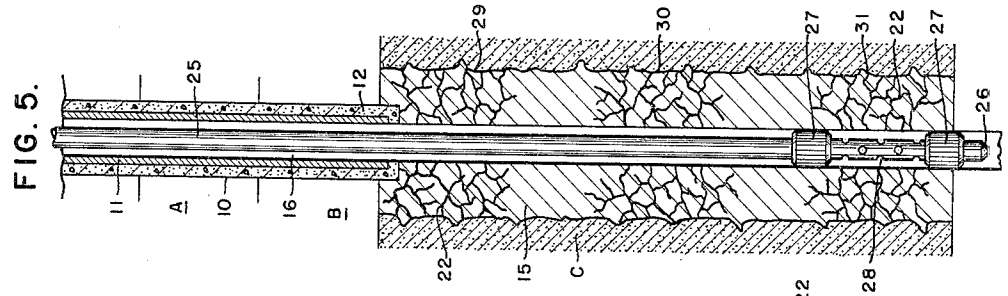
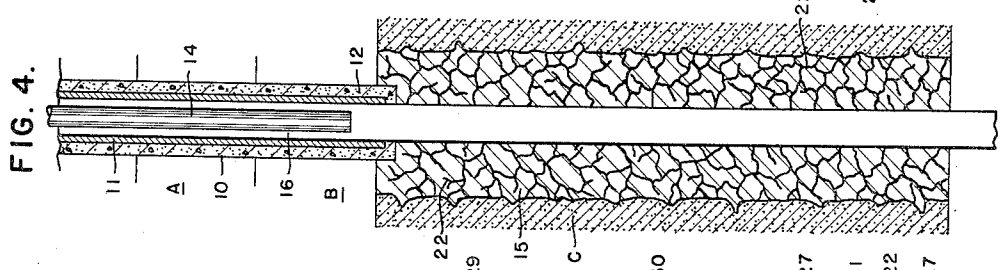
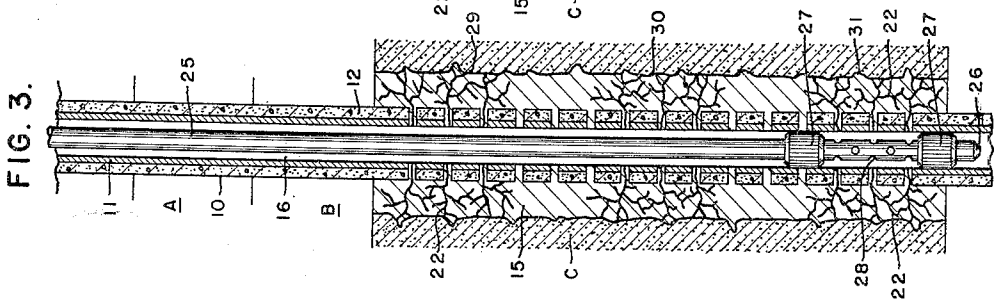
Dec. 25, 1962 C. E. REISTLE, JR 3,070,160

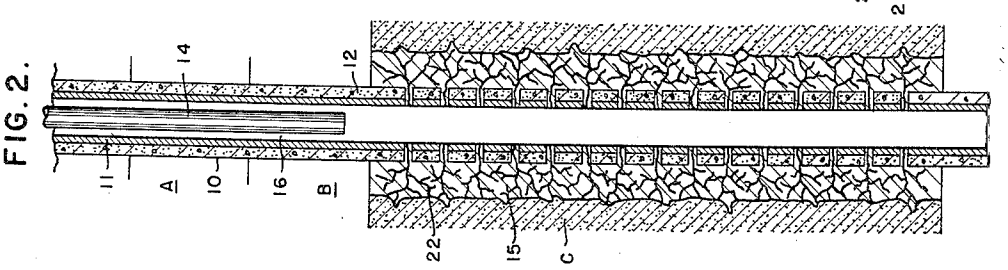
METHOD OF SAND CONTROL IN UNCONSOLIDATED FORMATIONS

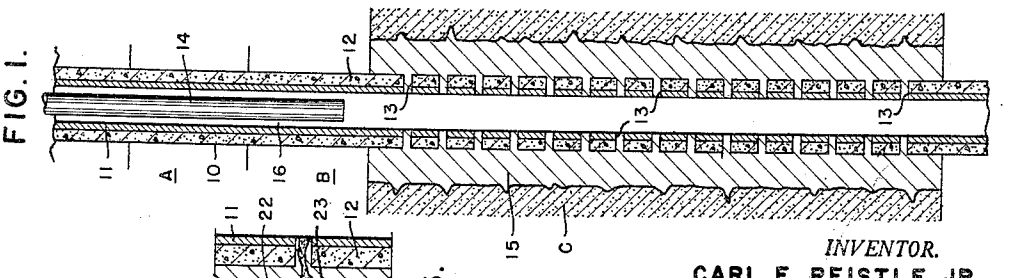
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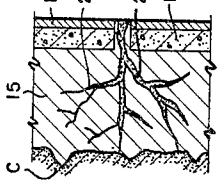


FIG. 6.

