

[54] **METHOD FOR OPERATING IN WELLS**

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[52] **U.S. Cl.**..... 166/253, 166/285, 174/4.51

[51] **Int. Cl.**..... E21b 33/13, E21b 47/00

[58] **Field of Search** 73/151, 155; 166/64, 66, 166/253, 254, 285; 175/4.51; 250/253, 254, 256, 258, 270

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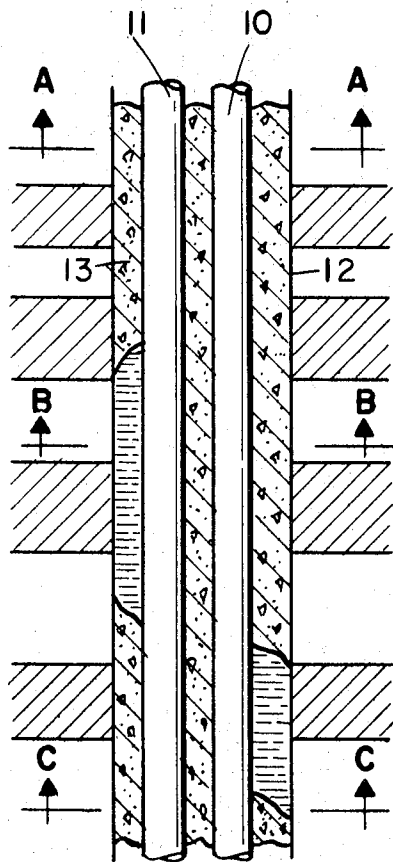
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Attorney, Agent, or Firm—John S. Schneider

[57] **ABSTRACT**

Primary cement channels formed in the cement surrounding the tubing or pipe strings are located and, thereafter, remedial or repair operations are conducted. In multiple tubingless oil and/or gas wells cement channels formed in the cement are revealed by comparing neutron logs run in each pipe string of the multiply completed well. Comparing each of the neutron logs with an open hole sonic log aids in identifying the cement channels. A series of oriented density log scans of the well bore defines the location and areal extent of the cement channels in more detail. In both single and multiple completions an oriented density log, suitably calibrated to measure apparent density, may be used alone to locate and define channels in the cement. Log interpretations and field examples are presented.

19 Claims, 43 Drawing Figures



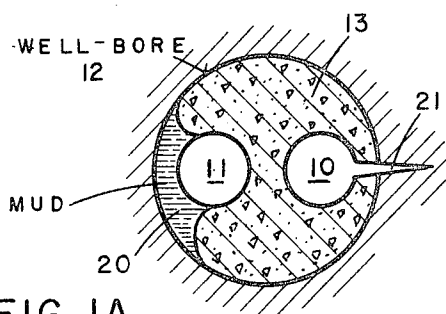


FIG. 1A.

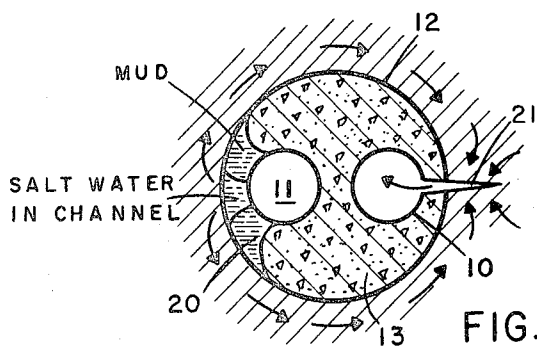


FIG. 2A

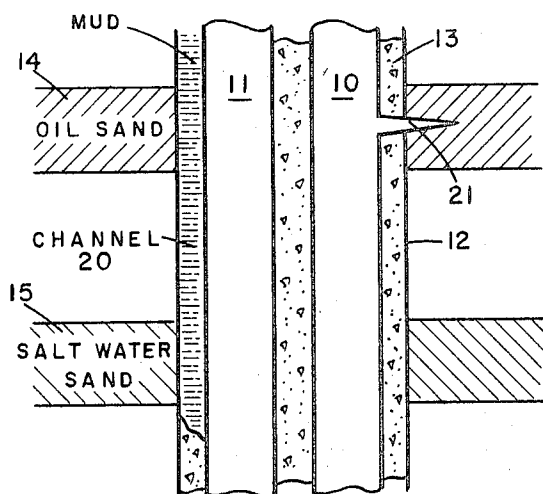


FIG. 1B. BEFORE PRODUCING

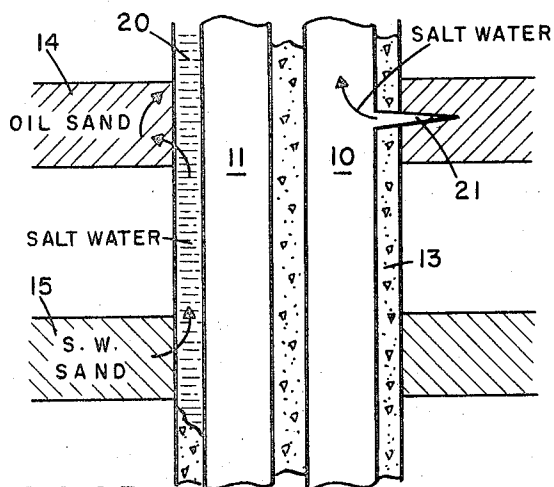


FIG. 2B. AFTER PRODUCING

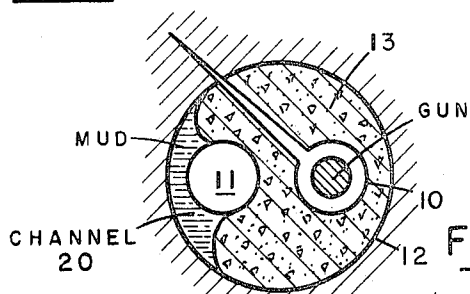


FIG. 3B.

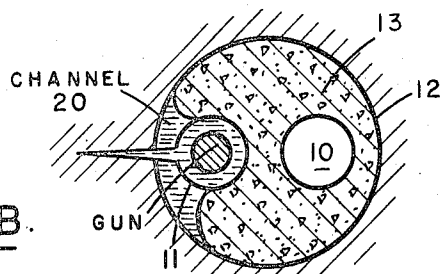


FIG. 3A.

