Oct. 19, 1948. N. D. COGGESHALL 2,451,472

METHOD OF CEMENTING WELLS

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Fig. 1.

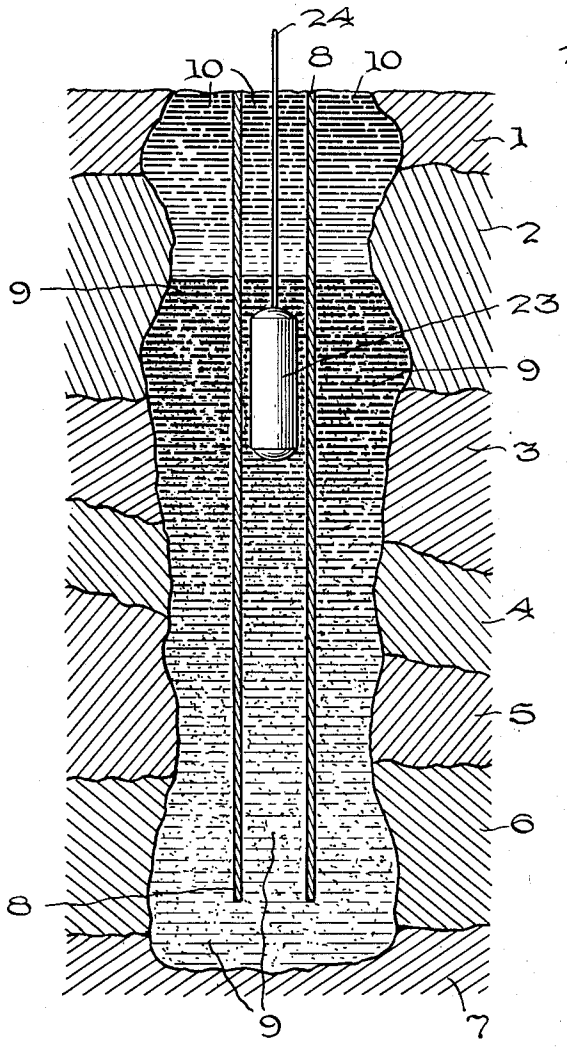
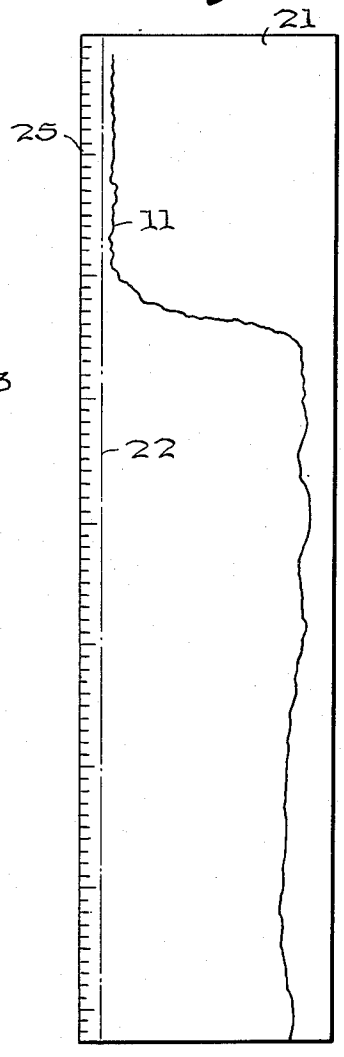


Fig. 2.



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Fig. 3.

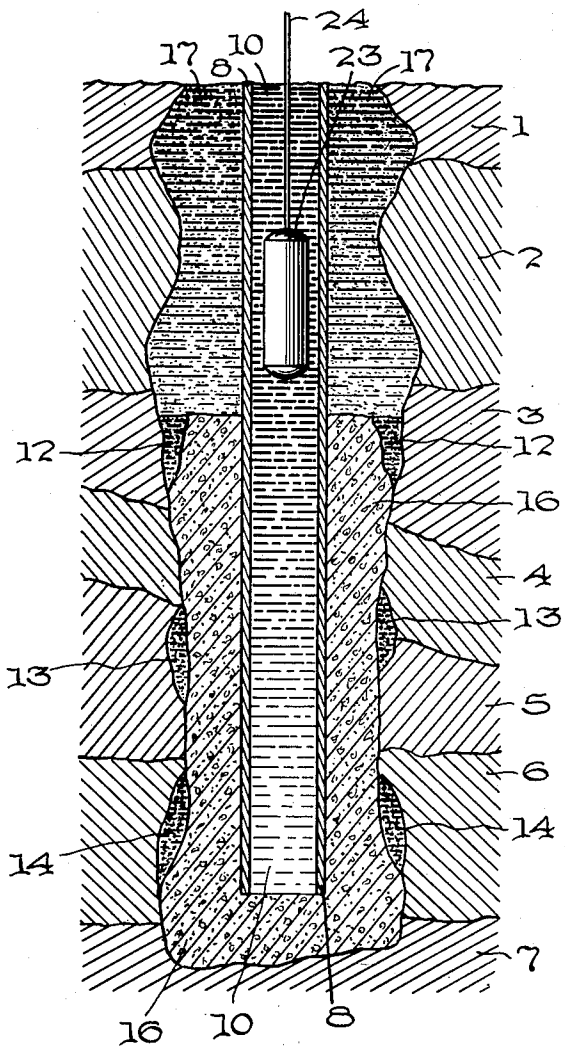
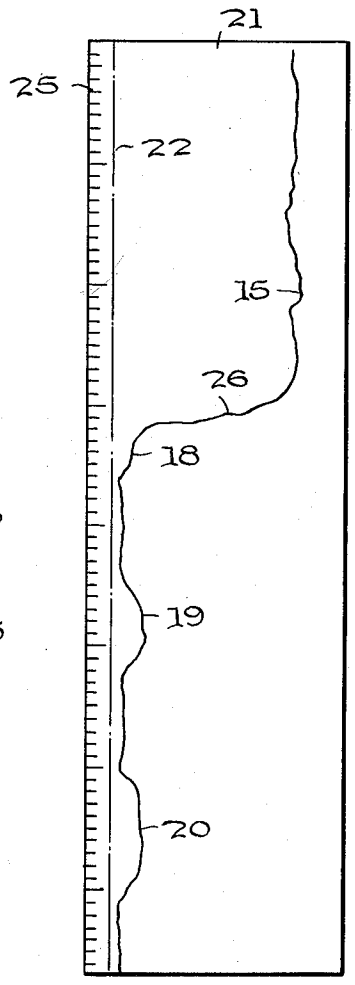


