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Closmann

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[54] **VERTICALLY EXPANDED STRUCTURE-BIASED HORIZONTAL FRACTURING**

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[52] **U.S. Cl.** **166/308**

[51] **Int. Cl.** **E21b 43/26**

[58] **Field of Search** 166/308, 271, 283, 302, 166/57, 60, 177

[56] **References Cited**

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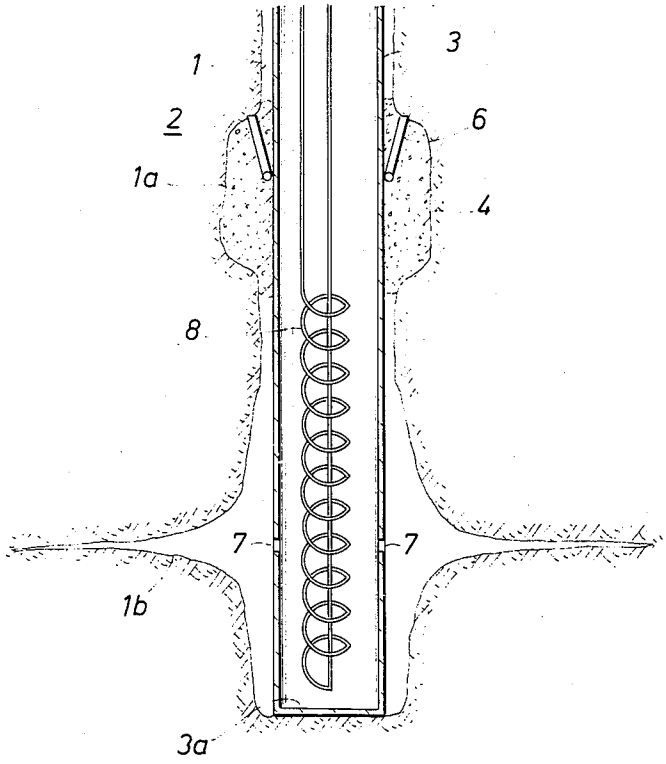
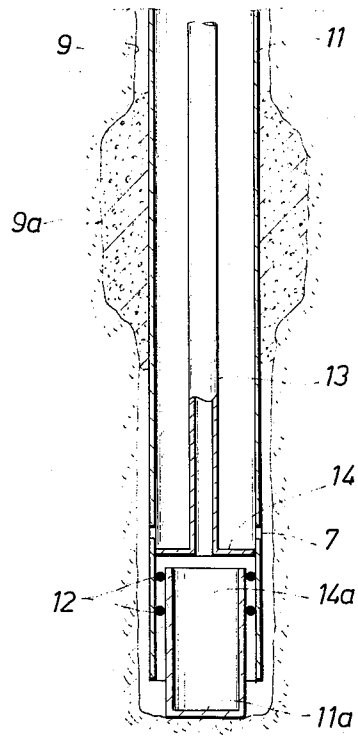
[57] **ABSTRACT**

A subterranean earth formation is fractured horizontally by connecting a vertically expandable structure above and below a selected depth within the earth formation, applying a vertical expanding force to the structure so that the applied force reduces the vertical compressive stress within the earth formation at the selected depth and, concurrently, increasing the fluid pressure against the earth formation to induce a fracture at the selected depth.