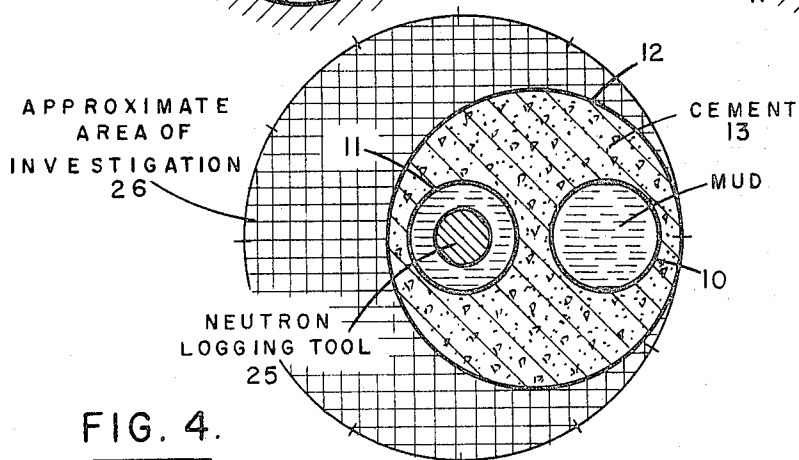


FIG. 4.

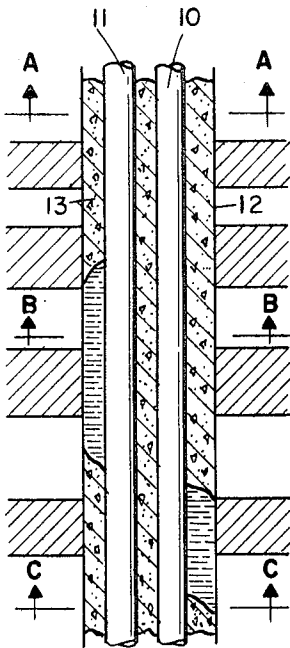


FIG. 5.

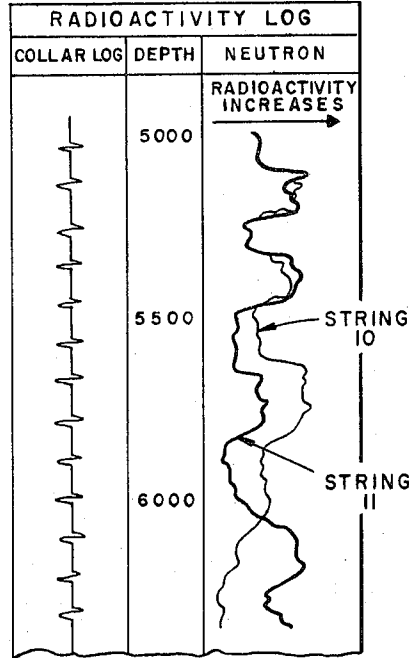


FIG. 5D.

FIG. 5A.

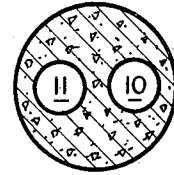


FIG. 5B.

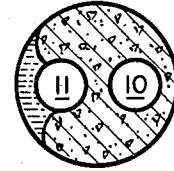


FIG. 5C.

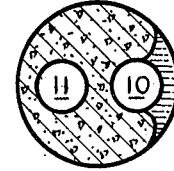
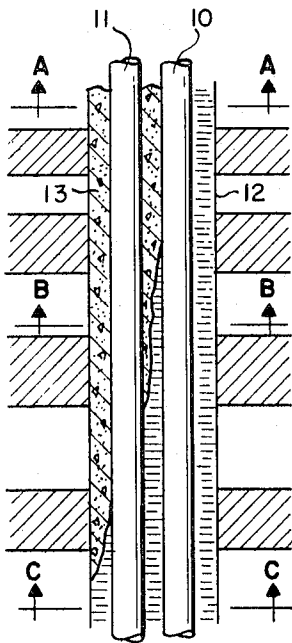


FIG. 6.

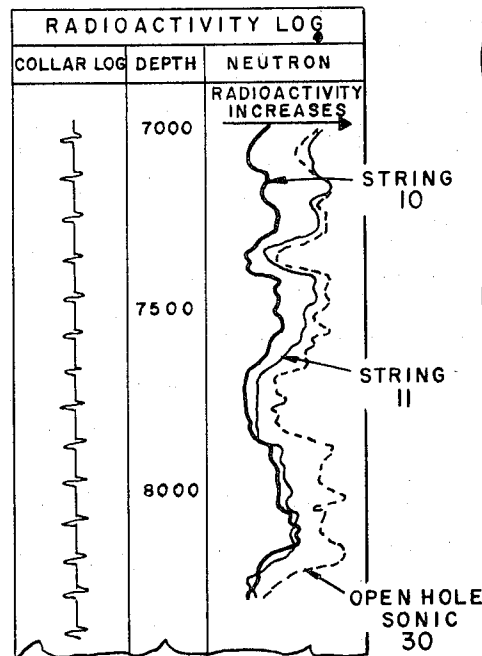


FIG. 6D.

FIG. 6A.

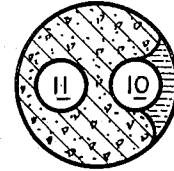


FIG. 6B.

