April 8, 1952 H. M. GREENE 2,591,807

OIL WELL CEMENTING

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Fig. 1.

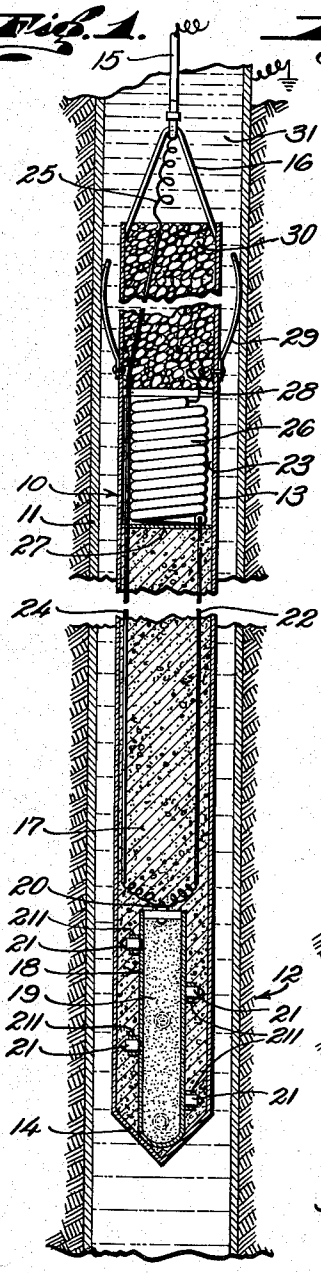


Fig. 2.

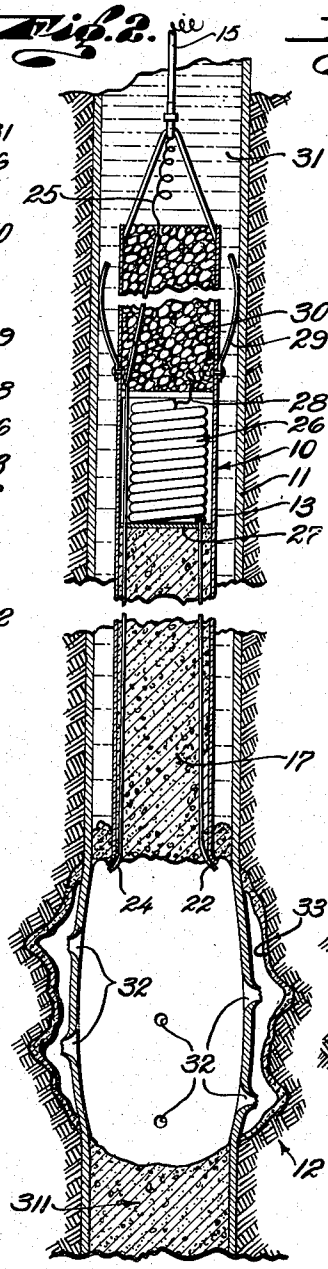
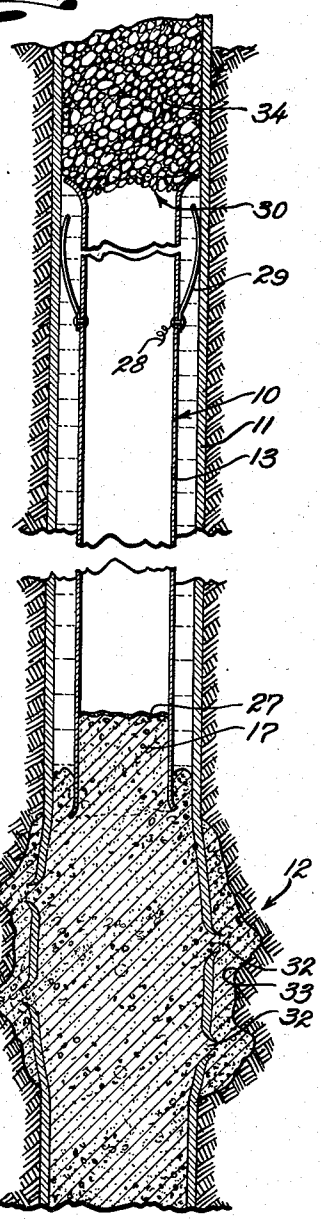


Fig. 3.



HASKELL M. GREENE
INVENTOR.

BY H. Calvin Tate

ATTORNEY

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OIL WELL CEMENTING

Haskell M. Greene, Whittier, Calif.

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7 Claims. (Cl. 166—1)

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This invention has to do with systems for carrying out cementing operations in oil wells, and is directed particularly to improved methods and equipment for displacing and compacting cement into a water shut-off or like zone by explosive force. The invention represents various improvements over the practices described in Patent No. 1,734,670, issued November 5, 1929, on "Means for Cementing Oil, Gas and Water Wells."

