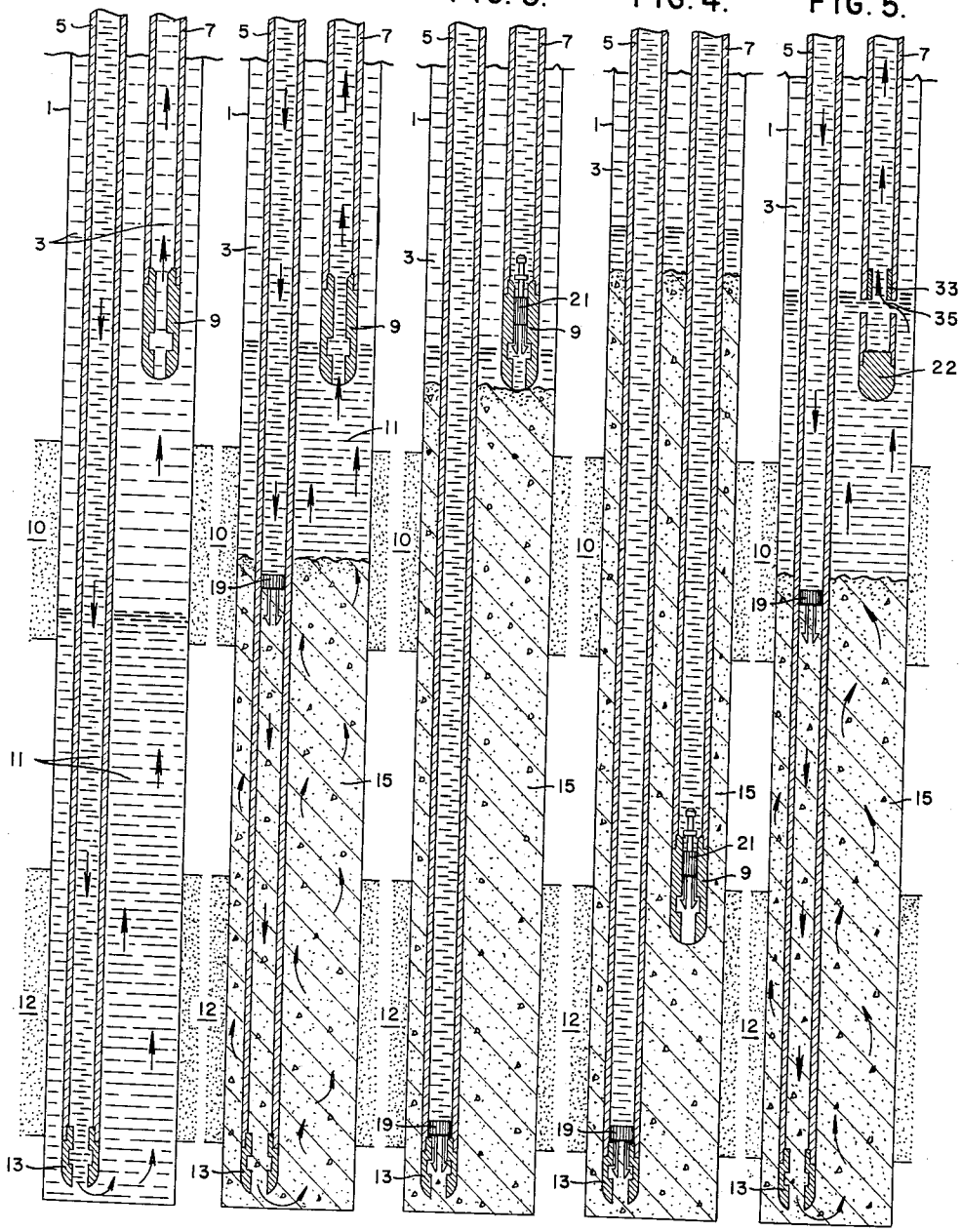
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CEMENTING MULTIPLE PIPE STRINGS IN WELL BORES

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FIG. 1. FIG. 2. FIG. 3. FIG. 4. FIG. 5.



