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ELECTRIC DETONATOR

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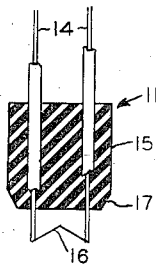


FIG. 1

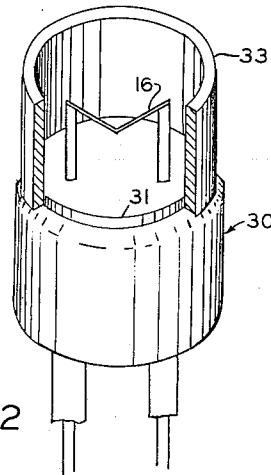


FIG. 2

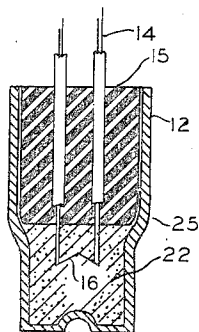


FIG. 3

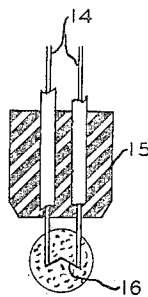


FIG. 6

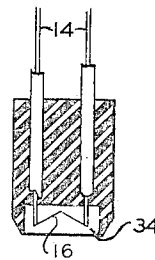


FIG. 5

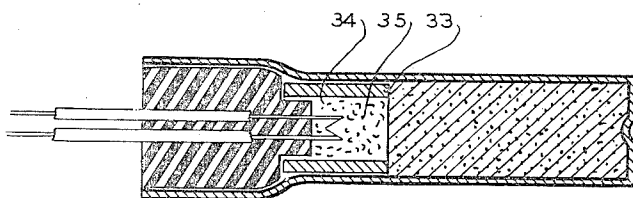


FIG. 4

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ELECTRIC DETONATOR

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6 Claims. (Cl. 102—28)

This invention relates to improved electric blasting devices in which the device is made waterproof solely by the insertion of the ignition assembly or plug into the cap shell, and more particularly, to electric blasting caps containing a dielectric plug sufficiently hard to expand the shell and produce a waterproof seal.

The various prior art blasting devices such as electric blasting caps, electric delay caps, and the like, normally contain a plug which either fits loosely into the cap and is then sealed therein by means of asphalt, or the like, or is sealed therein by means of crimping the shell into the plug itself. By these methods, caps can be made water resistant, but oftentimes due to temperature changes and various external reasons, the caps do not maintain their water resistance. In the prior devices, the manufacture of water-resistant caps is complicated and time consuming. Each of the known caps in order to be made water resistant requires a plurality of assembling operations.

The known caps which are supposedly waterproof are designed to include an explosive charge in the closed end of a bronze shell and an ignition assembly adjacent to the explosive charge which consists of a pair of lead wires electrically connected by means of a resistant wire and held in position by means of a plug. This ignition assembly, in the majority of instances, is inserted loosely into the cap and sealing means are superimposed thereon. In some instances, the plug is inserted into the cap and the cap shell is crimped into the plug.

The above-described known methods of producing water-resistant caps have met with commercial success but it has often been found that the caps so produced do not perform entirely satisfactorily since some few of these caps may lack complete waterproofness. The caps which do not maintain water resistance may cause trouble in firing various explosive shots and are therefore undesirable. The waterproofness of the caps may be seriously affected by hot storage conditions because waterproofing material such as asphalt tends to flow under hot storage conditions and either to exude out of the top of the cap or leak past the plug down into the explosive. Either type of flowage produces an unsatisfactory cap. In some instances, caps do not withstand cold storage because the waterproofing agent may harden and become brittle and pull away from the shell under low temperature conditions and thereby allow water to enter the shell. Prior art caps in which waterproofing is affected by

the use of asphalt are undesirably long. Those in which the water resistance is produced by crimping the shell into the plug are somewhat shorter but the crimping operation is difficult to control and some of the plugs must be heated to get the best crimps. Rubber plugs are not satisfactory due to the long curing times needed for production. Caps made by the method of this invention can be made shorter than by any of the prior processes and still be made waterproof. The short length caps are advantageous particularly for military purposes and have the advantage of conserving metal.

Now, in accordance with the present invention, the various disadvantages described above which are met when known caps are produced have been overcome and there has been produced an electric blasting cap which is of shorter over-all length, is completely waterproof and is so constructed that it will withstand hot or cold storage conditions.

