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R. W. CAIRNS ET AL
BLASTING INITIATOR

2,525,397

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2 Sheets-Sheet 1

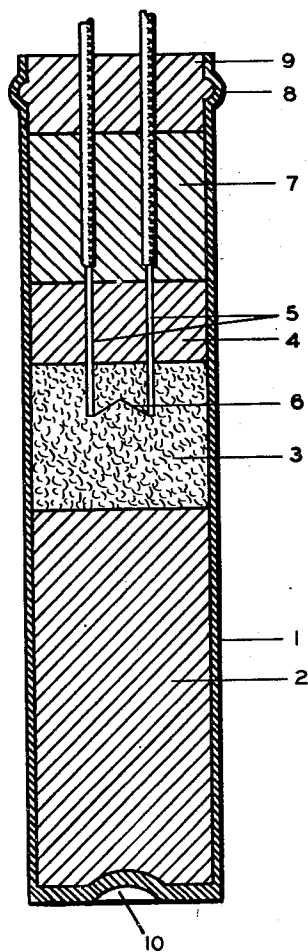


FIG. 1

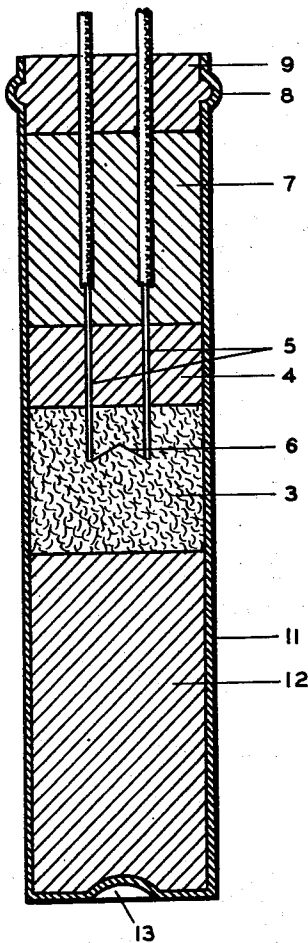


FIG. 2

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2 Sheets-Sheet 2

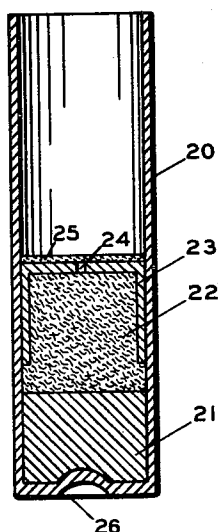


FIG. 3

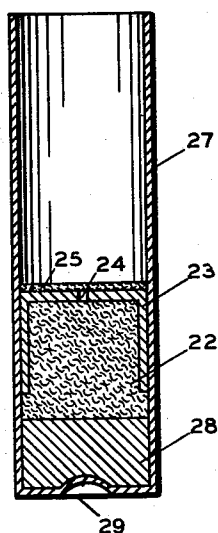


FIG. 4

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BLASTING INITIATOR

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10 Claims. (Cl. 102—28)

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This invention relates to blasting initiators and more particularly to blasting initiators of improved initiating power.

It is well known that blasting gelatin which consists of nitroglycerin gelatinized with about 7% by weight of nitrocellulose tends to become very insensitive on storage. This insensitiveness has usually been associated with the increased density which results from the gradual loss of air bubbles incorporated in the gelatin mix during manufacture. When the blasting gelatin is near its maximum density, i. e., between 1.58 and 1.61 g./cc., it is quite resistant to detonation by standard commercial blasting caps. However, when detonated at a high rate, high density blasting gelatin acquires a greater velocity than low density blasting gelatin and it is therefore desirable to employ a blasting gelatin with as high a density as possible.

When blasting gelatin of low density is detonated, it has been found that it will start with a low rate of detonation (2500–3000 m./sec.) and will then accelerate sharply to a high rate (about 7800 m./sec.). When blasting gelatin of high density is detonated, acceleration of a low rate of detonation to a high rate of detonation does not often occur. Thus, the problem of detonating high density gelatin has appeared to be one of producing an initial high rate of detonation. In an effort to accomplish this, the density of the base charge in the blasting initiator has been increased, thus obtaining a high energy density and improving its brisance. However, this expedient has not entirely solved the problem, for even with use of such initiators insensitive blasting gelatin has, in general, been detonated only at comparatively low rates or has failed to propagate detonation.

