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ELECTRIC DETONATOR IGNITION SYSTEMS

Filed March 25, 1965

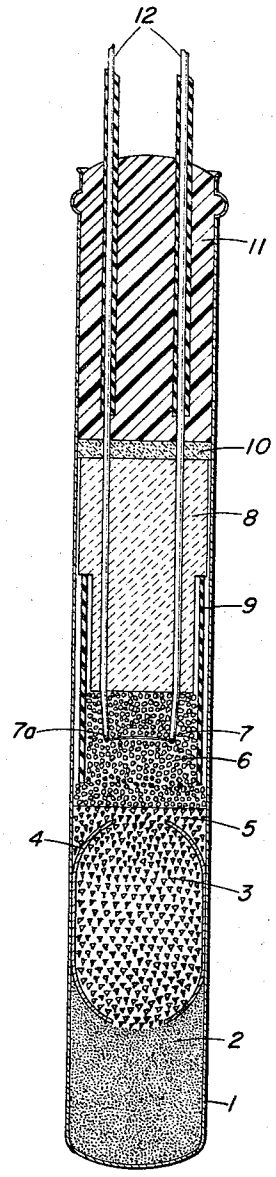


Fig - 1

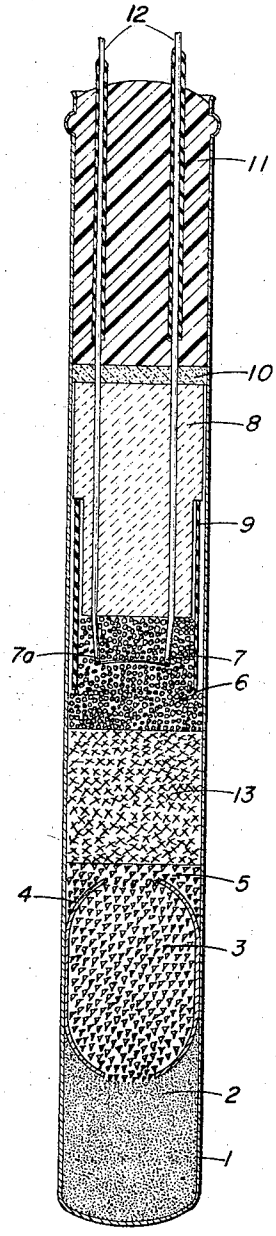


Fig - 2

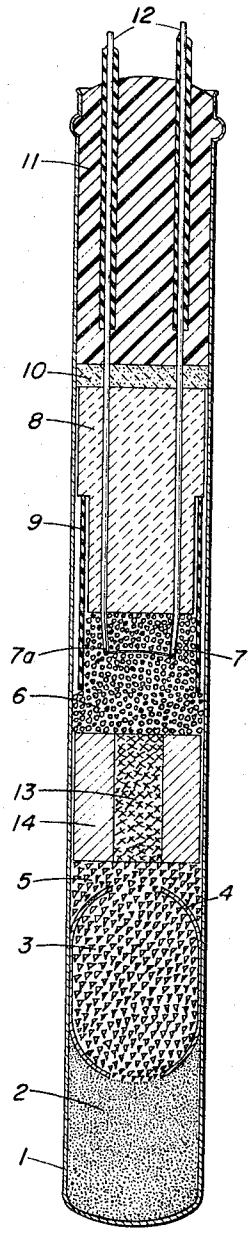


Fig - 3

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ELECTRIC DETONATOR IGNITION SYSTEMS

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9 Claims. (Cl. 102—28)

The invention relates generally to electric detonator systems. More particularly, it relates to (a) a novel ignition charge for electric blasting caps, (b) a method for preparing said ignition charge and (c) an electric blasting cap of high resistance to stray electric currents and electrostatic discharges.

