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DETONATION OF UNPRIMED BASE CHARGES

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2 Sheets-Sheet 1

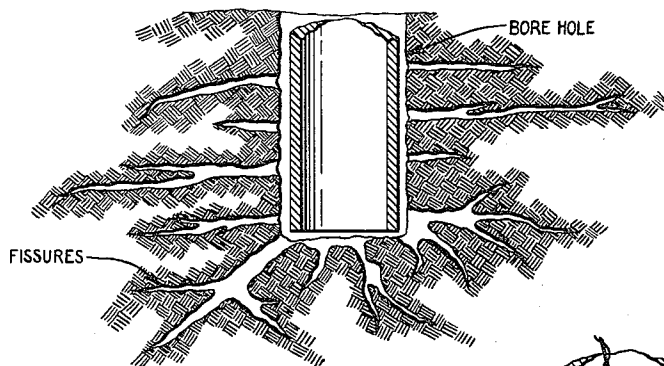


FIG. 1.

FIG. 2.

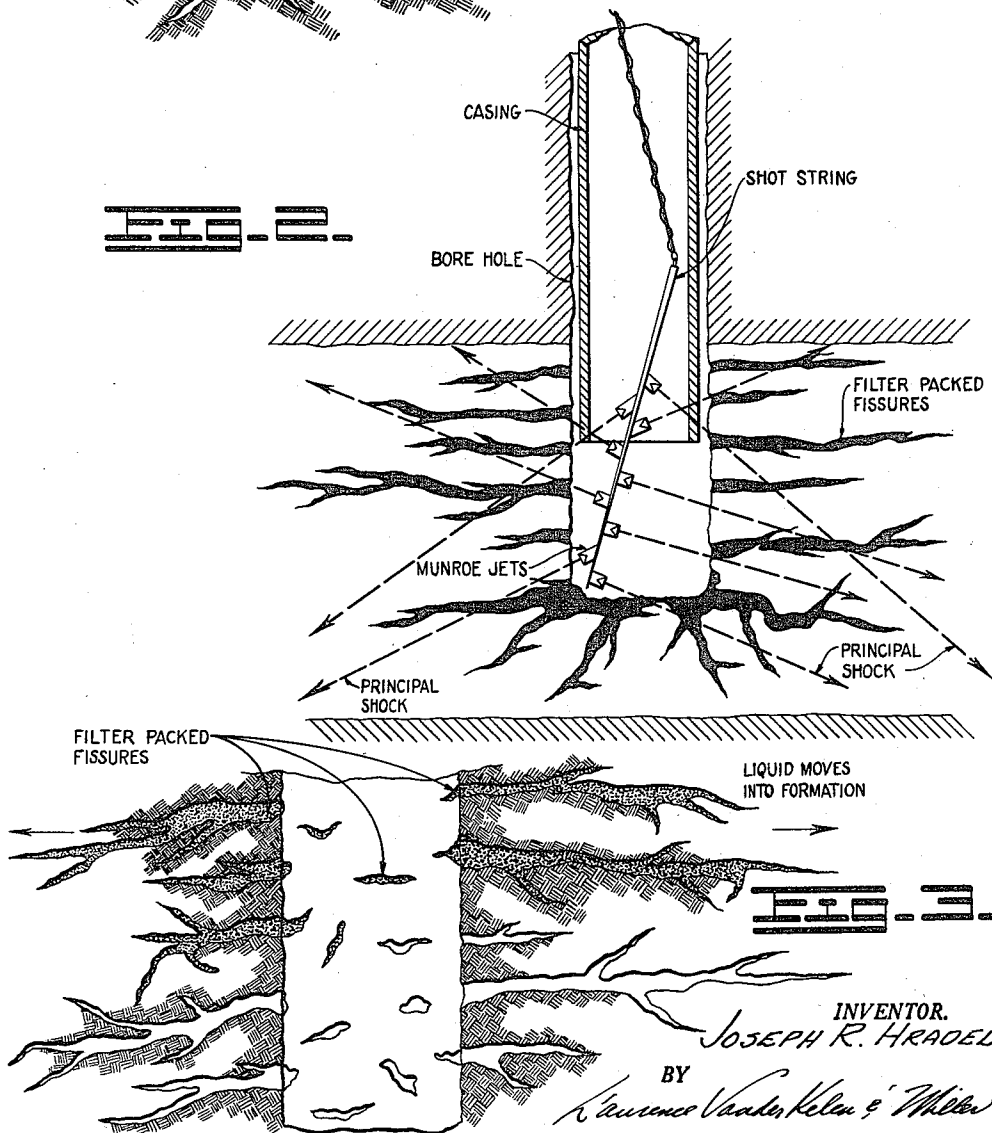


FIG. 3.

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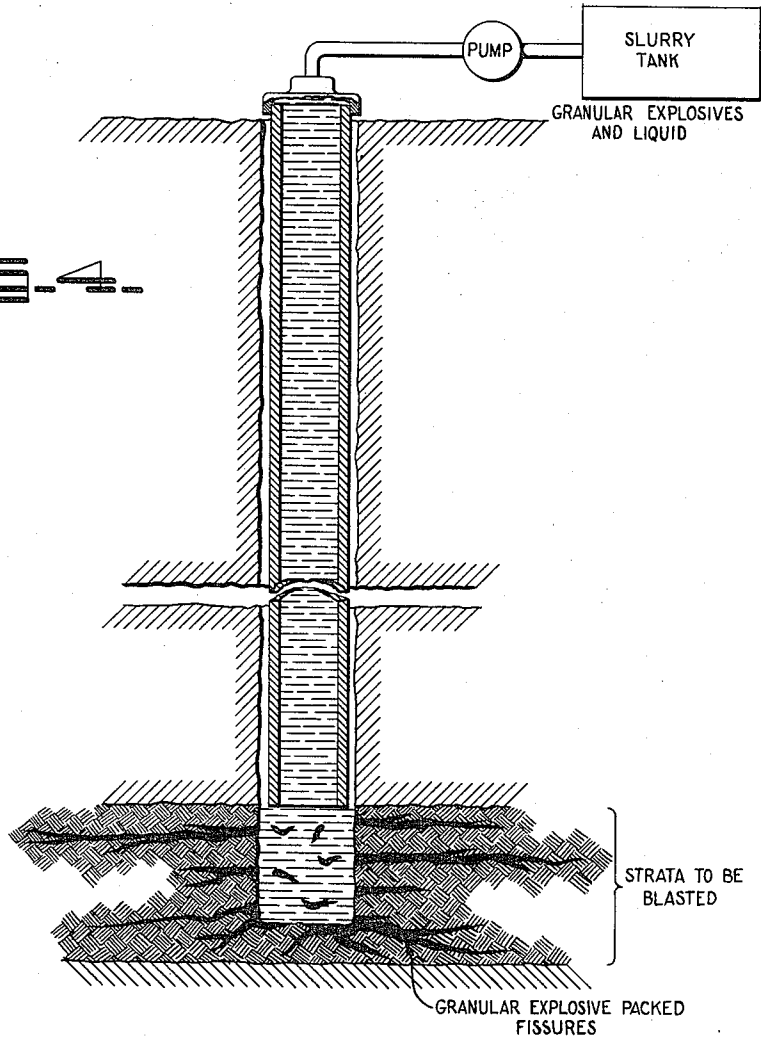
2,867,172

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2 Sheets-Sheet 2

FIG. 4.



EXPLOSIVE GRANULAR
FILTER PACKED

OIL ROCK WATER &
SAND

PRINCIPAL SHOCK
WAVE

STEEL

RANGE OF JET
THROUGH
INTERVENING BARRIERS

DETONATOR SEAT

MUNROE JET UNIT

FIG. 5.

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1

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DETONATION OF UNPRIMED BASE CHARGES

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9 Claims. (Cl. 102—23)

The present invention relates to the detonation of unprimed base charges of high explosives in earth strata and, more particularly, the invention is directed to a process for the loading and "shooting" of oilwell and mining bore holes using unprimed charges.