Now, in accordance with this invention, blasting initiators have been prepared which are capable of detonating insensitive explosive materials at a high rate. This is accomplished by employing an initiator carrying a base explosive charge of high density in a shell having a bottom weight less than the bottom weight in a standard commercial blasting initiator or cap.

The blasting initiators or caps in accordance with this invention may be prepared employing secondary or base explosives known to the art, such as pentaerythritol tetranitrate, nitromannite, cyclonite, mannitol hexanitrate, nitrolactose, and nitrosucrose. The explosive is placed in a shell whose bottom has a weight not more than about 0.10 gram, and pressed to a high density. A charge of priming explosive is added and the open end of the shell closed by a capsule

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if a fuse cap is desired or by an ignition assembly if an electric blasting cap is desired.

Having now indicated in a general way the nature of this invention, there follows a more detailed description of preferred embodiments thereof with reference to the accompanying drawings wherein reference symbols refer to like parts wherever they occur and in which:

Fig. 1 is a vertical, sectional view of a standard commercial electric blasting cap;

Fig. 2 is a vertical, sectional view of an electric blasting cap in accordance with this invention;

Fig. 3 is a vertical, sectional view of a standard commercial fuse blasting cap; and

Fig. 4 is a vertical, sectional view of a fuse blasting cap in accordance with this invention.

The commercial electric blasting cap of Fig. 1 includes a 0.30 caliber shell 1, which has an inside diameter of 0.77 cm., a bottom 0.053 cm. thick, and a wall 0.015 cm. thick, having a base charge 2 of high explosive pressed to a density less than 1.45 g./cc. Superimposed upon the base charge 2 is a loose priming charge 3 of initiating explosive. The shell is fitted with a plug 4 through which are inserted two leg wires 5. A bridge wire 6 is soldered to the leg wires 5. The bridge wire 6 is embedded in the loose priming charge 3. The shell 1 is made waterproof by a seal 7 composed of a waterproofing compound, and is provided with a crimp 8 to hold a sulfur seal 9 firmly in the shell.

The commercial electric blasting cap of Fig. 1 is distinguished from the blasting cap of Fig. 2 by the base charge 2 of greater height, due to its lower density, and the shell 1 with a bottom 10 of greater thickness and, accordingly, greater weight.

The electric blasting cap of Fig. 2 includes a 0.30 caliber shell 11, which has an inside diameter of 0.77 cm., a bottom 0.023 cm. thick, and a wall 0.015 cm. thick, having a base charge 12 of high explosive pressed to a density more than 1.45 g./cc.

A priming charge 3, plug 4, leg wires 5, bridge wire 6, seal 7, crimp 8, and sulfur seal 9 are provided for the cap and consist of the same materials applied in the same manner as described for the cap depicted in Fig. 1.

This electric blasting cap is distinguished from that of Fig. 1 and other standard commercial blasting caps by the base charge 12 of greater density, as indicated by its smaller height in the shell, and the shell 11 with a bottom 13 of reduced thickness and, accordingly, reduced weight.

The commercial fuse blasting cap of Fig. 3 includes a 0.22 caliber shell 20, which has an in-

side diameter of 0.56 cm., a bottom 0.043 cm. thick, and a wall 0.015 cm. thick, having a base charge 21 of high explosive pressed to a density less than 1.45 g./cc. A priming charge 22 of initiating explosive is disposed over the base charge. A gilding metal capsule 23 with an aperture 24 therein and a wafer charge 25, respectively, are provided in the shell.

The commercial fuse blasting cap of Fig. 3 is distinguished from the cap of Fig. 4 by the base charge 21 of greater height, due to its lower density, and the shell 20 with a bottom 26 of greater thickness and, accordingly, greater weight.

The fuse blasting cap of Fig. 4 includes a 0.22 caliber shell 21, which has an inside diameter of 0.56 cm., a bottom 0.023 cm. thick, and a wall 0.015 cm. thick, having a base charge 28 of high explosive pressed to a density of more than 1.45 g./cc. A priming charge 22, capsule 23, and wafer charge 25 are provided for the cap and consist of the same materials applied in the same manner as described for the cap depicted in Fig. 3.

