March 8, 1955 J. SUTHERLIN 2,703,619

METHOD OF FORMING PASSAGEWAYS INTO EARTH FORMATIONS PENETRATED BY A WELL BORE

Filed May 16, 1952

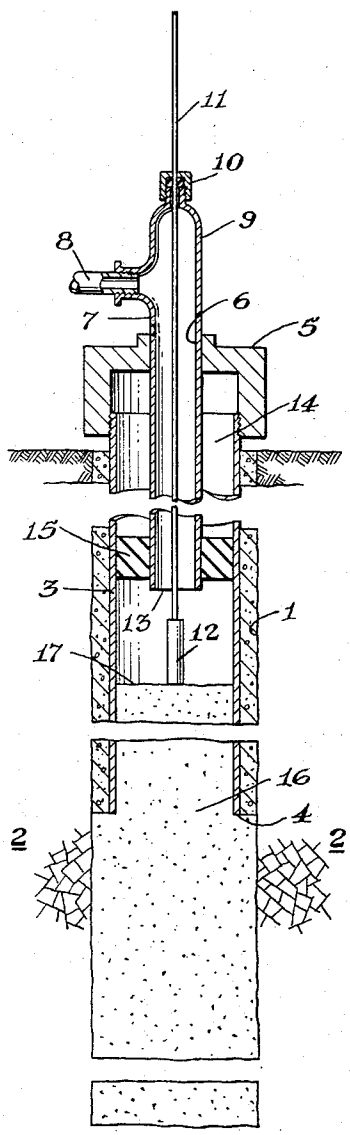


Fig. 1

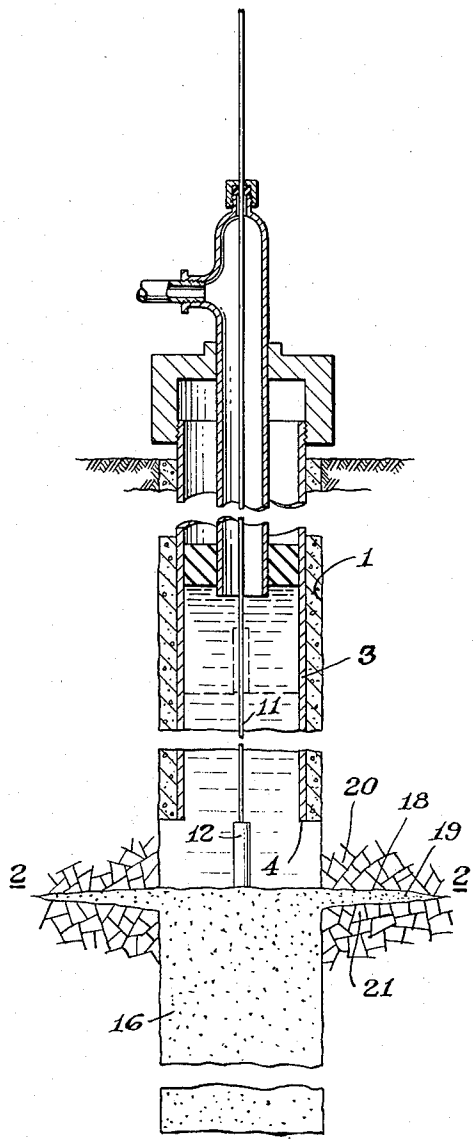


Fig. 2

INVENTOR

Jack Sutherlin

BY

Griswold & Burdick

ATTORNEYS

United States Patent Office 2,703,619 Patented Mar. 8, 1955

2,703,619

METHOD OF FORMING PASSAGEWAYS INTO EARTH FORMATIONS PENETRATED BY A WELL BORE

Jack Sutherlin, Wichita Falls, Tex., assignor to The Dow Chemical Company, Midland, Mich., a corporation of Delaware

Application May 16, 1952, Serial No. 288,275

1 Claim. (Cl. 166—42)

The invention relates to methods of treatment of wells drilled into the earth. It more particularly concerns an improved method for facilitating fluid flow from an earth formation into the bore of a well penetrating the fluid bearing formation and contemplates forming passageways from a well bore into the adjacent earth formation.

In drilling wells for oil, gas, or water, it is always the hope of the driller that the drill will penetrate a stratum from which the desired fluid therein will flow readily into the well. Such hopes are not always realized and the strata penetrated are oftentimes devoid of adequate passageways through which the earth fluids can reach the well. It is the principal object of the invention to provide a method of facilitating fluid flow from a fluid bearing stratum into the bore of a well drilled thereinto. According to the present invention, a method is provided for forming passageways into fluid bearing strata from a well bore as by subjecting the fluid bearing earth to a high enough hydraulic pressure to fracture and pry apart layers of the earth and introducing a propping agent in the form of solid particles into the resulting passageways so as to hold them open after the hydraulic pressure is released, and thereby facilitating the flow of fluid from the formation. The invention will be readily understood from the following description taken in conjunction with the accompanying drawing illustrating a preferred embodiment of the invention.

In the said drawing, Fig. 1 is a schematic elevation of a well equipped for carrying out the method and showing the initial stages of the method.

Fig. 2 is a similar view to Fig. 1 and shows the final stages of the method.

Referring to the drawing in detail, there is shown a well bore **1** drilled through a fluid stratum **2** which is to be opened according to the method of the invention. The bore above the fluid bearing stratum is provided with the usual casing **3** cemented in place, the lower end **4** of the casing extending to near the top of stratum **2**. The casing may be provided with a removable casing head **5** having an opening **6** through which a string of tubing **7** may be hung. The upper end of the tubing is provided with a pipe connection **8** for the admission of fluid to the interior of the tubing. The top of the tubing is provided with a closure in the form of a cap **9** carrying a stuffing box **10** through which a wire line **11** may be run carrying a bob **12** on its lower end.