Conventional "shooting" technique required the use of a detonator and a primed charge of highly sensitive explosive material in the bore hole. It was previously necessary that the detonator and primer be intimately associated with the basic explosive material. The sensitivity of such a preparation of primer and base explosive is so great as to require extensive safety precautions where shooting is being done. Further, the initiation into the bore hole of the primed material in a slurry form by conventional slurry pumps is not practical. If the slurried material could be forced into the formation it would be difficult, if not impossible, to initiate detonation with the explosive and primer remote from the detonator. Subsequent cleanout operations, where primed explosive residue remained, would be extremely hazardous.

It is, therefore, one of the objects of the present invention to provide a "shooting" method in which an unprimed charge can be slurried and pumped into the desired geological formation.

It is another object of the present invention to teach the detonation of unprimed base charges in a bore hole after the explosive material has been forced into the fissures of a geological formation or strata and the detonating means is separated from the explosive material.

It is another object to teach a practical utilization of shaped charges of the Munroe type in initiating detonations in bore hole shooting.

It is another object to teach efficient explosive procedures in bore hole shooting wherein the combination of slurried explosive material and shaped charges accomplish detonation results beyond the expectations of conventional "shooting" inasmuch as the explosion occurs in the fissures of the formation and not merely in the bore hole.

Further objects and advantages will become apparent to those skilled in the art as the description proceeds.

Figure 1 is a section view schematically illustrating the bottom of a bore hole and showing rock fissures in a formation to be blasted.

Figure 2 is a section view of the bottom portion of a bore hole and showing schematically the packed explosive in granular form which has been filtered out by the movement of the liquid portion of the explosive-liquid slurry through rock fissures and showing a shot string of Munroe jets in random position for firing with lines indicating the direction of the principal shock wave from each.

Figure 3 is an enlarged and exaggerated section view of a fissures permeated strata and illustrating the screening action of the fissures entrapping the granular explosive portion of a slurry such as ammonium nitrate.

2

Solid explosives such as ammonium nitrate, trinitrotoluene, RDX, composition B and other explosive materials in unprimed form are granulated and slurried. The slurry may be aqueous, oleaginous, or acid, depending upon the solubility and compatibility of the explosive in the particular material intended to become the vehicle of the slurry. It is, however, desirable that the particles of explosive material be well dispersed in the slurry, and that the dispersion of explosive material be substantially uniform.

The slurry thus prepared may be pumped into a well or bore hole using conventional slurry pump equipment. Pressure is applied to the slurry as desired and as dictated by the porosity of the formation into which the slurry is pumped. The fissures in the geologic strata act as filters and trap the granular explosive material to produce a continuous phase train of explosive material. The pressure of the slurry column assists in this fissure penetration and packs entrained explosive particles into the formation. Where the formation treated consists of open hole (uncased) the slurry moves directly into the formation and is prevented from traveling upward around the casing by cementing above the treated formation. Where the area sought to be treated by the explosive is behind cemented casing, the casing may be perforated using conventional type casing perforators before the slurry is introduced. In the latter case the slurry moves through the perforations and into the formation.

A shot train is then prepared which consists of a plurality of grouped shaped charges known in the art as "Munroe" jets. The shaped charge is a shaped block of explosive material focused by forming an open conical face wherein the primary shock wave is amplified and concentrated along the principal axis of the cone. An ordinary detonator imbedded in the shaped charge explodes the charge to form the Munroe jet. The plurality of shaped charges are arranged to direct their principal shock waves radially and angularly through the geologic formation. In this manner a diffusion of principal shock waves is accomplished calculated to intersect the explosive packed fissures and layers. Experimental results have proven that irrespective of intervening media, i. e., air, water, earth, stone, or combinations of these, the principal shock wave of the Munroe type shaped charge will shock penetrate the barriers, with sufficient intensity to initiate the unprimed base charge.

