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2,360,698

DETONATOR

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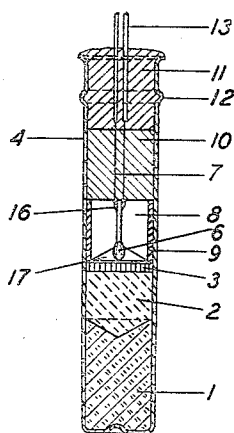


FIG. I

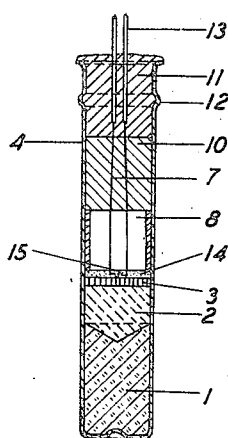


FIG. II

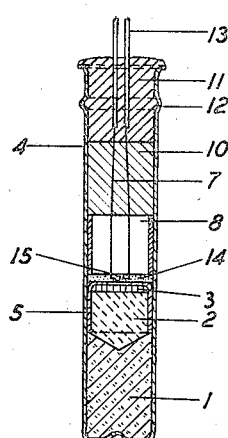


FIG. III

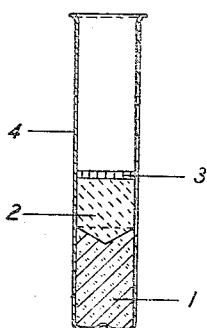


FIG. IV

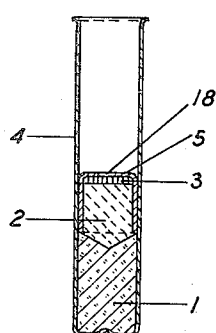


FIG. V

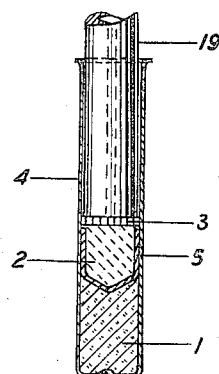


FIG. VI

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DETONATOR

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5 Claims. (Cl. 102—28)

My invention relates to blasting caps and electric blasting caps. By means of my invention I can produce blasting caps and electric blasting caps which are characterized by being safer to manufacture, handle, or use. My blasting caps and electric blasting caps can be subjected to greater blows and shocks, or rougher treatment without exploding than those now on the market. My electric blasting caps have the additional advantage that if accidentally introduced into a flame or otherwise momentarily subjected to a very high temperature, they show materially reduced tendency to explosion under such circumstances.

The materials used in making my blasting caps and electric blasting caps are well known in the art but the particular combinations of explosive materials which I use are novel and their use in the manner prescribed leads to unexpected results. For example, my blasting caps and electric blasting caps withstand without exploding the shock of more severe blows than the ordinary blasting caps and electric blasting caps, and in addition, the electric blasting cap can be placed in a hot flame without detonating. These are safety advantages and indicate that my blasting cap can receive rougher treatment than the ordinary blasting caps without resulting in accidents to the user.

The principle of my invention may be illustrated by the accompanying drawing. Figures I, II, and III show in section the invention as used in electric blasting caps, and Figures IV, V and VI show in section my invention applied to blasting caps.

Figure I shows an electric blasting cap of the matchhead type, Figure II shows the bridge wire type and Figure III shows the bridge wire type with an inner capsule 5 made of copper, gliding metal, or preferably aluminum which is not affected by the corrosive action of the lead azide. The capsule may be pressed into position at the same time the secondary charge is pressed or the secondary charge may be pressed into the capsule before it is inserted into the blasting cap shell.

Figure IV shows a blasting cap without the inner capsule. Figure V shows a blasting cap utilizing an inner capsule which is similar to the one used in the electric blasting caps and can be introduced into the shell by the same methods.

Referring to these figures, 4 is the usual outer metal shell used in the manufacture of blasting caps and electric blasting caps. It may be made