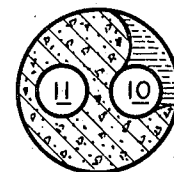
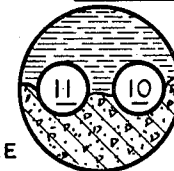
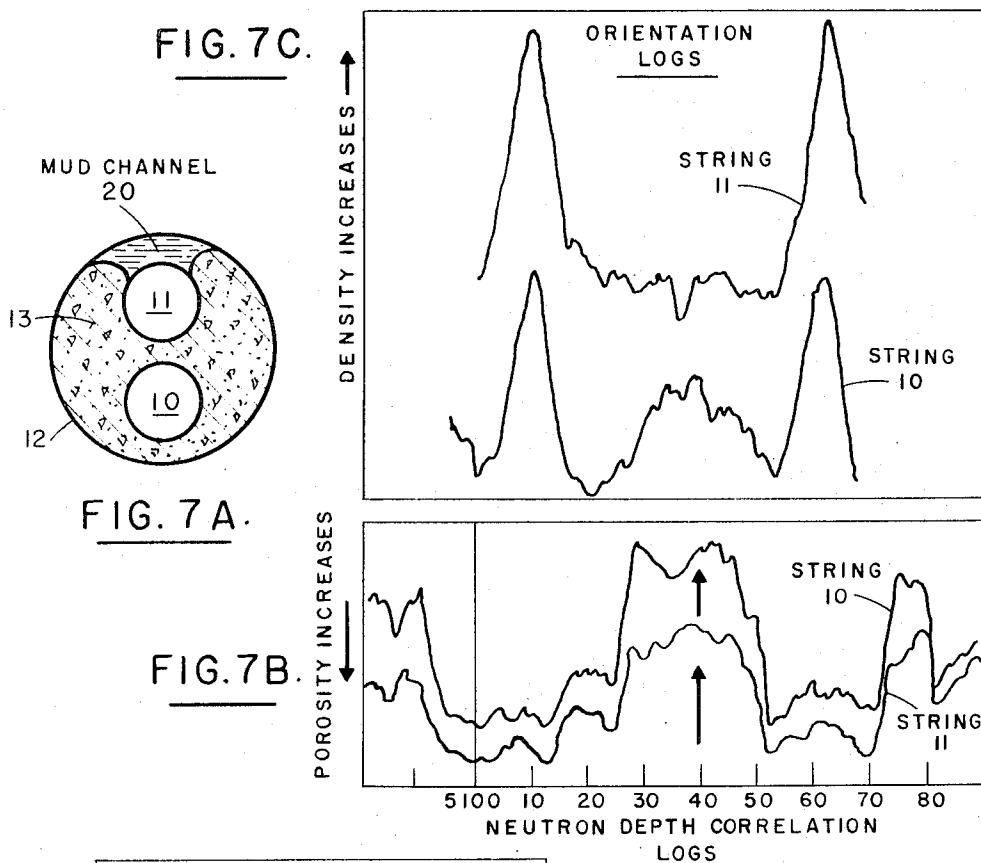
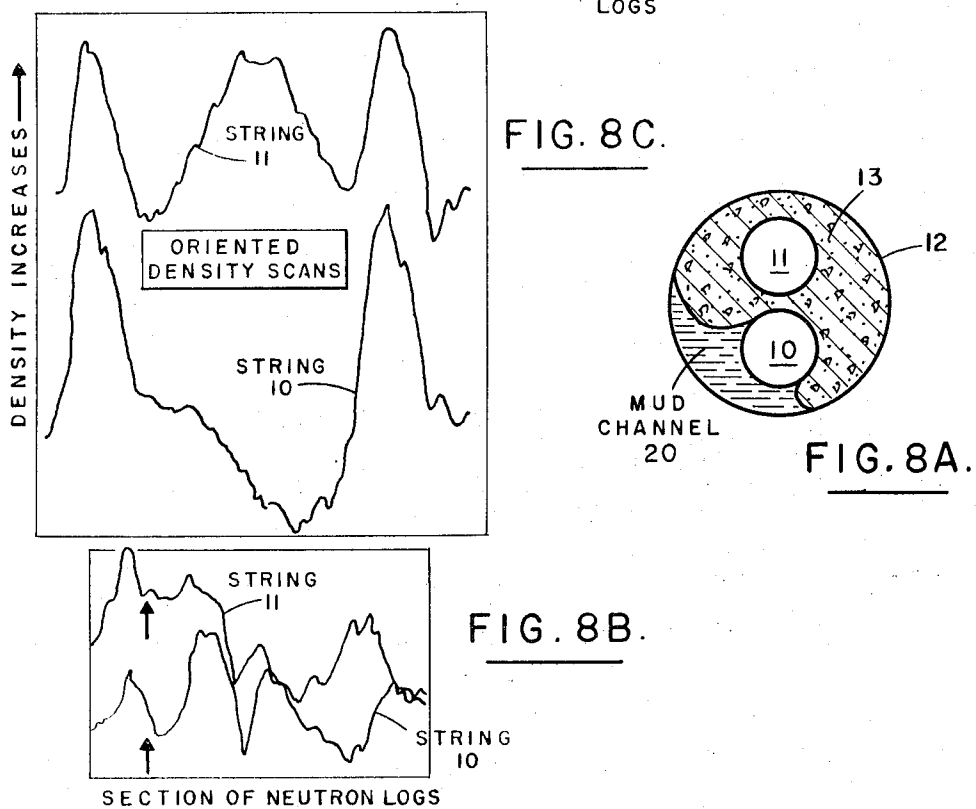
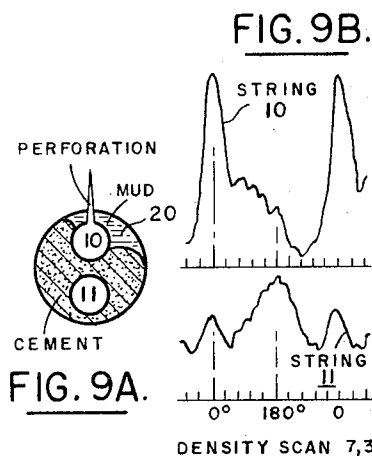
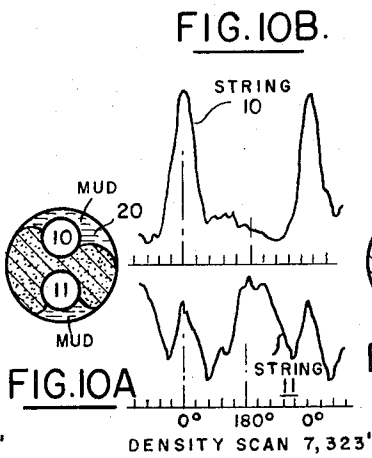
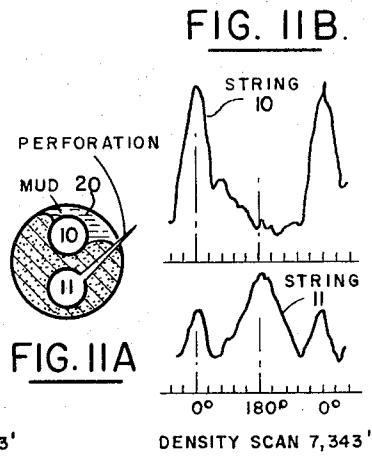
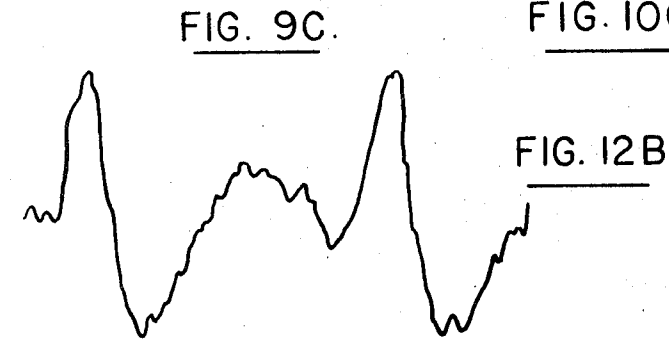
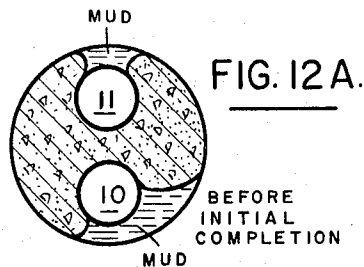
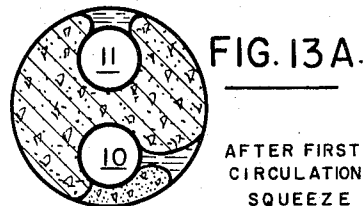
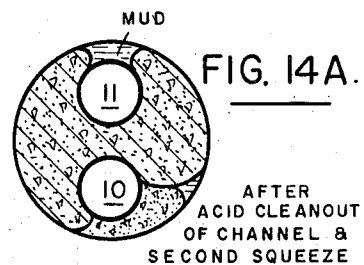
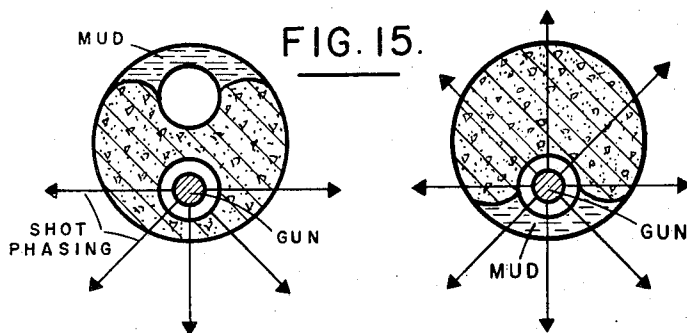