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METHOD OF SAND CONTROL IN UNCONSOLIDATED FORMATIONS

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3 Claims. (Cl. 166—12)

This invention is directed to a method of sand control in producing fluids, especially petroleum fluids, from unconsolidated or incompetent subsurface formations.

This application is a continuation-in-part of U.S. application Ser. No. 591,101, entitled "Method of Sand Control in Unconsolidated Formations" filed June 13, 1956, by C. E. Reistle, Jr., and now abandoned.

Considerable difficulty is experienced in wells which produce sand along with production fluids such as oil, gas, water, or mixtures thereof, including, for example, accumulation of sand in the well bore, difficulty in handling the produced fluids at the surface of the well and difficulty in later recompletion operations on the well. It is readily seen that if the formation is incompetent and is produced along with the fluids contained therein, the borehole will be enlarged thereby making it difficult to perform remedial operations in that section of the well bore.

To overcome these difficulties, various methods have been proposed and employed to inhibit production of sand along with production of the formation fluids. One technique that has been used is the provision of a gravel pack to prevent production of the formation sand. This technique is disadvantageous, however, because considerable effort and expense is required to remove the gravel pack when the well is recompleted. Another technique that has been used is plastic consolidation of the sands, however, this technique has not proven completely effective in controlling the production of sand from the unconsolidated formations. Additionally, many of the unsuccessful plastic consolidation jobs result in partial or complete plugging of the productive formation so that the well is unable to produce the desired quantity of fluids. A further disadvantage of the plastic treatment is that often high pressure differentials result across portions of the consolidated sand and this pressure differential has caused the plastic consolidated matrix to break down.

The present invention overcomes the disadvantages of prior attempts to inhibit production of sands from unconsolidated formations.

Briefly, the invention comprises forming a longitudinally extending, plastic retaining wall in the formation to be consolidated, fracturing the plastic retaining wall, and producing the formation. These steps may be performed in an open hole or in a cased well bore wherein the casing has been perforated adjacent the formation prior to plasticizing of the formation. The entire plastic wall or sheath may be fractured or only selected portions thereof may be fractured.

Accordingly, an object of the invention is to provide a method of sand control in unconsolidated formations which eliminates the necessity for removing material from the well bore when the well is recompleted; which will not result in plugging of the formation; and which eliminates or lessens high pressure differentials across portions of the formation.

Other objects and advantages of the present invention will be apparent from the following description taken in conjunction with the drawing wherein:

FIG. 1 is a cross-sectional view of a well bore having a casing arranged therein and illustrates surrounding the well bore with a wall or sheath of plastic consolidated formation;

FIG. 2 is a view similar to that shown in FIG. 1 and illustrates fracturing of the plastic sheath;

FIG. 3 is a view similar to the view of FIG. 2; and illustrates a modified technique for fracturing the plastic sheath;

FIG. 4 is a view similar to the view of FIG. 2 and illustrates fracturing a sheath formed in open hole;

FIG. 5 is a view of the fracturing device shown in FIG. 3 and illustrates fracturing a sheath formed in open hole; and

FIG. 6 is an enlarged view of a portion of the fractured plastic sheath.

Referring to the drawing in greater detail:

In FIGS. 1 through 5 a borehole **10** is shown traversing a plurality of subsurface formations A, B, and C. Formations A and B may be productive or non-productive formations or consolidated or unconsolidated formations. C is an unconsolidated productive formation to be treated according to the method of the invention. A casing **11** is shown in FIGS. 1 through 3 cemented in borehole **10** by means of cement **12** and extending through formation C. Casing **11** and cement **12** are perforated as at **13** adjacent formation C in any desired manner. To facilitate spotting of a resin-forming mixture in formation C according to the invention, a tubing **14** may be arranged in casing **11**, the lower open end of which is positioned adjacent formation C. Tubular extension apparatus which is not shown, but which is fully described in "Permanent Type Completion and Wireline Workovers," The Petroleum Engineer, September 1956 also may be employed.