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CEMENTING MULTIPLE PIPE STRINGS IN WELL BORES

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This invention relates to cementing a plurality of pipe strings in well bores, and more particularly to the cementing of multiple pipe strings in well bores having no lining or casing.

In recent years it has become practical to eliminate the pipe string that usually serves as a lining for well bores penetrating hydrocarbon productive earth formations. In such operations small diameter pipe strings, commonly referred to as tubing, are positioned in a well to serve as conduits for earth fluids produced from hydrocarbon productive earth formations. Where two or more flow tubings are used in the same well bore to produce two or more formations, means have been devised for the purpose of singly perforating the tubings after they have been cemented in the well bore. The cementing operation is necessary in order to protect fresh water sands and to prevent fluid migration between different hydrocarbon productive earth strata.

In the conventional multiple tubingless completion cementing operation, it is the practice to run two or more strings of pipe into the well bore while it is standing full of drilling mud. A cement slurry is then pumped down the longest pipe string and is immediately followed by a wiper plug so that the cement is entirely displaced from the pipe string and occupies the annulus between the pipe and the wall of the well bore up to a given level in the well bore. After the cement has set to a solid mass, it should prevent fluid communication between the earth formations penetrated by the well bore. However, in some instances the cement slurry does not completely displace the drilling mud, and channels are formed in the set cement by means of which fluid migration between earth formations can occur.

Various expedients have been used in the past in attempts to insure complete displacement of the drilling mud. For example, quantities of fresh water have been sent ahead of the cement to reduce the viscosity of the liquid displaced by the cement. This practice occasionally produces good results, but the results are far from consistent.

In accordance with the teachings of the present invention, a plurality of production pipe strings, or flow tubings, are lowered into a well bore traversing a plurality of hydrocarbon productive earth formations from which it is desired to extract formation fluids. The pipe strings are of different lengths and coextend from the usual well head apparatus at the earth's surface in side-by-side relationship. A cementitious liquid or slurry is injected into the longer pipe string and the fluids displaced by the cement are withdrawn up the shortest pipe string through an opening therein at a level above the uppermost productive earth formation to be produced. When the bottom of the borehole is filled with the desired volume of the cementitious slurry and before the cementitious slurry

has set, the shortest pipe string is adjusted to the position in the borehole that it will occupy during the production of the earth formations. Preferably, before the cement is injected into the longest pipe string, the drilling mud in the borehole is displaced by salt water, fresh water, or other clean fluids which may contain suitable coagulating or dispersing agents. This may be done simply by circulating the displacing liquid down the longest pipe string and up the borehole to an opening in the shortest pipe string and up the borehole to an opening in the shortest pipe string above the level of the uppermost productive earth formation to be produced, and up the shortest pipe string.

The invention will be more completely described with reference to the accompanying drawings, wherein:

Each of FIGS. 1 through 4 shows a semidiagrammatic, vertical, sectional view of a well, the various figures illustrating various steps in a preferred method of carrying out the invention; and

FIG. 5 is a view similar to FIG. 2 illustrating an alternative means for carrying out the step of FIG. 2.

In FIG. 1 there is illustrated a well bore 1 into which has been lowered a pair of pipe strings 5 and 7 which coextend from the earth's surface from a suitable well head equipment (not shown). While two pipe strings are shown to illustrate the invention, more than two pipe strings may be utilized. Pipe string 5 will henceforth be termed the long string, and pipe string 7 will be termed the short string. If more than two pipe strings are used, their lengths will be intermediate the lengths of long string 5 and short string 7.

The well bore 1 penetrates a plurality of productive earth formations; the productive earth formations are here designated by the reference numerals 10 and 12. The pipe strings 5 and 7 are respectively provided with guide shoes 13 and 9 at the lower ends thereof. The function of the guide shoes is to receive and hold cementing plugs.