This fuse blasting cap is distinguished from that of Fig. 3 and other standard commercial blasting caps by the base charge 12 of greater density, as indicated by its smaller height in the shell, and the shell 27 with a bottom 29 of reduced thickness and, accordingly, reduced weight.

The following examples illustrate the practical application of this invention:

EXAMPLE 1

Copper shells of 0.30 caliber (#6 commercial cap size) having an inside diameter of 0.77 cm. with a 0.015 cm. wall thickness and having various bottom thicknesses were charged with pentaerythritol tetranitrate pressed to various densities. These shells were further charged with 0.4 gram of a loose priming mixture containing 75% diazodinitrophenol and 25% potassium chlorate. A conventional ignition assembly such as that described for Fig. 1 was provided for each shell, thus providing a complete electric blasting cap. The detonating power of these caps was tested as follows: A column of glycerin trinitrate was placed in a glass tube of 19 mm. inside diameter. The cap being tested was inserted through a rubber stopper until the base charge was entirely surrounded by the explosive. The cap was then initiated by a suitable source of electric current. The detonation rate was determined by using a high speed camera. Since both the high and the low rates are characteristic, approximately 7700 m./sec. for the high rate and approximately 1700 m./sec. for the low rate, the data in the following tables merely show whether the rate of detonation was high (indicated by H) or low (indicated by L). The results of testing the caps of Example 1 are given in Table I:

Table I

PETN BASE CHARGES—COPPER SHELLS

	Thickness of Bottom, cm.	Weight of Bottom, g.	Weight of Charge, g.	Density of Charge, g./cc.	Rate of Detonation
1-----	0.021	0.090	0.25	1.45	H
2-----	0.021	0.090	0.25	1.35	L
3-----	0.030	0.136	0.25	1.58	L
4-----	0.041	0.182	0.25	1.60	L
5-----	0.053	0.242	0.50	1.37	L

EXAMPLE 2

Copper shells of 0.22 caliber (#6 commercial cap size) having an inside diameter of 0.56 cm. with a 0.015 cm. wall thickness and having various bottom thicknesses were charged with pentaerythritol tetranitrate pressed to various densities. These shells were further charged with 0.3 gram of a priming mixture containing 75% diazodinitrophenol and 25% potassium chlorate. A conventional gilding capsule with an aperture therein such as that described for Fig. 3 was placed in the shell and pressed on the priming charge. Then a wafer charge of 0.05 gram of the priming explosive mixture was added and pressed at the same pressure as the priming charge. The detonating power of these caps were tested as follows: A column of glycerin trinitrate was placed in a glass tube of 19 mm. inside diameter. The cap being tested was inserted through a rubber stopper until the base charge was entirely surrounded by the explosive. The cap was then initiated by a suitable fuse and the detonation rate was determined by using a high speed camera. The results are given in Table II:

Table II

PETN BASE CHARGES—COPPER SHELLS

	Thickness of Bottom, cm.	Weight of Bottom, g.	Weight of Charge, g.	Density of Charge, g./cc.	Rate of Detonation
1-----	0.010	0.025	0.25	1.47	H
2-----	0.010	0.025	0.25	1.44	L
3-----	0.015	0.037	0.25	1.43	H
4-----	0.015	0.037	0.25	1.43	L
5-----	0.023	0.055	0.10	1.65	H
6-----	0.023	0.055	0.25	1.52	H
7-----	0.023	0.055	0.25	1.50	H
8-----	0.035	0.086	0.10	1.65	H
9-----	0.035	0.086	0.25	1.48	H
10-----	0.035	0.086	0.25	1.41	L
11-----	0.043	0.105	1.00	1.59	L
12-----	0.043	0.105	0.50	1.59	L
13-----	0.043	0.105	0.25	1.57	L
14-----	0.043	0.105	0.20	1.40	L

EXAMPLE 3

Cellulose acetate shells of 0.22 caliber having an inside diameter of 0.56 cm. with a 0.076 cm. wall thickness and having various bottom thicknesses were charged with 0.25 gram of pentaerythritol tetranitrate pressed to various densities. These shells were further charged with 0.3 gram of a loose priming mixture containing 75% diazodinitrophenol and 25% potassium chlorate. A conventional ignition assembly such as that described for Fig. 1 was provided for each shell, thus providing a complete electric blasting cap. The detonating power of these caps was determined by the same procedure as utilized for testing the caps of Example 1. The results are given in Table III:

