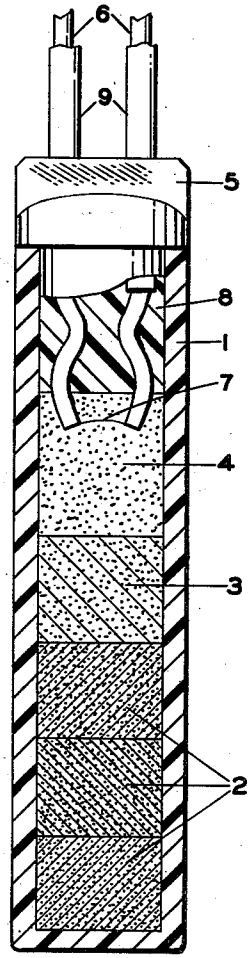
Oct. 23, 1956 F. R. SEAVEY 2,767,655

BLASTING CAPS

Filed June 15, 1953



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United States Patent Office 2,767,655
Patented Oct. 23, 1956

2,767,655

BLASTING CAPS

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Application June 15, 1953, Serial No. 361,600

4 Claims. (Cl. 102—28)

This invention relates to explosive initiators and particularly to detonators of the type employed for initiating the explosion of larger charges of explosives as in military or blasting operations.

Electric detonators usually consist of an explosive train contained in a cylindrical metal cup. This explosive train is initiated by a resistance or bridge wire embedded in a sensitive explosive within the case; the electric lead wires for the bridge wire being supported by a sulfur plug molded about them and positioned immediately above the igniter mix. The detonator is then sealed by pouring a relatively deep layer of a waterproofing composition such as pitch in place while in a heated fluid condition, and consequently rendered non-fluid by cooling to normal temperatures. This pitch seal is normally held in place by pouring a layer of sulfur over it.

Numerous disadvantages are inherent in the use and manufacture of this type of electric detonator; and many modifications have been made in electric blasting caps in efforts to improve their waterproofness, susceptibility to mechanical shock and to static electrical charges, and the emission of a large number of high velocity metal fragments upon firing of the cap. The most promising advantages made in the elimination of these difficulties have been made by replacing the metal detonator case with one formed from an organic plastic material and closing the plastic case by cementing a lead wire carrying plastic plug in place to close the open end of the plastic case. Detonators of this type provided with a plastic case and plug are particularly well exemplified in U. S. Patents 2,415,045 and 2,420,201 granted to Frederick R. Seavey. The detonators described in these patents present a definite advance in the field of blasting. It has been shown, for example, such detonators are markedly superior to metal cased detonators in their susceptibility to sympathetic detonation, emission of projectiles upon firing, and in their resistance to mechanical shock as well as to undesirable electrical stimuli. In spite of the superiority of these blasting caps over the conventional metal detonators as well as other detonators having plastic cases, it has been found desirable to provide detonators having improved waterproofness and resistance to impact and static electricity.

Therefore, it is an object of this invention to provide a new and novel blasting cap that overcomes the disadvantages and difficulty of previously known blasting caps. Another object of this invention is to provide an improved blasting cap housed in an organic plastic material. In addition, it is an object of this invention to provide a plastic detonator having increased resistance to accidental firing by mechanical shock and static electricity. Other objects will be apparent when the following detail description is read in connection with the accompanying drawing, which is a longitudinal sectional view of an electric blasting cap illustrating one embodiment of the present invention.

These objects are accomplished in accordance with this invention, generally stated, by providing blasting caps with cases prepared from organic plastic materials which are

sufficiently firm to resist deflection from minor mechanical shock and yet sufficiently pliable to flex when subjected to impacts and deforming forces equivalent to the most severe treatment to be expected in the field. These characteristics are obtained, for instance, when the case is formed of plastic modified with butadiene acrylonitrile copolymers. The copolymers of butadiene and acrylonitrile, more commonly and hereinafter referred to as nitrile rubber, are compatible with plastics such as polyvinyl chloride and serve as non-migratory non-volatile plasticizers providing unique characteristics particularly advantageous in detonator cases. Although the nitrile rubber can be compounded with such plastics in widely varying proportions, it is preferred to utilize formulations, for instance, in which the ratios of polyvinyl chloride to nitrile rubber are between about 3:1 and about 4:1. The conventional non-polymeric plasticizers, such as, for example, dioctyl phthalate, trioctyl phosphate, 2-ethyl hexyl adipate, dibutyl stearate, dibutyl phthalate and tri-butoxy ethyl phosphate can advantageously be used to complement the plasticizing effect of the nitrile rubber, but when they are added only a relatively small proportion of them need be used and generally less than 20% based on the weight of the polyvinyl chloride.