FIG. 6C.







APPARENT
BULK DENSITY
GMS / CC

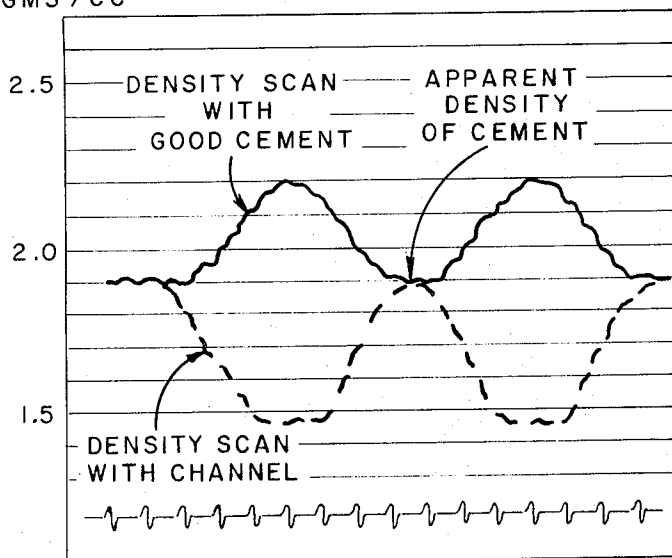


FIG. 17.

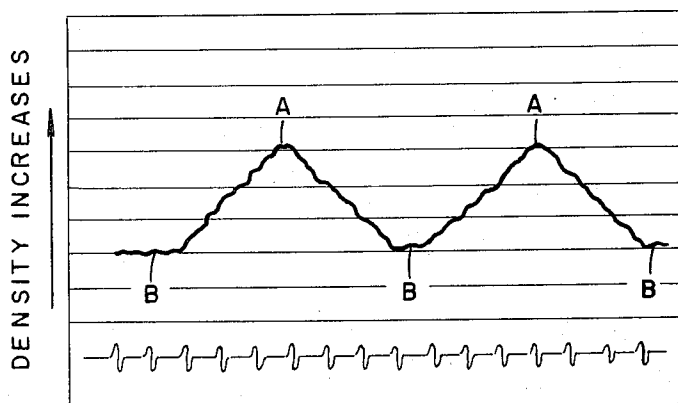


FIG. 17A.

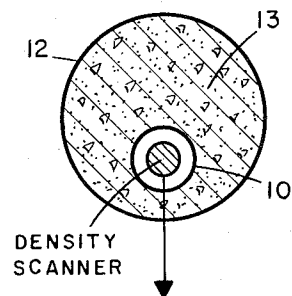
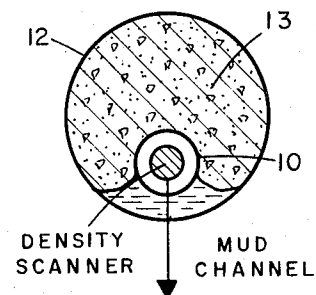


FIG. 17B.

FIG. 18.

METHOD FOR OPERATING IN WELLS

BACKGROUND OF THE INVENTION

The present invention concerns well completion operations and, in particular, operations in which channels formed in the cement surrounding well pipes are located. The invention also involves conducting remedial or repair operations once the cement channels are located.