According to the general method contemplated, a vertically elongated body of cement is lowered in a cased or uncased well bore to the cementing zone, for example a cased location where the cement is to be displaced to and compacted about the outside of the casing. (The same general procedure is applicable to cavitating and cementing in open hole.) By detonating an explosive charge in the cement mass, the resulting force tends to deform or cavitate the bore wall, and to displace the cement into the cavity with great force resulting in a densely compacted, strong binding and fluid impervious mass when set.

One of my major purposes is to confine the explosive force in a manner assuring its most effective application to the cement. For this purpose I place in the well bore above the cementing zone a plug or barrier sufficient to confine the explosive force, at least to a substantial degree, to the cementing zone below. Preferably, formation of the barrier is effected by virtue of and in closely timed relation to the creation of an explosive or pressure generating force, so that the effect of that force is confined for the most part to displacement of the cement to the intended location. Particularly contemplated is the provision in the cement container of a mass of material which is caused by the explosion force to bridge across and plug the well bore.

The invention further contemplates effecting the ultimate cement displacement by two explosive forces, the first acting to rupture the cement container, cavitate the well and perforate the casing (when the hole is cased) and to cause initial displacement of the cement into the cavity. A second explosive or pressure generating force, preferably of less shock intensity and greater duration than the first, is applied to a top portion of the cement body to serve the dual purposes of forming the barrier and of generating a sustained pressure which continues displacement and compaction of the cement to the limit of existing conditions. Of advantage is a timed or sequential relation in the firing of

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the two explosive charges, the second being detonated preferably a fraction of a second following detonation of the first so that perforation, cavitation and initial and final displacement of the cement follow in the order stated.

Where casing is to be opened to pass the cement into a space adjacent the formation, perforation of the casing may be accomplished by the simple expedient of placing at the outside of or within the cement mass a number of projectiles, preferably bullet-like and placed in prearranged order, which are driven by the cement-displacing explosion force through the casing, all as will later appear.

The abovementioned as well as various additional features and objects of the invention will be understood to better advantage from the following detailed description of certain typical procedures and equipment illustrated by the accompanying drawing, in which:

Fig. 1 is a sectional view showing the equipment lowered to an intermediate cementing zone in the well;

Fig. 2 is a similar view illustrating the condition of the hole and cement at the instant following explosion of the first charge; and

Fig. 3 illustrates the formation of the plug and ultimate displacement of the cement after explosion of the second charge.

As a typical environment, the cementing equipment, generally indicated at 10, is shown to be lowered in a well containing the usual casing 11, with the lower portion of the equipment brought opposite a zone 12 to be cemented as for shut-off of water formation, or any other purpose. The apparatus comprises an elongated shell 13, typically of aluminum base or other ruptureable material, closed at its lower guide end 14 and open at the top. The shell is suitably suspended, as by an electrical cable 15 attached to the bail 16. The shell contains an extended body of cement 17 sufficient in quantity for the particular cementing job.

Embedded in the bottom portion of the cement is a capsule 18 containing an explosive charge 19 to be fired by detonator 20 in the capsule head. Where casing is to be perforated, the capsule may serve also as a support for a plurality of radially positioned, bullet-like metal projectiles 21, received in barrels or sleeves 211 and pointed outwardly toward the casing. The detonator 20 is electrically connected to a conductor 22 extending upwardly into space 23, and with a second conductor 24 extending upwardly through the shell to connect at 25 with the conductor cable

15. The charge 19 is a relatively high velocity charge, rated at a velocity of for example 7000 feet per second, capable of creating a more instantaneous or shock explosion for cavitation and perforation of the casing. Being of this type, the charge 19 lacks the capacity of the slower burning upper charge 26 for prolonged gas and pressure generation.

The second explosive charge 26 contained in space 23 which may be separated from the cement by a suitable medium 27, typically is shown to be in the form of an explosion-type fuse connected to conductor 22 and at 28 to one of the casing-engaging spring guides 29. The explosive 26 may be of any of the known types and compositions characterized by its tendency to ignite practically instantaneously throughout its length, and to have, with relation to the first described charge 19, more sustained pressure and heat generating qualities. For example, the charge 26 may have a rated explosive velocity of around 2600 to 2800 feet per second, which gives the charge, upon detonation, less shattering force than the lower charge, and a tendency for prolonged burning to create a relatively extended pressure surge. To promote sustained heating, the charge 26 may contain a substantial quantity of small metal particles which tend to hold heat acquired by the initial detonation. Where the claims refer to an "explosive" it is intended to include any material capable upon ignition or detonation of producing large quantities of gas. Similarly, the term "explosive force" refers to the force created by any such gas generating material.

Above the charge 26, shell 13 contains a barrier forming material 30, which in the broad contemplation of the invention may be of any suitable composition capable of becoming displaced by the explosive force to bridge across the well or casing bore, at least to the extent of largely confining the second explosion created pressure to the zone below. As illustrative, the material 30 is shown to comprise a mass of small gravel-like and sand particles capable of expulsion from the shell and compaction by the combined effects of the force of the explosion below and the fluid column resistance above, to form a barrier or bridge mass in the casing.