Fig. 4.



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METHOD OF CEMENTING WELLS

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1 Claim. (Cl. 166—22)

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This invention concerns a method of procedure for use in the cementing of oil wells, and in particular it relates to a cementing method by which it is possible to subsequently determine the completeness of the cement job by the application of gamma ray logging.

Present day oil well completion practice consists in drilling the well to final depth through the producing formation, lowering a casing of smaller diameter than the borehole, and cementing the casing in the hole by forcing cement down through it and up into the annular space between the casing and the wall of the hole. The process of cementing the casing results in a sheath of cement around the outside of the casing extending from the bottom of the hole some distance up beyond the producing strata. The cemented casing is then perforated at the proper level by means of a gun perforator which produces holes through both the casing and the cement sheath, and it is through these holes that the oil and gas are produced. The cement sheath thus serves the extremely important function of blocking off the strata adjacent to the oil bearing zones. This is necessary because these adjacent strata often contain water or gas in such quantities that if such blocking were not effected the oil production would be seriously impeded.

Often the cementing operation discussed above is unsuccessful in that it does not completely block off the strata in the critical region. This failure is generally due to the fact that the cement, as it comes up around the casing, pushing the mud before it, does not completely clean out the mud as it goes along. This results in streaks or sheaths of mud which subsequently provide a means of communication between the oil bearing strata and others that contain water or gas. Heretofore it has been possible to determine if the cementing has been successful only after the casing is perforated and a production test made.

The object of this invention is to provide a method of determining the completeness of a well cementing operation.

A secondary object of this invention is to provide a method of locating any channels which may be left in the section of a well which has been cemented.

A further object of this invention is to provide a method of determining the completeness of a well cementing operation in the region to be perforated and before such perforating is attempted.

These objects are accomplished by the practice of this invention in the following manner. The first step in the procedure is to replace the drilling mud in the open hole, in the region to be cemented, by a mud of similar physical properties, such as visoscity and density, but having added to it a radioactive material, such as finely ground carnotite in suspended form or a salt of radium or other radioactive element in a dissolved form. This may be done either by spotting the radioactive mud through the drill pipe just before removing the latter, or by forcing the radioactive mud down through the casing after it is lowered into the hole. The first procedure is to be preferred because it results in obtaining a larger quantity of radioactive material in the mud cake. The cementing operation is then performed and it is expected that the cement will force all the radioactive mud on up the annular space ahead of it. If any uncemented pockets remain, they may subsequently be detected by running a radioactivity log, e. g., a gamma ray log.

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A further understanding of the invention may be obtained by reference to the drawings in which

Figure 1 shows a cross section of the borehole before the cementing operation is performed;

Figure 2 is an illustrative gamma ray log curve obtained before cementing;

Figure 3 is a cross section of the borehole after cementing; and

Figure 4 is a gamma ray log obtained after cementing and illustrates how channels in the cement are indicated.

Figure 1 illustrates the situation which would exist at the bottom of a well after the step of adding the radioactive mud. Here numerals 1, 2, 3, 4, 5, 6 and 7 represent the different strata traversed by the lower end of the borehole and 8 represents the casing suspended in the hole with its end near the bottom. For simplicity, the upper part of the well and the usual surface equipment are not shown, since these are conventional and do not form a part of this invention. The radioactive mud 9 is shown as having been spotted at the bottom of the hole, either through the casing 8 or through the drill pipe prior to the latter's removal. The level of radioactive mud 9 inside and outside the casing are shown as being the same, but they need not necessarily be so, and these levels depend on the manner of introducing the radioactive mud 9. The inert mud forced upward by the radioactive mud is designated by numeral 10.

