Oct. 10, 1961 F. M. McGEHEE 3,003,556

METHOD OF PERFORATING ONE OF A PLURALITY OF PARALLEL PIPE STRINGS

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FIG. 1.

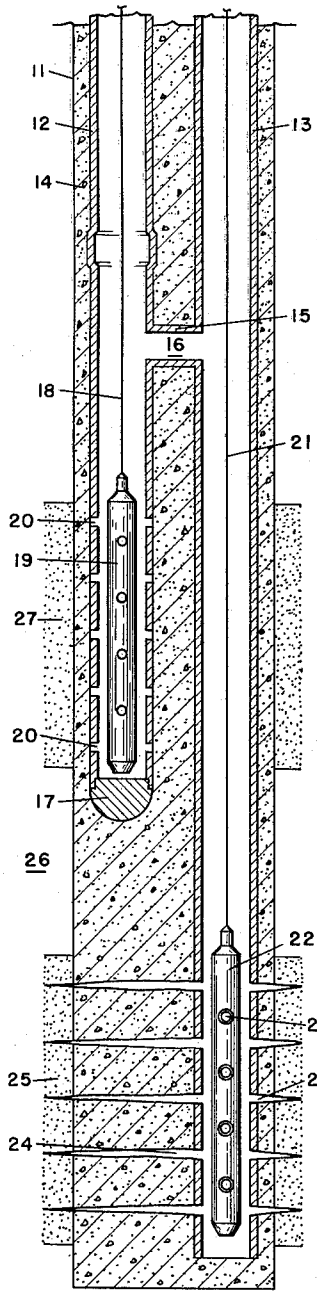


FIG. 2.

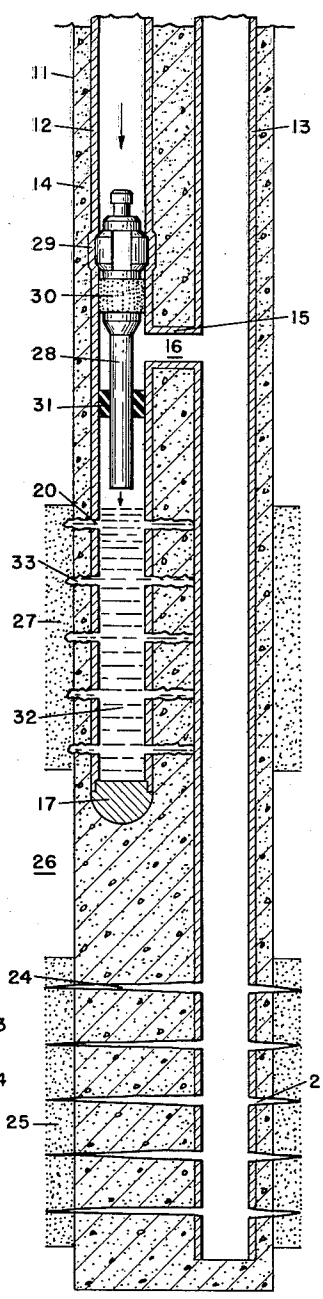
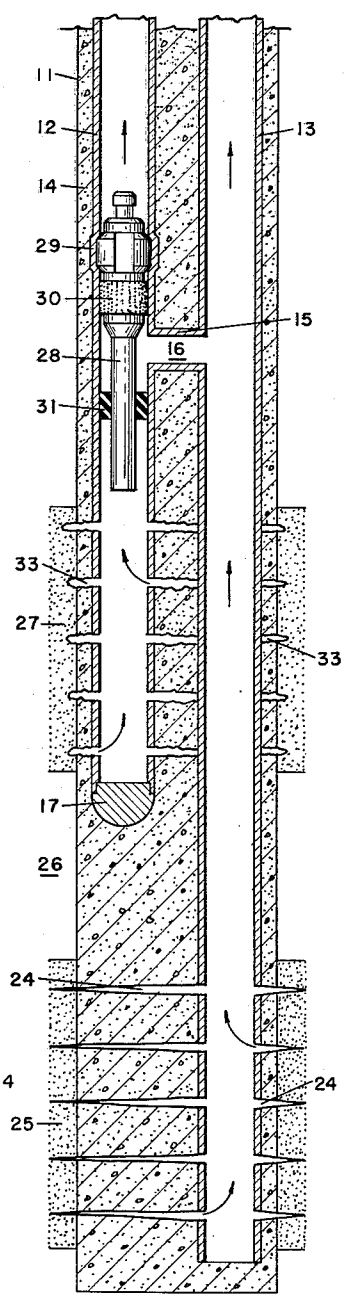