Referring more particularly to FIG. 1, a resin-forming mixture is pumped down tubing **14** and through perforations **13** into unconsolidated formation C. The mixture is retained quiescent in the formation until a sheath or retaining wall **15** of resinous reaction product is formed. Prior to setting or hardening of the plastic mixture, the resin-forming material remaining with casing **11** may be flushed out by circulating fluid down tubing **14** and up the annulus **16** between the tubing and the casing or, vice versa, circulation of fluid may be down annulus **16** and up tubing **14**. After the hardened plastic sheath **15** has formed in unconsolidated formation C, a fracturing liquid is pumped down tubing **14** and spotted adjacent the perforated casing **11** behind which plastic sheath **15** has formed. Then hydraulic pressure is applied to the fracturing liquid through either annulus **16** in which case tubing **14** would be plugged off or hydraulic pressure may be applied through tubing **14** in which case annulus **16** would be plugged off. Sufficient pressure is applied to the liquid column to force the liquid through perforations **13** to fracture plastic retaining wall **15**, as illustrated by fractures **22** in FIG. 2. Pressure on the liquid column is then released and the fracturing liquid is circulated or washed out of the well bore by circulating liquid down annulus **16** and up tubing **14** or vice versa. Production is obtained then through fractures **22** in sheath **15**, through perforations **13** in casing **11** and cement **12**, and up tubing **14** or annulus **16** to the well head, not shown.

FIG. 3 illustrates a modified method of operation which utilizes a tubing **25** plugged off at its lower end as at **26**, provided with spaced-apart packers **27** adapted to seal off the annulus between the tubing and the casing and perforations **28** arranged between the packers. In this embodiment, after spotting and hardening of the resin-forming mixture, tubing **14** is removed from the well and tubing **25** is lowered in casing **11** until packers **27** "isolate" a portion of consolidated formation C. Then, fracturing liquid is pumped down tubing **25**, through perforations **28** and through perforations **13** in casing **11** and cement **12**. Sufficient pressure is applied then to the fracturing liquid in tubing **25** to fracture plastic wall **15** in a selected portion **29** thereof. Pressure on the fracturing liquid is released and tubing **25** then is lowered a predetermined distance. Pressure is again applied to the fracturing liquid and plastic wall **15** is fractured in another portion **30** thereof. These fracturing operations at spaced intervals may be repeated until the entire length of the plastic wall **15** has been traversed. It is not necessary for the sequence of fracturing of the selected portions to be from top to bottom for any sequence of fracturing is permissible. After fracturing plastic wall **15** at the three selected intervals **29**, **30**, and **31**, illustrated tubing **25** is removed from the well bore and formation C produces fluid through fractures **22**, perforations **13**, and casing **11**.

FIGS. 4 and 5 illustrate methods similar to that shown in FIGS. 2 and 3 except casing **11** in the embodiments of FIGS. 4 and 5 is set above formation C thereby providing an open borehole below the lower open end of casing **11**. The operations are similar to the previous embodiments. With regard to FIG. 4, the resin-forming material is spotted adjacent formation C by displacing drilling mud and pressure is applied thereto to force the resin-forming mixture into formation C. However, instead of circulating out excess resin-forming mixture prior to hardening or solidification thereof, the resin-forming mixture is allowed to solidify in the borehole below the open end of casing **11** along with solidification of the resin-forming mixture in formation C to form the sheath or wall **15** of plastic. Tubing **14** is removed then from the borehole and the hardened plastic material is drilled out. Drilling out of the hardened plastic is necessary in order to permit the fracturing liquid which is to follow to have access to plastic sheath **15** along the length thereof as in FIG. 4, or to permit tubing **25** to be lowered or raised along the length of plastic sheath **15** for the purpose of selectively fracturing at spaced intervals as in FIG. 5. Thus, as in FIG. 4, after the resin-forming mixture has hardened, the plastic directly below casing **11** is drilled out and fracturing liquid is pumped down tubing **14** and spotted adjacent formation C after which sufficient pressure is applied to the fracturing liquid to fracture plastic sheath **15** as indicated by fractures **22**. Production from formation C is through fractures **22** into the well bore below casing **11** and tubing **14** and thence up tubing **14** or annulus **16** to the surface of the earth. With regard to FIG. 5, after the resin-forming mixture has solidified and hardened, it is drilled out below casing **11** and tubing **25** is lowered until perforations **28** are positioned along selected portions of the plastic sheath formed. Then, fracturing liquid is pumped down tubing **25** and the plastic sheath is fractured at spaced intervals **29**, **30**, and **31**, as shown, according to procedures described supra.

