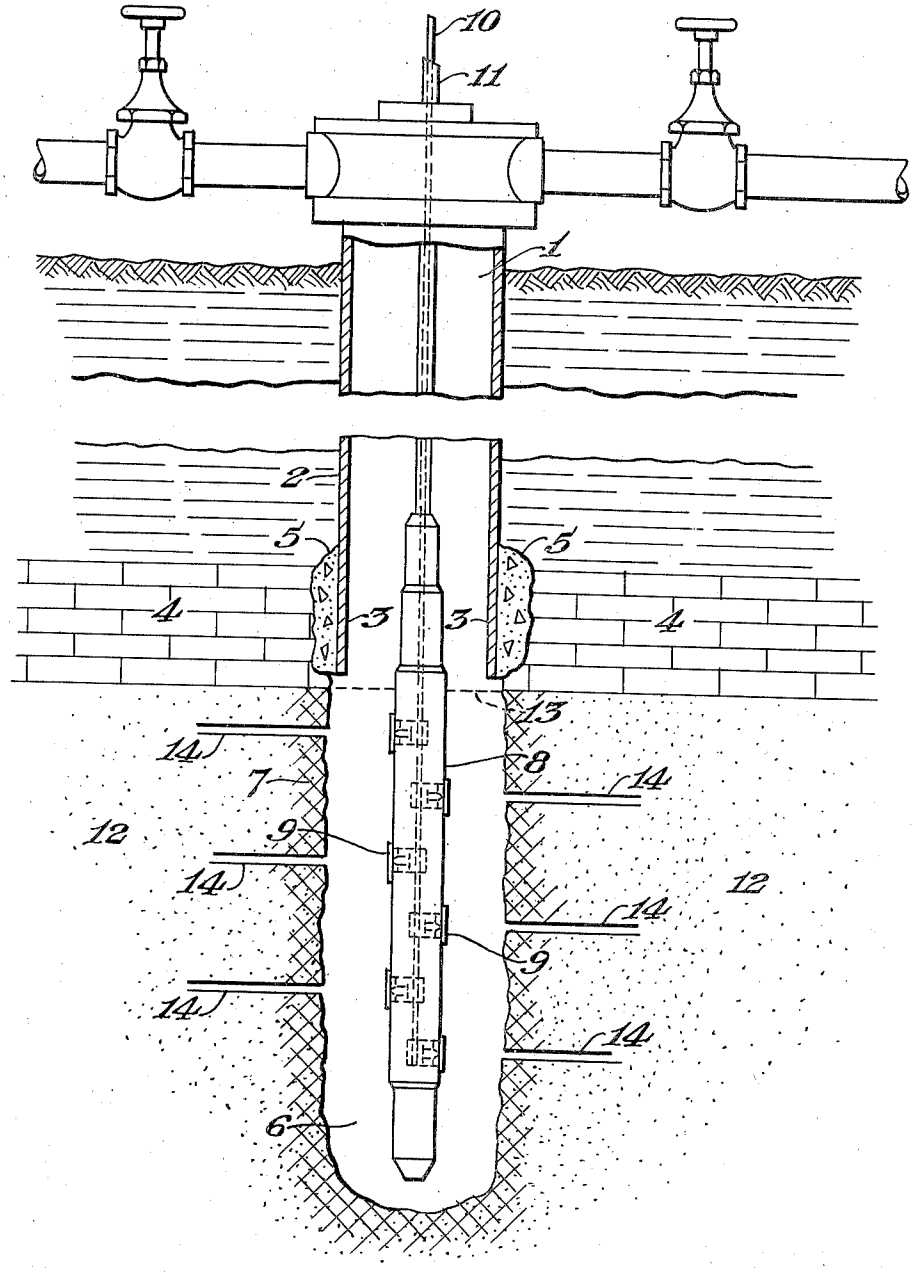
April 8, 1941. C. F. PRUTTON 2,237,313

METHOD OF TREATING WELL BORE WALLS

Filed Dec. 24, 1938



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Patented Apr. 8, 1941 2,237,313

UNITED STATES PATENT OFFICE

2,237,313

METHOD OF TREATING WELL BORE WALLS

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Application December 24, 1938, Serial No. 247,595

3 Claims. (Cl. 166—21)

The invention relates to an improved method of preparing the walls of a well bore penetrating a producing formation for the production of mineral fluids. It more particularly concerns a method of providing a channeled supporting wall for the producing portion of a well bore.