The shot train is lowered into the well or bore hole until it is adjacent the explosive impregnated structure. The detonator is initiated and the jets are fired. The principal shock waves radiate from the shot train in accord with the position of the shaped charges, and effectively penetrate through the intervening media to detonate with high order explosion the explosives packed in the fissures of the geologic formation. Surface testing has indicated that thin sections down to one-sixteenth ($\frac{1}{16}$) of an inch initiate efficiently. In tests utilizing composition B and, separately, ammonium nitrate, high order detonation was observed using a Munroe type jet for initiation through an air and solid media at various selected angles between zero degrees and ninety degrees. Composition B (60 percent trinitrotoluene and 40 percent RDX) was selected since it is characteristic of the family of "high explosives" and ammonium nitrate was selected because it characterizes a "low explosive" in performance. Some influence was noted of grain size and the tests demonstrated that grain size should preferably range below twenty mesh for best results. No evidences of unburned powder were observed.

Similarly, various slurries including water, brine, oil (crude) and containing high and low explosives in granular form exhibited excellent explosive results with no apparent dilutional effects in the presence of the various

materials. Detonation by means of the shaped charge was observed to be of high order. The term "high order detonation" herein has relation to completeness of detonation at maximum velocity for the explosive material employed. Surface testing was undertaken to indicate the underground phenomena under observable and controlled conditions. The test series included the following:

I—Jet penetration of intervening media test

Unprimed base charges were placed in containers remote from a Munroe jet and air, fluid, and solid media (earth) barriers were placed between the jet and the base charge. The experiments showed that an initiating shock wave was transmitted through the interposed barriers, alone or in combination, to detone explosive materials ranging in sensitivity from composition B and trinitrotoluene to ammonium nitrate. No detonation of the base charge was observed where conventional primers and detonators were remotely positioned from the base charge with or without interposing various barriers. Using conventional primers, explosion of the base charges was observed only when the detonator was intimately associated with the base charge.

II—Solubility and dilutional effects test

Control slurries of explosive materials in inhibited acid, brine, sweet and sour crude oil were detonated with Munroe jets and the degree of detonation was observed using a standard barograph recording machine. The concentration of granular explosive materials in the vehicle was maintained at two pounds per gallon throughout the series of tests using composition B, trinitrotoluene and ammonium nitrate. The controls were fired and the resultant shock was recorded on the barograph. Subsequently, and in the various media, identical samples were detonated after seven days exposure in the slurry concentration at a temperature of 100 degrees Fahrenheit. Upon detonation at the end of the exposure period no material deviation from the control observation was observed. Enhanced high order explosions occurred indicating an increase in explosive sensitivity as recorded on the barograph under identical positioning. Observations of the slurry material under dissolved suspension, or settled out conditions when detonation occurred indicate that the Munroe jet appears capable of detonating the explosive materials indicated in whatever state they may be in at the time of initiation in the bore hole.

III—Slurry insensitivity tests

To compare the effect of slurring the explosive material, concentrations of 2, 3 and 4 pounds of the explosive material trinitrotoluene, composition B and ammonium nitrate per gallon of inhibited acid, brine, and sweet and sour crude oil were prepared and thoroughly wetted. Conventional detonators were inserted in the slurries and uniformly below minimum control detonation effects were observed verifying conventional insensitivity of wetted explosive material. The same concentrations of explosive materials in slurries were fired using the Munroe jet and maximum power characteristics were observed with no evidences of unburned explosive material, thus indicating complete shot propagation. All shots exceeded the minimum recorded control indicating detonation in every case.

IV—Simulated strata tests

In order to simulate strata conditions, artificial fissures were created and filter packed with explosive materials in slurry form as indicated in prior tests. Using progressively diminishing sized simulated fissures down to and including one-sixteenth of an inch uniform shot propagation was observed in each detonation using the Munroe jet fired transversely of the plane of said fissure and in another shot fired parallel to the plane of said fissure notwithstanding interposed air, fluid, and solid media. No

simulated strata tests were conducted on fissures less than one-sixteenth of an inch across inasmuch as this size powder train was thought to reach a practical limit at this point insofar as the detonation in smaller fissures was believed to have little or no effect on opening earth strata. Detonation was complete in each fissure test with no unburned residue.