With the radioactive mud in the bottom of the hole as shown in Figure 1, a gamma ray detector 23 lowered into the borehole on cable 24 would give an intensity response such as illustrated in Figure 2, which is a chart obtained from a con-

ventional gamma ray logging apparatus. Numeral 11 represents a gamma ray intensity curve drawn by the apparatus on chart 21 in the customary manner. The zero line of the curve is indicated by line 22, and along the left hand edge of the chart a record of depth 25 tells the position of the detector at which the indicated intensities are observed. Here it is seen that the intensity increases to a very high value at the level where the bulk of the active mud begins, and it continues at a high intensity down the hole. The presence of the casing in the hole will not appreciably interfere, as the gamma rays of carnotite and radium, as well as other materials which would be used, are of sufficient hardness to penetrate the iron easily.

The next step in the procedure is to carry out the cementing as in any other well. The cement is forced down through the casing, and as it comes up the annular space, it forces the mud in the borehole ahead of it. If the cementing operation is "perfect," all the mud in the lower region of the hole will be forced ahead of the cement. If, however, the operations are imperfect, some mud will remain in the bottom part of the hole in the form of streaks or massive accumulations. Such a situation is shown in Figure 3.

In Figure 3 numeral 16 represents the cement which has been forced down the casing 8, while 17 represents the radioactive mud which has been forced along ahead of the cement. Accumulations or bodies of the radioactive mud which have not been displaced by the cement are illustrated at 12, 13 and 14. Such regions of mud as 12, 13 and 14 are undesirable as they later form channels which may admit excessive gas or water. By establishing the presence of imperfections 12, 13 and 14 and determining their location, the necessary squeeze cementing may be done in these regions of poor cementing prior to the perforation for production, thus saving time and the cost of poor completions.

The method of detecting such regions of poor cementing as 12, 13 and 14 is to again lower a gamma ray detector 23 into the casing 8 (shown in Figure 3 to be cleaned of cement) and to obtain a log of the gamma ray intensity versus depth as before. Such a curve is indicated by numeral 15 in Figure 4. The large intensity indicated at region 15 corresponds to the radioactive mud which has been forced ahead of the cement. A marked decrease is observed on the curve at point 26 opposite the cement, since the cement is not radioactive. Further down on the graph, the regions of anomalous intensity 18, 19, 20 are due to the radioactive mud in regions 12, 13 and 14, respectively. The regions of defective cementing 12, 13 and 14 may thus be located and corrective measures taken before the well is put in production.

In carrying out my invention, it is not only possible to locate regions of defective cementing but it is obvious that the method at the same time also tells the level to which the cement has been forced in the annular space around the casing. This is indicated by the decrease in curve 15 observed at point 26 opposite the top of the cement. This information is of considerable importance in all cementing operations.

The method of my invention may also be used advantageously in carrying out cementing operations further up the borehole. Thus, if a well has been producing from an upper horizon and begins to produce excessive water, it may be advisable to shut it off with cement. In performing such a cement job, I would first spot the radioactive mud opposite the perforations leading to this horizon and apply pressure to force the radioactive mud through the casing into the annular space behind it. Any excess is then removed from inside the casing and the usual cement spotted at the proper level with a conventional squeeze tool and forced through the casing into the annular space. The radioactive mud will be pushed ahead of the cement both above and below the cement plug. The top and bottom levels of the cement in the annular space may afterward be located by running a gamma ray log, and any intermediate improperly sealed regions will also show on the log due to the radioactive mud remaining in such imperfections.

This method of studying cementing may be contrasted with the procedure hitherto used of making the cement radioactive and attempting to interpret the resulting gamma ray curve regarding the success of the cementing operation. The latter method does not definitely establish the presence of incompletely cemented regions. However, the method of my invention does make it possible to determine whether the cementing is incomplete by indicating the presence of mud when the latter is not completely displaced.

The scope of this invention is not to be limited to the use of radioactive muds merely as replacement for the original drilling mud prior to cementing. It is also to include the use of radioactive tracers in the drilling mud with subsequent logging to determine the degree to which it has been displaced by the cement.

My invention may furthermore be advantageously used as a step in the completion of a cased well, said step insuring that a successful completion will result. By employing my invention channels and crevices in the cement may be avoided by perforating and recementing those regions where radioactive mud is found to remain undisplaced by the cement. This may be repeated until all such radioactive mud is effectively displaced whereupon no channels will remain. Subsequent perforations of the producing horizon will allow uncontaminated fluid to enter the well.

What I claim as my invention is:

A method of cementing a well so that the degree of completion of the cementing operation may be determined which comprises replacing the normally used drilling mud in the region to be cemented with a radioactive drilling mud introduced through the drill stem, removing the drill stem, inserting the casing into the well, measuring the variation with depth of the radioactivity in the well, forcing cement into place around the casing so as to displace the radioactive drilling mud in the annular space around the casing and again measuring the variation with depth of the radioactivity in the well, whereby by comparison with the first said measurement the location of undisplaced radioactive drilling mud may be determined.

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