Table III

PETN BASE CHARGES—CELLULOSE ACETATE SHELLS

	Thickness of Bottom, cm.	Weight of Bottom, g.	Weight of Charge, g.	Density of Charge, g./cc.	Rate of Detonation
1-----	0.064	0.033	0.25	1.47	H
2-----	0.160	0.083	0.25	1.57	H
3-----	0.160	0.083	0.25	1.40	L
4-----	0.230	0.117	0.25	1.57	L

With reference to the above tables, it will be seen that a high rate of detonation is obtained only by a combination of weight of shell bottom

not greater than 0.10 gram and a base charge having a density greater than 1.45 g./cc. for pentaerythritol tetranitrate. Further, it will be seen that a weight of charge as much as 1.00 gram pressed to a high density was ineffective to give a high rate of detonation when the weight of shell bottom was greater than 0.10 gram. On the other hand, a weight of charge as low as 0.10 gram pressed to a high density was effective to give a high rate of detonation when the weight of shell bottom was less than 0.10 gram. Still further it will be seen that identical caps as to weight of bottom less than 0.10 gram and weight of charge will not give a high rate of detonation unless the density is above a certain minimum for a given base charge.

In order to determine whether the strength or weakness of the shell bottom was important, the bottoms (0.043 cm. thick) were cut off a number of standard #6 copper shells. The bottoms were then sealed to the shell tube with rubber cement, producing a very weak joint. The shells were filled with explosive as in Example 2 and the caps were tested as in Example 2. It was found that these caps were no more effective in producing a high rate of detonation than standard #6 blasting cap shells. In other tests on copper shells, copper was cut from the junction of shell bottom and shell wall until it was only 0.010 cm. thick at this junction. Even this weakening of the shell did not result in any improvement in initiating efficiency in tests similar to the above.

Shells without bottoms are not satisfactory due to obvious handling problems and the impossibility of waterproofing bottomless shells.

Approximately 25% of the available energy in a 0.25 gram base charge is used in giving rapid motion to the bottom and wall shell fragments in the initial explosive action. This corresponds to about all the energy actually available while the explosive gases are expanding to twice their volume. On the other hand, the energy needed to burst the shell itself it probably less than 1% of that available. It is hypothesized that this is why the weight of the shell bottom adjacent to the base explosive is of importance while the weakness or the thinness of the shell at these points is relatively unimportant.

From the examples, it is seen that the effectiveness of the blasting caps in accordance with this invention are governed by several factors, namely, the weight of the shell bottom, the density of the base charge, and the particular base charge used. These are each interdependent. However, it is possible to fully define an operable blasting cap in accordance with this invention by specifying only the weight of the shell bottom and the density of the base charge. The weight of base charge ordinarily employed in commercial caps does not vary greatly and even if varied greatly as illustrated herein does not materially affect the rate of detonation. Ordinarily, the weight of base charge utilized in fuse type caps is from about 0.15 to about 0.25 gram for #6, from about 0.5 to about 0.6 gram for #8, from about 0.9 to about 1.0 gram for Army Engineer cap, and for electric type caps from about 0.25 to about 0.40 gram for #6, from about 0.45 to about 0.55 gram for #8, from about 0.9 to about 1.0 gram for Army Engineer cap. The relative detonating power of most common explosives is well known, hence the ranges of weight and charge density for various base charges may be determined from those of pentaerythritol tetranitrate by correction using a factor which repre-

sents such relative detonating power compared to pentaerythritol tetranitrate.

Thus, the density of the explosive should be such that it gives approximately the same bulk strength (explosive energy per unit volume) as pentaerythritol tetranitrate at a density of 1.45 g./cc. For example, cyclonite, nitromannite, mannitol hexanitrate, nitrolactose, and nitrosucrose are substantially equivalent to pentaerythritol tetranitrate when pressed to the density indicated. The pressing of various explosives to obtain a density that gives a desired bulk strength is well understood in the art and is not further elaborated here.