In conventional well drilling practice, it is customary to lower the casing string into the well bore to a point above the producing formation and cement it in place. The well is then produced in the usual manner, as by pumping. Recently, however, it has been the practice in some fields to extend the casing through the producing formation to the bottom of the well bore in order to guard against sloughing of the walls of the bore and to prevent the infiltration of water or brine from contiguous formations. Cement is then forced up into the annular space behind the metal casing to hold it in place. To produce a well equipped in this manner, it is necessary to perforate both the casing and surrounding cement liner to allow the fluid from the producing formation to enter the well bore. This is accomplished by lowering a gun perforator of conventional type into the well through the casing to a point opposite the producing formation and discharging steel projectiles from the gun through the casing and cement liner into the formation.

Using a gun perforator in the above manner has a decided disadvantage that the projectiles from the gun penetrate only a relatively short distance into the formation, it being necessary for them first to penetrate the steel casing and the surrounding cement before they can reach the formation. A still further disadvantage of the method lies in the fact that perforations made in the conventional cement liner surrounding the metal casing often become partially or entirely clogged or plugged due to cracking or crumbling of the cement resulting from the shattering action of the projectiles, thus curtailing or completely stopping the inflow of oil into the well. In addition, the cracks produced in the cement liner near the top or bottom of the producing formation when these areas are perforated may permit the infiltration of undesirable fluids if these portions are contiguous to water-bearing formations.

It is, therefore, the principal object of the invention to provide an improved method of supporting the wall of a well bore adjacent a producing formation, whereby said wall may be opened to production by explosive means without the necessity of using a metal pipe to support the wall or cement grout to seal said pipe in place. Still other further objects of the invention will be apparent as the description proceeds.

In carrying out the method of the invention in a well which has been drilled in the stratum from which production is to be obtained, the well is first lined with a metal pipe down to a point above the producing formation and the pipe is then cemented in place. The producing formation immediately surrounding the well bore is then impregnated with a chemical solution which is of itself capable of transformation into a solid sealing mass, or capable of reacting with a solution of a chemical later introduced to form such a sealing mass. After the solution or solutions, as the case may be, have been allowed to react and solidify thus consolidating and solidifying the walls of the well bore and the formation immediately surrounding the well bore, the formation is opened to production by explosive means, such as by discharging steel projectiles into it from a gun perforator or by setting off a charge of an explosive such as dynamite, nitroglycerin, or the like opposite the formation.

The invention, then, consists of the method hereinafter fully described and particularly pointed out in the claims, reference being made to the accompanying drawing illustrating a preferred mode of carrying out the invention in a well bore.

The single figure illustrates in vertical section a well suitably equipped for carrying out the invention. As shown, the upper portion of the well bore is cased with a metal casing 2 and passes through non-productive earth and rock, the lower portion 3 of the casing being cemented in rock stratum 4 with cement 5. The lower uncased portion of the well bore 6 is shown penetrating productive stratum 12 with the walls of the well bore and adjacent formation impregnated with a solidified sealing mass 7. Gun perforator 8 equipped with a series of laterally directed sockets 9 and fuse lead 10 attached thereto and to an electrical device (not shown) above the ground for firing steel projectiles from the sockets is shown suspended from cable 11 in the well opposite the producing formation 12.

