April 30, 1946. C. O. DAVIS ET AL 2,399,211

METHOD OF PERFORATING WELL CASINGS

Filed March 19, 1942

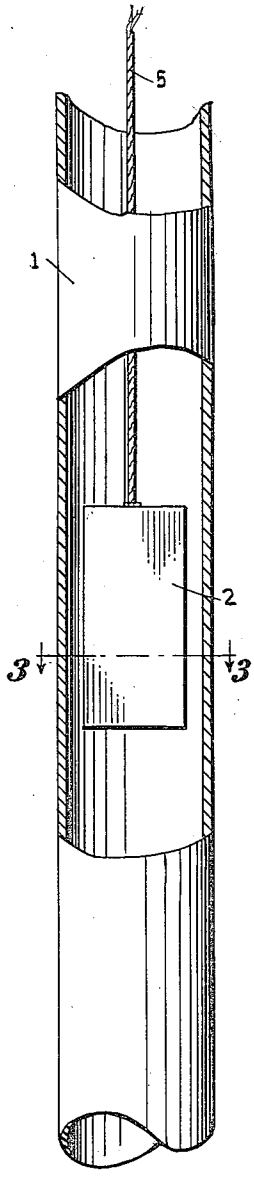

Fig. 1

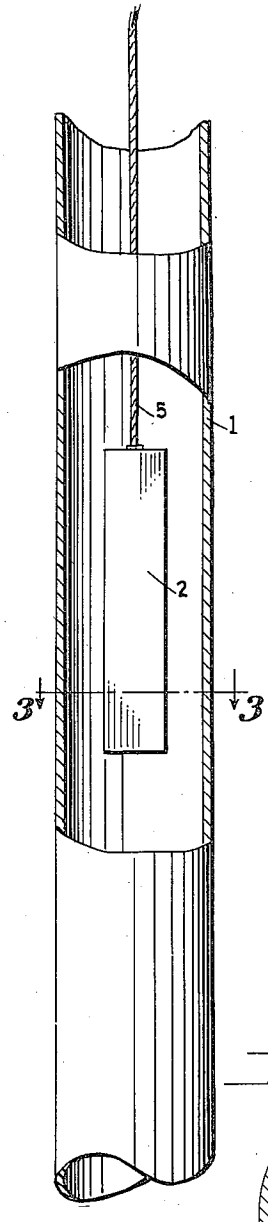

Fig. 2

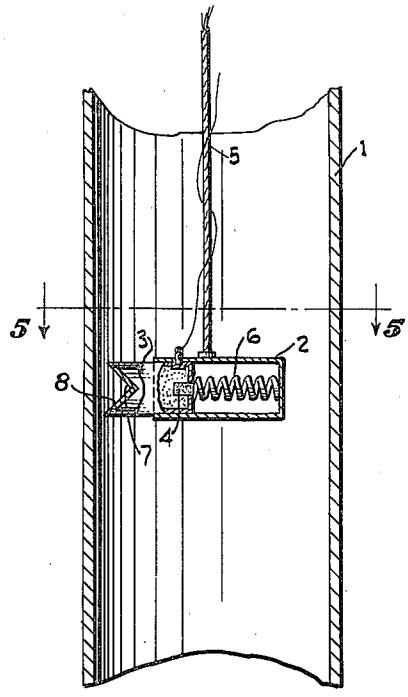

Fig. 4

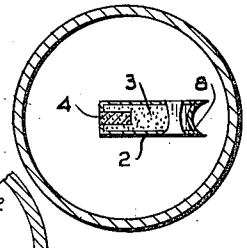

Fig. 3

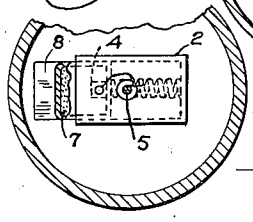

Fig. 5

C. O. Davis
L. A. Burrows
INVENTORS

BY Thos. A. Wilson
ATTORNEY

Patented Apr. 30, 1946 2,399,211

UNITED STATES PATENT OFFICE

2,399,211

METHOD OF PERFORATING WELL CASINGS

Clyde O. Davis and Lawton A. Burrows, Woodbury, N. J., assignors to E. I. du Pont de Nemours & Company, Wilmington, Del., a corporation of Delaware

Application March 19, 1942, Serial No. 435,342

8 Claims. (Cl. 164—0.5)

This invention relates to a novel method of perforating well casings, especially in oil and gas wells, and more particularly to a method adapted to more efficient utilization of the explosive effect.

