

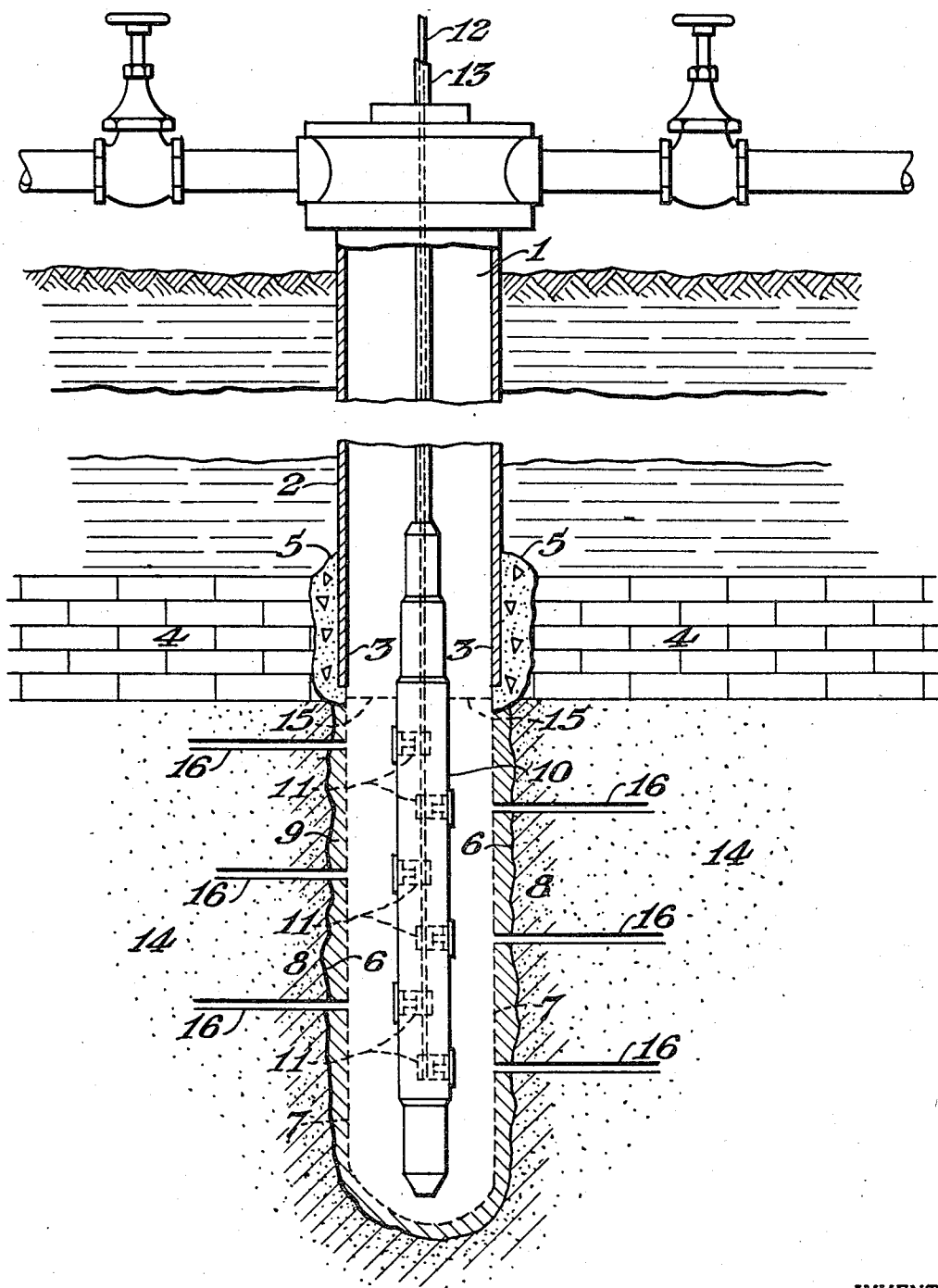
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METHOD OF LINING WELL BORES

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METHOD OF LINING WELL BORES

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The invention relates to an improved method of lining well bores. It more particularly concerns a method of providing a channeled supporting lining for the productive 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 around the 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 that section of the formation to be opened to production and discharging the steel projectiles from the gun through the casing and cement liner into the producing formation.

Using a gun perforator in the above manner has the decided disadvantage that the projectiles from the gun penetrate only a relatively short distance, if at all, into the producing formation, it being necessary for them to first pass through both the metal casing and surrounding cement before they can reach said formation. A still further disadvantage of this method lies in the fact that perforations made in the conventional cement liner surrounding the casing often become partially clogged or plugged up due to cracking or crumbling of the cement resulting from the shattering action of the projectiles, thus curtailing the inflow of oil into the well. Frequently these holes become so clogged that the inflow of oil is entirely shut off. 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, as when these portions are contiguous to water-bearing formations.