When the pipe strings 5 and 7 are lowered into the well bore, the well bore is filled with drilling mud. The long string 5 is lowered until its lower end is near the bottom of the borehole 1 or at least below the lower interface of productive earth formation 12. Short string 7, which is shown as being open-ended, is adjusted in the borehole so that its opening is above the upper interface of uppermost productive earth formation 10. The distance above the earth formation 10 at which the open end of the pipe is located will depend upon governmental regulations. In certain states it is necessary to cement wells to a distance of at least 600 feet above the upper interface of the uppermost productive earth formation. The open end of the short pipe string 7 should be no deeper than the level to which it is desired to cement the well bore.

Initially, a quantity of clean water is circulated down the long pipe string 5, through the guide shoe 13, up the borehole into the short pipe string 7, and up the short pipe string 7. This operation is illustrated in FIG. 1. Drilling mud in the borehole below the level of the open end of pipe string 7 is removed from the circulating system. Clean salt water may be circulated as long as is desired to properly condition the walls of the well bore in order to remove as much of the filter cake as possible below the level of the open end of the short pipe string 7. As indicated above, salt water or fresh water may be

used either alone or in combination with dispersing agents such as sodium hexametaphosphate or alkaline tannate solutions, such as caustic quebracho or a lignosulfonate, or with coagulating agents such as a product of the Dowell Division of Dow Chemical Company, which includes a mixture of hydrochloric acid and ammonium fluoride, sold under the trade name of "Mud Acid."

After the clean water has circulated for a desired period of time, a quantity of a cement slurry **15** is injected into the long pipe string **5** followed by a wiper plug and a suitable clean fluid. The cement is circulated down the long pipe string **5** and out the lower end thereof and is allowed to rise in the well bore. Simultaneously therewith, the clean water which was previously injected into the well bore is removed therefrom by means of the short pipe string **7** through open lower end thereof.

When the cement slurry has passed completely out of the lower end of long pipe string **5** and has risen to substantially the level of the lower end of short pipe string **7**, as shown in FIG. 3, a closure plug **21**, which may be a conventional wiper plug, is lowered down short string **7** and latched into guide shoe **9**. The wiper plug **19**, which was used to wipe pipe string **5** clean of cement after the cement slurry **15** was passed therethrough, is latched into the lower end of pipe string **5**. As is shown in FIG. 4, pipe string **7** is now lowered so that the lower so that the lower end thereof is below the lower interface of earth formation **10**, so that the pipe string **7** is in the position that it will occupy during production operations. Lowering the pipe string in this manner insures a better bond between the cement and the pipe string, and between the cement and the walls of the borehole. After the cement slurry has set, the pipe strings may be perforated in the usual manner to open up fluid communication between the earth formations **10** and **12** and the pipe strings **5** and **7**, respectively, so that pipe **5** produces earth formation **12** and pipe string **7** produces earth formation **10**.

FIG. 5 illustrates an alternative manner of carrying out the step of the invention illustrated in FIG. 2. Pipe string **7** is provided with a bull plug **22** at the lower end thereof so as to seal off the lower end of the pipe string. Ports **35** are provided in the pipe string near the lower end thereof. A sleeve valve **33**, which is adapted to be opened and closed by wireline tools, is provided for the purpose of opening and closing ports **35**. A sleeve valve of this nature (Garrett Oil Tools Full Bore Circulating Valve, Type B–1) is described at page 1976 of the Composite Catalog of Oil Field Equipment and Services, 1957 edition. When the clean water is circulated, as is shown in FIG. 1, and when cement is being injected into the pipe string **5**, as is shown in FIG. 2, sleeve valve **33** will open the ports **35** so that the fluid at the bottom of the well bore below the ports **35** may be withdrawn from the well bore and up pipe string **7**. The sleeve valve **33** is then closed so that the short pipe string **7** may be lowered into the cement in the manner shown in FIG. 4.