The use of explosive charges in so-called gun perforators is well known for the propulsion of projectiles through well casings, whereby ready access is provided to formations and strata previously closed off by cementing. By such methods, accurate perforation can be accomplished at the desired place and there is no breaking up of the casing or cement.

The object of the present invention is an improved method of perforating well casings whereby a different type of explosive may be employed. A further object is a method allowing a better directed explosive effect. A still further object is a method involving the use of less complicated means for effecting the perforation. Additional objects will be disclosed as the invention is described more at length hereinafter.

We have found that the foregoing objects are accomplished when we employ a detonating explosive as the source of the perforating force and when a hollowing of the explosive charge is provided on that side toward which the explosive force is to be directed. Preferably, also, we maintain adjacent to the hollowed portion of the charge, and between it and the casing, a metal piece conforming generally in shape to the hollowed portion of the charge and adapted to function as a projectile at the time of the explosion. This cavity or hollowing in the charge may take the form of an inverted cone. It may be oval or hemispherical in form or be an indentation of any shape. Under all such arrangements, the explosive having a hollowing or cavity in the side directed toward the wall of the casing, with or without a metal lining in said cavity, is capable of perforating the casing. When a suitable liner is used, not only is the casing perforated, but a metal projectile formed from the liner is projected at very high velocity through the perforation and into the adjacent strata.

A detonating explosive is used according to the invention, and preferably one of high density, such as a pressed or cast solid organic nitrate or nitrocompound or a high density blend of more than one such compound. Compressed pentaerythritol tetranitrate is a suitable material for such use, or compressed or cast blends of this compound with trinitrotoluene, for example in 50–50 mixtures. Likewise, trimethylene trinitramine is a suitable explosive, as are its high density mixtures with TNT, one suitable blend of these consisting of 80 parts of the former and 20 parts of TNT. The foregoing materials are well adapted for our use since they possess high strength and high velocity and at the same time pick up rapidly to their maximum velocity; hence, they are highly brisant explosives when used in relatively small amounts. Various other detonating explosives, however, are well adapted for use according to our invention. High strength commercial dynamites may be used, also, but are less adapted in many ways than the solid organic explosives.

In order to describe the invention more clearly, reference is made to the accompanying drawing, which will illustrate several embodiments for carrying out the process. This is done by way of illustration only and is not to be regarded in any way as a limitation on the scope of the invention.

Referring generally to the drawing, Figure 1 is a vertical cross-section of a portion of the casing, with suspended gun perforator. Figure 2 is a similar cross-section showing a different type. Figure 3 is a section illustrating an explosive charge according to Figures 1 and 2. Figure 4 is a modification which is a vertical elevation and cross-section of a portion of the casing showing the gun perforator and one method of placing the explosive in position for firing. Fig. 5 is a section on 5—5 of Fig. 4.

Referring in greater detail to the various figures in the drawing, 1 in Figure 1 represents a fragment of well casing showing the gun perforator housing 2 suspended within said casing by a lowering line 5. In Figure 2 a similar assembly is shown with the gun perforator housing 2 occupying a relatively smaller portion of the bore and with more space between the outer surfaces of the perforator housing and the casing wall. Figure 3 shows a cut-away view of the explosive charge with respect to the carriage in the casing conforming to Figure 1. The explosive charge 3 of compressed pentaerythritol tetranitrate, of a density of 1.60, is enclosed in a water-tight envelope, said container of the explosive having an oval hollowed section 8 on the side adjacent to the casing to be perforated. The detonator 4 is adapted to bring about the explosion of the main charge 3. The means of ignition of the detonator is not shown, but this will preferably be brought about electrically with the use of suitable lead wires from the source of current.

Figure 4 illustrates a section of a casing 1 showing the gun perforator housing or carriage 2 suspended by lowering line 5. The housing in this figure is spaced at a considerable distance from

the casing, in accordance with the arrangement of Figure 2. By means of spring mechanism 6, the explosive charge 3 is released and allowed to spring out so that it is positioned close to the casing wall. The explosive charge consists of a cast mixture of pentaerythritol tetranitrate and TNT in equal proportions, and has a conical depression 7 at the outer surface. Preferably, this is enclosed by a conical metal piece 8 which will function as a high velocity projectile at the time of explosion. The metal cone is not essential, however, and the increased blasting effect of the explosive will perforate the casing in either case. Initiation is brought about by means of detonator 4, preferably initiated electrically by means not shown in detail.

