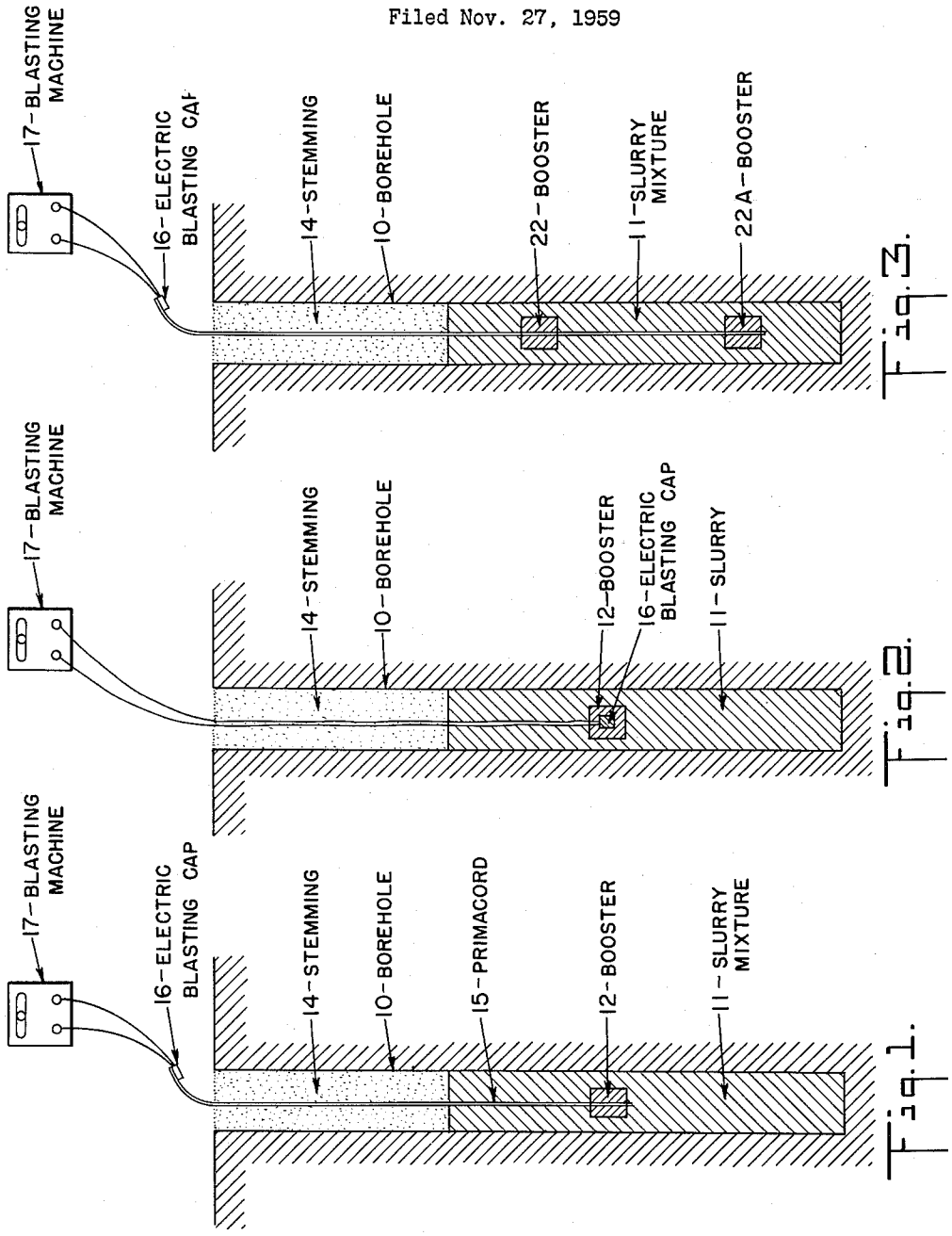
Feb. 22, 1966 L. W. TOWLE 3,236,180

BLASTING CHARGE AND METHOD

Filed Nov. 27, 1959



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United States Patent Office

3,236,180

Patented Feb. 22, 1966

3,236,180

BLASTING CHARGE AND METHOD

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Filed Nov. 27, 1959, Ser. No. 855,558
6 Claims. (Cl. 102—22)

This invention has to do with a blasting charge employing nitrate explosives in a thick aqueous slurry, and a method of blasting therewith.