FIG. 3.



INVENTOR.

FARLEY M. McGEHEE,

BY

ATTORNEY.

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METHOD OF PERFORATING ONE OF A PLURALITY OF PARALLEL PIPE STRINGS

Farley M. McGehee, Genoa, Tex., assignor, by mesne assignments, to Jersey Production Research Company, Tulsa, Okla., a corporation of Delaware

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6 Claims. (Cl. 166—35)

The present invention is directed to a method of completing wells in a plurality of zones. More particularly, it is concerned with well completion operations in which a plurality of pipe strings are arranged in a well bore. In its more specific aspects, the invention is concerned with establishing fluid communication between a selected pipe string and a zone of interest in a well bore while avoiding perforation of another pipe string.

The present invention may be briefly described as a method of completing a well which penetrates a plurality of productive zones and has a plurality of parallel eccentric coextending pipe strings cemented therein in which an opening is formed in a selected one of the pipe strings in a selected of the zones while avoiding the formation of an opening in other of the pipe strings and then forming a passage fluidly communicating the selected zone with the opening in the selected pipe string through the cement whereby fluid is flowable through the opening in the pipe string and the passage between the selected zone and the selected pipe string. Thus, the other pipe strings are maintained free of any opening in the selected zone.

The opening may be formed in the selected pipe string by employing a bullet gun using a deflecting type of bullet, using a chemical perforator which jets a stream of chemical against the wall of the selected pipe string or by employing wire line tools which cut, punch, mill, or otherwise form openings or perforations in the selected pipe string only. Such devices are well-known in the art and involve cam type punches and the like.

Communication between the opening and the zone of interest which may contain hydrocarbons such as oil and/or gas is suitably established by treating the cement through the opening with an inhibited acid which will dissolve the cement but which will not attack the metal making up the selected and other pipe strings in the well. It may also be possible to establish fluid communication through the opening and the zone of interest by employing the so-called fracturing technique by way of which fluid pressure is exerted on the cement and the earth zone through the opening to cause formation and opening up of fractures in the cement and in the rock making up the earth zone to be exploited for oil and/or gas production.

The present invention will be further illustrated by reference to the drawing illustrating a preferred mode in which:

FIG. 1 shows the perforation of a plurality of spaced-apart earth zones;

FIG. 2 illustrates the acidizing of a selected zone to form a passageway in the cement; and

FIG. 3 illustrates the simultaneous production of both zones.

Referring now to the drawing in which identical numerals will be employed to designate identical parts, numeral **11** designates a well bore having a first pipe string **12** and a second pipe string **13** cemented therein with cement **14**. The pipe strings **12** and **13** are fluidly interconnected by a fluid interconnecting means **15** forming a passageway **16**. The lower end of the pipe string **12** is closed by metal plug or plate **17**. Lowered and suspended in the pipe string **12** on a wire line or cable **18** is a mechanical or chemical perforator **19** or a perforator firing a deflecting bullet which punches, mills, or dissolves openings **20** in the pipe string **12** only, the perforator **19** being of a nature that openings will be formed only in the wall of the pipe string **12**.

