Sept. 14, 1954 T. O. ALLEN ET AL 2,689,008

METHOD FOR CEMENTING WELLS

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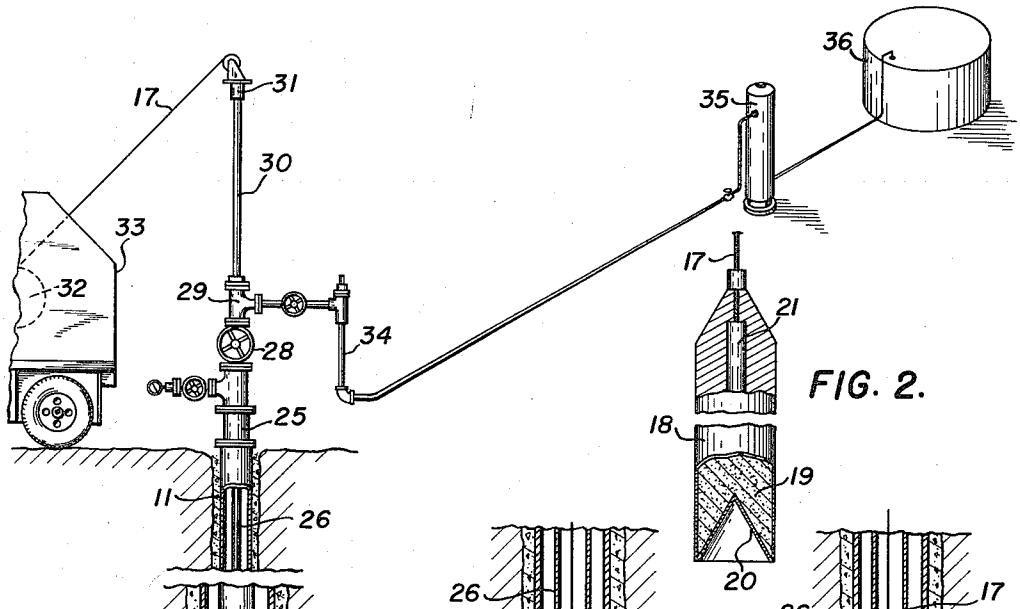

FIG. 2.

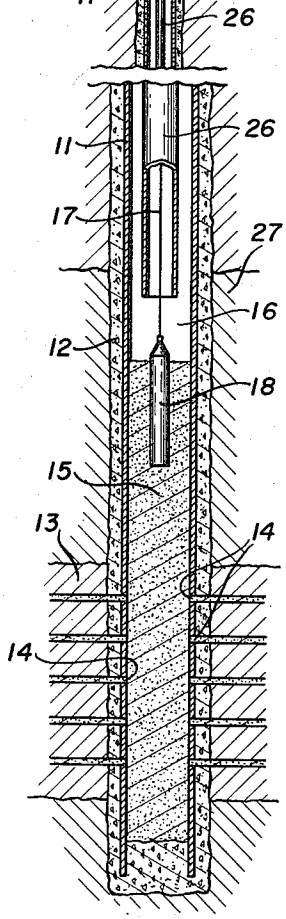

FIG. 3.

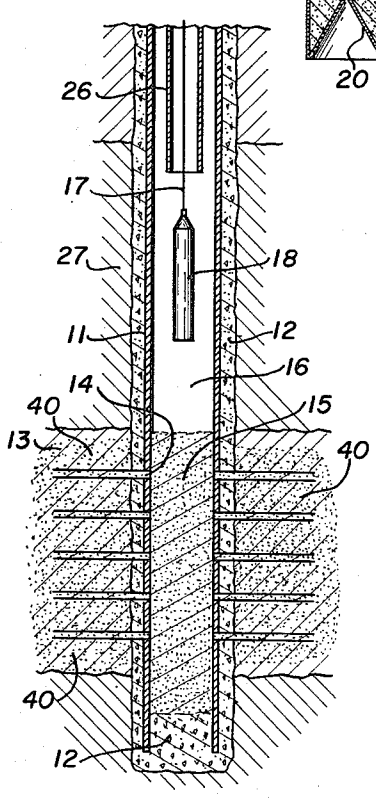

FIG. 4.

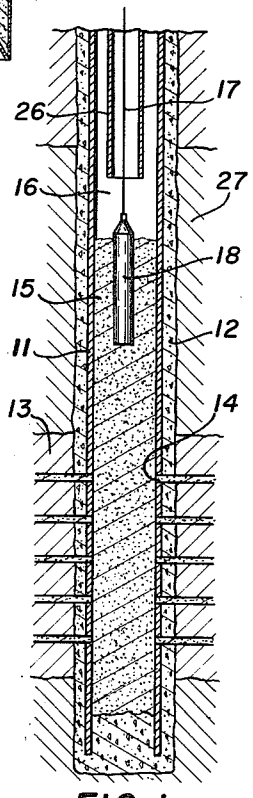

FIG. 1.