I have found that good blasting results can be obtained, without the use of any high (i.e., class A) explosive as a component of the dispersed explosive material in the slurry, by forming in the bore a blasting charge consisting essentially of (1) a thick aqueous slurry of dispersed ammonium nitrate particles as the predominant explosive material with or without a lesser amount of sodium, calcium or other nitrate in like dispersion, a portion of the nitrate forming with the water a saturated aqueous solution which serves as a matrix or continuous liquid phase surrounding the dispersed undissolved particles of nitrate; and (2) one or more localized (i.e., undispersed) solid bodies of booster explosive within the body of slurry.

Conventional means are used for detonating the booster, such as a blasting cap, an electric blasting cap or a detonating fuse.

The slurry may be formed in the bore, or may be preformed and packaged for shipment, the latter being preferable. In either case, the booster may be set in place, in proper relation to the top level of the column of slurry, either before or during loading or after the slurry is in place.

When pre-packaged, the slurry is preferably removed from its container before being introduced into the bore, because it then better fills the bore laterally to eliminate voids. However, useful results can be obtained by filling the bore to the desired depth with flexible plastic containers of the slurry, with the booster body or bodies suitably placed in the resulting column of slurry. It is also possible but less desirable to package the slurry in long cylindrical spiral-paper containers, with the booster body inserted in the contained slurry, or between containers of slurry, the diameter of the container being such as to substantially fill the bore.

This blasting charge is useful in wet holes as well as in dry holes, and is especially useful in wet holes when the slurry has dispersed in it a thickener of known type, preferably a gelling agent, such as guar gum, starch or the like. With such a thickener the slurry needs no container even in a wet hole. It displaces the water in the hole and maintains its integrity without dilution for a sufficient time to meet all ordinary needs of time lapse before detonation.

I prefer to disperse in the slurry a liquid or solid carbonaceous fuel in amount at least sufficient to combine with the oxygen released by the nitrate, and also, as stated, a gum or other thickener in an amount of the order of 0.5%–1.0% of the weight of the slurry. Other minor adjuvants such as a catalyst, of no significance in themselves as explosive components, may be used in accordance with known practice.

In the accompanying drawing, FIG. 1 is a schematic diagram of the bottom part of a bore **10**, such as a well drilled blast hole, showing the blasting charge consisting of a slurry **11**, as here described, and a single localized booster **12**. The booster **12** consists of a localized charge of high explosive such as a body of high velocity gelatin explosive or commercial booster placed about midway between the top and the bottom of the column of slurry. There is suitable stemming **14** above the slurry, and a

primacord detonating fuse **15** running from the booster to the surface, outside the bore where an electric blasting cap **16**, attached to the primacord detonating fuse, is connected to a firing device such as a blasting machine **17**. An alternative is shown in FIGURE 2 where the electric blasting cap **16** is within the booster and is connected to the blasting machine **17** by an electric wire or cable.

FIGURE 3 is a similar diagram showing the same system, with corresponding components similarly numbered, but with the booster formed of two localized bodies of high explosive **22** and **22***a*. One body of booster is in the upper half of the slurry column **11**, and nearer its upper end, and the other is in the lower half and nearer the bottom. More than two spaced bodies of booster may be used, surrounded by the slurry column. In this case, the detonating fuse connects the bodies of booster in series and leads as before to an electric blasting cap **16** and blasting machine at the surface.

Whether the slurry is packaged or not, the body or bodies of booster are placed in immediate active relation to the slurry by reason of being within the whole column of slurry.

The slurry component **11** of the charge is so constituted as to form a thick mass at the temperature of the blasting site. Its predominant explosive constituent is ammonium nitrate in particle form, which may be grains, prills or flakes, dispersed in the liquid phase provided by the saturated solution of nitrate. Calcium, sodium or other inorganic nitrate particles, similarly dispersed, may be included in an amount up to about 20% or 25% of the weight of the slurry. Also, there may be a minor content of chromate particles or of aluminum or of other oxidizer known in explosive mixtures. No significant amount of class A explosive is used as a dispersed constituent, and preferably none; that is, no more than a few percent which, being insignificant, would be present only adventitiously or for some purpose other than to contribute materially to the explosive power.

