent in the fracture.

6. A method as set forth in claim 5 in which the well is substantially horizontal at the opening of the fracture into the well.

7. A method for increasing recovery capacity of a well penetrating an oil-bearing formation penetrated by the borehole of a well, said borehole extending through the oil-bearing formation at an angle of at least 45° with the vertical comprising cutting a notch extending from the well into the oil-bearing formation in a plane substantially perpendicular to the axis of the well, displacing a fracturing fluid down the well into the notch, increasing the pressure on the fracturing fluid to break down the formation and create a single fracture extending from the notch substantially perpendicular to the well, and depositing a propping agent in the fracture.

References Cited by the Examiner

UNITED STATES PATENTS

2,758,653	8/1956	Desbrow	166—42.1
2,970,645	2/1961	Glass	166—42.1
3,002,454	10/1961	Chesnut	166—42.1
3,058,521	10/1962	Gilbert	166—42.1
3,097,694	7/1963	Kerver	166—42.1
3,130,786	4/1964	Brown et al.	166—42.1

JACOB L. NACKENOFF, *Primary Examiner*.

CHARLES E. O'CONNELL, *Examiner*.

J. A. LEPPINK, *Assistant Examiner*.