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METHOD FOR CEMENTING WELLS

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6 Claims. (Cl. 166—23)

1

The present invention relates to a process for cementing wells. More particularly, the invention relates to a method for squeezing cement from a well bore into a formation adjacent thereto.

The present invention may be described briefly as involving a method for cementing a well in which a body of a cementitious material is located in a well bore adjacent a formation to be sealed. A shock wave or waves is then generated in the body of the cementitious material which results in the cementitious material being forced into the producing formation, the effect of the high pressure shock wave or waves being to dehydrate rapidly the cementitious material when a hydraulic cement is employed and to cause substantially a flash setting thereof.

The shock wave employed in the practice of the present invention may be generated by discharging a high explosive in the well bore at a point above the formation to be sealed. Usually the high explosive will be detonated or discharged when in the body of the cementitious material itself but it is contemplated that the explosive may be placed in a fluid media including fluid cementitious material In short, it is contemplated that the body of fluid cementitious material may be located adjacent the producing formation and the well substantially completely filled with a fluid media such as drilling fluid which may be a suspension of solids in an aqueous or oily media.

We prefer to generate a high pressure shock wave in the well bore by detonating a high explosive in the cementitious body above the point to be sealed or in the well fluids above the formation to be sealed. The high explosive may be of any type, such as pentolite, tetryl, TNT and other well known high explosives and may be augmented by any suitably chosen booster explosive material. For example, tetryl could be used as a suitable booster for pentolite, since tetryl is more sensitive to shock than is pentolite. Furthermore, we prefer to employ the high explosive used to generate the shock wave in the form of a shaped charge such as is well known in which a cone-shaped cavity with the base open is provided in the high explosive. The cone-shaped cavity is suitably formed by employing a conical shaped wall to confine the lower

2

portion of the high explosive. The type of apparatus to be employed when using shaped charges will be described in further detail hereinafter.

The cementitious material employed in the practice of the present invention may suitably be a hydraulic cement, such as Portland cement, either of the normal type or slow setting cement. The hydraulic cement may also be an anhydrous gypsum cement such as the type known on the market as Cal-Seal. The cementitious material may also be a thermosetting plastic, such as a resinous material of the phenol-formaldehyde type. Other thermosetting plastic materials such as urea-formaldehydes and melamine-formaldehydes may be used as the cementitious material in lieu of hydraulic cement. Ordinarily, however, we will prefer to use a hydraulic cement rather than a thermosetting plastic but some conditions will make the use of the latter preferable

In practicing the present invention the desired cementitious material, such as thermosetting plastic or cement, would be placed in the well at a proper depth to cover the area to be sealed with a sufficient quantity of material employed to create an excess of sealing material standing above the area to be sealed. Sealing materials may be placed by conventional techniques, such as by use of a dump bailer or circulation. The container or tool in which the high explosive is arranged or in which the material used to generate the shock wave is employed would then be run on pipe or on a wire line to a point within the bore above the top of the sealing material. Subsequent detonation or discharge of the explosive creates high pressure gases resulting in a shock wave which forces the sealing material in the formation or through perforations when a cased well bore is treated.

As mentioned before, it is preferred to use a shaped charge in generating the high pressure shock wave since the shaped charge has the particular advantage of a directional explosion by positioning the tool containing the shaped charge above the area to be cemented. All of the high pressure gases generated by detonation are directed downwardly in the well bore thus causing temporary confinement and compression of the sealing material below the tool from which the sealing material or cementitious material could

only escape into the permeable earth formations or through the casing or liner perforation openings.

Furthermore the use of a hydraulic cement for a sealing material enhances the advantages of the explosive squeeze tool of the present invention because the high pressures generated by detonation of an explosive charge causes dehydration of the cement adjacent to the formation as well as forcing the cement into the formation or casing perforations. Effective dehydration by high pressure gases from an explosion results in an effective seal because dehydration is accomplished in a substantially faster operation than ordinarily by virtue of the pressure generated by the high explosive being detonated in the well bore resulting in a shock wave therein.

The invention will be further illustrated by reference to the drawing in which

Fig. 1 shows an arrangement of apparatus in a perforated cased well bore with a body of fluid cementitious material arranged therein prior to the generation of the high pressure shock wave;

Fig. 2 is a detail of apparatus employed for generating a shock wave in the well bore;

Fig. 3 shows an arrangement of apparatus prior to shooting in a permanent type well completion arrangement; and

Fig. 4 shows the condition of a well after detonation of a high explosive therein and generation of a shock wave in the fluid cementitious material.

