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METHOD OF TREATING A WELL

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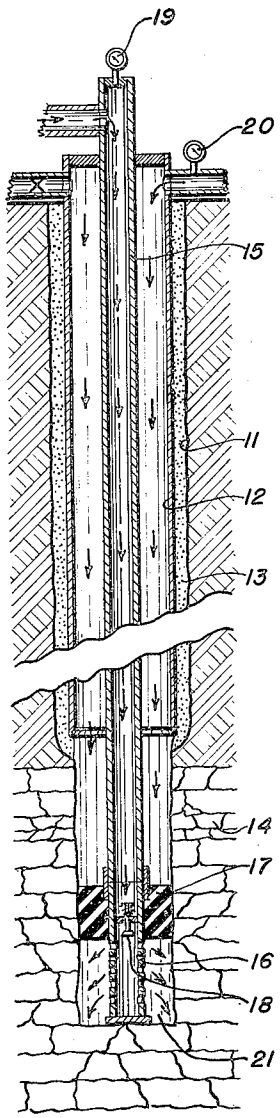


Fig. 1.

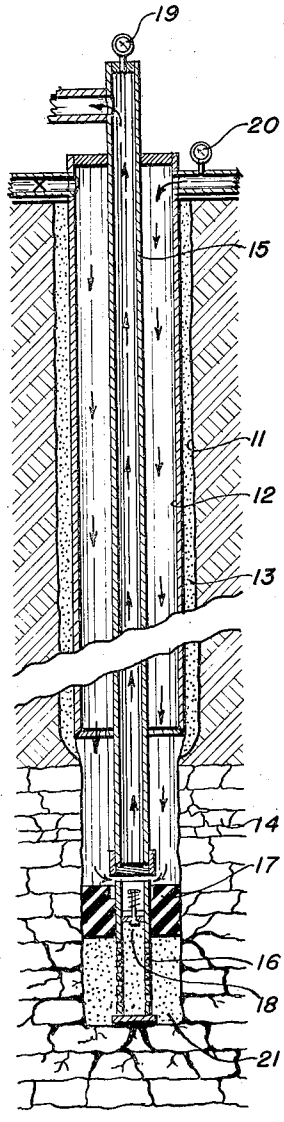


Fig. 2.

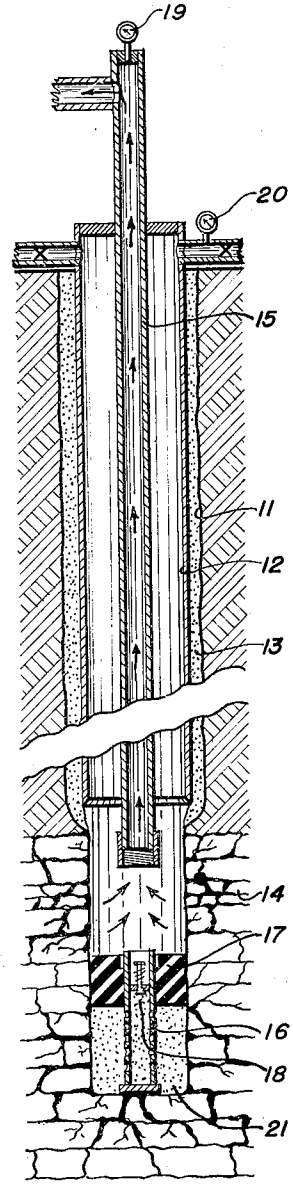


Fig. 3.

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METHOD OF TREATING A WELL

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3 Claims. (Cl. 166—21)

This invention relates to the making of oil wells or the like and more particularly to methods of eliminating bottom water commonly produced concurrently with oil and gas from limestone formations.

Since the beginning of the oil industry there has been a wholesome and well-founded fear of water. Water encroachment probably has been the most important factor contributing to oil well abandonment and, consequently, waste of a valuable natural resource.

Almost without exception all oil producing formations sooner or later in the life of the well produce from small to very large amounts of salt water concurrently with the oil and gas. This is due to the fact that the petroleum-bearing formations are usually very close to water-bearing formations and are usually above the water-bearing formations.

It will be readily understood that the production of water with the oil is a highly undesirable condition from all standpoints and that if the water can be eliminated from the production then the cost of oil production will be decreased and the productive life of the well will be lengthened.

In wells producing from sand, ordinary "plug back" cement jobs have commonly been used to cut off the water production, but the results have often not been satisfactory. More recently the "squeeze job" type of cementing has been developed in which the cement is forced back into the water-bearing portion of the sand at high pressure.

Due to the different nature of limestone from sand, it is in general impractical to use an ordinary "squeeze job" to shut off encroaching water in the limestone formation. The inherent difference between the nature of flow through sand along bedding planes, as compared to flow in limestone through fractures and crevices, as well as some actual flow through the pores of the formation, makes it difficult to force the cement under high pressure into a limestone formation.