Lowerable through the pipe string **13** on a wire line or cable **21** is preferably a bullet or shaped charge perforator **22** provided with bullet guns or shaped charges **23** which, when fired, forms perforations **24** in the pipe string **13**, pierces the cement **14**, and extends into the lower earth zone, formation, sand, stratum, or horizon **25** from which hydrocarbons may be producible. While a bullet or shaped charge perforator **22** is preferred, the chemical or mechanical perforator is not excluded from use in the zone **25**.

The zone **25** is separated by nonproductive zone **26** from an upper productive zone **27** in the well bore. It is to be understood that zones **25** and **27** are given by way of illustration since a plurality of productive zones greater than two may be simultaneously produced in accordance with the present invention, utilizing a plurality of pipe strings such as **12** and **13**, each producing from a separate zone.

Once the openings **20** have been formed in the pipe string **12**, it is necessary to form a passage through the cement **14** and to this end operations are so conducted to form such passage. Referring particularly to FIG. 2, a tubular member **28** is lowered on a wire line such as **18** and positioned in a landing nipple or suitable supporting or anchoring means **29** in the tubing **12** above the fluid interconnecting means **15**. The tubular member **28** is suitably sealed by means of a sealing means **30** on its upper end and by sealing means **31** on its lower end such that fluid is flowable through the tubular member **28** but fluid may not be flowed through the passageway **16**. Inhibited hydrochloric acid having a strength in the range from about 5 to 25% but which may range up to 38% HCl is flowed down through the pipe string **12** to form a body of inhibited hydrochloric acid **32** which flows through the opening **20** and forms passageways **33** out to the formation or zone **27** by dissolving out the cement **14**. The presence of the metal plate or plug **17** prevents the acid from attacking the cement through the bottom of the pipe string **12**. The passageways **33** are extended until fluid communication is established with the formation or zone **27**, as shown more clearly in FIG. 3. Once the fluid communication has been established between the pipe string **12** and the formation or zone **27**, production may be initiated from the zone **27**, which will cause the inhibited acid **32** to be displaced upwardly through the pipe string. Simultaneously, production may be obtained from the zone **25** through the perforations **24** and up the pipe string **13**, as shown in FIG. 3.

While the body of acid **32** may suitably be displaced by the production fluid, it may be preferred to circulate it out by replacing the tubular member **28** with a tubular member not shown but similar to the tubular member **28** and omitting the seal **31** such that by employing a longer tubular member, the fluid may be circulated out by flowing fluid down the pipe string **13** to displace the body of acid **32** up through the pipe string **13**.

Inhibited hydrochloric acid is a well-known article of commerce and acids of varying strength may suitably be used. The acid strengths may range from strong acids having about 43% HCl by weight down to about 5% HCl. The inhibitors employed may include arsenic acid; arsenic trioxide; furfural; furans; nitrogen bases such as aniline, pyridine, quinoline and the like; organic sulfur compounds and acid sludges derived from sulphuric acid treatment of petroleum fractions. Crude petroleum phenol extracts such as described in U.S. 2,380,254 may also be used. Naphthenyl amines and salts thereof as described in U.S. 2,818,383 are also suitable. Other inhibitors may include by way of illustration and not by way of limitation alkali metal dehydrated phosphate

derivatives such as described in U.S. 2,813,075, rosin amine derivatives as described in U.S. 2,758,970, aliphatic thiourea compounds such as described in U.S. 2,799,-648, quaternized normal heterocyclic polyoxyethylene derivatives as described in U.S. 2,814,593, and other similar corrosion inhibitors may suitably be employed. For example, polyalkylene glycols, as described and claimed in U.S. 2,799,649, may be usable in the practice of the present invention as corrosion inhibitors.