In carrying out the invention, the tubing string is hung in the well, preferably as shown, with the lower end **13** well above the bottom **4** of the casing and the annulus **14** closed near the lower end **13** of the tubing by means of a suitable packer **15**. After the tubing is in place, the well is partially filled with a free-flowing hard granular material to form thereof the column **16**. The top **17** of the column extends at least several feet above the stratum **2**. The particles of the free-flowing hard granular material are more or less equiaxed and, for example, may consist of sand particles, glass beads, ceramic particles, metal particles, and the like. The particle size may range from those just small enough to pass through a Number 6 standard sieve to as small as those just large enough to be retained on a Number 100 standard sieve. Sands having particles passing through a 12 mesh and remaining on a 40 mesh sieve are used preferably. The particulated material may be introduced into the well in any convenient manner as by means of a dump bailer. Usually the granular material may be introduced by

simply pouring it down the tubing or casing. The depth of the column of fill **16** is ascertainable by lowering the bob **12** until it strikes the top **17** of the column and measuring the length of the line **11** so run into the well.

After the granular fill is in place, a pressuring fluid is introduced into the tubing through the pipe connection **8** while the wire line **11**, stuffing box **10**, and cap **9** are in place, and the packer **15** is set. The fluid so-introduced fills the space above the column **16** and penetrates the column of particulated material **16**. Hydraulic pressure is also thereby exerted upon the stratum **2** below the end **4** of the casing. This hydraulic pressure is made great enough to exceed the weight of the overburden of earth per unit area thereof and thereby produce cracks or fissures in the adjacent stratum and lifting the overburden. As fracturing or cracking is thus produced and the overburden held up by the lifting action of the pressuring fluid, the free-flowing particulated material of the column **16** above stratum **2** flows into the fractures or cracks which deepen and widen as they fill with the particles while the hydraulic action of the pressuring fluid continues. This action is illustrated in Fig. 2 in which the stratum **2** is shown having a fracture or crack **18** formed therein extending outwardly from the well bore and filled with particulated material **19** from the column **16** the top of which thereby descends until it reaches the top of the crack. The rate of descent of the top **17** of the column **16** as the particulated material enters the crack shows an abrupt change as the top **17** approaches the top of the crack and can be followed readily by means of the bob **12** on wire line **11** which is allowed to descend with the top of the column **16**.

On obtaining such an indication of cessation of flow of particulated material into a stratum, the hydraulic pressure may be released. The particulated material so introduced into the crack remains therein and acts to hold apart the resulting separated earth layers as indicated at **20** and **21**. If desired, an additional quantity of particulated material may be introduced into the well and the pressuring operation repeated using the bob **12** and line **11** to ascertain, as described, whether or not the column of particulated material so introduced descends in the casing and thus enters the stratum adjacent to the column.

The following example is illustrative of the practice of the invention.

Example

A well having a total depth of 785 feet drilled into 13 feet of Pennsylvania pay sand and having a 7 inch casing extending to a depth of 772 feet produced 23 API gravity oil at the rate of 3 barrels per day before treatment. The well was shut down and then treated as follows. Into this well was dumped 42 gallons (600 pounds) of Ottawa sand and after allowing 15 hours for the sand to settle a measuring line and bob was run into the well to locate the top of the resulting sand column which was thereby found to be at a depth of 763.5 feet. There was 100 feet of oil standing in the well. A retainer was run into the well on 2-inch tubing and the retainer set at a depth of 753 feet. 2 barrels of 23 API gravity oil were pumped into the well at the rate of 20 G. P. M., thereby producing a pressure at the head of the well of 1000 p. s. i. 2 minutes later, the pressure had declined to 600 p. s. i. while the pumping rate was increased to 60 G. P. M. The injection of oil was then halted and the top of the sand column again located by the wire line and bob. The top of the sand column was thereby found to have descended 11 feet to a depth of 771 feet. The oil injection was then resumed at the rate of 100 G. P. M. causing the injection pressure to reach 1000 p. s. i. which was maintained for 5 minutes. The injection was then halted and the top of the sand column was found to have descended 2.5 feet lower to a depth of 773.5 feet. An additional injection of oil, at the same rate, did not lower the top of the sand column. Three weeks after the foregoing treatment, the well was producing at the rate of 15 barrels of oil per day compared to the rate of 3 barrels per day before the treatment.

Although the practice of the invention has been illustrated using crude oil and sand to produce the earth fracturing and the propping action, respectively, it is to

be understood that other hard particulated materials and fluids may be used and in various amounts. For example, from 300 to 5000 pounds or more of the particulated solid material may be used and other oils or even water may be used for the pressuring fluid.

I claim:

In a method of treating an earth formation penetrated by the bore of a deep well so as to facilitate fluid flow from the formation into the well having the usual casing therein, the steps which consist in filling the bore with a free-flowing particulated hard solid material in amount sufficient to form a column extending from the bottom of the well to a level above the bottom of the casing; introducing into the well to contact the column of particulated material therein a liquid under a pressure sufficient

to lift the overburden of earth adjacent to the said column below the top thereof said liquid permeating and passing through said sand column, whereby the said adjacent formation is fractured forming a crack admitting particulated solid material from the said column and decreasing the height of the said column, and thereafter releasing the pressure on and withdrawing fluid from the well bore.

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