As is well known, electric blasting caps generally contain a base charge of a detonating explosive, such as PETN (pentaerythritol tetranitrate), a heat sensitive initiation charge, such as DDNP (diazodinitrophenol), superimposed on the base charge, and a readily ignitable ignition charge capable of firing the initiation charge by the heat generated. Delay electric blasting caps may also contain a charge of slow-burning mixture or a length of delay fuse positioned between the ignition charge and the initiation charge to provide a specified time between the application of the firing current and explosion of the base charge.

Electric blasting caps have been used with advantage for many years. However, their use has involved certain hazards not encountered when fuse caps were used. A particularly dangerous hazard is that of premature detonation caused by stray electric currents or electrostatic discharges. In attempting to offset these hazards, various types of ignition charges and/or constructible designs of blasting caps have been proposed. To date, however, no economically feasible blasting cap has been proposed which provides complete protection against these hazards. The present invention is concerned with the provision of a blasting cap with markedly superior resistance to these hazards.

Accordingly, it is the primary object of the invention to provide a practical blasting cap which exhibits unusually high resistance to stray electric currents and electrostatic discharges. It is a further object to provide, as the ignition charge for said cap, a composition having unusual and advantageous properties. A still further object is the provision of a method for forming the ignition charge in a free-flowing granular form without the use of a graining agent. Other and further objects will be apparent from the following detailed description of the invention.

In accordance with one aspect of the invention, a novel ignition charge for a static and stray current resistant blasting cap is provided by forming an intimate, uniform mixture of amorphous boron and PbO or Pb_3O_4 in certain defined proportions and in such a manner as to provide essentially spherical, free-flowing aggregates thereof. The proportions of boron and PbO or Pb_3O_4, of which these mixtures are comprised, are as follows:

Mixture	Percent Boron	Percent PbO	Percent Pb_3O_4
Type 1	1.5–2.5	97.5–98.5	----------
Type 2	8–30	70–92	----------
Type 3	15–30	----------	70–85

It has been found that these three types of mixtures exhibit unusually high levels of voltage breakdown; hence, when used in electric blasting caps designed with a short arc path between the leading wires and the shell, but outside the locus of any sensitive component, they provide unusually high resistance to stray electric currents or static charges normally encountered in the use of the caps. Also, the three types of mixtures burn in a non-violent manner and without formation of combustion gases or development of excessive heat whereby they are particularly suitable for use in blasting caps without the need of a gas expansion chamber.

The three types of mixtures also exhibit ready and consistent ignitability by a hot bridgewire of given composition and dimensions which has been heated by the flow of a limited current of specified magnitude and duration. This property of consistent bridgewire sensitivity is most unusual in view of the wide variation in compositions which the three types of mixtures represent. Usually the bridgewire sensitivity of such fuel-oxidizer mixtures changes significantly with only minor variations in the proportions of the components. It is essential that consistent bridgewire sensitivtiy be maintained in the manufacture of electric blasting caps in order for the caps to be fired in series without failures, particularly when large numbers of caps are used in a blast. Also, hazardous misfires can occur in a series circuit when the bridgewire sensitivity of the caps is not uniform.

As has been indicated, an important feature of the present invention is the method of preparing the ignition compositions in granular, free-flowing form, without the employment of a graining agent. Essentially, this novel process involves the following steps. The required proportions of the finely divided amorphous boron and the PbO, or Pb_3O_4, are combined by a wet mixing process to form an intimate uniform mixture. This may be done in a mill jar with suitable balls and a liquid medium, such as acetone or water, or a mixture of acetone and water. After drying, the resultant cake is crushed and forced through a screen of 20–60 mesh size. The screened material is then placed in a dielectric container such as a jar made of glass, plastic or other non-conductive material, and electrostatically grained to substantially spherical form by tumbling for a period of at least about 1 hour. No material graining agent, or binder, is required.

