Aug. 21, 1956 J. J. O'NEILL, JR 2,759,417

ELECTRIC BLASTING CAP AND PERFORATING GUN CONTAINING SAID CAP

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FIG. 1.

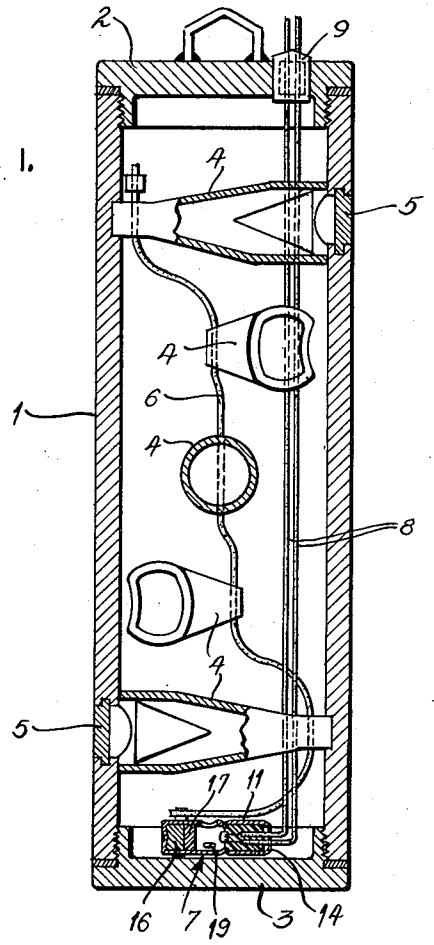
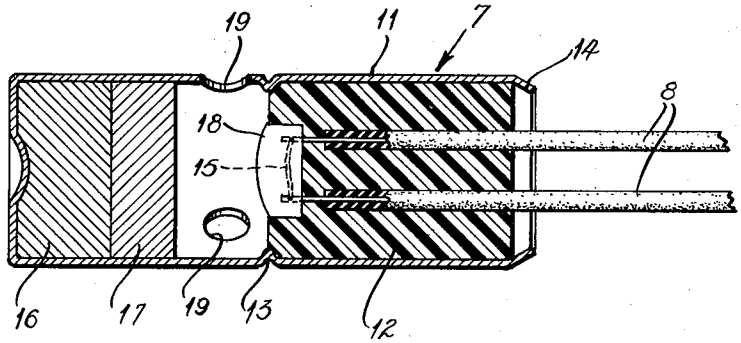



FIG. 2.

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# ELECTRIC BLASTING CAP AND PERFORATING GUN CONTAINING SAID CAP

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6 Claims. (Cl. 102—20)

This invention relates generally to electric blasting caps, and particularly to caps suitable for use in connection with explosive operations at great depths in the earth, such as in oil well bore holes.

In the use of explosives in oil wells at depths on the order of 10,000 feet or more, difficulties have been encountered in controlling the instant of the detonating of the explosive. An example of such use of explosives is the practice of perforating casing, cement lining, and the walls of bore holes at the producing stratum of an oil well by means of "shaped charges" of explosive. Such practice is typified by U. S. Patent No. 2,494,256 to Muskat et al., granted January 10, 1950. In this practice a number of shaped charges are disposed within a supporting barrel or emplaced in a block. The charges are connected together by a detonating fuse and the latter is provided with an electric blasting cap to initiate its detonation. The assembly is lowered into the well to the proper depth with a firing circuit connected to the electric blasting cap and extending to the surface of the ground so that it may be energized at the proper time to set off the detonation. The ordinary electric blasting caps have been found to be unreliable for this use because they have a tendency to either detonate prematurely or fail to detonate at all. In the latter case, great inconvenience results, requiring replacement of the blasting cap and frequently also of the explosive charge, while in the former case irreparable damage may be done. This erratic performance of conventional blasting caps at great depths has been a troublesome problem in the industry.

Moreover, where the shaped charges are disposed within a barrel in accordance with one of the practices indicated by the aforesaid patent to Muskat et al, extensive damage is liable to occur if the shaped charges are detonated while the space within the barrel and about the charges (which is normally occupied by air at atmospheric pressure) is filled with liquid. In such case the reaction from the explosion is not absorbed but is transmitted by the surrounding liquid to the walls of the barrel, with the result that the latter may rupture or expand, and be thus ruined. Frequently the barrel can not be withdrawn from the well when such occurs.