Small amounts of the standard stabilizers are also advantageously added to such plastic compositions to prevent subsequent discoloration and diminution of plasticity. Thus the plastic composition normally used in preparing the blasting cap cases of this invention may contain up to 5% of one or more such stabilizers, for example, basic lead carbonate, dibasic lead stearate, the epoxy stearates of cadmium, barium and calcium, barium ricinoleate, metallic soaps including the oleates, stearates and palmitates of aluminum, magnesium, chromium, calcium, zinc, barium and zirconium, as well as waxes and oils. Stabilizers such as barium ricinoleate are particularly advantageous because they also have a dual function as mold releases and lubricants. In addition to the above components, the plastic compositions under consideration may be provided with fillers to impart the requisite degree of hardness to the plastic. It is preferred to use a mineral filler such as, for example, calcium carbonate, finely ground slate, gypsum, barium sulfate, calcium sulfate, china clay, infusorial earth and the like. Pigments and dyes may also be added when desired.

Although in accordance with this invention it is preferred to provide detonator cases prepared from nitrile rubber modified polyvinyl chloride, because of the favorably dielectric characteristics satisfactory results can also be obtained with other nitrile rubber modified plastic compositions having equivalent physical properties, e. g., toughness and flexibility, for instance polyethylene, neoprene, polystyrene, polymerized tetrafluoro ethylene, linear polyamides and other plastic formulations having suitable characteristics.

While the objects and advantages of this invention can be realized by providing detonator cases of the above described type regardless of the explosives train contained therein, the advantage of the invention are particularly pronounced when the sensitive explosives, i. e., the igniter and initiator, are lightly packed so as to form mobile masses capable of assuming new shapes without fracturing when the detonator case enclosing them is deformed by an external force. More particularly, the initiating material is pressed into the shell with the minimum pressure necessary to form the charge into a consolidated mass so as to prevent it from mixing with the igniter charge, and the igniter composition is merely poured into the case above the initiator charge and lightly consolidated by the applied pressure incidental to sealing the igniter plug.

When the invention is used in connection with electric detonators, it is preferable that the case, the sealing plug

the preferred embodiment of the invention disclosed, all and the insultion on the lead wires be formulated from material of the same plastic base. In this way, the formation of permanent hermetic seals between the lead wire insulation and the plug and between the plug and the case is greatly facilitated; and in addition, sealing failures due to differences in the thermal coefficients of expansion of the component parts are eliminated. Different materials may of course be used for the plug and lead wire insulation provided their coefficients of expansion are not too divergent and their chemical compatibility is such that a good seal is formed.

In order to more fully explain and further clarify the invention, reference is made to the drawing for an illustrative embodiment thereof. In this embodiment, the detonator consists of a case 1 of polyvinyl chloride modified with nitrile rubber having the following approximate composition:

60% polyvinyl chloride
17.5% nitrile rubber
10% calcium carbonate
2% disbasic lead stearate and basic lead carbonate (about 60:40)
0.5% barium ricinoleate
6% dioctyl phthalate
4% trioctyl phosphate

The detonator shell contains a suitably prepelleted explosive base charge 2 of cyclonite at a density of about 1.5 gm./cc. Above the base charge an initiator charge 3 of lead azide lightly pressed to a density of about 2.3 gm./cc., or other suitable explosive material may be placed. The ignition charge 4 is positioned above the initiator. The ignition material used in this embodiment is the triple salt of lead styphnate, basic lead styphnate, and lead hypophosphite, which salt is described and covered by U. S. Patent 2,292,956, but lead styphnate and other suitable igniters can be used in its stead. The ignition charge is actuated by a bridge wire 7 connected between a pair of lead wires 6.