Assuming the shell to be lowered to the position of Fig. 1 in a hydrostatic column 31, passage of current through the conductor cable 15 first fires the detonator 20 to explode the charge 19, the effect of which is to drive the projectiles 21 through the casing to form the perforations 32, see Fig. 2, and to start the cement displacement through the perforations into a cavity 33 formed or enlarged by the explosive force. A portion of the cement may bridge the casing below the explosion zone, as indicated at 311. The bottom extent of the container 13 is of course ruptured leaving the upper extent of the cement column free for downward displacement in the casing and out through the perforations. The burning qualities of the charge 26 are such that upon passage of the current through it, the fuse will explode a fraction of a second following explosion of the charge 19. The initial effect of the explosive force of the upper charge is to displace the material 30 upwardly and out of the shell into a barrier mass 34, in which the particles may become densely compacted into a substantially fluid imprevious body which plugs the casing as illustrated in Fig. 3. As will be understood, the upper portion of the casing 13 will at least be deformed, and frequently completely ruptured by the internal explosive pressure. The relatively prolonged pressure generation resulting from burning of the upper charge, displaces the cement downwardly with great force so that it may be caused to completely fill the casing and cavity 33 at the zone 12, as an extremely dense and compact mass strongly bonded to the formation by reason of the transmitted pressures and condition of the cement. Thus the residual effect of the explosion of charge 26 and the closed condition at 34 of the hole above, is to apply to the cement a sustained pressure assuring its retention in place until the cement sets. Thereafter the barrier 34 and cement plug may be drilled through, or allowed to remain, depending upon the objectives of the particular operation.

I claim:

1. Apparatus for depositing cement in a zone within a well bore, comprising a vertically elongated container to be lowered to said zone and containing a body of cement, a relatively high velocity explosive charge in a lower portion of said container and serving upon ignition to cavitate the well bore at said zone, a relatively lower velocity explosive charge in the container above said body of cement serving upon ignition to force cement downwardly and outwardly into said cavity, and fuse means for igniting said charges extending first to said high velocity charge and then to the lower velocity charge to ignite the charges in that order.

2. The method of depositing cement in a zone within a well bore, that includes lowering in the well to said zone a vertically elongated body of cement, creating an explosive force at the lower portion of said body, cavitating the bore wall adjacent said lower portion of the body and moving the cement into the resulting cavity both by virtue of said force, and creating a second explosive force above said body resulting in prolonged application of pressure, independently of the normal well pressure, to cause displacement and compacting of the cement downwardly and into the cavity.

3. The method of depositing cement in a zone within a well bore, that includes lowering in the well to said zone a vertically elongated body of cement, creating an explosive force at the lower portion of said body, cavitating the bore wall adjacent said lower portion of the body by said force, creating above said body and below a location where said bore is to be plugged a second and sequential explosive force, and forming at said location a plug across the bore and displacing and compacting the cement against the bore wall at said zone by virtue of said second explosive force.

4. The method of depositing cement in a zone within a well bore, that includes lowering in the well to said zone a vertically elongated body of cement, creating at a lower portion of said body a relatively high velocity explosive force, cavitating the bore wall adjacent said lower portion of the body and moving the cement into the resulting cavity both by virtue of said force, igniting above said body and below a location where said bore is to be plugged a relatively slow burning charge, forming at said location a plug across the bore by the combustion force of said charge, and compacting the cement against the bore wall at said zone also by sustained application of pressure to the cement resulting from the burning of said charge.

5. Apparatus for depositing cement in a zone within a well bore, comprising a vertically elongated container to be lowered to said zone and

containing a body of cement, an explosive first charge in a lower portion of said container and serving upon ignition to cavitate the well bore at said zone, a second ignitable charge in the container above said first charge, radially expansible plugging means carried by the container above said second charge and adapted to be expanded against the bore wall by the force of said second charge to form a barrier across the well bore above said cavity, and means for igniting said charges.

6. Apparatus for depositing cement in a zone within a well bore, comprising a vertically elongated container to be lowered to said zone and containing a body of cement, an explosive first charge in a lower portion of said container and serving upon ignition to cavitate the well bore at said zone, a second ignitable charge in the container above said body of cement, radially expansible plugging material carried by the container above said second charge and adapted to be expanded against the bore wall by the force of said second charge to form a barrier in the well bore above said cavity, and means for sequentially igniting said charges in the order named.

7. The method of depositing cement in a zone within a well bore, that includes lowering in the well to said zone a vertically elongated body of cement, creating an explosive force at the lower portion of said body, cavitating the bore wall adjacent said lower portion of the body by virtue of said force, and creating a second explosive force above said body resulting in prolonged application of pressure, independently of the normal well pressure, to cause displacement and compacting of the cement downwardly and into the cavity.

HASKELL M. GREENE.

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