The bulk density of the grained ignition mixture is controlled within selected limits, i.e., from 1.2 to 3.0 g./cc. by varying the initial particle size, the diameter of the jar, the speed of rotation and the duration of the rotation. This control of bulk density is necessary to permit the use of volumetric chargers during manufacturing operations. Typical preparational procedures are illustrated in the following specific examples in which all parts are by weight.

Example 1

Ten grams of 90–97% purity amorphous boron and 490 grams of −5 micron PbO of 99+% purity are placed in a ceramic mill jar of ½ gallon capacity containing 1 kg. of ¼-inch diameter and 1 kg. ½-inch diameter stainless steel balls, and 0.7 kg. water and mixed for 16 hours. Following mixing, the wet mixture is poured through a ⅛-inch mesh screen to remove the balls. The wet mixture is caught in a 2-inch x 10-inch x 12-inch stainless steel pan and dried to a moisture content of not more than 0.1% in a suitable forced-draft electric oven operating at 212° to 225° F. over a period of approximately four

hours. After drying, the resultant cake is crushed with a non-sparking spatula (soft rubber preferred) and forced through a 20-mesh screen using the same spatula. The 500 g. of screened particles are then placed in a glass jar 10 inches in length and 6 inches in diameter and electrostatically grained by rotating the jar on its length-wise axis at 65 r.p.m. for 2.25 hours. The grained material has a bulk density of 2±0.2 g./cc.

Examples 2–4

Additional examples of Type 1 (supra) mixtures of the invention were prepared according to the procedures and specifications of Example 1, except that the proportions of boron and PbO used were as follows: 1.5% boron/98.5% PbO (Example 2); 2.25% boron/97.75 PbO (Example 3); and, 2.5% boron/97.5% PbO (Example 4).

Example 5

A more rapid burning composition than that described in Example 1, but with the same desirable properties, results when 10 parts, by weight, of 90–97% purity amorphous boron and 90 parts, by weight, of −5 micron PbO of 99+% purity is prepared according to the procedure of Example 1. This mixture is especially suitable for use as the ignition mixture in delay caps designed to function in less than 300 milliseconds. It releases an average of 217 calories per gram as compared to 133 calories per gram for the 2% boron/98% PbO mixture of Example 1. The bulk density is 1.5±0.2 g./cc. when grained as described.

Examples 6–10

Additional examples of Type 2 (supra) mixtures of the invention, prepared according to the procedures and specifications of Example 1, except for the proportions of boron and PbO used, are the following: 8% boron/92% PbO (Example 6); 15% boron/85% PbO (Example 7); 20% boron/80% PbO (Example 8); 25% boron/75% PbO (Example 9); and, 30% boron/70% PbO (Example 10).

Example 11

A composition composed of 25 parts by weight of 90–97% purity amorphous boron and 75 parts by weight of −5 micron Pb_3O_4 of not less than 90% purity was prepared by the procedure of Example 1. This composition burns at about the same rate as the 10% boron/90% PbO but releases an average of 248 calories per gram. Hence, this mixture is most suitable as the ignition mixture for very rapid delays or the ignition-energy charge for heat motors and the like. Bulk density is approximately 1.2 g./cc.

Examples 12–15

Additional examples of Type 3 (supra) mixtures of the invention, prepared as in Example 11, except for the proportions of boron and Pb_3O_4 used, are the following: 8% boron/92% Pb_3O_4 (Example 12); 15% boron/85% Pb_3O_4 (Example 13); 20% boron/80% Pb_3O_4 (Example 14); and, 30% boron/70% Pb_3O_4 (Example 15).

As opposed to the foregoing examples of iginition mixtures of this inventions, mixtures of boron and PbO, or Pb_3O_4, in proportions at or near stoichiometric levels, when initiated by a hot bridgewire, spark or flame, react more violently than the heat liberated would indicate. Examples of these are the following.