One of the objects of my invention is to provide an improved liner for the productive stratum of a well bore.

Another object is to provide a method of lining a well bore, which method provides a means of supporting the walls of a producing formation

without the necessity of using either a metal casing extending through the producing formation or cement grout to hold the casing in place.

Another object is to provide a lining for a producing formation which is capable of being easily and cleanly perforated to open the formation to production.

Still further objects and advantages of the invention will be apparent as the description of the invention proceeds.

As a preliminary step in carrying out the invention in a well which has been drilled through the stratum from which production is to be obtained, I first case the well down to a point above the producing formation and cement the casing in place. This may be done in the usual conventional manner. I then proceed according to the invention to form a support for the walls of the producing formation by impregnating the formation close to the well bore with a resin-forming liquid thereby forming a sheath or lining in the well bore. This may be accomplished in the following manner. A quantity of a resin-forming liquid in amount sufficient to fill the well bore to a point slightly above the producing formation is introduced into the well and allowed to solidify, thereby forming a resin plug in the bore. An axial hole is then drilled therethrough by employing a conventional rotary drill, or other suitable drilling means, to leave a cylindrical resin sheath or liner surrounded by resin impregnated earth or rock. Thereafter the well may be opened to production by any suitable means, as by discharging steel projectiles from a conventional gun perforator so as to penetrate through the resin sheath or lining and into the producing formation, or by setting off a charge of an explosive in the well bore opposite the resin cased producing stratum.

The invention, then, consists of the method hereinafter fully described and particularly pointed out in the claims, reference being made to the accompanying drawing showing a preferred mode of carrying out the invention in a well bore. Variations of the method described may be employed without departing from the scope of the invention.

The single figure illustrates in vertical section a well suitably equipped for carrying out the invention. As shown, the upper portion 1 of the well bore is cased with metal casing 2 and passes through non-productive earth and rock, the lower portion 3 of the casing being cemented in the rock stratum 4 with cement 5. The lower por-

tion of the well bore 6 is shown lined with a thin resin sheath indicated by numeral 9, said sheath having been formed when solidified resin was drilled out of the well bore along the dotted lines 7. The solidified resin-forming liquid is also shown impregnating the formation a short distance from the well bore indicated by the numeral 8. Gun perforator 10, equipped with a series of laterally directed sockets 11, and fuse lead 12, attached thereto and to an electrical device (not shown) above the ground for firing steel projectiles from the sockets, is shown suspended by a cable 13 in the well opposite the resin sheath 9 and the impregnated portion of the formation 8 which is to be perforated.

In carrying out the method of the invention, there is introduced into the lower portion of the well bore 6 a quantity of a resin-forming liquid in amount sufficient to fill the bore to a point 15, for example, above the producing formation 14. Pressure is then applied to the resin-forming liquid, if necessary, to displace a small portion of it from the well bore, so as to impregnate the formation 14 a relatively short distance from the well bore as indicated by numeral 8. The resin-forming liquid is then allowed to solidify in the bore and the formation where it acts to consolidate the walls of the well bore. Generally from 2-48 hours are required for complete solidification of the resin-forming liquid, depending, however, upon the type of resin-forming liquid employed. After the resin-forming liquid has solidified, a drill having any suitable diameter, preferably just slightly less than the diameter of the casing, is lowered into the well and the central portion of the solidified resin is drilled out, leaving a relatively thin cylindrical resin liner 9 or sheath integral with the surrounding resin impregnated formation 14. The extent of the resin support thus formed in the well bore may be varied over relatively wide limits, depending upon the extent to which the resin-forming liquid is allowed to impregnate the surrounding formation and the thickness of the resin sheath formed in the well bore. For example, if desired, a resin liner may be left in the well bore having a thickness of from between about one-half inch to two inches or more. The gun perforator 10 is then lowered into the well bore to a point opposite the producing formation and discharged. The steel projectiles readily penetrate through the resin sheath 9 and the impregnated portion of the formation 8 forming holes or channels 16, through which mineral fluid flows into the well from the producing formation 14.

Various modifications of the above procedure may be suitably employed. For example, instead of employing a gun perforator, a charge of explosive such as dynamite, nitro glycerin, or the like, may be lowered into the well bore through the casing and exploded at a point opposite the resin sheath. This leaves the resin sheath in a fissured or channelled condition thus allowing the mineral fluid to flow into the well readily. Since the resin surrounding the holes or fissures in the resin sheath does not crumble as does the conventional cement sheath when subjected to gun perforation or shooting with a charge of explosive, improved results are obtained as regards free flow of mineral fluid into the well bore.