The water content of the slurry is such as to dissolve a portion only of the nitrate, so as to form a solution that is saturated at the temperature of the slurry leaving another portion of the nitrate as undissolved dispersed solids. The water content is gauged to the resulting physical state of the slurry at that temperature, being made no greater, or insubstantially greater, than is necessary to provide a saturated solution forming a continuous matrix for the undissolved particles, coating and lubricating them and yielding what I term a thick slurry, as distinguished from a mass of solid particles lacking a substantially continuous surrounding liquid phase. Any excess of water beyond that needed to provide this condition is undesirable from the standpoint of sensitivity and strength, and gives no compensating advantage in improving the physical state of the mass. Any considerable excess makes the charge useless in practical work by unduly reducing its sensitivity. I find however that the amount of water minimally needed to serve the foregoing purpose of creating a thick slurry is tolerable, and that the resulting charge composed of such a slurry and a quite practical amount of localized booster accomplishes good blasting in the absence of any class A explosive as a dispersed slurry constituent. The economy is evident, having regard to the cost of nitrates relative to that of nitroglycerine, TNT and the like.

So determined, the water content of the slurry does not exceed 20% by weight of the slurry in any case, and commonly is from 10% to 12%. The use of water absorbing adjuvants leads to somewhat higher total water contents to produce the same physical state of the the resulting slurry. Water contents below 10%, and down to 5%, are possible under special conditions where

the lesser amount still serves to provide a saturated solution, forming a continuous liquid phase around the dispersed solid particles.

It is to be noted, although well known, that the solubility of these nitrates in water varies considerably with temperature, so that if the slurry is pre-formed at a different site, of different temperature from that of the blasting site, the slurry initially may have a higher or lower content of undissolved particles. Thus, at a lower temperature at which the solubility is less, the content of undissolved particles is greater and there may be insufficient liquid to form a continuous matrix. Conversely, at a higher temperature at which the solubility is higher, there is lesser content of undissolved particles and the slurry is thinner. In either case, when the slurry (in the ideal case) comes to the temperature of the sub-surface blasting site it has such a content of undissolved particles that the aqueous phase is just sufficient to coat and surround all of the solid particles and provide the desired continuous phase, without excess liquid. In the practical case there is of course some leeway in which the slurry may depart from this ideal state at the temperature of the blasting site, with tolerable variance from optimum performance; but care to attain a close approximation of the ideal state, without excess water, is recommended as well worthwhile.

The class of materials useful as thickeners of such a slurry is known, and is illustrated by such materials as guar gum, gum arabic, starch, pregelatinized starch and carboxymethyl cellulose.

The booster is preferably one of the known forms of gelatin dynamite such as that known as 60% high velocity gelatin. Other useful boosters are Pentolite, trinitrotoluol, Cyclotol, semi-gelatin dynamites, composition B and commercially available boosters which in some cases include a combination of explosives.

The amount of any particular booster needed depends of course on the size of the blasting charge as well as on the size of the bore. For the preferred booster, that is, the 60% high velocity gelatin, the weight of booster ranges from about 1% to about 20% of the weight of slurry, for bores of 4 inches or larger in diameter.

The size and type of cap and detonating fuse are selected in accordance with known practice in the use of the particular booster chosen for use.

A typical preferred example of a blasting charge in accordance with this invention, useful for blasting hard rock, is as follows. A bore of 12 inches in diameter is drilled to a depth of 50 feet. For use at a temperature of 80° F., a slurry is prepared consisting of about 85% of grained ammonium nitrate, about 10% of water, about 0.4 to 0.8% of guar gum (Guartec F, sold by General Mills, Inc., 9200 Wayzata Blvd., Minneapolis 26, Minn.), and about 4% of paraffin oil. About 1000 pounds of this slurry, unpackaged, are placed in the bore filling it to a depth of 15 feet; and boosters consisting of two 8-foot lengths of 3-inch diameter 60% high velocity gelatin are lowered and suspended on strands of detonating fuse forming a continuous column of primer through the slurry charge. These strands of detonating fuse extend out of the hole and are attached to a trunk line of detonating fuse which is detonated by a No. 6 electric blasting cap and blasting machine.