Primary cementing of single and multiple tubingless wells continues to be a major problem in the oil industry. Although it is apparent that complete displacement of drilling mud by cement is critical to a successful primary cement job, no adequate means has been available to examine the cement in place to evaluate how successful the displacement has been. The difficulty in relying on traditional percent success from well test data in evaluating primary cement jobs is well known. Often, wells which have apparently been completed satisfactorily, thus indicating a good primary cement job, suddenly start producing extraneous fluids. Squeeze cementing repair operations may cure the problem. However, often, particularly in multiple tubingless completions, repeated squeeze and reperforate operations fail to shut off the unwanted fluid. Heretofore, neutron, acoustic, and density logs have been run in well pipe strings in single completions in an attempt to evaluate cement jobs and in a paper by Richard L. Cardwell, "Well Logging in the USSR", Seventh Annual Logging Symposium Transactions, Society Professional Well Logging Analysts, Denver, Colorado, June 11 to 14, 1967, a density logging tool designed to locate channels in cement surrounding a pipe string in a well bore is described which uses a gamma ray source and three or four gamma ray detectors. None of these prior methods involved multiple tubingless well operations or any unique application of the various logging techniques or use of calibrated oriented density logs in single or multiple tubingless operations. The method of the present invention overcomes previous difficulties in cementing operations in wells. Channels in the cement surrounding single or multiple pipe strings are located and defined so that proper remedial operations may be carried out.

The neutron, sonic (velocity) and oriented density logs used in the method of the present invention are well known and commercially available logs. Neutron logging is discussed on pages 546 to 549 of "History of Petroleum Engineering" published by American Petroleum Institute, 1961. Sonic logging is discussed in that same publication on pages 549 to 554. The oriented density logging tool is preferably a focused gamma-gamma density orienting tool used to orient a perforating gun away from other strings of pipe in the borehole. A continuous stream of gamma rays emitted from a strong radioactive source, preferably cesium, is directed in a narrow beam towards the surrounding media. It is rotated by a downhole motor to obtain a full 360° investigation of the well bore and adjacent formation rock. The backscatter of gamma rays from this bombardment reaches the detector approximately 9 inches above the radioactive source and is measured by a Geiger-Mueller tube focused in the same vertical plane. Scattering of the gamma rays is proportional to the atomic number of the materials in the scattering medium. The higher the atomic number, or density, the

greater will be the attenuation (less scatter), and therefore fewer counts will reach the detector. The logging technique and a tool capable of performing it are described in U.S. Pat. No. 3,426,851 entitled "Method and Apparatus for Operating In Wells", issued to H. S. Arendt, Feb. 11, 1969.

SUMMARY OF THE INVENTION

One aspect of the present invention involves a method for locating channels in cement surrounding at least two pipe strings cemented in a well which comprises running a neutron log in each of the pipe strings and then comparing the neutron logs with each other, the differences in these logs providing indications of channels in the cement. Another aspect of the present invention involves comparing the neutron logs with a sonic log previously run in open hole. Still another aspect of the present invention involves a method for defining channels in cement surrounding one or more pipe strings cemented in a well which comprises logging (by scanning) the areas surrounding the pipes in the well with an oriented density logging tool. These logs are made at various depths in the well as deemed necessary. The oriented density logs when made at the same level in two or more strings are compared with each other, and differences in the logs provide indications of channels in the cement. The oriented density logs may be used alone or, preferably, in the multiply completed wells, in conjunction with the neutron log comparisons and the comparison of the sonic log with the neutron logs in order to locate and define the channels in the cement more accurately. The oriented density log when calibrated to measure apparent density may be used alone to locate and define channels in the cement surrounding one or more strings of pipe.

Once the channels in the cement have been located and accurately surveyed, various remedial operations such as reperforation and cement squeeze techniques may be conducted. For instance, perforations can be oriented in one string of pipe to gain access to the channel above and below the interval to be repaired. The mud can then be circulated from the channel and be replaced with cement by methods well known and/or readily apparent to those skilled in this art.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1A and 1B are top and elevation views, respectively, of a dual completion illustrating a portion of the well before production;

FIGS. 2A and 2B are also top and elevation views, respectively, illustrating the same portion of the well shown in FIGS. 1A and 1B after production;

FIGS. 3A and 3B are top views of a dual completion illustrating two perforating shot orientations;

FIG. 4 is a top view of a dually completed well illustrating the area of investigation of a neutron logging tool;

FIG. 5 is an elevation view of a dual completion; FIGS. 5A, B, and C are respectively views taken along lines A—A, B—B, and C—C of FIG. 5; and FIG. 5D illustrates neutron logs run in each of the pipe strings of FIG. 5;

FIG. 6 is an elevation view of a deeper section of another dual completion; FIGS. 6A, B, and C are, respectively, views taken along lines A—A, B—B, and C—C of FIG. 6; and FIG. 6D illustrates neutron logs run in

each of the pipe strings of FIG. 6 and a sonic log run in the open borehole of FIG. 6;

FIG. 7A is a top view of a dual completion; FIG. 7B illustrates neutron logs run in each pipe string of FIG. 7A; and FIG. 7C illustrates oriented density logs run at the same depth in each pipe string of FIG. 7A;

FIGS. 8A, 8B, and 8C are similar to FIGS. 7A, 7B, and 7C, respectively, illustrating logs run in a deeper portion of the well;

FIG. 9A is a top view of a dual completion; and FIGS. 9B and 9C illustrate oriented density logs run at a selected depth in each pipe string of FIG. 9A;

FIGS. 10A, 10B, and 10C are similar to FIGS. 9A, 9B, and 9C, respectively, illustrating logs run at a lower point in the well;

FIGS. 11A, 11B, and 11C are similar to FIGS. 10A, 10B, and 10C, respectively, run at a still deeper location in the well;

FIG. 12A is a top view of a dual completion before initial completion thereof; and FIG. 12B illustrates an oriented density log run in one of the pipe strings of FIG. 12A;

FIG. 13A is a view similar to FIG. 12A illustrating the well after a first circulation cement squeeze; and FIG. 13B is an oriented density log run in one of the pipe strings of FIG. 13A;

FIG. 14A is a view similar to FIG. 12A illustrating the well after acid cleanout of the channel and a second cement squeeze and FIG. 14B illustrates an oriented density log run in one of the pipe strings of FIG. 14A;

FIGS. 15 and 16 are top view of wells illustrating shot phasing for a dual and single string completion, respectively;

FIG. 17 illustrates logs obtained with calibrated oriented density logging tools showing variations in apparent bulk densities measured under the conditions shown in FIGS. 17A and 17B;