Detonation via primers or conventional detonators was unsuccessful unless the primers were inserted in the fissures in intimate association with the explosive material. Unburned powder residue was observed in each test shot using conventional detonators even when in association with the explosive material indicating poor propagation.

The above tests were made to simulate conditions obtained underground and effective explosive propagation was observed under variant conditions to the end that an enhanced explosive underground result could be obtained and so that theoretical underground conditions could be verified by measured observation.

In oilwells and bore holes, granular explosive material can now be slurried and pumped into selected geologic strata. Detonation is accomplished using a string or shot train of shaped charges lowered into the explosive impregnated formation. High order detonation was observed using these procedures. Subsequent clean-out operations after initiation showed little to no undetonated residue indicating excellent explosion propagation within the range of the jets produced by the shaped charges.

It will have been observed that at no time during the slurry or pumping operations is the high explosive material primed. It is not primed after insertion into the bore hole, yet it can be effectively detonated as desired in a safe manner. Explosives handling is greatly simplified and shooting effectiveness is vastly increased by reason of the fissure entrapment of granulated explosive materials under pressure. The blasting of strata in bore holes and oilwells has been simplified and rendered more effective by reason of this invention.

"Unprimed" as used herein, in reference to explosive materials, relates to the unsensitized condition of the explosive material as it is slurried.

"Slurry" as used herein, with respect to the condition of explosive material and fluid prepared for insertion in a borehole, has reference to a dispersion of solid granular explosive material where the grain or particle size is maintained discrete in a relatively thin pumpable liquid mix with water, for example, and wherein the explosive material is relatively insoluble in the fluid.

Having thus described my invention it will be understood that certain obvious modifications are intended to be included, limited only by the scope of the hereinafter appended claims.

I claim:

1. In a process for loading and shooting bore holes as in oilwell and mining operations, the steps which include: preparing a slurry of granular unsensitized explosive material in a fluid media; forcing said slurry material into a geologic formation whereby the fissures in said formation filter pack said granular unprimed explosive allowing the liquid media to pass through; lowering a string of shaped charges down said bore hole adjacent said filter packed formation; detonating said shaped charges causing shock detonation of said explosive material in said geologic formation through intervening barriers.

2. The process in accord with claim 1 wherein said fluid in said slurry is crude petroleum where the explosive is substantially insoluble in said fluid.

3. The process in accord with claim 1 wherein said fluid in said slurry is brine water where the explosive is substantially insoluble in said fluid.

4. The process in accord with claim 1 wherein said fluid is inhibited acid where the explosive is substantially insoluble in said fluid.

5

5. The process in accord with claim 1 wherein said granular explosive material in said slurry is of a particle size ranging between 20 mesh and size admitting the suspension of solid particles in a given liquid and wherein said explosive material is substantially insoluble in said liquid.

6. In a process for loading and shooting bore holes in oil well drilling and mining operations, the steps which include: slurring a mixture of liquid and granular explosive material; pumping said slurry into a geologic formation thus filter packing openings in said formation with granular explosive material; lowering at least one shaped charge into said bore hole so that upon positioning, the principal axis of said shaped charge intersects, upon projection, the geologic formation bearing said filter packed explosive; detonating said shaped charge thereby remotely initiating said filter packed explosive through intervening media.

7. The process in accord with claim 6 wherein said granular explosive is ammonium nitrate.

8. In a process for loading and shooting bore holes, the steps which include: slurring a mixture of a fluid and granular explosive material; pumping said slurry into a geologic formation, thus filter packing openings in said formation with granular explosive material, the fluid ma-

6

terial passing into the formation; lowering a shaped charge into said bore hole so that upon positioning it is adjacent to the formation bearing said filter packed explosive; and detonating said shaped charge to initiate detonation of said filter packed explosive through intervening media.

9. The process in accord with claim 8 wherein said granular explosive is ammonium nitrate.

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