In some instances, usually where relatively low rock pressures are encountered, it is unnecessary to form a resin sheath or lining in the well bore to lend support to the bore walls, since impregnation of the walls alone with a suitable resin-form-

ing liquid prevents them from caving. In such cases the drilling operation can be dispensed with, since the resin-forming liquid can be completely displaced from the well bore so as to impregnate the surrounding formation by introducing into the well on top of the resin-forming liquid a non-penetrating liquid mixture and applying pressure thereto. The term "non-penetrating liquid mixture" used herein and in the appended claims means a liquid mixture comprising a dispersion or solution in a liquid of a material which prevents the mixture from penetrating porous formations at relatively high pressures, but which is of sufficient fluidity to be introduced into the well and readily withdrawn therefrom. The non-penetrating liquid mixture introduced into the well on top of the resin-forming liquid acts as a piston which, as pressure is applied, completely displaces the resin-forming liquid from the bore hole into the surrounding formation immediately adjacent the well bore.

Examples of non-penetrating liquid mixtures useful for the purpose at hand are those liquid mixtures having a specific gravity approximately the same as, or lower than, that of the resin-forming liquid 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 cooling 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 amount up to 5 per cent. Such a mixture is substantially non-penetrating and is not readily miscible with the resin-forming liquids. Other non-penetrating liquid mixtures may be used for the purpose at hand provided that they do not mix readily with the resin-forming liquid to be displaced into the formation and do not substantially penetrate into the formation.

Suitable resin-forming liquids for use according to my invention are preferably those which form resins insoluble in oil and water, and, if the well is to be later acidized, they should also be insoluble in acid. Also, they must be capable of forming a strong, impermeable sheath when allowed to set in the well bore.

The following are illustrative examples of various resin-forming liquids which are suitable for use in carrying out the method of the invention.

Example 1

Mix together 60 parts of unpolymerized styrene, 30 parts of oil pitch, and 10 parts of petroleum oil, and then add a suitable catalyst in amount such that transformation of the liquid mixture into a solid resin will occur after a predetermined time. Stannic chloride may be used for this purpose, the amount selected being sufficient to bring about polymerization at a convenient rate. The addition of about 2½ per cent of stannic chloride by volume, based on the volume of styrene used, makes a liquid mixture which is quite fluid and remains so for about 90 minutes at ordinary temperatures. The mixture becomes a strong resinous solid, insoluble in oil, water, or hydrochloric acid, within 10 hours.

Example 2

Unpolymerized or monomeric styrene may be used undiluted or without a catalyst when the temperature of the well at the point containing the resin-forming liquid is high enough to cause polymerization. At 150° F. the mixture becomes a solid resin within 7 days.

Example 3

Mix together 70 parts of liquid vinylidene chloride and 30 parts of hexachloro-diphenyloxide. When ready for use add a catalyst mixture of benzoyl peroxide and tetraethyl lead, a suitable amount being about 0.5 per cent of each catalyst based upon the volume of vinylidene chloride in the mixture. This resin-forming liquid becomes non-fluid in about 2 hours at 110° F. and solid in about 6 hours.

Example 4

Petroleum oil is mixed with unpolymerized styrene in amount up to about 30 per cent by volume and about 2 per cent of stannic chloride based on the volume of styrene is added. The function of the petroleum oil is to act as a diluent reducing the speed of reaction. When no oil is added, the mixture of styrene and catalyst alone becomes polymerized in about 2½ hours at 100° F. When about 30 per cent of oil is incorporated in the mixture, it becomes a semi-solid in about 18 hours and becomes quite solid in about 30 hours.

Example 5

Mix together equal proportions of vinylidene chloride and hexachloro-diphenyloxide. A catalyst mixture of benzoyl peroxide and tetraethyl lead is then added to the mixture, a suitable amount being about 0.25 per cent benzoyl peroxide and 2 per cent tetraethyl lead, based on the volume of vinylidene chloride in the mixture. This resin-forming liquid mixture has a specific gravity of about 1.4 and spontaneously undergoes polymerization into an insoluble resinous solid in about 30 hours.

Example 6

Mix together 80 parts of unpolymerized styrene and 20 parts of hexachloro-diphenyloxide, and about 1.6 per cent of stannic chloride, based on the volume of styrene used. Such a mixture has a specific gravity of about 1.15 and will polymerize into a resinous solid in about 16 hours at 100° F.