In general, the waterproof electric blasting caps of the present invention comprise a normal though shorter shell preferably of copper, bronze, or aluminum having an explosive charge in the closed end and having superimposed upon this explosive charge an ignition assembly comprising a hard, rigid, dielectric plug having a pair of leg wires therethrough in diametric relation with one another and a resistant wire electrically connecting the terminal ends of these leg wires. The ignition assembly plug is preferably of a hard resinous material and is designed so that the outside diameter thereof is sufficiently larger than the inside diameter of the blasting cap shell to cause expansion or bulging of the shell when the plug is inserted therein. The insertion of the plug into the cap shell, in accordance with the present invention is accomplished by means of a press and may be facilitated by means of a slight taper on the entrance end of the plug or by slightly flaring the open end of the shell, either method allows the end of the plug to be slightly smaller than the entrance of the shell.

In general, the device of the present invention when completely assembled resembles a normal electric blasting cap with the exception that it is considerably shorter and that it has substantially straight sides with the exception of a very slight bulging of the upper portion of the shell. This bulging normally will produce a diameter which is not greater than about three thousandths of an inch over the diameter of the base of the shell but may be as much as forty thousandths of an inch greater, being limited only by the shell char-

acteristics. The insertion of the plug in a manner such that the shell is caused to bulge results in a device which is completely waterproof due to the friction seal between the plug and the interior surface of the shell.

Having now described this invention in general terms, there follows a more detailed description of preferred embodiments thereof with reference to the accompanying drawing in which:

Fig. 1 is a cross-sectional view of a plug assembly;

Fig. 2 is a perspective view with parts cut away of a plug assembly of the cavity type;

Fig. 3 is a longitudinal, cross-sectional view of an electric blasting cap sealed by the plug of Fig. 1;

Fig. 4 is a longitudinal, cross-sectional view of an electric blasting cap sealed by the plug assembly of Fig. 2;

Fig. 5 is a cross-sectional view of a cavity-type plug; and

Fig. 6 is a cross-sectional view of a match-head type plug.

Referring now to the drawing and more particularly to Figs. 1 and 3, the invention comprises a plug assembly 11 which is inserted into a blasting cap shell 12 and forms thereby a waterproof seal. The assembly 11 comprises a pair of insulated leg wires 14 molded into a plug 15 and electrically connected by means of a bridge wire 16. The plug 15 is of a non-conductive material such as a thermoplastic or a thermosetting resin which is sufficiently rigid to cause expansion of the cap shell 12 when pressed thereinto, and which thereafter is not subject to cold flow due to the pressure exerted by expanded cap shell 12 to an extent sufficient to cause loss of waterproof quality. The plug assembly 11 is shown to have a slight taper 17 at its lower end and this taper 17 is the means preferred to permit the easy insertion of the plug into the cap shell 12. When a blasting cap assembly is to be produced such as is shown in Fig. 3, the plug assembly 11 is forced into the blasting cap shell 12, which shell contains an explosive charge 22 in the base. The plug is forced into the shell until the bridge wire 16 is embedded into the explosive charge 22. The plug assembly 11 is guided by means of the taper 17 but must be forced into the shell by suitable means, i. e. an arbor press because plug 11 is substantially larger in diameter than the interior diameter of shell 12. The material of the plug is of sufficient hardness to cause expansion of the shell which produces the bulge 25 when the plug is completely inserted into the shell. By this procedure, there is formed a completely waterproof seal between the shell and the plug and the shell grips the plug sufficiently tightly to maintain it in position.

The explosive charge 22 is shown to consist of a single charge of loose material, but this explosive charge may be any of the normal explosive charges used in blasting caps. Thus, for example, it may consist of an admixture of loose mercury fulminate and potassium chlorate, or it may consist of a base charge of tetryl, nitro-starch, pentaerythritol tetranitrate, and the like, having superimposed thereon a charge consisting of an admixture of mercury fulminate and potassium chlorate, diazodinitrophenol and potassium chlorate, or lead azide. The use of the various known explosive compositions and their arrangement within the base of the cap is well known to the art and does not form part of the present invention.

In producing blasting caps, it is sometimes normal in the art to use a cavity plug, a bead type ignition assembly, or a match-head and by means of the present invention these types of assemblies can be fabricated from a rigid resinous material with such a diameter that a waterproof seal may be obtained by insertion of the plug into a shell with expansion of the shell and the consequent production of a waterproof cap.