The plug 5 is molded about the lead wires 6 and is preferably formed of the same material as the detonator casing. However, other plastic materials having comparable solubilities and rates of thermal expansion may also be used. For example, suitable plug materials include copolymers of vinyl chloride and acetate, polystyrene, linear polyamides and ethyl cellulose. The smaller diameter portion 8 of the plug forms a sliding fit with the interior of the detonator case 1; and the larger diameter portion of the plug is substantially flush with the outer surface of the case. The plug is molded about the spaced lead wires 6, which in this preferred embodiment are provided with an insulating sheath 9 of the same composition as the plug and the detonator case.

The plug and case are most conveniently formed into a unit, so as to effectively seal the detonator, by moistening them with a solvent such as tetrahydrofuran and forcing them together after a film of lacquer has been formed on the surfaces. The blending of the lacquers thus formed on the surfaces of the respective parts autogenously welds the same together upon evaporation of the solvent. Thus a strong and effective seal is formed.

The formation of an effective seal can be further insured by dipping the completed detonator in a lacquer of plasticized and stabilized polyvinyl chloride dissolved in tetrahydrofuran. The entire blasting cap including a short length of the lead wire is submerged in the lacquer to close any failures in the seals at the junctures of the plug and lead wire insulation and of the plug and the mouth of the detonator case. The detonator thus formed is completely housed in polyvinyl chloride modified with nitrile rubber and covered with a lacquer of polyvinyl chloride. In this manner failures of the seals due to incompatibility of the component parts or differences in their rate of thermal expansion are completely eliminated.

In order to illustrate the marked advantages in safety obtained by the present caps, they were tested in direct comparison with commercial No. 6 electric blasting metal cased caps and with electric caps differing from those of this invention only in that they were housed in a relatively hard brittle polyvinyl chloride case not containing nitrile rubber.

The relatively safety of these caps to mechanical impact was determined by positioning each detonator being tested on its side on a heavy metal anvil, and allowing a ten-pound weight to fall on the detonator from heights of one to seven feet, with 5 tests being made at each two-foot increment at and between these heights. The results of this test are tabulated below, wherein the number of caps fired at each height is indicated.

Height of Drop in Feet	Plastic Case with Nitrile Rubber	Plastic Case without Nitrile Rubber	Metal Case
1	0	0	0
3	0	1	5
5	0	5	5
7	0	5	5

The above data shows that the present cap has an impact sensitivity many times less that of previously manufactured plastic and metal caps. Thus, of the twenty caps made in accordance with this invention and subjected to this vigorous test, not one was detonated by the falling ten-pound weight, while 11 of the prior plastic caps and 15 of the metal caps were detonated. It should also be noted that none of the prior caps survived the impact of the weight dropped from heights greater than 3 feet.

In order to determine the relative resistance of the detonators of this invention to initiation by static electricity, they were tested in comparison with the prior plastic detonators described above and also with metal-cased detonators provided with conductive bridge plugs to equalize the potentials of the shell wall and the firing circuit. The apparatus used to generate the static charge consisted of a bank of four condensers, rated at 0.5 microfarads capacitance, and capable of being charged to any desired potential up to 20,000 volts. The detonator under test was connected to this bank of condensers, one condenser terminal being attached to the shunted lead wires of the cap, and the other condenser terminal making good electrical contact with the case of the detonator. In this test, none of the caps of the present invention was fired when the full capacity of the apparatus, 20,000 volts at 0.5 microfarads, was placed across the gap between the shunted lead wires and the wall of the detonator case. By way of comparison, approximately one-half of the prior plastic caps were initiated under the same circumstances; and all of the metal-cased detonators were initiated at voltages of 10,000 or less.