FIG. 17A is a top view of a single-string completion with good cement placement in the annulus between the casing and borehole wall;

FIG. 17B is the same completion with a mud filled channel in the cement between the casing and borehole wall; and

FIG. 18 illustrates the log obtained with an oriented density logging tool.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIGS. 1A, 1B, and 2A, 2B, illustrate the problem of interzone fluid migration in a dual tubingless completion. Two pipe strings 10 and 11 of, for example, 2 7/8 inch casing pipe have been centralized and cemented in a, for example, 7 7/8 inch well bore 12 by cement indicated at 13. An oil sand 14 and a salt water sand 15 are penetrated by well bore 12. Inefficient displacement of the cement results in a mud filled channel 20 between pipe string 11 and the wall of borehole 12. Channel 20 spans the distance between oil sand 14 and salt water sand 15 and may extend vertically hundreds and even thousands of feet. As shown at 21, pipe string 10 is perforated in oil sand 14 in a direction 180° away from pipe string 11 using a conventional oriented gun perforation procedure. Since channel 20 is on the opposite side of the borehole behind pipe string 11, the only flow path between perforation 21 and channel 20 is through the pores of the reservoir rock. After the

well has been placed on production, as illustrated in FIGS. 2A and 2B, pressure in oil sand 14 immediately adjacent to the well bore may be drawn down sufficiently to allow salt water from the salt water sand 15 to break through the mud in channel 20, flow out into oil sand 14 and around the well bore and enter perforation 21 as indicated by the arrowed lines. Since a cement slurry cannot be pumped through the pores of the reservoir rock, repeated squeeze cementing operations may fail to reach channel 20 and shut off the water. The cement slurry, which is an excellent frac fluid, would merely be placed in a vertical fracture in the formation to form a vertical dike extending outward for a distance dependent on the volume of cement employed in the squeeze job.

Knowledge of the primary cement problem described with reference to FIGS. 1A, 1B, and 2A, 2B, permits completion remedies such as illustrated in FIGS. 3A and 3B. Well completion procedures may be altered to select pipe string 11 for the completion attempt as shown in FIG. 3A. In the event pipe string 11 cannot be used for the completion, the perforating gun may be oriented in pipe string 10 toward channel 20 in a direction that will just miss pipe string 11 as illustrated in FIG. 2B. Conventional perforation procedures such as illustrated in FIGS. 1A, 1B in which channel 20 is completely avoided by perforating in pipe string 10 directly away from channel 20 would be satisfactory so long as the gelled mud provided a satisfactory seal. Direct penetration of channel 20 as illustrated in FIG. 3A would be reserved for those cases in which simple squeeze cementing techniques failed to repair the communication problem.

The neutron logging tool is used in many operating areas for perforating depth control. This tool responds primarily to hydrogen and therefore measures changes in the amount of pore fluids (water or hydrocarbons) or porosity of the formation. Because of the limited depth of investigation of the neutron logging tool, a relatively high percent of its response comes from material in the borehole, particularly in tubingless completions. As seen in FIG. 4 the two pipe strings 10 and 11 of the dual tubingless completion are cemented in borehole 12 by cement 13. A neutron logging tool 25 run in pipe string 11 has an approximate area of investigation indicated at 26. The borehole material, cement, contains a very high percent of hydrogen. With uniform cement placement in the annulus, the counting rate of the cement plus other strings of casing although high is constant and the logs run in each string of a multiple tubingless completion would be essentially identical. However, if the cement placement is not uniform the effect of the borehole material on the neutron logs is readily apparent.

The "cement effect" in a dual tubingless completion is illustrated in FIGS. 5, 5A, 5B, 5C, and 5D. In order to simplify the description, the parts of the wells have been given the same number designations in each figure. Thus, pipe strings are referred to as 10 and 11 and the borehole is designated 12 and the cement 13 and the mud channel 20. With good cement placement in the annulus from 5,000 to 5,500 feet (the depth at FIG. 5A) neutron logs run in both pipe strings show essentially identical responses in FIG. 5D. The borehole effect from each string is the same. Below 5,500 feet mud channel 20 in cement 13 occurs between pipe string 11 and the borehole wall (the depth of FIG. 5B) in the in-

terval between 5,500 and 6,000 feet. The borehole contributes a different effect at this depth. The neutrons emitted from the neutron logging tool in pipe string 11 must now travel through the fluid filled channel 20 where they are heavily attenuated before logging the formation. A marked reduction in counting rate or shift to the left towards higher porosity (radioactivity decrease) results. Pipe string 10 surrounded by good cement produces an essentially normal neutron log. In the interval below 6,000 feet (the depth of FIG. 5C) the two logs cross as channel 20 changes to a position between pipe string 10 and the borehole wall.

A good match between the two neutron logs does not necessarily indicate the absence of a mud channel. A channel equidistant between the two strings of pipe would cause both logs to shift by the same amount. An additional reference is desirable and one is available from an open hole sonic log. The sonic log measures porosity, but since it is run in open hole, it is uninfluenced by any cement effects. Since neutron logs and sonic logs measure porosity, they should closely resemble each other when the neutron logs are recorded at the same relative amplitude as the sonic log. A radical departure of one or both neutron logs from the acoustic log may indicate presence of a mud channel in the primary cement.

In FIGS. 6, 6A, 6B, 6C, and 6D, a deeper section of the well discussed with reference to FIG. 5 is illustrated. In FIG. 6D an open hole acoustic log indicated as dashed lines 30 has been superimposed on the neutron logs run in pipe strings 10 and 11. At 7,000 feet the abnormally low counting rate observed in the neutron log of string 10 is caused by channel 20 in the cement between string 10 and the borehole wall (at the depth of FIG. 6A). The neutron log of string 11 agrees reasonably well with the acoustic log 30 in this section. The two neutron logs gradually converge with depth until they are essentially the same at 8,000 feet. Without another reference one would interpret the logs as showing good cement in the lower part of the borehole. A lack of good match with the open hole acoustic log, however, reveals that the channel is a continuation of the one observed in the section of FIG. 6A and with depth has moved from behind pipe string 10 as indicated in the section of FIG. 6B to a position adjacent to the two pipe strings as shown in the section of FIG. 6C.