It has always been common practice to stop drilling just short of the water-bearing formation. When the water-bearing formation is penetrated the drilling is immediately stopped and some method of plugging the hole up is attempted. In every case the idea has been to have as little formation exposed to water as possible. This has been a contributing factor in the failure of previous methods in insuring a complete and permanent shut off because the amount of formation exposed to the cement is insufficient to give a bond to the plug which is capable of withstanding the upward thrust of the water which in most cases exceeds a thousand pounds per square inch.

In accordance with the present invention it is proposed to depart from what was previously regarded as the best practice. It is proposed to drill the hole well into the water-bearing formation instead of stopping just short of this formation, then treat the water-bearing formation with a chemical such as acid, to enlarge the fissures, crevices or pores and then force a body of cement into the water-bearing formation after it has thus been opened up so as to seal off the water.

Accordingly, it is one object of the invention to treat a water-bearing formation adjacent a petroleum-bearing formation in a well by first opening up the water-bearing formation and then injecting some sealing material therein to shut off the water.

It is a further object of the invention to open up a water-bearing formation in an oil well so as to make it more permeable so that cement or other sealing means can be placed therein to seal off the water.

It is still another object of the invention to combine two heretofore separate and distinct processes in the same well to accomplish through their joint use the shutting off of water in a formation.

Other objects reside in certain novel features of the method, as will be more apparent from the following description taken in connection with the accompanying drawing, in which:

Figure 1 is a diagrammatic representation of an oil well in vertical cross-section and illustrating the first step in a process to be carried out in accordance with the principles of the present invention;

Figure 2 is a view of the same well, illustrating a later step in the process; and

Figure 3 is a view of the same well, illustrating the production of oil therefrom after the process of the present invention has been completed.

The process of the present invention may be carried on in a number of different ways. The method of solving three separate problems will be described herein, these three covering the basic field of application of the process, although it will be apparent to those skilled in the art that various field conditions will warrant the use of slight changes in the procedure.

In certain Kansas oil fields there is a definite separation of the oil- and water-bearing portions of limestone by a thin layer of hard, closely compacted limestone to which layer the wells are customarily drilled. After completion of the well in

such a case it is frequently found that water soon appears when the well is being produced. The explanation for this is believed to be that the water existing below the hard and normally impervious layer works its way upwardly into the bore of the hole through small holes gradually eaten away in the hard, separated layer, this being due to the tendency of the water to seek its way toward a region of lower pressure. It is probable also that this water seepage takes place radially within the region where the pressure of the formation is lowered by the production of oil.

In other oil fields where this hard, impervious layer is not present, water appears when oil is being produced due to the natural encroachment, the water traveling both upwardly through the formation in the region of lowered pressure and laterally through the formation toward the bore hole as it normally does in the case of sand wells.

To illustrate the principles of the present invention, one method of carrying out the process has been illustrated in the drawing.

Referring to Figure 1, it will be seen that a bore hole is there illustrated at 11, the well being provided with a casing 12 which is cemented in place by means of the cement shown at 13. Let us assume that the well has previously been drilled down into an oil-bearing limestone formation indicated generally at 14 and that this formation contains oil in its upper portion and water in its lower portion so that when the well is producing, both oil and water are brought to the surface: In accordance with the present invention, it is proposed to lower suitable tubing 15 into the well, the tubing having a perforated section 16 at its lower end and a packer 17 immediately above the same. The packer may be of any desired construction, either a rat hole packer or a wall packer, depending upon the nature of the well beneath the shoe of the casing, and in the showing of Figure 1 the packer 17 is intended to be only a diagrammatic representation.

The tubing 15 may be provided with a suitable back pressure valve, as shown at 18, this valve being preferably within or below the packer 17. Under some circumstances both the packer 17 and the valve 18 may be dispensed with.

Let us assume now that the well is an old one which has been flowing or has been pumped but is making considerable water. In carrying out the present process, one procedure may be as follows:

Whether the well is flowing naturally or is being produced by other means, an accurate gauge is made and the production records are checked to determine the actual water/oil ratio in the production. If the well is flowing it is next killed, or if a pumper, the rods are removed, together with the standing barrel of the pump. The well is next circulated with water or other fluid until all oil is removed, as well as all loose material which may be on the bottom. In the event the well cannot be filled with water, a bailer or sand pump should be run to insure a clean bottom section. The next step may be varied to suit field conditions but usually consists in removing the tubing and deepening the well until it passes entirely through the water-bearing section of the limestone formation. Usually when the well is drilled deeper the hole should be of the same size as that existing from the casing shoe to the original bottom of the well. A wall or open hole packer, such as is diagrammatically represented at 17, is next attached to the tubing 15 with sufficient anchor pipe below the packer to place the top of the packer slightly above the natural water level in the well. This level may have been previously determined by means of electrical logging, or otherwise. The tubing and packer assembly is then run in the well until it strikes the bottom and the packer is set. Water is then pumped into the well, first through the tubing from which it is forced into the well below the packer, and then through the casing, so that it is forced into the formation above the packer. By means of pressure gauges represented at 19 and 20 in the drawing, it is thus possible to determine the entry pressures into the formation. After these have been determined, the pumps force some water into the formation both above and below the packer. The water below the packer is then followed by acid through the tubing.