Example 16

A stoichiometric mixture of boron and lead monoxide was prepared by the procedure of Example 1 utilizing 3.1 parts by weight of amorphous boron and 96.9 parts by weight of PbO, both to the same specifications given in Example 1. The mixture burns with explosive violence while releasing an average of 194 calories per gram. The grained material has an average bulk density of 1.9 g./cc.

Example 17

A stoichiometric mixture of 4.05 parts, by weight, of 90–97% purity boron and 95.95 parts, by weight, of Pb_3O_4 of 90%-plus purity was prepared by the procedure of Example 1. This mixture also burns with explosive violence. It releases an average of 294 calories per gram. The bulk density of the grained material averages 1.9 g./cc.

Mixtures such as in Examples 16 and 17 must be avoided in the construction of delay caps designed without gas expansion chambers. A violent or extremely hot mixture can rupture the cap shell and cause the delay cap to fail to detonate by (a) failure to initiate the delay train, (b) snuffing out the flame in the delay train, and/or (c) complete separation of the ignition section from the explosive section of the delay cap. Certain violent ignition systems can also cause malfunctioning of a delay cap by changing the pressure conditions within the atmospheric gases entrapped within the particles of the ignition mixture. In a delay system, this pressure head factor contributes to the burning rate of the column of delay powder; hence, in these caps the pressure head must be maintained otherwise the desired time interval may not be attained. Proper time intervals between explosions in multiple hole blasting operations can be critical to the obtainment of the required results.

Advantageous properties of the ignition mixtures of the invention will be evident from the data in Table I which shows the results of comparative tests, namely, (a) Heat of Reaction, (b) Ignition Temperature, and (c) Voltage Breakdown, conducted on typical compositions of the invention and the stoichiometric mixtures of Examples 16 and 17. Three other types of ignition charges conventionally used in blasting caps, namely diazodinitrophenol, a stoichiometric mixture of selenium and lead powder, and a mercury fulminate match-head type mixture were also tested. All compositions and the DDNP were in free-flowing form suitable for use in electric blasting caps. The calorimeter tests were made in a No. 1411 Parr bomb filled with argon. Ignition points were dtermined by dropping a sample of the test material onto aluminum foil floating on molten lead heated to the minimum temperature which would produce instantaneous ignition. Voltage breakdown tests were conducted in electric blasting cap assemblies of this invention (shown in FIGURES 1, 2, and 3 of the accompanying drawing) with the voltage applied to the shunted leg wires and the cap shell. These cap assemblies are described in detail further on in the specification.

From the data in the table, it will be apparent that the three preferred compositions, i.e., Examples 1, 5, and 11 and twelve usable, similar compositions, i.e., Examples 2–4, 6–10 and 12–15, which have been made by the procedures of Example 1 have high levels of voltage breakdown when used in caps of the designs of the invention adequate to resist stray currents and static charges normally encountered during the use of caps in the field. The compositions of the invention also have much higher ignition points than DDNP (Example 18), 27.6% Se/72.4% Pb (Example 19), or a gas-forming match composition (Example 20), hence, are less hazardous in this respect. The match composition releases gas when it is fired, hence, requires a gas expansion chamber. Since the Se/Pb mixture is conductive, a cap design, not now apparent, would be required before stray current and static resistance could be attained with this mixture. The DDNP detonates when ignited in confinement, hence, its use is usually as an initiator for a high explosive charge. The stoichiometric mixtures, i.e., Examples 16 and 17, likewise react too violently to be used as ignition mixtures in blasting caps without provision of a gas expansion space or a confining means for

dissipation and/or restriction of the violence of the reactions.