The present invention has been described and illustrated with inhibited acids being used to form a passage through the cement. It is also contemplated in the practice of the present invention that a fracturing technique may be used for forming a fracture or passage through the cement and into the formation. In this type of operation, a procedure such as described with respect to FIG. 2 would be employed with the exception that a low fluid loss fracturing fluid would be employed and pressure would be exerted through the openings **20** on the cement **14** to form fractures or passages through the cement **14** into the formation **27**. The technique of fracturing formations is well-known and involves preferably the employment of a low fluid loss fluid on which pressure is exerted to form the fracture or to open an existing minute fracture of crevice for fluid communication. This technique may be applied to communicating between the perforation **20** and the formation of zone **27** to form an opening or channel such as **33** described in FIGS. 2 and 3. The sequence of steps is substantially as described with respect to FIG. 2 with sufficient hydraulic pressure being exerted on the fracturing fluid, which, rather than being a low fluid loss fluid, may be water, crude petroleum and/or its fractions, or any one of the many materials now being used for this type of operation.

In the description taken with the drawing, the invention has been described and illustrated showing a plurality of fluidly interconnected pipe strings. The invention may equally be practiced employing a plurality of pipe strings in a well bore which are not fluidly interconnected. Therefore, it is contemplated that this invention will include well completions either in fluidly interconnected, parallel pipe strings, or in parallel pipe strings which are not fluidly interconnected.

Also, the invention has been described and illustrated by reference to a well having two substantially parallel pipe strings therein. The invention is also applicable where three, four, or more pipe strings are arranged and/or cemented in a well bore whether they be fluidly interconnected intermediate their ends or not.

Reference has been made in the description taken with the drawing to the use of mechanical type of perforators. These perforators usually operate on a wedge principle with one wedge moving vertically to drive another wedge laterally to which the punch or mill is connected. Thus the vertically movable wedge is actuated by a mechanical jar and is then exerted on the laterally movable wedge or by an explosive force to cause perforation of the pipe string and formation of an opening therein. Likewise, these perforators may be actuated by cam action.

The invention has also been illustrated by reference to producing formation fluids but it may equally be practiced in injecting fluids into the formation or zone. Thus, after fluid communication has been established, operations such as well stimulation, including acidizing, injecting of surface-active agents, cementing, secondary recovery where water and/or other fluids such as gas and the like are introduced into the zone or formation of interest, may be practiced. These several operations are given by way of illustration and not by way of limitation.

The nature and objects of the present invention having been completely described and illustrated, what I wish to claim as new and useful and secure by Letters Patent is:

1. In a well penetrating a plurality of productive zones and having a plurality of parallel adjacent eccentric coextending continuous metallic pipe strings, separated from each other by a cement sheath, the method of completing said well which comprises selectively perforating the metal wall of a selected of said pipe strings in any direction in a selected of said zones while maintaining the cement around said selected pipe string, and the metal wall of other of the pipe strings, free of any perforation in said selected zone, and then forming an opening in any direction through the cement in alignment with the perforation in said selected pipe string to fluidly communicate said selected zone through said cement with the perforation in the selected pipe string whereby fluid is flowable through said perforations in said selected zone and between the selected zone and the selected pipe string.

2. A method in accordance with claim 1 in which the selected pipe string is selectively perforated by punching through the metal wall of the selected pipe string.

3. A method in accordance with claim 1 in which the selected pipe string is selectively perforated by chemical reaction with the wall of the selected pipe string.

4. A method in accordance with claim 1 in which the opening in any direction through the cement is formed by dissolving a passage through the cement with acid.

5. A method in accordance with claim 1 in which the opening in any direction through the cement is formed by applying sufficient fluid pressure to the cement to form a fracture through the cement.

6. A method in accordance with claim 1 in which the metal wall of another of said pipe strings is selectively perforated in any direction in a second selected zone vertically displaced from said selected of said zones while maintaining the cement around said another pipe string and the metal wall of other pipe strings free of any perforation in said second selected zone, and then forming an opening in any direction through the cement in alignment with the perforation in said another pipe string to fluidly communicate said second selected zone through said cement with the perforation in said another pipe string.

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