It is this phase of the process that is illustrated in Figure 1, the arrows indicating the direction of the passage of water through the casing and acid through the tubing. The acid may consist of hydrochloric acid or other acid capable of reacting with the limestone to enlarge the pores thereof and may be pumped as taught in the patent to Frasch, No. 556,669 granted March 17, 1896, for "Increasing the flow of oil wells".

After the acid has been forced into the limestone formation beneath the packer 17 it should be allowed to remain there for a period of say three to five hours to allow for reaction of the acid with the limestone.

The next step in the process consists in mixing and pumping a quantity of neat cement slurry down through the tubing into the formation beneath the packer 17. During this step the pressure within the casing is maintained as during the forcing of acid into this part of the formation by forcing water downwardly through the casing and into the formation above the packer. The cement is displaced downwardly through the tubing until say thirty to sixty feet of cement are left inside the tubing at which time the tubing may be disconnected from the perforated section 16 and the excess cement washed out. It will be obvious to those skilled in the art that this step may also be carried out by the use of a circulating valve in the tubing above the packer, such as is commonly used in cementing operations.

The condition of the well at this time is illustrated in Figure 2. It will be seen that the fissures or crevices within the limestone formation beneath the packer have been enlarged by the pumping of the acid thereinto so that they may receive the cement slurry. This slurry not only seals off these fissures but acts as anchoring means integral with the cement which remains in the well around the anchor pipe so that this portion represented at 21 effectively plugs the well.

In circulating any excess cement remaining in the tubing above the packer, the valve 18 will close, as illustrated in Figure 2.

The washing out process is preferably carried on by forcing water downwardly through the casing, the return being upwardly through the tubing, as illustrated by the arrows in Figure 2. In this manner all cement is removed both from the tubing and from the lower portion of the well above the packer 17 should any cement have leaked around the packer. It will be noted further that at the same time pressure is maintained against the oil-bearing portion of the formation so as to prevent cement traveling into this portion.

Circulation of fluid, as illustrated in Figure 2, should be maintained until the cement beneath the packer and in the lower portion of the formation has jelled or set to a consistency where it will

not flow. This time varies with different cements and different well conditions, but will probably not exceed eight hours in any case. If a circulating valve is used the tubing will still be connected to the packer at this time but should now be disconnected and slowly pulled upwardly within the well high enough inside the casing to be safe from sticking in the open hole section. The well head is now closed and pressure applied equal to that required for entry of water into the formation. This pressure is maintained until the cement has taken its final set which will usually be about three days.

The well may now be again brought into production by running the tubing and circulating oil and by swabbing or other methods practiced in various areas in bringing wells into production.

After the cement in the lower portion of the formation 14 has taken its final set, the upper or oil-bearing portion of the formation may be acidized to increase its production in the normal manner without fear of having the acid penetrate into the old water-bearing portion of the formation which is now completely sealed off not only in the well but also radially from the well.

The condition of the well in its final state under the method outlined above is illustrated in Figure 3. It will be seen that as there illustrated both the water-bearing portion of the formation 14 and the oil-bearing portion have been acidized so as to enlarge the crevices or fissures therein. It is to be understood, however, that the fissures and crevices in the lower portion of the formation have been effectively sealed off or plugged with cement.

In the process just described it was assumed that the method was applied to an old well. It is possible to carry out the process in making a new well, however, and it is logical to believe that if in making a new well in an oil-bearing limestone formation the section of the formation which carries water is filled with cement both below and radially around the well before actual production has commenced, encroachment of water will be long delayed and perhaps even completely averted. The process in drilling a new well may be carried on as follows:

When the drill encounters the oil-bearing limestone formation, cores should be taken for a short distance and the well tested prior to the setting of casing. If the casing has been set and the cement plug drilled out, the hole is cored while being drilled deeper until the water level is reached, which may be determined either by drill stem testing of the type disclosed in the United States patent to Simmons, 1,930,987, or by electrical logging. The well may then be drilled deeper either for a considerable distance into the water-bearing portion of the formation or completely through this portion. Where large-sized casing has been set and small core cutters used, the well should be reamed down full-gauge, to a point just above the water level, thus providing a seat where a cone packer may be used. Where a small casing has been used and where the seat is not sufficient for the use of a cone packer, a wall packer as previously described may be set just above the water level. The procedure from this point on may be identical with that described above in connection with the Figures 1, 2 and 3 of the drawing. It should be remarked, however, that in most cases it will be preferable to acidize the oil-bearing portion of the formation before attempting to complete the well, whereas this will not always be necessary in the case of old wells.