of any suitable ductile metals such as, aluminum, copper, or gliding metal and the copper or gliding metal may be coated with tin. In this drawing, 1 is the main explosive charge; the quantity of explosive used in the main charge is determined chiefly by the initiating strength desired in the blasting cap. The main charge may consist of any explosive composition which will not detonate when placed in the blasting cap shell and struck with a blow equivalent to the impact produced by a 16 pound weight falling at least 30"; however, this explosive mixture must be sufficiently sensitive to explode completely by the detonation of the secondary explosive charge 2, which is pressed in the shell on top of the main charge. Examples of main charges that are suitable for use in my blasting caps are: mannitol hexanitrate, mixtures of pentaerythritol tetranitrate and trinitrophenyl-methyl-nitramine, the latter component being hereinafter referred to as "tetryl," and mixtures of pentaerythritol tetranitrate and trinitrotoluene. The mixtures of pentaerythritol tetranitrate and trinitrotoluene which I have found suitable are those which contain from 15 to 30 parts of trinitrotoluene in 100 parts by weight of the mixture. If less than 15 parts of trinitrotoluene are used the mixture is too sensitive to impact and if more than 30 parts of trinitrotoluene are used, the mixture becomes less efficient as an agent to initiate the detonation of other substances. In the case of the tetryl-pentaerythritol tetranitrate mixtures relatively greater proportions of tetryl in the mixture are desirable as for example, 20 to 35 parts by weight of tetryl per 100 parts by weight of mixture. I do not, however, wish to be limited by the above maximum proportions of trinitrotoluene or tetryl.

The secondary explosive charge 2 is an important link in the chain of explosive mixtures comprising my blasting caps. This secondary charge is a mixture of trinitrotoluene and lead azide. The proportion of lead azide in the mixture can vary between 20 and 30 parts of lead azide in 100 parts of the mixture. The lead azide used should preferably be the grade which comprises the exceedingly small particle form now being used for the manufacture of blasting caps. Best results are obtained when the trinitrotoluene used has a particle size such that all the trinitrotoluene will pass through a No. 60 mesh sieve. These mixtures will not explode if they are pressed in blasting cap shells and subjected to the impact of a 16 lb. weight falling through 30" and striking the blasting cap shell held in a

horizontal position on a smooth steel surface. I prefer to use 0.3 gm. of explosive in the secondary charge if the secondary charge is to be used in conjunction with a main charge of different composition such as these described above. This secondary charge of lead azide-trinitrotoluene may weigh as little as 0.2 gm. and it may be substituted for the main charge of different composition in which case its quantity is increased to obtain the desired initiating efficiency.

In making up these blasting caps the explosive charges are pressed with the force of 270 kg. per sq. cm. This pressure may, however, be varied without departing from the spirit of my invention. The main charge is preferably pressed into the blasting cap shell by means of a pin which has a conical point so that a conical recess is left in the charge. Suitable results are obtained when the apex angle of the cone is 120°. Instead of the recess being in the form of an inverted cone it may have any other convenient shape. Into the recess in the main charge the secondary charge 2 is pressed. Satisfactory blasting caps can be made without recessing the main charge, in which case the secondary charge is pressed flat against the main charge.

Another necessary component of my explosive train is the charge 3 which is present in very small amounts and which accepts ignition from the igniting means, as: the spit of safety fuse 19 Figure VI, in the case of the blasting caps, the spit of the matchhead 6 in the electric blasting cap shown in Figure I; and the flash of the ignition mixture 14 in the bridge wire type electric blasting caps shown in Figures II and III. This charge 3 converts the ignition to a detonation which is communicated to the secondary or booster charge 2 which in turn passes the detonation along to the main charge 1 which detonates with full efficiency. In this manner a simple ignition is converted to strong detonation by means of a series of special explosive mixtures which in themselves either do not explode from mild impact or a flame, or are present in such small amounts that they do not explode when cap is crushed by the impact of a blow.

This small charge 3, which initiates detonation, I designate as the initiator charge. In the blasting caps shown in Figures IV and V the initiator charge 3 comprises 0.05 gm. of lead azide, and in the electric blasting caps as shown in Figures I, II, and III this igniter charge should consist of 0.1 gm. of a mixture of lead azide and trinitrotoluene consisting of 25 to 35 parts of trinitrotoluene per 100 parts by weight of the mixture.

The quantity of such a sensitive compound as lead azide or a mixture consisting essentially of lead azide must be necessarily small to prevent explosion when the blasting cap is crushed. In the case of the blasting caps 0.05 gm. of lead azide initiates proper detonation of booster or secondary charge when it is exposed to the spit of fuse and is sufficiently small not to cause explosion when the cap is crushed. In the case of the electric blasting caps 0.05 gm. of lead azide is not sufficient to insure proper initiation in every case and it is advisable to increase the amount but if an increased amount of lead azide is used the cap explodes on impact so that it is necessary to use a larger initiator charge, preferably 0.1 gm., in which case trinitrotoluene should be added to it to the extent of 25 to 35 parts by weight per 100 parts of mixture in order to reduce its impact sensitiveness. These propor-

tions of trinitrotoluene give satisfactory results. These mixtures have an impact sensitiveness such that when used to the extent of 0.1 gm. as an initiator, they will not explode when the cap is crushed as for example by being struck with a 16 lb. weight falling 30 inches. At the same time 0.1 gm. charges of these trinitrotoluene-lead azide mixtures are sufficient to properly initiate detonation of the booster charge.