Referring now to the drawing in which similar numerals will be employed to designate identical parts, numeral 11 designates a cased well bore which has been cemented by setting of cement around the casing as indicated by numeral 12. The cased well bore penetrates a producing formation 13 which it is desired to seal and which has been perforated by a suitable gun perforator. As will be seen the casing 11 has been perforated at a plurality of points indicated generally by numeral 14.

Arranged in the casing 11 by conventional well-known techniques, such as by circulation or by a dump bailer, is a body of fluid cementitious material 15. Above the body of fluid cementitious material and extending substantially to the well head substantially completely filling the well is a body of a fluid medium 16 which may be a drilling fluid either of an aqueous or an oily base. Suspended from the well head, not shown, by a wire line or an electric cable 17 is a container or tool 18 which is shown more clearly in Fig. 2. This container or tool 18 may have arranged therein a high explosive. A high explosive 19 is a shaped charge and is confined in tool 18 by a conical wall member 20 constructed of a suitable material which may be a ferrous or non-ferrous metal. The function and use of shaped charges are well known and further details of the jetting, exploding action thereof will not be given here since a discussion thereof will be found in the literature such as in the patent to Muskat et al., 2,494,256. The tool 18 is suspended by means of wire line 17 which may suitably be an electrical cable which acts as a suspending means and also as means for providing electrical energy to detonator 21 which may be of a well known type which serves to fire electrically the high explosive 19 in the tool 18.

Referring now to Fig. 3, it will be seen that the casing 11 has been cemented by cement 12 in the well bore and that a plurality of perforations 14 have been formed in casing 11 by a gun perforator as is well known. Similarly, as in Fig. 1, a body of cementitious material 15 has been arranged in the casing 11 and a container or explosive tool 18 lowered down the well bore from the well head 25 as will be described further. In this embodiment of our invention a tubing 26 is arranged in the well bore above a formation 13 which is to be sealed or cemented.

The wire line or electric cable 17 extends to the well head 25 through the usual valve equipment and control apparatus indicated generally as 28. Arranged above the control apparatus 28 and above the T connection 29 which connects to the tubing 26 is a pipe 30 provided with a stuffing box 31 through which the wire line or cable 17 extends to reel or drum 32 which suitably may be arranged in a service truck 33. Connections 34 to tubing 26 allow the well fluid such as crude petroleum to be routed therethrough to gas separator 35 and lease tank 36.

Referring now to Fig. 4, the condition of the cased well bore 11 immediately after the shooting is shown. The shaped charge 19 in the tool 18 has been detonated which caused generation of a high pressure shock wave in a body of cementitious material 15 which caused the cementitious material 15 to be forced out through the perforations 14 into the producing formation 13 as indicated generally by numeral 40 causing a substantial sealing of the formation 13 from the formation 27. The tool 18, if it has not been destroyed by the rapid generation of gases, may then be retrieved by reeling up the wire line or removal of cable 17 on drum 32.

The mode of operation of the apparatus illustrated in Figs. 1 to 4 is substantially as follows:

As mentioned before the body of cementitious material is located in the well bore adjacent the formation or in the region of or adjacent the perforations to be sealed. A tool or container containing a high explosive or a material which will generate a high pressure shock wave is then lowered into the well bore on a wire line or electric cable. The high explosive is then discharged and the material which is used to generate the shock wave is caused to expand to generate gases as has been described before to cause rupture of the container. Assuming that a high explosive shaped charge is employed gases are rapidly generated which causes rapid dehydration and forcing of the cement into a producing formation to be sealed or through perforations into a formation to be sealed. The rapid expansion of gases serves to lift the column of drilling fluid in the well bore above the point where the explosive is discharged, causing displacement of a portion of the drilling fluid from the well bore. The amount displaced is not large, however, and the remainder of the drilling fluid in the well then drops back and exerts a hammer effect on the cement in the well bore and that which has been displaced into the formation treated. In effect then, a dual action is obtained in our invention: the high pressure shock wave serves to displace the cement into the formation and dehydrate same in place and the hammer of the descending column of well fluid causes further squeezing of cement, insuring complete filling of voids and crevices. Thereafter the tool employed to cause rapid setting of the cement or cementitious material is then withdrawn. The well treated, as described, may then be further serviced or operated.

As seen from the foregoing description taken with the drawing the invention is not limited to

cementing in cased boreholes but may suitably be used in an open borehole. It is possible in accordance with the practice of our invention to generate a high pressure shock wave in cementitious material of the types mentioned before which will cause rapid setting of the cementitious material in the perforations or in the formation. This rapid setting of the cementitious material leaves the excess of the cementitious material in the well bore in a fluid condition. It may be desirable to remove such excess fluid cementitious material which may be done by conventional means, such as by bailing or by circulation.