As a third method of carrying out the process of the present invention, the well may be drilled through the producing horizon and on down through the water-bearing portion of the formation, as previously described, and the casing may be set through this entire strata without regard to water level. The casing may then be perforated completely across both the oil- and water-bearing portions of the limestone strata, after which the water level may be determined by successive drill stem tests using a hook wall packer. The strata which produces the oil should then be perforated from top to bottom. A cement retainer may then be set on tubing or drill pipe just above the water level.

The well will then be in condition for treating the portion of the formation beneath the cement retainer with acid and cement, as outlined above, after which the portion of the formation above the cement retainer may be acidized if necessary and be brought into production.

The theory underlying the various features and methods of carrying out the process is based upon the fact that where acid has been injected into water-bearing section of a limestone formation, cement may easily be placed in the same section both in the well and to some distance radially from the well. The cement placed as described will be in intimate contact with the formation, and thereby take far better bond onto the formation than could be expected with an ordinary plug back type of cementing operation. Further, cement so placed entirely through the water-bearing section will prevent encroachment of water upwardly into the oil production region when the pressure in this portion is lowered by production. The large body of cement surrounding the well in the water section of the formation and lapping over into the oil section will materially retard the rise of the water table and at least to some extent eliminate the water coning action in the formation, as often occurs in many fields.

The maintenance of the entry pressure on the oil section while acidizing and cementing, as described above in connection with Figures 1 and 2, prevents the acid and cement from working its way too far into the oil section. The acid is caused to open the channels of the water section, thereby reducing the entry pressure therein and allowing the cement to follow, but no appreciable amount of cement will flow into the oil section as might occur were a squeeze type job of cementing attempted.

It is obvious that the process may be carried out in a great variety of cases both in old and new wells. The methods herein have been described with particular reference to formations having lime or other calcareous material therein, but it is obvious that they may be applied in any case where a water-bearing formation may be opened up by treating it with some chemical known to react with it.

While only a few methods have been shown and described herein, it will be obvious to those skilled in the art, therefore, that various changes may be made in the method and a wide variety of apparatus used, without departing from the principles of the invention or the scope of the annexed claims.

We claim:

1. The method of making a petroleum well from a location in which a petroleum product and wa-

ter exist by nature adjacent each other in a calcareous formation of the earth, which method includes drilling a hole into the formation to a sufficient extent to pass into both the petroleum-bearing and the water-bearing portions thereof, placing acid in the water-bearing portion of the formation while substantially sealing the petroleum-bearing portion of the formation from the acid, thereby opening up the water-bearing portion of the formation, injecting cement into the opened up portion of the formation, allowing the cement to harden and subsequently placing acid in the petroleum-bearing portion of the formation to open up the same, thereby enabling the petroleum to be produced comparatively free from water.

2. The method of making a petroleum well from a location in which a petroleum product and water exist by nature adjacent each other in the earth with the water below the petroleum product, which method includes drilling a hole into the earth to a sufficient extent to pass into both the petroleum-bearing and water bearing portions thereof, lowering a pipe with a packer thereon into the hole until the packer is located substantially between said petroleum-bearing and water bearing portions, setting the packer at that point, to seal the hole, placing an acid in the said water bearing portion beneath the packer which will react with that portion of the earth and thereby open up the same and injecting sealing material into said portion which has been opened up by the acid.

3. The method of making a petroleum well from a location in which a petroleum product and water exist by nature adjacent each other in the earth with the water below the petroleum product, which method includes drilling a hole into the earth to a sufficient extent to pass into both the petroleum-bearing and water bearing portions thereof, lowering a pipe with a packer thereon into the hole until the packer is located substantially between said petroleum-bearing and water bearing portions, setting the packer at that point, to seal the hole, pumping an inert fluid down in the hole on the outside of said pipe to enter the petroleum-bearing portion above said packer and an acid down through the inside of said pipe to enter the portion of the earth beneath the packer, said acid being capable of reacting with said portion and thereby open up the same, exerting pressure on said inert fluid to an extent sufficient to prevent flow of fluid from the water bearing portion to the petroleum-bearing portion and injecting sealing material into the water bearing portion which has thus been opened up while maintaining said pressure on said inert fluid.

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