TABLE I

Example No.	Ignition Mixture Date			Cap Assembly Data Voltage Breakdown, Avg. A.C.
	Composition, percent by Weight	Heat of Reaction. cal./g.	Instantaneous Ignition Temp. ° C.	
1	2% B/98% PbO	133	398	1,400
2	1.5% B/98.5% PbO	[1] N.R.	454	1,935
3	2.25% B/9.75% PbO	N.D.	408	1,970
4	2.5% B/97.5% PbO	158	412	2,200
5	10% B/90% PbO	217	371	1,470
6	8% B/92% PbO	202	380	1,955
7	15% B/85% PbO	190	420	2,220
8	20% B/80% PbO	180	438	2,030
9	25% B/75% PbO	171	N.D.	1,405
10	30% B/70% PbO	165	450	1,450
11	25% B/75% Pb_3O_4	248	425	2,060
12	8% B/92% Pb_3O_4	N.D.	415	1,840
13	15% B/85% Pb_3O_4	268	434	1,800
14	20% B/80% Pb_3O_4	256	438	1,880
15	30% B/70% Pb_3O_4	N.D.	445	1,860
16	3.1% B/96.9% PbO	194	[2] N.D.	[2] N.D.
17	4.05% B/95.95% Pb_3O_4	294	[2] N.D.	[2] N.D.
18	Diazodinitrophenol	N.D.	176	N.D.
19	27.6% Se/72.4% Pb	83	220	80
20	Match Composition	N.D.	204	1,820

[1] No reaction in the argon atmosphere of the calorimeter bomb.
[2] These values were not determined because the mixtures react too violently to be of interest.

As has been indicated previously, the compositions of the invention are particularly suitable for use in blasting caps designed without an expansion chamber since they are non-violent and non-gas-forming when ignited. An important aspect of the invention is a blasting cap designed without an expansion chamber and for use in which the compositions of the invention are eminently suitable.

FIGURE 1 represents a cross-sectional view of a static and stray current resistant electric blasting cap in accordance with the invention.

Referring to FIGURE 1 which illustrates a cap of the "Zero Delay" type, item **1** is the shell containing the various components. A pressed charge **2** of PETN is at the base of the shell. Super-imposed on the base charge is a capsule **4** which contains most of the initiation charge **3** of DDNP so as to protect it from excessive pressure when it is compressed to form a sound base **5** for the ignition charge **6** which is the defined ignition charge of this invention. At **7** and **7***a*, a bridgewire is attached to the poles of lead wires **12**. A section of dielectric tubing **9** is fitted to the lower half of bridge plug **8** and encompasses most of ignition charge **6**, thus providing a longer potential arc path between the points **7** and **7***a* and shell **1** than the arc path provided between the lead wires **12** and shell **1** through the layer of porous dielectric **10**. The contents of the cap are protected against ingress of water by the waterproof seal **11**.

FIGURE 2 shows a cross-sectional view of a delay-type electric blasting cap within the scope of the invention, the only difference from the cap illustrated in FIGURE 1 being the presence of a delay column of fuse powder **13**, interposed between initiation charge **5** and ignition charge **6**.

FIGURE 3 is a cross-sectional view of a blasting cap similar to that shown in FIGURE 2, except that delay column **13** is a core of fuse powder contained in a thick-walled tubular section **14**.

It is seen that the present invention provides a novel class of ignition mixtures for electric blasting caps which are gasless and non-violent, thereby eliminating the need for a gas expansion chamber in the design of electric blasting caps. They are also non-conductive, thereby increasing the resistance of the cap in which they are used to premature ignition by stray currents and static discharges. Further, although differing quite widely in range of composition, the mixtures are substantially uniform in their sensitivity to hot bridgewire and are, therefore, eminently adaptable for firing in series circuits. It will be appreciated that besides blasting caps, the properties of the mixtures make them highly useful as ignition charges for electric squibs, electric detonators, electrically initiated heat motors, electrically initiated gas generators, explosive bolts, and the like.

Secondly, the invention provides a unique method for preparing the ignition mixtures whereby the use of a graining agent is eliminated.

Thirdly, the invention provides a new blasting cap assembly involving the use therein of the novel ignition mixtures which assembly greatly reduces the hazards of premature detonation caused by stray electric currents and static discharges normally associated with electric blasting caps and which in addition provides an important, economical advantage by eliminating the need for an expansion chamber in such devices.