In the trinitrotoluene-lead azide mixtures already described the trinitrotoluene may be replaced by an explosive substance of equivalent impact sensitiveness. Tetryl is too sensitive to give satisfactory results in these azide mixtures.

In the azide mixtures described the proportions are given on a weight basis. The reason these mixtures function as they do will be better observed if the mixtures are considered on a volume basis. Lead azide has a specific gravity equal to about 3 times that of trinitrotoluene. Therefore a mixture containing 75 parts by weight of lead azide and 25 parts by weight of trinitrotoluene has three times as much lead azide by weight as trinitrotoluene but if the proportion is calculated on a bulk basis it will be found that the volume of lead azide in this mixture is about equal to the volume of the trinitrotoluene present. Therefore there is sufficient bulk of trinitrotoluene to effectively separate or screen the exceedingly fine lead azide particles specified for these mixtures, from each other so that in case a few crystals of lead azide explode by impact they cannot communicate their explosion to other lead azide particles and a detonation of the whole charge is not set up.

The main charge, secondary charge, and initiator charge are each charged separately in this order and each is pressed or consolidated before the next charge is added. A pressure of about 270 kg. per sq. cm. gives satisfactory results.

In blasting caps having an attached fuse which conducts the flame to the explosive charge in the cap, the initiator charge, the secondary or booster charge and the main charge form the explosive elements. It should of course be understood that the secondary charge can be increased in quantity and substituted for the main charge but the main charge specified makes a blasting cap that is a very efficient detonation initiator.

Also, in the matchhead type electric blasting cap the above three explosive charges, namely, the initiator charge, the secondary or booster charge, and the main charge, are all that are necessary in a very efficient electric blasting cap. In the bridge wire type of electric blasting cap, however, an ignition or igniter charge is required. Such a charge is shown at 14 in Figures II and III. It is charged in an unpressed condition so that the bridge wire 15 is embedded in it. The igniter 14 is heated to its ignition temperature by the bridge wire 15 when a suitable electric current is passed through the wire.

One suitable igniter composition is as follows:

	Per cent by weight
Nitrocellulose	45.00
Potassium chlorate.....	27.00
Lead sulphocyanate.....	27.00
Stabilizer	1.00
	100.00

The composition of the igniter is not critical

and I do not wish to be limited to the example given either as to proportions or components. It is merely offered by way of illustrating one workable ignition mixture.

The quantity of the igniter should be such as to surround the bridge and keep the bridge from bearing forcibly on the last explosive charge 3 pressed into the cap. Its amount varies therefore with the diameter of the blasting cap shell and the distance the bridge wire 14 projects below its sulphur plug 8. The quantity and composition of the igniter can be varied so as to regulate the degree of "sustained ignition" of the electric blasting cap. The term "sustained ignition" refers to a definite time interval between ignition of the igniter by the effect of the electric current on the bridge wire and detonation of the cap. A uniform length of "sustained ignition" of short duration is desirable in some types of electric blasting caps in order to insure proper ignition of all the charges in the blasting circuit before the circuit is broken by the explosion of any electric blasting cap. A sustained ignition of 0.006 second affords quite satisfactory results and this can be secured with a charge of 0.27 gm. of the above ignition mixture in a cap 0.27 inch in diameter. With certain igniter compositions the duration of sustained ignition is so short as to be practically nil.

My invention should not be limited as to quantity of ignition mixture because satisfactory types of bridge wire electric blasting caps can be made with different quantities of igniter.

I have now described the essential explosive and ignition elements of my new blasting caps. The other components of the matchhead type electric blasting cap which are more or less standard in the industry, as shown in Figure I are: 6, a matchhead of any suitable type now used in electric detonators and is usually made by coating the two broad faces of a small strip of dielectric material such as fibre or strong paper board, with metal foil, soldering a fine platinum bridge wire to each of the metal foil surfaces and dipping this assembly in a match composition; the bare leg wires 7 are soldered to the exposed metal foil faces of the matchhead at 16; 9 is a paper tube which fits snugly in the shell and forms a mold for the sulphur-talc or sulphur-mica mixture 8 which is poured into the tube and allowed to solidify, thereby anchoring the matchhead in fixed position; 17 is a small air space; 10 is a "waterproofing" composition used to seal the cap so that water is prevented from reaching the explosive charge; 11 is a sulphur-talc composition which is poured into the top of the cap and fills the corrugation 12 in the shell thereby anchoring or "fixing" the assembled components in place in the shell after the melted composition has cooled and solidified; and 13 is ordinary insulation material for the leg wires 7.