The invention is also susceptible to obtaining very tight seals in formations which it is desired to seal off from the well bore. For example, by virtue of the high pressure shock waves the cementitious material when the pressure of the shock wave is sufficiently great and the permeability of the earth formation is sufficiently high causes displacement of cement into the formation. This may be in the form of filling pore voids a relatively short distance from the well bore. It is specifically contemplated that the high pressure shock wave may cause hydraulic fracturing of the formation along formation bedding planes or native formation fractures resulting in the cement being displaced a considerable distance from the well bore by the high pressure shock wave.

In the detonation of high explosives in accordance with the present invention in a well bore to cause cementing in perforations or formations, the detonation of the high explosive generating high pressure gases in the cementitious material will initiate a shock wave therein. This wave moves sealing material or cementitious material into any available openings, such as perforations or pore voids in the face of permeable formations where the desired sealing or cementing is to be effected. Since the cementing material has previously been located over the interval of the formation to be cemented or sealed the effect of the shock wave is to insure complete filling of openings by pressure differential or squeeze from the well bore to the formation.

The present invention is not to be limited to the particular examples which are given by way of illustration and not by way of limitation. For example, a plurality of shots may be desirable where it is desired to seal or cement a plurality of formations or to discharge high explosives in sequence to cause build up or setting of layers of cementitious material in perforations or in formations. For example, a plurality of tools, such as shown in Fig. 2, may be spaced at intervals along wire line 17 and each of the tools containing a high explosive may be detonated in sequence with the lower being exploded first and the subsequent charges being exploded sequentially going up the well bore.

The invention may be used in building up desired seals or used in cementing operations in stages where fracturing occurs easily in formations of great permeability. The invention may also be used in building up a sheath around a well bore thereby plugging formation voids, fractures, and crevices in combatting lost returns in drilling operations.

It may be seen from the foregoing description that the invention is broadly directed to locating a body of cement in a well bore and generating in said body of cement a shock wave which causes dehydration of the cementitious material and setting of the cement in bore voids and crevices adjacent to the well bore. It is, therefore, intended that the invention is broadly directed to such operations.

The nature and objects of the present invention having been completely described and illustrated, what we wish to claim as new and useful and to secure by Letters Patent is:

1. A method for cementing a well having a perforated casing therein which comprises locating a body of hydraulic cementitious material in said perforated casing in the region of, and adjacent said perforations, locating a high explosive detonating charge in the body of cementitious material, and discharging said charge and forcing at least a portion of said cementitious material through the perforations, thereby dehydrating and setting said portion of cementitious material to seal the perforations.

2. A method for cementing a well having a perforated casing therein which comprises locating a body of hydraulic cementitious material in said perforated casing in the region of and adjacent said perforations, locating a high explosive detonating charge in the body of cementitious material, discharging said charge and forcing at least a portion of said cementitious material through the perforations, thereby dehydrating and setting said portion of cementitious material to seal the perforations, and removing excess remaining cementitious material from said casing after discharging said charge and before said excess cement has set.

3. A method for cementing a well having a perforated casing therein which comprises locating a body of fluid hydraulic cementitious material in said perforated casing in the region of and adjacent said perforations, locating a downwardly directed high explosive detonating charge in the body of cementitious material, discharging said charge and forcing at least a portion of said cementitious material through the perforations, thereby dehydrating and setting said portion of cementitious material to seal the perforations.

4. A method in accordance with claim 3 in which the downwardly directed explosive charge is a shaped charge.

5. A method for cementing a well having a perforated casing therein which comprises locating a body of fluid hydraulic cementitious material in said perforated casing in the region of and adjacent said perforations, locating a high explosive detonating shaped charge in said body of cementitious material above said perforations, discharging said charge and forcing at least a portion of said cementitious material through the perforations, thereby dehydrating and setting said portion of cementitious material to seal the perforations and removing excess fluid cementitious material from said casing after discharging said charge.

6. A method for cementing a well having a perforated casing therein in which a column of fluid media is arranged substantially filling said well which comprises locating a body of fluid hydraulic cementitious material in said perforated casing in the region of and adjacent said perforations below the column of fluid media, locating a downwardly directed high explosive detonating shaped charge in the body of cementitious material above said perforations, discharging said charge and forcing at least a portion of said cementitious material through the perforations, the discharge of said charge lifting the column of fluid media in said well and then dropping

same on said cementitious material, thereby dehydrating and setting said portion of said cementitious material to seal the perforations, and then removing excess remaining fluid cementitious material from said casing after said fluid media has been lifted and dropped.

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