Therefore, in accordance with the present invention, the weight of the shell bottom should be as low as practical. The weight should be not more than about 0.10 gram, preferably from about 0.02 to about 0.09 gram. The base charge utilized may be secondary explosives, such as pentaerythritol tetranitrate, cyclonite, nitromannite, mannitol hexanitrate, nitrolactose, nitrosucrose, and the like. The density of the base charge should be such that it gives approximately the same explosive energy per unit volume as pentaerythritol tetranitrate at a density of 1.45 g./cc. The explosives referred to above give approximately the same explosive energy per unit volume at a density of 1.45 g./cc. as pentaerythritol tetranitrate at the same density. Preferably, these secondary explosives should have a density of from about 1.50 to about 1.70 g./cc.

Various priming explosives such as lead azide, silver azide, mercury fulminate, mixtures of sulfur nitride with potassium chlorate or lead azide, etc., in addition to diazodinitrophenol or the diazodinitrophenol - potassium chlorate mixture shown in the examples, may be used. Materials used in the shells of this invention may include copper, aluminum, zinc, steel and other metals, cellulose acetate, ethyl cellulose, phenol-formaldehyde resins, and other plastics. The plugs for electric blasting caps may be formed of sulfur, rubber or plastic materials such as phenol-formaldehyde resins, polystyrene, ethyl cellulose, porcelain, etc. If desired, the plugs may be sealed in the caps using a sealing or waterproofing compound such as sulfur, asphalt, wax, or other material. The lead wires may be of any electrical conductive material and may be insulated using enamel, cotton or plastic materials. The bridge wire connecting the terminal ends of the leg wires may be electrically-resistant wire composed of noble or base metals or alloys thereof, such as platinum, Nichrome, copper-nickel, etc.

Where in the specification and appended claims the term "bottom" is used, the entire base is meant, in other words, the outside diameter of the blasting cap shell at its base is equivalent to the diameter of the "bottom," and the "weight" is determined from the area thereof times the thickness of the material forming the base times the weight of such material in grams.

The improved blasting initiators according to this invention have been found particularly useful for insuring the detonating of blasting gelatin of extremely high density at its maximum rate. It thus provides for propagation of the explosion under the severe conditions of use met in firing under high liquid heads in oil well shooting and geophysical prospecting.

What we claim and desire to protect by Letters Patent is:

1. In a blasting initiator, the combination of a shell having a bottom whose weight is not more than 0.10 gram, and a base charge of a secondary explosive having an explosive energy per unit volume equivalent to pentaerythritol tetranitrate at a density of 1.45 g./cc.

2. In a blasting initiator, the combination of a shell having a bottom whose weight is from 0.02 to 0.09 gram, and a base charge of a secondary explosive having an explosive energy per unit volume equivalent to pentaerythritol tetranitrate at a density of 1.45 g./cc.

3. In a blasting initiator, the combination of a shell having a bottom whose weight is from 0.02 to 0.09 gram, and a base charge of pentaerythritol tetranitrate having a density of more than 1.45 g./cc.

4. In a blasting initiator, the combination of a shell having a bottom whose weight is from 0.02 to 0.09 gram, and a base charge of cyclonite having a density of more than 1.45 g./cc.

5. In a blasting initiator, the combination of a shell having a bottom whose weight is from 0.02 to 0.09 gram, and a base charge of nitro-lactose having a density of more than 1.45 g./cc.

6. In a blasting initiator, the combination of a shell having a bottom whose weight is from 0.02 to 0.09 gram, and a base charge of pentaerythritol tetranitrate having a density from 1.50 to 1.70 g./cc.

7. In a blasting initiator, the combination of a shell having a bottom whose weight is from 0.02 to 0.09 gram, and a base charge of cyclonite having a density from 1.50 to 1.70 g./cc.

8. In a blasting initiator, the combination of a shell having a bottom whose weight is from 0.02 to 0.09 gram, and a base charge of nitro-lactose having a density from 1.50 to 1.70 g./cc.

9. In a #6 commercial blasting cap, the combination of a shell having a bottom whose weight is not more than 0.10 gram, and a base charge of a secondary explosive having an explosive energy per unit volume equivalent to pentaerythritol tetranitrate at a density of 1.45 g./cc.

10. In a #8 commercial blasting cap, the combination of a shell having a bottom whose weight is not more than 0.10 gram, and a base charge of a secondary explosive having an explosive energy per unit volume equivalent to pentaerythritol tetranitrate at a density of 1.45 g./cc.

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