In carrying out the method of the invention, a quantity of a liquid silicate mixture of the type which is of itself capable of spontaneous transformation into a firm, solid gel after a time is introduced in the lower portion of the well bore 6 in an amount sufficient to fill the bore of the well to a point 13 just above the producing formation 12. The liquid silicate mixture is then

displaced from the well bore so as to impregnate the surrounding formation by introducing into the well on top of the liquid silicate mixture a quantity of a non-penetrating liquid mixture. The term "non-penetrating liquid mixture" used herein and in the appended claims means a liquid mixture comprising a dispersion or a solution in a liquid of a material which is capable of preventing the mixture from penetrating porous formations at relatively high pressures but which is of sufficient fluidity to be introduced into the well bore and readily withdrawn therefrom. The non-penetrating liquid mixture introduced into the well on top of the liquid silicate mixture acts as a piston which, as pressure is applied, completely displaces the liquid silicate mixture from the bore hole into the surrounding formation immediately adjacent the bore hole. After the liquid silicate mixture has been completely displaced from the well bore into the surrounding formation, pressure is held upon the non-penetrating liquid mixture, if necessary, until the liquid silicate mixture has solidified. The non-penetrating liquid mixture is then withdrawn from the well and the gun perforator 8 is lowered to a point opposite the producing formation and discharged. The steel projectiles readily penetrate through the portion of the formation impregnated by the sealing agent, forming channels 14 therein through which the mineral fluid may flow into the well bore.

Various modifications of the above procedure may be employed. For example, instead of employing a gun perforator, a charge of explosive, such as dynamite, nitroglycerin, or the like, may be lowered into the well bore through the casing and exploded opposite the impregnated formation. This leaves the consolidated walls and the surrounding formation in a fissured or channeled condition, thus allowing the mineral fluid to flow into the well readily.

Among the liquid silicate mixtures capable of spontaneous transformation to a strong solid gel after a predetermined length of time are the following illustrative examples.

Example 1

A dilute solution of sodium silicate is prepared by diluting 40 per cent commercial sodium silicate ($Na_2O \cdot 3.22\ SiO_2$) with water to a specific gravity of 1.171, giving a solution containing 19.1 per cent by weight of sodium silicate. The dilute solution of sodium silicate so prepared is then added with vigorous stirring to a dilute solution of hydrochloric acid prepared by adding water to concentrated (37 per cent by weight) hydrochloric acid in the following proportions by volume:

	Per cent by volume
Dilute solution of sodium silicate (19.1% by weight $Na_2O \cdot 3.22\ SiO_2$)	10–75
Concentrated hydrochloric acid (37% by weight)	10–20
Water	12–70

Liquid silicate mixtures having a composition within the range of the above proportions spontaneously become solid gels in from ½ to 25 hours at 120° F. depending on the proportion of each ingredient.

Example 2

A dilute solution of sodium silicate is prepared by diluting 40 per cent sodium silicate ($Na_2O \cdot 3.22\ SiO_2$) with water to the specific gravity of 1.171, giving a solution containing 19.1 per cent by weight of sodium silicate. The dilute solution of sodium silicate so prepared is then added with stirring to a solution of ammonium bicarbonate, prepared by diluting with water a stock aqueous solution of ammonium bicarbonate containing 16.9 per cent by weight of the carbonate in the following proportions by volume:

	Per cent by volume
Dilute solution of sodium silicate (19.1% by weight $Na_2O \cdot 3.22\ SiO_2$)	5–85
Aqueous ammonium bicarbonate solution	5–85
Water	0–85

Liquid silicate mixtures having a composition with the range of the above proportions spontaneously become solid gels in from ½ to 15 hours at 120° F. depending upon the proportion of each ingredient.

Although the invention has been described with particular reference to the use of a solution of a settable liquid silicate mixture as the sealing agent to be used in impregnating and consolidating the walls of the well bore in the formation prior to opening the formation to production by explosive means, it is to be understood that other chemical sealing agents may also be suitably employed. For example, chemical solutions of the type reactable with a second chemical solution to produce a sealing mass may also be employed in accordance with the invention. By successively impregnating the formation with the two solutions whereby they are caused to react a sealing effect may be produced. Illustrative examples of such chemical solutions which may be reacted in the above manner are water-soluble soaps and a solution of calcium chloride, a solution of sodium sulphate and a solution of barium chloride, and a solution of a soluble silicate and a solution of calcium chloride. Other sealing agents of a similar nature may also be employed.