The foregoing examples are merely illustrative of several resin-forming liquids which may be used according to my invention, but other resin-forming liquids, e. g. partially condensed phenol-

formaldehyde mixtures, vinyl chloride or vinyl esters, such as vinyl acetate, etc., may be employed similarly according to my invention.

To secure the maximum advantages of my improved method, the thickness of the resin sheath and the quantity of the resin-forming liquid forced into the formation should be regulated with care. If relatively low pressure is encountered in the producing formation, it is generally necessary to impregnate the formation only a relatively short distance to prevent the walls of the well bore from caving. However, when excessive pressures are encountered, it is usually desirable to impregnate the formation a greater distance and to form a relatively thick sheath of the solid resin in the well bore. In general, it is desirable to have the resin sheath as thin as possible and yet be strong enough to withstand the pressure of the particular formation treated without caving, since greater penetration, and therefore greater increase in production will thus be obtained as the sheath is gun perforated or shot with a charge of explosive.

Among the advantages of my invention are that openings may be made much farther into the surrounding formation due to the fact that it is unnecessary to perforate through both a metal casing and cement liner surrounding it, as is necessary in a conventional treatment. In addition, in a treatment according to my improved method it is never necessary to use a metal casing long enough to extend to the bottom of the producing formation. Further, the use of a resin sealing agent permits the flow of clean oil into the well bore and will not allow infiltration of undesirable fluids from contiguous formations which often occurs when the conventional cement liner is used, due to cracking or crumbling of the cement.

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 lining for a well bore penetrating a fluid producing formation, the steps which consist in introducing into the well bore a sufficient amount of a resin-forming liquid to cover the fluid producing formation and allowing the liquid to set in situ into a solid resin body, drilling a passage through the central portion of said solid resin body whereby a tubular resin lining is formed in the well bore covering the fluid producing formation, and then forming flow channels in the tubular resin lining and the formation by explosive means.

2. In a method of providing a channeled supporting lining for a well bore penetrating a fluid producing formation, the steps which consist in introducing into the well bore a sufficient amount of a resin-forming liquid to cover the fluid producing formation and allowing the liquid to set in situ into a solid resin body, drilling a passage through the central portion of said solid resin body whereby a tubular resin lining is formed in the well bore covering the fluid producing formation, and then perforating said lining with a gun

perforator to permit the passage of fluids there-through to the well.

3. In a method of providing a channeled supporting lining for the bore of a well penetrating a fluid producing formation, the steps which consist in introducing into the well bore a sufficient amount of unpolymerized styrene to cover the fluid producing formation and allowing said styrene to set in situ to a solid polymerized body, drilling a passage through the central portion of said solid polymerized body whereby a tubular resin lining is formed in the well bore covering the fluid producing formation, and then forming flow channels in the tubular resin lining and the formation by explosive means.

4. In a method of providing a channeled supporting lining for the bore of a well penetrating a fluid producing formation, the steps which consist in introducing into the well bore a sufficient amount of a settable mixture of vinylidene chloride and hexachloro-diphenyloxide to cover the fluid producing formation and allowing said settable mixture to set in situ to a solid body, drilling a passage through the central portion of the said solid body whereby a tubular resin lining is formed in the well bore covering the fluid producing formation, and then forming flow channels in the tubular resin lining and the formation by explosive means.

5. In a method of providing a channeled supporting lining for the bore of a well penetrating a fluid producing formation, the steps which consist in introducing into the well bore a sufficient amount of a settable mixture of petroleum oil and

styrene to cover the fluid producing formation and allowing said settable mixture to set to a solid body in situ, drilling a passage through the central portion of the said solid body whereby a tubular resin lining is formed in the well bore covering the fluid producing formation, and then forming flow channels in the tubular resin lining and the formation by explosive means.

6. In a method of providing a channeled supporting lining for a well bore penetrating a fluid producing formation, the steps which comprise introducing into the well bore a sufficient amount of a resin-forming liquid to cover the producing formation, thereafter introducing a quantity of a non-penetrating liquid mixture into the well bore and applying pressure thereto whereby the resin-forming liquid is displaced into the surrounding formation impregnating the formation, allowing the resin-forming liquid to solidify, removing the non-penetrating liquid mixture from the well bore, and thereafter forming flow channels in the so-impregnated formation by explosive means.

7. In a method of providing a channeled supporting lining for a well bore penetrating a fluid producing formation, the steps which comprise introducing a resin-forming liquid into the well bore, forming a solid resin lining on the walls of the well bore as well as a solid consolidating deposit of resin in the formation immediately adjacent the well bore, and then forming flow channels in the so-formed resin lining and the formation by explosive means.

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