The present invention is extremely advantageous in that it enables an operator to remove drilling fluid from the borehole over the interval to be cemented in such a manner that the drilling fluid is not mixed with cement. The drilling fluid may be replaced with clean fluid before cement is injected into the lower end of the borehole. Inasmuch as the clean fluid is removed at the same rate that cement is injected, the possibility of mixing the cement with the fluid in the borehole is minimized. Furthermore, even if such mixing does occur, there will be a minimum amount of drilling mud intermixed with the cement, and the bond of the cement to the pipe string and to the sides of the well bore will be extremely effective.

The invention is not necessarily to be restricted to the specific arrangement of parts or procedures described herein, as various modifications thereof may be effected without departing from the spirit and scope of the invention.

The objects and features of the invention having been completely described above, what is desired to be claimed is:

1. In the multiple tubingless completion of wells in the earth wherein at least two side-by-side production pipe strings of different lengths coextend into a well bore to different depths for the purpose of producing earth fluids from different earth formations traversed by said well bore, the method comprising: injecting cement down the longest pipe string and withdrawing well bore fluid displaced by the cement into the shortest pipe string at a level above the uppermost productive earth formation to be produced until the bottom of the well bore is filled with cement to a level above the upper interface of the uppermost earth formation to be produced; closing said shortest pipe string to entry of well bore fluids thereinto; and lowering said shortest pipe string into the cement in the borehole until it is in the position in the well bore which it is to occupy when earth fluids from the uppermost earth formation are being produced.

2. In the multiple tubingless completion of wells in the earth wherein at least two side-by-side production pipe strings of different lengths coextend into a well bore to different depths for the purpose of producing earth fluids from different earth formations traversed by the well bore, and wherein the shortest pipe string is provided with an opening at or near the lower end thereof, the method comprising: injecting cement down the longest pipe string and withdrawing well fluids up the shortest pipe string through the opening therein at a level above the upper interface of the uppermost productive earth formation, to fill the lower end of the well bore with cement up to a given level therein above the uppermost productive earth formation; closing the opening in said shortest pipe string through which well bore fluids are withdrawn, and adjusting said shortest pipe string in the well bore until at least a portion thereof is immersed in cement, and until said shortest pipe string is in the position at which it is to produce well fluids from the uppermost productive earth formation to be produced.

3. In the multiple tubingless completion of wells in the earth wherein at least two side-by-side production pipe strings of different lengths coextend into a well bore to different depths for the purpose of producing earth fluids from different earth formations traversed by the well bore, and wherein the shortest pipe string is provided with an opening at or near the lower end thereof, the method comprising: positioning the shortest pipe string in the well until the opening therein is at a given level above the uppermost productive earth formation to be produced; injecting cement down the longest pipe string and withdrawing well fluids up the shortest pipe string through the opening in the shortest pipe string to fill the lower end of the well bore up to a level between the opening and the uppermost earth formation to be produced; closing the opening in said shortest pipe string through which well bore fluids are withdrawn; and adjusting said shortest pipe string in the well bore until at least a portion thereof is immersed in cement, and until said shortest pipe string is in the position that it is to occupy during the production of well fluids therethrough from the uppermost earth formation to be produced.

4. In the multiple tubingless completion of wells in the earth wherein at least two side-by-side production pipe strings of different lengths coextend into a well bore to different depths for the purpose of producing earth fluids from different earth formations traversed by the well bore, and wherein the shortest pipe string is provided with an opening at or near the lower end thereof, the method comprising: removing drilling fluid from the bottom portion of the well bore below the shortest pipe string by circulating a clean liquid down the longest pipe string and up the shortest pipe string through the opening

therein; injected a fluid cementitious mixture down the longest pipe string and simultaneously removing the clean liquid displaced by the cementitious mixture by means of the shortest pipe string through the opening therein until the cementitious mixture fills the lower end of the well bore up to a desired level above the uppermost productive earth formation; closing the opening in the lower end of said shortest pipe string; and lowering said shortest pipe string into the cementitious mixture to the position that it is to occupy while producing the uppermost productive earth formation.

5. The method of claim 4 wherein the clean liquid contains a coagulating agent.

6. The method of claim 4 wherein the clean liquid contains a dispersing agent.

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