Examples of non-penetrating liquid mixtures useful for displacing the sealing agent from the well bore are those liquid mixtures having a specific gravity approximately the same as, or lower than, that of the agent to be displaced into the formation. One type of such a non-penetrating liquid mixture consists of a solution or a dispersion of an organic jellifying material in water. By "organic jellifying material" is meant an organic material capable of being dispersed or dissolved in water to make a mobile liquid dispersion or solution which exhibits jellifying characteristics after a time. Suitable organic jellifying materials may be prepared from starches, such as those of cassava or rice, by mixing them with water to form a thin paste and boiling the mixture until the starch is hydrolyzed. The cooked starch is dried at about 80° C. and the dried material ground, preferably to a fine powder. The powder so produced may be mixed with water in a concentration of from about 1 to 8 per cent by weight to make a dispersion or solution which possesses suitable non-penetrating characteristics. Another type of non-penetrating liquid mixture having gel-like characteristics may be made by mixing from 3 to 5 per cent of certain soaps, such as aluminum stearate and aluminum palmitate, with liquids, such as kerosene, gasoline and benzene, and preferably crude oil because of its cheapness, and then heating the mixture to from 50° to 80° C. After cool-

ing to a normal temperature, the mixture is ready for use.

Still another type of non-penetrating liquid mixture of an inorganic nature may be prepared by mixing bentonite with water in amounts up to 5 per cent. Such a mixture is substantially non-penetrating and is not readily miscible with the sealing solution. Other non-penetrating liquid mixtures may also be suitably used for the purpose at hand provided that they do not mix readily with the sealing agent to be displaced into the formation and do not substantially penetrate into the formation.

Among the advantages of the invention are that openings may be made much farther into the surrounding formation due to the fact that it is unnecessary to penetrate through both the metal casing and cement liner surrounding it, as is necessary in a conventional treatment, thus giving greatly improved results as regards increased yield from the well. In addition, in the treatment according to my improved method, it is unnecessary to use a metal casing long enough to extend to the bottom of a producing formation.

This application is a continuation-in-part of my co-pending application, Serial No. 212,769, filed June 9, 1938.

Other modes of applying the principle of my invention may be employed instead of those explained, change being made as regards the method herein disclosed, provided the step or steps stated by any of the following claims or the equivalent of such stated step or steps be employed.

I therefore particularly point out and distinctly claim as my invention:

1. In a method of providing a channeled supporting wall for a well bore penetrating a fluid producing formation, the steps which consist in depositing in the pores of the formation a liquid sealing mixture characterized by having a ready penetration into the fine pores of an earth or rock formation which are so small as to prevent the penetration of cement slurry thereinto, and thereafter forming flow channels in said formation by explosive means.

2. In a method of providing a channeled supporting wall for a well bore penetrating a fluid-producing formation, the steps which consist in introducing into the well bore a liquid silicate mixture of the type which is of itself capable of spontaneous transformation into a firm gel after a time in an amount sufficient to fill the well bore to a point above the producing formation, thereafter introducing into the well bore a quantity of a non-penetrating liquid mixture and applying pressure thereto whereby the liquid silicate mixture is displaced into the formation immediately surrounding the well bore, allowing said liquid silicate mixture to solidify, removing from the well bore the non-penetrating liquid mixture previously introduced, and thereafter forming flow channels in the formation by explosive means.

3. In a method of providing a channeled supporting wall for a well bore penetrating a fluid-producing formation, the steps which consist in introducing into the well bore a liquid silicate mixture of the type which is of itself capable of spontaneous transformation into a firm gel after a time in an amount sufficient to fill the well bore to a point above the producing formation, thereafter introducing into the well bore a quantity of a non-penetrating liquid mixture and applying pressure thereto whereby the liquid silicate mixture is displaced into the formation immediately surrounding the well bore, allowing said liquid silicate mixture to solidify, removing from the well bore the non-penetrating liquid mixture previously introduced, and thereafter perforating the formation with a gun perforator to permit the passage of fluids therethrough to the well.

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