Figs. 2, 4 and 5 are directed to plugs made in accordance with this invention and suitable for use with explosive devices using cavity type plugs. Fig. 2 shows a plug 30 which is similar to the plug of Fig. 1 but which has an extended shoulder of smaller diameter 31 than the plug 30. This extension 31 is so shaped that it may receive an annular member 33 which will surround the bridge wire 16 and form a cavity into which an ignition charge may be placed. Reference to Fig. 4 shows the plug of Fig. 2 in cross section with the cavity 34 filled with an ignition explosive 35. The annular member 33 which forms the cavity 34 by fitting over extension 31 is of an outside diameter smaller than the entrance diameter of the shell (Fig. 4). However, the plug 30 upon which the annular member 33 is mounted is sufficiently large in outside diameter to cause the blasting cap shell to expand when it is inserted thereinto.

Instead of the extension 31 to receive annular member 33 to form cavity 34, the invention contemplates the provision of a groove or other suitable means to hold member 33 in position. Further, it is contemplated that the cavity 34 may be formed as shown in Fig. 5. However, the cavity type shown in Fig. 5 usually requires two molding operations and the bridging is not as satisfactory; therefore, the cavity of Fig. 2 is preferable.

The match-head type plug and the bead type plug can be substituted for the cavity plug or resistant wire plug with the same result.

The present invention may be illustrated by the following examples:

Example I

An electric blasting cap was fabricated by molding a plug of a phenolic thermosetting type resin (Bakelite) about a pair of leg wires held in dielectric relation to one another. The leg wires were then bridged by means of a high resistant wire and this plug, which was .306" in diameter, inserted by means of an arbor press into a bronze shell having an inside diameter of .303. In the bottom of the bronze shell was a tetryl charge pressed into place and superimposed thereupon was a loose charge of an admixture of diazodinitrophenol and potassium chlorate. The plug was positioned on top of the shell and guided thereinto by means of a slight taper which reduced the entrance end of the plug to an outside diameter of .300. Upon pressing the plug into the shell, the shell was caused to bulge slightly but there was no tendency for the shell to split.

About 200 blasting caps were prepared in the above manner and then tested by complete immersion in water under 100 lbs. per sq. in. for 24 hours. Upon removal of the caps, they were fired without a failure showing that no water had entered the cap.

Example II

100 caps were prepared and tested in accordance with Example I except that the plugs were molded from a polystyrene thermoplastic type resin. These caps were tested for waterproof-

ness as in Example I and were entirely satisfactory.

Example III

A series of caps was prepared and in each cap the plug assembly was varied by either altering the plastic composition thereof or by varying the outside diameter. This series of caps shows the effective waterproof devices which may be obtained in accordance with this invention.

Cap	Plug material	Plug O. D.	Shell I. D.
1.....	Phenol-formaldehyde resin.....	0.309	0.303
2.....	do.....	.265	.259
3.....	Polystyrene.....	.265	.259
4.....	Phenol-formaldehyde resin.....	.340	.303
5.....	Cellulose acetate.....	.328	.303
6.....	Urea aldehyde resin.....	.312	.303
7.....	Ethyl cellulose.....	.285	.259

A plurality of caps 1 to 7 were prepared and tested for waterproofness as in Example I with satisfactory results.

Example IV

The caps described in Example III above each contain normal electric blasting cap plugs as shown in Fig. 1. Similar caps have been made using cavity type plugs formed by placing annular members over the end of the plug and around the bridge wire as shown in Fig. 4. The results obtained when the caps were fired after being stored under water at 100 lbs. pressure per sq. in. for 24 hours showed the caps to be waterproof.

It is to be noted that U. S. Government specification only requires electric blasting caps to resist 15 lbs. per sq. in. in water for a period of 4 hours at 70° F. and that the caps of this invention were thus tested under very severe conditions.

In accordance with the invention, the plug assemblies containing the pair of leg wires there-through are made in any diameter from about .003" greater than the inside diameter of the shell into which the plug is to be inserted to about a diameter .040" greater than the inside diameter of the shell. Each of the plugs is either tapered on the end which enters the shell to a diameter which is between .001 and .005" smaller than the entrance diameter of the shell into which it is to be inserted or the shell is flared to allow insertion. This taper or flare facilitates easy assembly of the caps. In assembling caps, it has been found that most efficient assembling operation is accomplished and waterproof caps are produced when a plug which has a diameter about .006" greater than the inside of the shell, is employed. The preferable range of diameter is between .003 and .009" greater than the inside diameter of the shell.

The diameters of the plugs and shells provide control for waterproof seals, thus it has been found that the length of the plug does not affect the waterproofness to any great extent. Plugs which have a bearing surface of from about $\frac{1}{16}$ " to about $\frac{1}{4}$ " are found most preferable but longer plugs may be used. Plugs shorter than $\frac{1}{16}$ " are difficult to handle and are not preferred.

Although the finished cap has been described as having an upper portion slightly larger than the base or lower portion, it is possible to constrict the upper portion prior to insertion of the plug (such as in the knock-out operation during drawing) and thus produce a shell with straight sides or even shells with upper portions having a smaller diameter than the base portion. The enlarged

or expanded upper portion is preferable due to ease of manufacture.

The shells used in producing the caps of this invention are usually of the same diameter as normally used in the production of electric blasting caps. The shells may be of any desirable copper alloy but usually they are bronze; however, they may also be of aluminum or similar alloys. The strength and thickness of walls of shells now commonly used in the art are sufficient to allow expansion when the over-sized plug is forced thereto. Further, the characteristics of the shell wall are such that splitting does not occur even when it is desired to expand the shell as much as about 10 to about 14% in diameter.

In the manufacturing processes used to produce the plugs of this invention, it has been found most desirable to employ thermosetting resins such as, for example, the urea or phenol aldehyde resins (Bakelite, Catalin, Textolite). Of the thermoplastic resins, the polystyrene type resins have been found to be preferable as a plug material since they do not tend to cold flow. The thermosetting resins are preferable because they do not exhibit cold flow and therefore maintain the waterproof joint under the most severe storage conditions. In the use of the thermoplastic resins, especially of the softer type, there is a tendency to cold flow due to the pressure exerted on the plug by the expanded shell. Thus, it is noted that the dielectric material which is used for plugs in accordance with this invention preferably has good resistance to cold flow and also has sufficient hardness so that it causes expansion of the shell when forced thereto.

In the drawing, it is noted that the plugs when inserted into the cap are inserted sufficiently far to be flush with the top of the cap shell. However, if desirable, these plugs may be inserted below the top of the cap shell and then the top of the shell be crimped or folded over the plug. This type of crimping increases the resistance of the plug to accidental removal by tension on the wires and also improves the appearance of the finished product. In turning over the shell onto the plug, it is contemplated that the fold be at 90° or less. Thus, the top of the plug may be tapered and the shell folded onto the taper such as, for example, at a 45° angle.

The leg wires which are used in the caps of the present invention are the normal leg wires used in the art. Thus, they may be No. 20 or No. 22, copper wire either plain, tinned or enameled or they may be No. 22 iron wire either plain or tinned. Further, the leg wires may be insulated in a desirable manner such as, for example, by cotton servings or by plastic materials well known in the art. Either the cotton or plastic insulated wires are readily molded into the plug in a waterproof manner.

The bridge wire which is used in the caps of this invention may either be noble metal or base metal resistant wire. Thus, for example, platinum alloys or iron alloys may be used and such resistant wires are well known. The resistant wires are joined to the leg wires either by swaging, soldering or welding.

The invention has described caps of the instantaneous type; however, the plugs are adaptable for use in electric blasting caps of the delay type or may be used in the production of electric squibs and the like. In each instance the use of the dielectric plug of the present invention provides a completely waterproof device which is shorter than normal devices and presents a

much neater appearance. The production of the devices is less complicated as there are fewer steps than needed when known electric firing devices are produced.

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

1. An electric firing device which comprises a charged shell; an ignition assembly comprising a plug of hard dielectric material inserted into the shell, said plug being of sufficient hardness and size to expand said shell and thereby provide a waterproof joint between the shell and the plug; and a bulge in that portion of the shell in contact with the plug, said bulge being formed by insertion of the plug into the shell.

2. An electric firing device which comprises a charged shell; an ignition assembly comprising a plug of thermosetting resin inserted into the shell, said plug being of sufficient hardness and size to expand said shell and thereby provide a waterproof joint between the shell and the plug;

and a bulge in that portion of the shell in contact with the plug, said bulge being formed by insertion of the plug into the shell.

3. An electric firing device which comprises a charged shell; an ignition assembly comprising a plug of thermoplastic resin inserted into the shell, said plug being of sufficient hardness and size to expand said shell and thereby provide a waterproof joint between the shell and the plug; and a bulge in that portion of the shell in contact with the plug, said bulge being formed by insertion of the plug into the shell.

4. The electric firing device of claim 2 wherein the thermosetting resin comprises phenol aldehyde.

5. The electric firing device of claim 2 wherein the thermosetting resin comprises urea aldehyde.

6. The electric firing device of claim 3 wherein the thermoplastic resin comprises polystyrene.

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