Procedures for enhancing neutron logging operations for use in cement channel detection are as follows:

1. Adjust the logging instrument sensitivity to give the same departure between sands and shales as that recorded by the open hole acoustic log;
2. Use a carefully centralized detector for each logging run;
3. Record all logs at the same sensitivity setting; and

4. Record instrument zero before and after each run to detect any change in recording characteristics. Make no shift of the reference zero between runs.

Oriented density logs may be compared with the neutron logs with or without comparison with the open hole sonic log to define better the location and extent of the channels in the cement. To evaluate the effectiveness of neutron and oriented density logs in distinguishing between good and poor cement placement, a number of special surveys were run in dual string wells cemented in 7 7/8 inch diameter holes. The tests in-

involved running neutron logs in each pipe string followed by a large number of scans with the oriented density tool at various depths. The scans were made in pairs, that is, at the same depth in each pipe string. Scans were made at selected depths to confirm neutron log interpretation of spiraling channels.

As shown in FIG. 7A a channel 20 is located behind pipe string 11. In FIG. 7B a neutron correlation log of pipe string 11 is shown superimposed on a neutron log of pipe string 10. The general shift downward exhibited by pipe string 11 indicates the presence of channel 20 behind pipe string 11. To confirm this interpretation, scans with the oriented density logging tool were made in both pipe strings at 5,140 feet the depth denoted by the arrows in FIG. 7B. The oriented density patterns recorded are shown in FIG. 7C. The two pipe strings were centralized and the logs were recorded on the same instrument sensitivity. Therefore, with the same fluid in each pipe string essentially identical logs would be expected. However, it is to be noted that the pipe anomaly is weaker in the scan obtained from pipe string 10 than that obtained from pipe string 11. It is also to be noted that the formation anomaly is missing from the pattern obtained in pipe string 11 despite the fact that the formation should have been well within the field of view of the detector.

The lack of formation anomaly in the pattern recorded in pipe string 11 could have been caused by a mud filled channel between the pipe string and the borehole wall. The low density of the mud would cancel the effects of the higher density formation resulting in the pattern shown in FIG. 7C. The pattern obtained in pipe string 10 confirms this interpretation. The pipe anomaly is relatively low, thus indicating mud in the direction of the other pipe string. The mud could not be between the two pipe strings; otherwise the scan in pipe string 11 would also have seen a low pipe anomaly looking in the direction of pipe string 10. The normal formation anomaly observed by the logging tool looking from pipe string 10 indicates probably good cement between it and the wall of the hole. In this particular well a comparison of the two neutron logs indicated that the channel shown in FIG. 7A extended downward over a considerable distance but spiraled slowly. Approximately 800 feet lower in the well as illustrated in FIGS. 8A, 8B, and 8C the logs indicated that the channel had moved behind pipe string 10. For instance, in this interval, the neutron log for pipe string 10 shows a shift downward as indicated by the arrowed line in FIG. 8B. Oriented density log scans (FIG. 8C) in both pipe strings at that depth confirms the existence of channel 20. The off-center negative anomaly recorded in pipe string 10 is interpreted as a channel in the annulus behind pipe string 10 and extending clockwise for a short distance as shown in the well bore cross section of FIG. 8A.

In another well, a dual 2 7/8 inch in 7 7/8 inch hole, was drilled directionally to 7,426 feet. The centralized pipe strings were cemented in the borehole. A comparison of the two neutron depth correlation logs indicated a possible channel behind pipe string 10 extending vertically for several hundred feet and through both intended completion intervals (see FIGS. 9A, 10A, and 11A). The oriented density log scans shown in FIGS. 9B, 9C, 10B, 10C, and 11B, 11C were made in the intervals of interest to confirm channel 20. The logs of FIGS. 9B and 9C were made at a depth of 7,312 feet

and the logs of FIGS. 10B and 10C were made 11 feet lower and the logs of FIGS. 11B and 11C were made at a depth of 7,343 feet. Pipe string 10 was perforated from 7,312 feet to 7,317 feet into channel 20 as illustrated in FIG. 9A for the upper completion. Scans between the two intervals FIGS. 10B and 10C and within the lower interval FIGS. 11B and 11C confirmed that channel 20 was continuous between the two intervals. Therefore, pipe string 11 for the lower completion, was perforated with the shots oriented toward channel 20 for confirmation. The packer leakage test showed communication between the two zones and circulation was readily established between the two pipe strings. The bottom interval was squeezed while pressure was held on the other pipe string 10. After reperfing the lower interval, another packer leakage test revealed that the communication had been repaired.

The oriented density logs run heretofore have been uncalibrated. These logs have shown only relative changes in density as the tool is rotated. Thus logs run in one string alone have been difficult to interpret. The solid line curve of FIG. 17 is an example of a density scan obtained by a calibrated oriented density logging tool run in a single string of, for example 2 7/8 inch pipe cemented in a borehole. Since it is known that the density of cement is approximately 1.9 grams/cc and formation rock is 2.1 to 2.5 grams/cc, the log reveals that the pipe is surrounded by good cement and is eccentric in the borehole, as shown in FIG. 17A. The dash line curve of FIG. 17 is a log obtained when a fluid filled channel is present within the borehole. Since the densities of all commonly expected fluids (drilling mud, water, gas) in channels within the borehole are less than cement, formation rock or other pipe strings, their presence is revealed on the log when densities less than 1.9 grams/cc are detected. The dash line curve illustrates the log obtained with a mud filled channel adjacent to the pipe string of FIG. 17B. FIG. 18 illustrates the density log obtainable with the oriented density tool. It is readily apparent that without a density reference it is impossible to tell whether the log represents the borehole condition shown in FIG. 17A, with good borehole cement at point B, or the borehole condition shown in FIG. 17B with cement at point A and a fluid filled channel at point B.

Calibration of the oriented density tool can be accomplished by methods well known to ones skilled in the art. Other variations involving the use of a focused scattered gamma tool to scan the region surrounding pipe in a borehole will be readily apparent to those skilled in the art. For instance, one variation is a continuous scan of the borehole raising or lowering the tool.