While the present invention has been described herein in terms of specific examples and embodiments thereof, it is not intended that its scope be limited in any way thereby, but only as indicated in the following claims.

We claim:

1. An electric blasting cap resistant to static discharges and stray currents comprising an elongated tubular metal shell, a base charge of a detonating explosive at the bottom of said shell, an initiation charge super-imposed directly on said base charge, an ignition charge super-imposed directly on said initiation charge, a bridgewire connected to the ends of a pair of leg wires imbedded in said ignition charge, a bridge plug of insulated material surrounding and supporting said leg wires, the base of said plug being super-imposed directly on said ignition charge, a layer of porous dielectric material surrounding said leg wires and being super-imposed directly on said plug, a layer of water-proof sealing material surrounding said leg wires and being super-imposed directly on said layer of porous dielectric material; the lower portion of said plug having a smaller circumference than the upper portion thereof, a section of dielectric tubing fitted over said lower portion of said plug so as to fill the annular space between the lower portion of said plug and said shell wall, said tubing being of a length such that its lower portion extends downward around a portion of the ignition charge and below the level of the bridgewire so as to provide a longer potential arc path between the ends of said leg wires and said shell than the potential arc path between the lead wires and said shell through said porous dielectric layer, said ignition charge being a composition selected from the group consisting of

(a) a mixture composed of from 1.5 to 2.5%, by weight, of amorphous boron and from 98.5 to 97.5% by weight, of PbO;

(b) a mixture composed of from 8 to 30%, by weight, of amorphous boron and from 92 to 70%, by weight, of PbO and;

(c) a mixture composed of 15 to 30%, by weight, of amorphous boron and from 85 to 70%, by weight, of Pb_3O_4;

said composition being in granular, free-flowing form and having a bulk density of from 1.2 to 3 grams per cc.

2. An electric blasting cap according to claim **1** having a delay charge interposed between said initiation charge and said ignition charge, said delay charge being super-imposed directly on said initiation charge and said ignition charge being super-imposed directly on said delay charge.

3. An electric blasting cap according to claim **1** wherein said ignition charge is a mixture composed of 2%, by weight, of amorphous boron and 98%, by weight, of PbO.

4. An electric blasting cap according to claim **1** wherein the ignition mixture is composed of 10%, by weight, of amorphous boron and 90%, by weight, of PbO.

5. An electric blasting cap according to claim **1** wherein the ignition charge is composed of 25%, by weight, of amorphous boron and 75%, by weight, of Pb_3O_4.

6. A composition for use as an ignition charge in electric blasting caps selected from the group consisting of

(a) a mixture composed of from about 1.5 to about 2.5%, by weight, of amorphous boron and from 98.5 to 97.5%, by weight, of PbO;

(b) a mixture composed of from 8 to 30%, by weight, of amorphous boron and from 92 to 70%, by weight, of PbO; and

(c) a mixture composed of from 15 to 30%, by weight, of amorphous boron and from 85 to 70%, by weight, of Pb_3O_4;

said composition being in granular, free-flowing form and having a bulk density of 1.2 to 3 grams per cc.

7. As an ignition charge for electric blasting caps a mixture composed of 2%, by weight, of amorphous boron and 98%, by weight, of PbO.

8. As an ignition charge for electric blasting caps comprising a mixture composed of 10%, by weight, of amorphous boron and 90%, by weight, of PbO.

9. As an ignition charge for electric blasting caps a mixture composed of 25%, by weight, of amorphous boron and 75%, by weight, of Pb_3O_4.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,286,628 November 22, 1966

Guy Bayard Young et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 5, TABLE I, in the heading to the second main column, for "Date" read -- Data --; same table, second column, line 3 thereof, for "9.75%" read -- 97.75% --.

Signed and sealed this 12th day of September 1967.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents