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EXPLOSIVE INITIATORS

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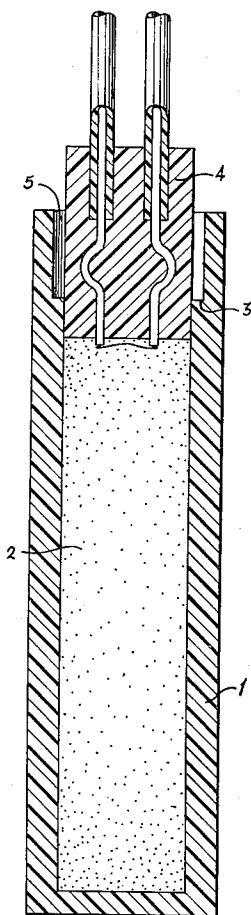


FIG. 1

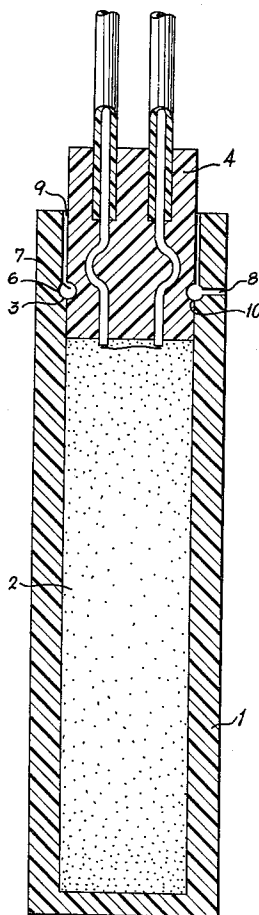


FIG. 2

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1 Claim. (Cl. 86—1)

This invention relates to explosive initiators and particularly to a method of sealing such initiators having plastic components.

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

More recently, the metallic casing has been replaced with a plastic shell and the detonator has been closed by a molded plastic bridge plug carrying the lead wires. The detonator is then sealed by cementing the plastic bridge plug to the plastic case. Such detonators are markedly superior to metallic cased detonators in their susceptibility to sympathetic detonation, emission of shrapnel upon firing and in their resistance to mechanical shock as well as to undesirable electric stimuli. Also, generally speaking, they exhibit improved resistance to the ingress of water when compared with the conventional metallic blasting caps.

However, the sealing of plastic detonators is still attended by difficulty and also by a definite amount of uncertainty. Thus, it is practically impossible to insure that all plastic detonators of any given batch have been properly sealed unless they are subjected to time consuming water immersion tests followed by destructive firing tests.

Therefore, it is an object of this invention to provide a new and novel blasting cap that overcomes the disadvantages and difficulties of previously known blasting caps. Another object of this invention is a novel process of sealing plastic detonators. A further object of this invention is to provide a process to improve the water resistance of plastic detonators. A more specific object is to provide an economical, simplified method for the manufacture of waterproof plastic detonators.

These and other objects are accomplished in accordance with this invention, generally speaking, by providing a plastic detonator with an annular space between the bridge plug and case and filling the space with a polymerizable material which is cured in place. The polymerizable plastic material is substantially solvent-free and thus can have no desensitizing effect upon the ignition mixture in the detonator. When the polymerizable material is cured or polymerized in contact with both the plastic bridge plug and the plastic case, it conforms exactly to the configuration of the space between these components and is securely bonded to both of them. Thus, the detonator is provided with a unitary plastic housing.

The annular space between the plug and the case is positioned above the base of the plug and can be provided by a variety of means. Thus, with a substantially cylindrical bridge plug, the mouth of the detonator case can be internally flared or slightly inclined. Also, the diameter of the detonator case above the base of the bridge plug can be made slightly larger than the internal diameter of the remainder of the detonator case. Alternately, a two-diameter cylindrical bridge plug can be provided in which

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the larger portion of the bridge plug is at its base and is of such a size as to form a sliding fit with the detonator case. The annular space can also be formed by providing the bridge plug with a circumferential groove. When such a groove is used, it has been desirable in some instances to provide the internal surface of the detonator case with a cooperating groove so as to increase the volume of the annular space. In those instances where one or more peripheral grooves are utilized, it is desirable that the groove be connected to a right cylindrical space above the groove and extended to the top of the detonator case.

In operation, the detonator case is charged with a suitable explosive train and the bridge plug is seated above the explosive material within the mouth of the detonator case. If desired, the proper positioning of the bridge plug within the case can be insured by providing the bridge plug with an integral shoulder designed to rest on the wall of the detonator case. Also, the detonator case can be provided with a ledge or other internal protuberance on which the bridge plug is seated, or the bridge plug itself can be provided with one or more protuberances to serve the same purpose. After the bridge plug has been properly positioned in the mouth of the detonator case, the polymerizable plastic material is injected into the space between the bridge plug and the plastic case. This material can be injected by means of a hypodermic needle or any other conventional injection nozzles connected to a polymerizable fluid source. When the annular space between the plug and case extends to the open end of the case, the polymerizable liquid can be injected into the mouth of the detonator so as to substantially fill the cavity. In most instances, and particularly when one or more cooperating grooves are utilized to form the cavity, it is preferred to provide the detonator case with an injection port cooperating with the annular space. Such injection ports are used in conjunction with vent holes in the case through which the air replaced by the polymerizable liquid can escape.

Any plastic resinous material that is in liquid or flowable form in its monomeric or pre-polymeric state can be utilized in effecting the seal of the present invention. Polymeric preparations of this type that can be used include the epoxy resins, the polyamides, polyurethanes, and other liquid materials that can be polymerized by catalysts and/or the application of moderate heat. Also, the present invention contemplates the utilization of self-curing or water-catalyzed polymeric preparations, such as alpha-cyanoacrylic acid and the like. When this type of material is used, no curing agent or additional catalyst is required, nor is it necessary to heat the injected liquid to effect curing or polymerization thereof.

While the most commonly used polymerizable materials in accordance with the invention are in liquid form, solid prepolymers such as various types of epoxy resins that become flowable on heating can be used with equal facility.

The present invention contemplates that the bridge plug and case can be made of any suitable resinous plastic material. Thus, these components can be thermoplastic or thermosetting and soluble or insoluble in conventional organic reagents. Suitable thermoplastic materials that can be used include ethyl cellulose, cellulose acetate butyrate, polyvinyl chloride, polystyrene and polyethylene, or the like. Thermosetting resins especially adapted for the formation of such detonator components are based on resins of phenol formaldehyde, casein formaldehyde, urea formaldehyde, phenol furfural, silicon base resins, epoxy resins, and other similar resins.

The manner in which the objects of the present invention are accomplished will be more readily appreciated by those skilled in the art by reference to the following

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illustrative embodiments of the invention taken together with the drawing in which:

FIGURE 1 is a longitudinal sectional view illustrating one embodiment of the present invention; and

FIGURE 2 is a similar view illustrating another embodiment of the invention.

As shown in FIGURE 1, the detonator is provided with an ethyl cellulose case 1 which is charged with a suitable explosive material indicated generally at 2. Near the open end of the detonator case, a ledge 3 is formed by increasing the internal diameter of the case near its open end. Bridge plug 4 also molded of ethyl cellulose was then inserted into the open end of the detonator as shown so as to form an annular space 5 between the upper end of the detonator case and the bridge plug. An epoxy resin prepolymer containing about 8% diethylene triamine as a cross-linking catalyst was injected into the annular space, thus completely filling it. The particular resin used was Shell Epon Resin No. 828, but it will be readily appreciated that many of the commercially available epoxy resin preparations can also be used. The resin was then cured by placing the assembled detonators in a heating chamber at about 45° C. for about three days. After the curing process, the detonators were submerged in water under a pressure of 100 p.s.i. for 20 hours and then tested for waterproofness. All of the caps made in this way were found to be completely waterproof.

In the embodiment shown in FIGURE 2, the detonator is also provided with an ethyl cellulose case 1 which is filled with an explosive train shown generally at 2. Here again, the detonator case has a ledge 3 near the open end thereof formed by increasing the internal diameter of the case near its mouth. In this case, however, the ethyl cellulose bridge plug 4 is provided with a peripheral groove 10 which cooperates with groove 6 on the internal wall of the detonator case to form a space 7 which is roughly circular in cross-section. After the bridge plug has been seated as shown into the mouth of the detonator, the detonator was sealed by injecting the epoxy resin used in the foregoing example into the cavity through port 8. A conventional injection needle was utilized for this purpose and sufficient pressure was applied to insure that the prepolymeric resin completely filled space 7. In fact, a sufficient amount of the resin was injected to fill annular space 9 above the circumferential grooves in the case and plug. In this instance, the detonator case was also provided with a small vent hole (not shown) to permit the ready egress of air from the space between the plug and case. When, as in this embodiment, the liquid polymerizable material is injected below the open end of the detonator and sufficient material is used to cause it to flow upward to the end of the detonator case, visual inspection can be safely relied upon to determine the completeness of the sealing operation. Twenty detonators sealed in this way were cured as de-

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scribed above at 45° C. for about 3 days and then submerged in water under 100 p.s.i. for 20 hours. At the end of this period, these detonators were tested and all were found to be completely waterproof.

While in the above embodiments the detonator case and bridge plug are both made of ethyl cellulose, it will be understood that any other suitable plastic resinous material can be utilized and that these two components need not be made of the same material. Also, many modifications can be made in the configuration of the bridge plug and/or detonator case to provide an annular space between them. The preferred embodiments shown above both illustrate the annular spaces extending to the open end of the detonator case. Such an extension is not essential and the annular space can take the form of one or more peripheral grooves about the bridge plug not communicating with the top of the case.

The term "detonator" or "electric initiator" is used herein in a generic sense to encompass all types of electrically activated explosive initiators including detonators, blasting caps, squibs, deflagrating devices, and the like.

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

Having thus described the invention, what is claimed is:

A method of sealing an electric blasting cap comprising providing a substantially cylindrical plastic bridge plug, molding a plastic detonator case closed at one end and open at the other and with an internal diameter adapted to form a sliding fit with the base portion of the bridge plug, and the portion of the case adjacent the open end thereof having a larger internal diameter through a distance less than the length of the bridge plug and being provided with a passageway through the case and transverse to the longitudinal axis of the case in the area of the larger diameter, inserting the bridge plug into the open end of the detonator case whereby an annular gap is formed between the plug and that portion of the case having a larger internal diameter, injecting a polymerizable material through the passageway into the gap, and polymerizing the polymerizable material while so positioned.

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