3 Claims, 3 Drawing Figures





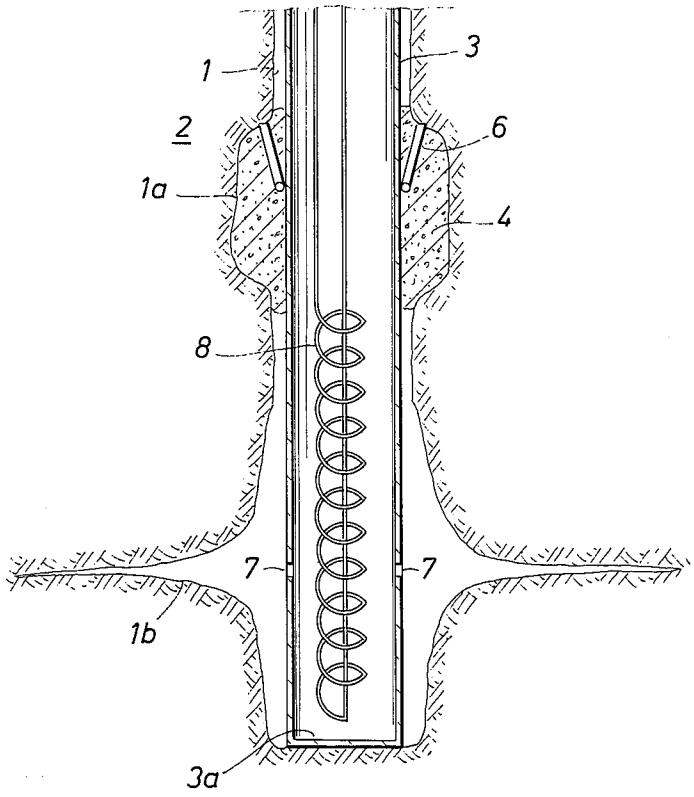


FIG. 1

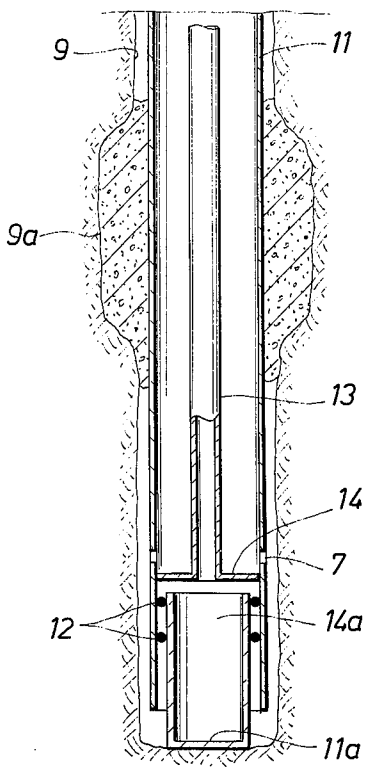


FIG. 2

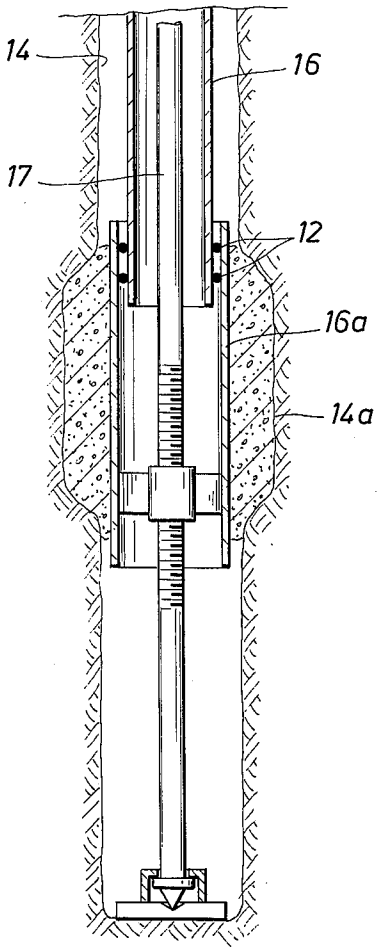


FIG. 3

VERTICALLY EXPANDED STRUCTURE-BIASED HORIZONTAL FRACTURING

BACKGROUND OF THE INVENTION

The invention relates to fracturing a subterranean earth formation so that the plane of the fracture is generally horizontal.

The value of forming fractures that are horizontal and the difficulty of doing so, are well-known. The vertical compressive stresses tend to be the largest of the mutually perpendicular compressive stresses that exist within subterranean earth formations. And, a hydraulically inducted fracture tends to form along a plane perpendicular to the least of the compressive stresses.

SUMMARY OF THE INVENTION

In accordance with this invention, a subterranean earth formation is fractured horizontally by connecting a vertically expandable structure above and below a selected depth within the earth formation, applying a vertical expanding force to the structure so that the applied force reduces the vertical compressive stress within the earth formation at the selected depth and, concurrently, increasing the fluid pressure against the earth formation to induce a fracture at the selected depth.

DESCRIPTION OF THE DRAWING

FIGS. **1, 2** and **3,** are schematic illustrations of portions of well boreholes and different embodiments of equipment used in practicing the present invention.

DESCRIPTION OF THE INVENTION

Vertically-expandable structures suitable for use in this invention comprise substantially any that are adapted to be connected between vertically separated locations within a subterranean earth formations and caused to undergo a vertical expansion with little or no horizontal expansion. The connections between the structure and the earth formations can be effected (or aided) by substantially any grouting material such as cement, resin, or the like, or metal arms, or braces, or the like, that extend between the structure and the earth formation, or notches, or ledges, or the like, in the earth formations, and/or the structure, as long as the connections are adapted to transmit vertical forces from the structure to the earth formations.