In order to illustrate the added safety characteristics achieved by using a loosely packed initiator charge in conjunction with the tough pliable detonator case previously described, two series of detonators differing only in the packing density of their initiating charges were subjected to the beforementioned mechanical impact test. One series of detonators tested was made in accordance with the above illustrative embodiment, being provided with cases of a plastic composition including about 6 parts polyvinyl chloride, 2 parts nitrile rubber, 1 part non-polymeric plasticizer and 1 part mineral filler, and containing an initiating charge of lead azide at a density of about 2.3 gm./cc. which was pressed into place with a loading pressure of about 1500 lbs./sq. in.; while the other series of detonators differed from the detonators of the illustrative embodiment only in that the initiating charge of lead azide was pressed into place under a loading pressure of about 4000 lbs./sq. in. to a density of about 2.6 gm./cc.

By the simple expedient of thus reducing the packing density of the initiator charge in a tough pliable plastic case, the resistance of the detonator to accidental firing by mechanical impact was very markedly increased. From these tests, it was shown that detonators containing lead azide packed to a density of 2.6/cc. could be initiated by dropping a 10 pound weight from a height of only 5 feet, but that the ten pound weight must be dropped at least 8 feet on detonators containing lead azide packed to a density of 2.3 gm./cc. in order to initiate them. Thus it was necessary to drop the 10 pound weight from a much greater height to effect the impact initiation of any of the detonators provided with the loosely packed initiating charge.

While the detonator shown in the accompanying drawing, and hereinbefore especially described for the purpose of illustration is an electric detonator provided with a bridge wire and a relatively unconsolidated ignition charge, it is to be understood that the features of this invention are also applicable to other types of electric detonators as well as to fuse type detonators. In the case of fuse detonators, however, it is desirable to provide some means for securing the fuse in position in the open end of the detonator case. This may be accomplished by providing a suitable anchoring device in the open end of the detonator case, as for example a spring metal ferrule having prongs directed inward from the mouth of the detonator shell, so as to permit a fuse to be inserted but to prevent its being withdrawn. Such a ferrule may be molded in position in the plastic case, or may be driven therein after the explosive ingredients have been inserted. Alternatively, a metal sleeve may be provided in the open end of the plastic detonator case, extending sufficiently beyond the end of the plastic case to permit the application of a crimping tool for crimping the fuse in position, as has heretofore been done in the case of fuse type detonators having metal cases. The loose ignition material in the fuse caps may be maintained in position by a nitrocellulose wad or membrane attached to or held in place by the lower end of the metal ferrule or sleeve, or by other appropriate means.

Since variations in the specific embodiments which have been described may be made within the spirit and scope of this invention, the detail description is not to be considered as limitative except in the light of the appended claims.

Having thus described the inventions, what is claimed is:

1. An electric blasting cap having a case, closure plug and lead wire insulation sheaths of organic plastic material comprising polyvinyl chloride modified with a copolymer of butadiene and acrylonitrile, a non-polymeric plasticizer and a mineral filler, in which the ratio of polyvinyl chloride to copolymer of butadiene and acrylonitrile is between 3:1 and about 4:1.

2. A blasting cap having a case of organic plastic material comprising polyvinyl chloride modified with a copolymer of butadiene and acrylonitrile, a non-polymeric plasticizer, and a mineral filler, in which the ratio of polyvinyl chloride to copolymer of butadiene and acrylonitrile is between about 3:1 and about 4:1, said blasting cap containing mobile ignition and initiator charges.

3. An electric blasting cap having a case of organic plastic material comprising about 6 parts of polyvinyl chloride, 2 parts of a copolymer of butadiene and acrylonitrile, 1 part of non-polymeric plasticizer and 1 part of mineral filler, said blasting cap being provided with a pre-pelleted base charge, an initiator charge of lead azide pressed to a density of about 2.3 gm./cc., and an unpressed ignition charge.

4. An electric blasting cap comprising a case of organic plastic material consisting essentially of polyvinyl chloride modified with a copolymer of butadiene and acrylonitrile, a non-polymeric plasticizer and a mineral filler in which the ratio of polyvinyl chloride to copolymer of butadiene and acrylonitrile is about 3:1 and about 4:1, the said cap containing an initiating charge pressed into the shell with the minimum pressure necessary to form the charge into a consolidated mass so as to prevent it from mixing with the ignition charge and a loose ignition charge.

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