The parts shown in the bridge wire assemblies and not already described, see Figures II and III, are: leg wires 7, across the bare separated ends of which the fine bridge wire 15 is soldered, the leg wires also being held firmly in the sulphur-talc plug 8 which fits snugly into the shell 4; 10 is "waterproofing" compound the purpose of which has been described in the matchhead type electric blasting cap; and 11, 12, and 13 are identical with the same parts discussed in the matchhead type.

The inner capsule 5 in Figures III and V is a thin-walled copper, or gilding metal, tinned copper, aluminum, etc. cup with a hole 18 in its base. In Figures III and V the capsule is shown with its mouth or fully opened end downward. It may be inserted with the fully opened end up, as 5 in Figure VI, in which case the hole in the base of the cup is not necessary. This capsule fits snugly in the shell and adds additional confinement to the initiator and secondary charges, thereby causing these charges to function with greater efficiency. If this capsule is made of aluminum or tinned copper it is useful in case the shell is made of copper in preventing the lead azide from coming in contact with copper upon which it exerts a corrosive action and hence the cap will remain in a serviceable state over long periods of storage.

The following claims are illustrative.

I claim:

1. A blasting cap consisting of three separately charged and pressed explosive charges, namely, an initiating charge, a secondary charge, and a main charge which are charged in inverse order; the initiating charge consisting of less than .10 gm. lead azide, the secondary charge consisting of .25 to .35 gm. of a mixture of lead azide and trinitrotoluene, the ratio of the weight of lead azide to the weight of trinitrotoluene varying between .25 and .429, and the main charge comprising a mixture of pentaerythritol tetranitrate and trinitrotoluene, the ratio of pentaerythritol tetranitrate to trinitrotoluene, by weight, varying between 5.67 and 2.33.
2. A matchhead type electric blasting cap comprising a matchhead and three separately charged and pressed explosive charges, namely, an initiating charge comprising 0.08 to 0.12 gm. of lead azide-trinitrotoluene mixture in which the ratio of weight of lead azide to weight of trinitrotoluene is between 3.0 and 1.9; 0.25 and 0.35 gm. of secondary charge comprising a lead azide-trinitrotoluene mixture in which the ratio of weight of lead azide to weight of trinitrotoluene is between .25 and .429; and a main charge comprising a mixture of pentaerythritol tetranitrate and trinitrotoluene, the ratio of pentaerythritol tetranitrate to trinitrotoluene, by weight, varying between 5.67 and 2.33, the order of introducing the explosive charges being, first the main charge, then the secondary charge and finally the initiating charges.
3. An electric blasting cap comprising an initiating charge consisting of 0.08 to 0.12 gm. of lead azide-trinitrotoluene mixture in which the ratio of weight of lead azide to weight of trinitrotoluene is between 3.0 and 1.9; 0.25 to 0.35 gm. of secondary charge comprising a lead azide-trinitrotoluene mixture in which the ratio of weight of lead azide to weight of trinitrotoluene is between .25 and .429; and a main charge comprising a mixture of pentaerythritol tetranitrate and trinitrotoluene, the ratio of pentaerythritol tetranitrate to trinitrotoluene, by weight, varying between 5.67 and 2.33; the above three explosive charges being separately charged and pressed in inverse order into the blasting cap shell.
4. A bridge wire type electric blasting cap comprising a bridge wire embedded in an unpressed ignition mixture which is charged on three separately charged and pressed explosive mixtures as follows: an initiator charge comprising .08 to .12 gm. lead azide-trinitrotoluene mixture in

which the ratio of weight of lead azide to weight of trinitrotoluene is between 3.0 and 1.9; .25 to .35 gm. of secondary charge comprising a lead azide-trinitrotoluene mixture in which the ratio of weight of lead azide to weight of trinitrotoluene is between .25 and .429; and a main charge comprising a mixture of pentaerythritol tetranitrate and trinitrotoluene, the ratio of pentaerythritol tetranitrate to trinitrotoluene, by weight, varying between 5.67 and 2.33, the order of introducing the explosive charges being, first the main charge, then the secondary charge, and finally the initiating charge.

5. An electric blasting cap comprising an initiator charge consisting of .08 to .12 gm. of lead

15 azide-trinitrotoluene mixture in which the ratio of weight of lead azide to weight of trinitrotoluene is between 3.0 and 1.9; .25 to .35 gm. of secondary charge comprising a lead azide-trinitrotoluene mixture in which the ratio of weight of lead azide to weight of trinitrotoluene is between .25 and .429; and a main charge comprising a mixture of pentaerythritol tetranitrate and tetryl, the ratio of pentaerythritol tetranitrate to tetryl, by weight, varying between 4.0 and 1.86, the three explosive charges being separately charged and pressed in inverse order into the electric blasting cap shell.

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