FIG. **1** shows a well borehole **1** in surrounding earth formations **2.** The borehole has been notched at the depth locations **1***a* and **1***b*. Such a borehole and notches can readily be formed by means of conventional equipment and techniques for drilling into an earth formation.

A vertically expandable structure **3,** comprising a heavy-walled section of casing is installed within the borehole. The casing is cemented to the earth formation by means of cement **4** to connect one portion of the expandable structure to the earth formation at a depth **1***a* above the depth **1***b* selected for the fracture location. The casing-to-earth-formation connection is strengthened by the spring-loaded arms **6** mounted on the casing. The lower end of the casing, which is closed by a bottom plate **3***a*, is connected to the adjacent earth formations at a point below the fracture location by simply setting the casing on the bottom of the borehole. The wall of the casing is penetrated by perforations **7** to provide fluid communication between the casing and the earth formation.

Without the notch **1***b* such a fracture will tend to form at the weakest point between the locations at which the expandable structure is connected to the earth formations. The notching or a perforating of the earth formations by explosive or abrasive perforating devices tends to ensure that the fracturing occurs at a particular selected depth.

In operating the invention, a vertical expanding force is applied to casing **3** by inserting and operating the heating device **8** to cause a thermal expansion of the casing walls. Such a heating device can be an electrical or gas operated device of a type that is commercially available. The expanding force applied to the casing reduces the vertical compressive stress in the earth formation **2** at the depth **1***b*. The fluid pressure in the casing and surrounding borehole is increased to form a fracture at the depth **1***b*. The fracturing can be effected by conventional equipment and techniques.

In the above embodiment, the vertically expandable structure can be partially or completely composed of columns or posts or can be a perforated pipe section of substantially any heat-expandable compressively strong material such as iron or steel or the like. The perforations can be pre-formed or formed after the casing is inserted, or can comprise the opening between columns of a heat-expandable material. Such a structure can be connected to the earth formation below the depth selected for fracturing, by means of notching and/or cementing or the like.

FIG. **2** shows a borehole **9** in which a casing assembly **11** has been installed and cemented to the borehole wall at the depth **9***a*. The casing contains perforations **7** and a closed bottom portion **11***a*, which rests on the bottom of the borehole, is slideably connected to the upper portion of the assembly and is provided with slideable seals **12.** The casing contains an internal conduit **13** that extends through an internal casing closure **14.** The closure provides a vertically expandable chamber **14***a* which can be selectively pressurized by injecting fluid through conduit **13.**

In operating this embodiment, the vertically expandable structure is expanded by injecting fluid through conduit **13.** Concurrently, the fluid pressure against the earth formation is increased by injecting fluid through the casing **11** and perforations **7** to induce the fracturing of the earth formation.

FIG. **3** shows a borehole **14** containing a casing assembly **16.** The assembly includes a moveably mounted lower portion **16***a*, which is sealed to the upper portion of the casing assembly and is provided with slideable sealing devices **12.** The portion **16***a* is cemented to the borehole wall at the location **14***a*. A lifting screw **17** is arranged to transmit the rotary motion from a surface location and apply an expanding force between the casing section **16***a* and the bottom of the borehole.

In operating this embodiment, an expanding force is applied by rotating the lifting screw **17.** Concurrently, the fluid pressure against the formation to be fractured is increased by pressuring the fluid within casing **16,** which opens into an uncased lower portion of the borehole.

What is claimed is:

1. A process for horizontally fracturing a subterranean earth formation, which process comprises:

connecting a vertically expandable structure to said formation at locations above and below a selected depth within the earth formation;

applying a vertical expanding force to the structure so that the applied force causes a vertical expansion substantially free of horizontal expansion and reduces the vertical compressive stress within the earth formation until it becomes the least of the mutually perpendicular compressive stresses within the earth formation at the selected depth; and

concurrently, pressurizing fluid in contact with the so-treated earth formation to induce a fracture at or near the selected depth.

2. The process of claim **1** in which:

the vertically expandable structure is a metal structure that expands vertically when heated; and

the vertical expanding force is applied by heating the metal structure.

3. The process of claim **1** in which:

The vertically expandable structure includes a closed chamber that is vertically expanded by increasing the fluid pressure within the chamber; and

the vertical expanding force is applied to that structure by increasing the fluid pressure within that chamber.

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