The fracturing liquid contains a propping agent, such as sand or gravel, which acts to prop open the fractures formed in plastic sheath **15** to assist in maintaining channels of flow after the plastic sheath has been fractured, and to retain the formation sands. Thus, in FIG. 6 particles **23** of a propping agent are shown located in fractures **22**. The fracturing liquid is preferably a low viscosity liquid. For example, crude oil may be employed alone as the fracturing liquid or a bodying agent may be added thereto. The bodying agent may comprise, for example, colloid materials, a metallic soap of an organic acid, a high molecular weight olefin polymer, a molecular linear polymer, such as polypropylene, or a plastering agent, such as blown asphalt, pitch, or the like. Other illustrations of suitable fracturing liquids for fracturing the plastic sheath **15** are water and dilute hydrochloric acid. The fracturing material may be in form of a gel rather than a liquid. Suitable gels are, for example, a mixture of heavy metal soaps and hydrocarbons, such as fuel oil, crude oil, and lighter fractions of crude petroleum. Also, suitable organic compounds of the plastic group which have the property of reverting to a non-viscous condition with the passage of time or through the action of certain chemicals or through appropriate changes in temperature or pressure are suitable as the fracturing liquid containing the propping agent.

The resin-forming mixture may be a porous setting or a solid setting resin. The invention is not limited to the use of conventional sand consolidating plastics since penetrating type plastics may be employed. Conventional types of sand consolidating plastics that may be used include (1) a type of plastic wherein a phase separation takes place and the hardened plastic remains around the sand grains leaving open pore space between the sand grains to allow the flow of fluids into the well bore; (2) a type of plastic wherein the plastic shrinks upon setting and allows cracks or openings to form within the consolidated sand, thus allowing passage of fluids from the reservoir into the well bore; and (3) a type of plastic wherein the plastic is pumped into the sand to be consolidated and then a portion of the plastic is washed from the sand by pumping oil, water, or other fluids through the interval invaded by plastic so that the plastic consolidated sand retains sufficient permeability to allow flow of oil or gas into the well bore. One suitable plastic or resin-forming mixture comprises the mixture of a low molecular weight hydroxy aryl compound and a low molecular weight aliphatic aldehyde catalyzed by either an alkaline catalyst such as guanidine carbonate or an acidic catalyst such as stannous chloride. The volumes of fracturing liquid and plastic and the injection rate thereof may vary over a wide range and are dependent upon the size of the selected formation, the degree of unconsolidation of the selected formation, the type of plastic employed, and the type of fracturing materials employed. Suitable resin-forming mixtures for use in the method of the invention are those disclosed in U.S. Patent No. 2,476,015, entitled, "Method for Consolidation of Sands," issued July 12, 1949, to G. G. Wrightsman, and U.S. Patent No. 2,378,817, entitled "Producing Oil," issued June 19, 1945, to G. G. Wrightsman.

Having fully described and illustrated the practice of the present invention, I claim:

1. A method of inhibiting the production of sand from an unconsolidated fluid containing formation penetrated by a borehole when fluids are produced therefrom which comprises the steps of pumping through said borehole and into said formation a resin-forming fluid mixture adapted to set and bind together the sand particles of said formation, permitting said resin-forming mixture pumped into said formation to remain quiescent a sufficient time to set and consolidate the portion of said formation surrounding said borehole contacted by said resin-forming mixture, placing a fracturing liquid in the borehole adjacent the resin consolidated formation and then applying sufficient pressure to said fracturing liquid to produce fractures extending through said resin consolidated portion of said formation to thereby fluidly communicate the unconsolidated portion of said formation and said well bore, said fracturing liquid employing propping agents for propping open the fractures formed, the amount of said resin-forming liquid pumped into said formation being sufficient to form a longitudinally extending plastic sheath in said formation of sufficient thickness to support the

sands of said formation and the fractures in the sheath resulting from the fracturing step and to permit fractures of sufficient length to form so that the propping agents will lodge in and effectively sustain the fractures.

2. A method as recited in claim 1 including casing said well bore and perforating said casing adjacent said formation prior to injecting said resin-forming mixture into said unconsolidated formation.

3. A method as recited in claim 1 including fracturing said resin consolidated formation at selected spaced intervals.

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