The following example illustrates the effectiveness of a squeeze cementing operation in displacing mud when repairing a channel in the cement. Two strings of 2 7/8 inch casing pipe were cemented in a 7 7/8 inch hole for two pressure maintenance water injection completions 32 feet apart. Neutron correlation and oriented density logs showed severe channeling throughout the entire cement column particularly behind pipe string 10 (see FIGS. 12A, 13A, 14A). In some intervals, however, the channel was behind pipe string 11 or behind and between both pipe strings simultaneously. An attempt was made to avoid the channel in the initial completion attempt but the winding channel could not be avoided and circulation was established between the two pipe

strings. Salt water was circulated between the two pipe strings through the channel. After circulating cement between the two sets of perforations (7,158 to 7,165 feet in pipe string 11 and 7,197 to 7,217 feet in pipe string 10) the pattern of FIGS. 13A and 13B showed considerable improvement in the formation anomaly at 7,194 feet. The fact that the formation anomaly was still not as wide at the base as normally expected led to the conclusion that the mud had not been completely removed from the channel. Following the recompletion attempt, a wash acid job to increase injectivity reestablished communication between the pipe strings. A second cement circulation squeeze following a mud acid circulation cleanout operation improved the pattern further as shown in FIGS. 14A and 14B.

Thus, the oriented density log can be a valuable follow-up tool in improving remedial cementing techniques. Also, improved perforating gun design and more uniform and improved orienting practices have resulted from these tests. A change in perforating gun shot orientation is illustrated in FIGS. 15 and 16. Complete wellbore coverage from a multi-directional 45 degree shot phasing instead of the existing single phase 180 degree phasing is preferable for single string wells. A spread pattern arrangement instead of single phase orientation is recommended for multiply completed wells. These changes in shot phasing as illustrated in FIGS. 15 and 16 would provide better coverage of the wellbore and thus assure maximum opportunity for successfully repairing channels.

Changes and modifications may be made in the specific, illustrative embodiments of the invention shown and/or described herein without departing from the scope of the invention as defined in the appended claims.

Having fully described the method, objects and advantages of my invention, I claim:

1. A method for locating channels in cement resulting from the incomplete displacement of mud by said cement surrounding at least two pipe strings cemented in a well comprising:

running a neutron log in each of said pipe strings while recording each of said logs at the same logging instrument sensitivity and while maintaining the same reference zero for each logging run for detecting said channels in said cement; and comparing said neutron logs with each other to locate departures of said neutron logs from each other, said departures in said logs indicating said channels in said cement.

2. A method as recited in claim 1 including running a sonic log in open hole prior to cementing said pipe strings in said well; and comparing said neutron logs with said sonic log to aid in identifying said cement channels.

3. A method for locating channels in cement surrounding at least two pipe strings cemented in a well comprising:

running a neutron log in each of said pipe strings; comparing said neutron logs with each other to locate said channels in said cement, the differences in said logs indicating said channels in said cement; obtaining oriented density logs in each of said pipe strings at the same selected depths in said well; and

comparing said density logs to determine the location of said channels in said cement.

4. A method as recited in claim 3 including performing remedial operations including perforating into said channel.

5. A method for operating in a well containing at least two pipe strings cemented therein comprising the steps of:

running neutron depth correlation logs in each pipe string;
superimposing said neutron logs to the same reference zero; and
comparing said superimposed logs for departures of the neutron logs from each other to indicate location of channels in said cement.

6. A method as recited in claim 5, including:
running a sonic log in open hole prior to running and cementing said pipe strings in said well;
adjusting recording sensitivity of said neutron logs to the same relative sensitivity of said sonic logs; and

comparing said superimposed neutron logs and said sonic logs to indicate location of channels in said cement.

7. A method as recited in claim 6 including making at least one oriented density scan in one of said pipe strings at a selected depth to confirm location of a channel in said cement.

8. A method as recited in claim 6 including making at least one oriented density scan in each of said pipe strings at the same selected depth to confirm location of a channel in said cement.

9. A method as recited in claim 8 including perforating from within one of said pipe strings and directing the perforating shots either into or away from a channel located in said cement.

10. A method for operating in a well having at least two pipestrings cemented therein comprising the steps of:

running neutron depth correlation logs in each pipe string;
comparing said neutron logs for departures from each other to indicate location of channels in said cement;
making oriented density scans in each of said pipe strings at the same depth, at which depth a channel in said cement has been indicated by departures in said neutron logs; and
then lowering a directional perforating gun in one of said pipe strings and firing said perforating gun.

11. A method as recited in claim 10 in which the channel in said cement is located between the wall of the borehole and one of said pipe strings and said perforating gun is lowered in said one pipe string and directed to fire into said channel.

12. A method as recited in claim 10 in which the channel in said cement is located between the borehole wall and one of said pipe strings and said perforating gun is lowered in the other pipe string and directed to fire away from said one pipe string.

13. A method as recited in claim 10 in which the channel in said cement is located between the wall of the wellbore and one of said pipe strings and the perforating gun is lowered in said other pipe string and directed to fire as close to said one pipe string as possible.

14. A method for locating mud-filled channels in cement resulting from the incomplete displacement of mud by said cement, said channels surrounding at least one pipe string cemented in a well comprising:
scanning the region surrounding said pipe string with a calibrated oriented density logging tool; and
plotting said density scan, the density variations in said plot providing indications of channels in said cement.

15. A method as recited in claim 14 including performing remedial operations to offset adverse effects of channels existing in said cement.

16. A method for operating in a well in which at least two pipe strings are cemented therein comprising
logging said pipe strings to locate channels in the cement surrounding said pipe strings;
perforating into a channel in said cement in one pipe string at a selected depth;
perforating into said channel in another pipe string at a different selected depth; and
pumping cement into said channel to close said channel with the circulation flow path being through the perforations in said one pipe string, through said channel and out the perforations in said other pipe string.

17. A method as recited in claim 16 in which water is circulated through said circulation flow path prior to circulating said cement therethrough.

18. A method for locating mud-filled channels in cement resulting from incomplete displacement of mud by cement, said channels surrounding at least two pipe strings cemented in a well comprising:

running a neutron log in each of said pipe strings while recording each of said logs at the same logging instrument sensitivity and while maintaining the same reference zero for each logging run in order to determine the location of said channels in said cement, the differences in said logs indicating said channels in said cement.

19. A method as recited in claim 18 in which said logging instrument is centralized during each logging run.

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