In another example, the booster consists of eight 25-pound charges of 60% ammonia gelatin equally spaced through the slurry column. A detonating cord running through or alongside the booster extends from the hole and is tied to a detonating cord trunk line which is initiated by an electric blasting cap.

Practical blasting results were obtained with each of the following slurries, using in each case a single localized booster, centrally placed in the bore and consisting of 800 grams of 60% high velocity gelatin in 40 lbs. of slurry placed in a bore of 6 inches in diameter, with conventional stemming. The booster in each case was a cylindrical body 2¼ inches in diameter and 8 inches long, placed centrally in a slurry column 20 inches in length and filing the bore laterally.

Percentage composition, by weight

	Ammonium Nitrate #—grains	Sodium Nitrate	Water	Guar	Paraffin Oil
A	88.69		6.30	.53	4.48
B	87.38		8.25	.41	3.96
C	85.1		10.0	.4	4.5
D	65.1	20.0	10.0	.4	4.5

The invention provides an economical method of blasting, requiring no high explosive (class A) as a constituent of the main slurried charge, apart from the localized booster that is placed as a solid body in the slurry. The method consists of (1) placing at the bottom of a bore in the earth, or other solid mass to be blasted, a column of nitrate slurry of the sort described; (2) placing one or more localized bodies of booster within the column of slurry; (3) connecting each booster to a detonating fuse which extends outside the hole; and (4) then causing a blast by firing the detonating fuse with a blasting cap or electric blasting cap. More than one hole may be fired by connecting the detonating fuses from each hole to a trunk line which is fired by a blasting cap or electric blasting cap. The first three steps above constitute a method of preparing a blasting charge for detonation, and the first alone constitutes a key step therein.

I disclaim, as being not within the present invention, blasting charges and methods employing slurried explosive mixtures containing more than about 5% by weight of class A explosive as a dispersed constituent of the slurry. Preferably, according to my invention, the nitrate slurry contains no dispersed class A explosive, but a content of such explosive up to about 5% by weight of the slurry I regard as insignificant in that it produces no materially different practical result, and I do not exclude such a content from the scope of my invention.

I claim:

1. A blasting charge comprising an aqueous slurry of dispersed particles of explosive material, consisting of at least about 95% of nitrate explosive, predominantly ammonium nitrate, a dispersed thickener as a minor constituent, and from 0% to not over about 5% of high explosive, the water content of said slurry forming about from 5% to 20% by weight of the slurry and serving to form a saturated solution of nitrate explosive material which, at the temperature of use, produces a thick mass and provides a continuous liquid phase surrounding the solid particles of the slurry, together with at least one localized body of booster placed in immediate active relation to the slurry.

2. A blasting charge in accordance with claim 1 which includes a carbonaceous fuel as a minor dispersed constitutent of the slurry.

3. A blasting charge otherwise in accordance with cliam 1 in which the water content of the slurry is about 10 to 12% by weight of the slurry and is approximately sufficient to just provide at the temperature of use a continuous liquid phase surrounding the dispersed solid constituents of the slurry.

4. As a sub-combination, an aqueous slurry adapted to form a part of a blasting charge and comprising dispersed particles of explosive material consisting of at least about 95% by weight of nitrate explosive, predominantly ammonium nitrate, a dispersed thickener as a minor constituent, and not over about 5% by weight of high explosive material, the water content of said slurry being about from 5% to 20% by weight of the slurry and serving to form a saturated solution of nitrate

explosive material which at the temperature of use produces a thick mass and provides a continuous liquid phase surrounding the dispersed solids of the slurry.

5. As a sub-combination, an aqueous slurry otherwise in accordance with claim **4** in which the water content is about 10% to 12% of the weight of the slurry.

6. An explosive mixture detonable by a primer when under confinement, consisting essentially of a mixture of a solid inorganic nitrate and a carbonaceous fuel, the inorganic nitrate containing at least 50% ammonium nitrate, the fuel being present in sufficient amount to provide at least 75% of the amount required for the oxygen balance of the inorganic nitrate, sufficient water, within the range from about 5 to 20% by weight, substantially uniformly intermixed therewith to slurry the mixture, and a thickening agent in an amount to appreciably increase the viscosity of the mixture.

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