The invention employs a detonating explosive, that is to say one having a decomposition velocity above 1000 meters per second, and desirably very much higher than that, when measured by methods ordinarily employed for high explosives. The relatively small diameters of well bores inside the casing make it impossible to use gun barrels of considerable length; hence the ordinary types of low velocity or deflagrating explosives such as are commonly employed to propel bullets or projectiles are at a disadvantage. For such explosives, the barrel is not sufficient in length to allow the building up of the desired amount of pressure. With detonating explosives, on the other hand, the decomposition or conversion of the solid explosive into hot gases is so nearly instantaneous that the initial pressure is sufficient to impart the desired perforating force. The provision of an inverted cone or other indentation in the explosive, together with the use of a projectile of the same general shape, allows better direction of the pressure as well as greatly increased explosive effect, such as to perforate cleanly and deeply the casing and neighboring strata.

Since the action of detonating explosives is rather violent, special arrangements are desirably made for protecting the gun carriage and for minimizing damage. In some cases, it may be desirable to use a gun body of easily destructible material, for example of cardboard, various plastics, and the like. The carriage will then presumably be replaced with each new series of shots. In other cases, for example, when employing the assembly shown in Figure 4, the explosive charge may be moved outward toward the casing previous to the firing, so that the housing is protected. It will be understood that in such cases the explosive may or may not be enclosed in a watertight container, as desired. Explosives of the type cited are generally insensitive to the action of water and impervious thereto, particularly when in cast form, which is a preferred condition of charge.

Our invention has been described at some length in the foregoing. It will be understood, however, that many variations may be made in the assembly of the gun perforator elements, in the composition of the explosive used, and in other details of procedure, without departure from the spirit of the invention. We intend to be limited therefore only by the following patent claims.

We claim:

1. The method of perforating well casings which comprises introducing into a well at approximately the depth where perforation is desired at least one charge of a detonating explosive, providing a hollowing of said charge on one side, bringing about the detonation of said explosive charge, and thereby effecting the perforation of the casing on the side adjacent to the hollowed portion.

2. The method of perforating well casings which comprises introducing into a well at approximately the depth where perforation is desired, at least one charge of a detonating explosive comprising pentaerythritol tetranitrate, providing a hollowing of said charge on one side, bringing about the detonation of said explosive charge, and thereby effecting the perforation of the casing on the side adjacent to the hollowed portion.

3. The method of perforating well casings which comprises introducing into a well at approximately the depth where perforation is desired, at least one charge of a detonating explosive comprising a high density blend of pentaerythritol tetranitrate and trinitrotoluene.

4. The method of perforating well casings which comprises introducing into a well at approximately the depth where perforation is desired, at least one charge of a detonating explosive comprising a high density blend of trimethylene trinitramine and trinitrotoluene.

5. The method of perforating well casings which comprises introducing into a well at least one charge of a detonating explosive, providing a hollowing of said charge on one side, maintaining adjacent to and between said hollowed portion and the casing a rigid projectile shaped in general conformity to the hollowed portion of the explosive, effecting the detonation of the explosive charge, and causing the perforation of the casing by said projectile.

6. The method of perforating well casings which comprises introducing into a well at least one relatively high density charge of a solid detonating explosive impervious to the liquids normally present in oil wells, providing a hollowing of said charge on one side, maintaining adjacent to said hollowed portion a metal projectile shaped in general conformity to the hollowed portion of the explosive, exploding the charge, directing the force of the charge toward said metal, and thereby effecting perforation of the well casing.

7. The method of perforating well casings which comprises introducing into a well at least one relatively high density charge of a detonating explosive, enclosing said charge in a substantially impervious container, maintaining a hollowed metal piece adjacent to the explosive charge with the hollowed side toward the casing, exploding the charge, directing the force of the explosion toward said hollowed metal piece, and thereby effecting perforation of the well casing.

8. An explosive unit adapted to the perforation of oil well casings comprising a container and an explosive charge therein, said charge being provided with a hollowed portion on one side.

CLYDE O. DAVIS.
LAWTON A. BURROWS.