The object of the present invention, generally stated, is to provide an electric blasting cap whose performance is dependable and consistent when used at great depths, as in oil well bore holes.

A further object of the invention is to provide a device for preventing the detonation of the explosive charges when the barrel supporting them leaks.

Other objects will become apparent to those skilled in the art when the following description is read in connection with the accompanying drawing.

In accordance with the present invention, electric blasting caps for use in initiating the detonation of shaped charges of explosives in well bores and the like are constructed and arranged to obviate the premature detonation and the failure to detonate as well as to



become insensitive upon leakage or otherwise accidental admission of liquid into the barrel supporting the shaped charges.

The former aspect of the present invention is predicated upon the discovery that the erratic performance (both premature detonation and failure to detonate) of conventional electric blasting caps at great depths in the earth is due to the effect of the high temperatures encountered thereat. Where the blasting cap contains in its explosive train a component whose flash point is below the ambient temperature at the locus of placement, it is manifest that premature detonation will occur unless the hiatus between placement and intentional firing is less than the time required for the component of low flash point to reach the ambient temperature. The failure to detonate has at times been attributed to mechanical failure, due to pressures, but I have discovered that certain common components of the explosive train deteriorate, so as to become desensitized or insensitive upon prolonged exposure to temperatures less than their flash point, but nonetheless within the temperature range encountered at great depths in oil well bore holes. Accordingly, the invention contemplates an electric blasting cap wherein all of the ingredients of the explosive train remain stable and sensitive after prolonged (at least two hours) exposure to temperatures of 350° F. Among the numerous explosives in common use in electric blasting caps, lead azide, cyclonite, and lead styphnate have the property of remaining stable and sensitive after prolonged exposure to a temperature of 350° F. Trinitrotoluene may also be used as one ingredient of the explosive train provided precaution is taken to confine it so that, when melted, it cannot migrate and desensitize other ingredients of the train. Trinitrotoluene thus confined is herein termed "capsulated trinitrotoluene."

The desensitization-upon-leakage-of-the- barrel aspect of the present invention involves the disposition within the barrel (which is normally hermetically sealed) of a device which prevents detonation of the cap upon ingress of liquid into the barrel. One or more components of the cap may be rendered non-functioning in response to being wetted by well liquids or in response to increased pressure within the barrel or by the interposition of a layer of well liquid between spaced members of the explosive train. Except where the non-functioning is a result of increased pressure, it is important that the sensitive part be disposed within the barrel at a level such that the in-leaked liquids have access to it before the liquid has risen to an elevation sufficient to surround any one of the shaped charges within the barrel. The latter dictates disposition of the sensitizing device in the bottom of the barrel.

Where the explosive charge of an electric blasting cap consists entirely of ingredients which remain stable and sensitive after prolonged exposure to high temperatures, it is manifest that the firing device, such as the conventional bridge wire or match head used in connection therewith, must be capable of developing more heat than would be necessary to initiate the detonation of ingredients having a lower flash point. This feature is of special advantage in the oil well uses contemplated where it is desirable to make use of the cap circuit as an exploratory circuit prior to the actual firing. Accordingly, the caps of the present invention lend themselves to such use because electric currents of the magnitude required for control of the exploratory operations are insufficient to develop the heat required for initiating the cap. For such use, it is desirable, however, to use a bridge wire of other resistance element of a material whose temperature coefficient of resistance is high, so that the temperature generated by the control current is less than the flash

point temperatures of the igniter component in the explosion train.

In order to obtain the full benefit of a detonating charge which remains stable and sensitive at high temperatures, it is essential, and the invention contemplates, that all other components of the cap (including the case, plug, seal, liner, and wire insulation) be likewise capable of withstanding temperatures of 350° F. for prolonged periods without impairing their functionability. Accordingly, the plug may be formed of silicone rubber, paraplex resin, neoprene, nylon, or other material which is physically stable at temperatures in the neighborhood of those to be encountered in use. The wires are insulated with similar material, or with glass fiber or nylon. The seal between the usual metallic case and the plug is effected in a manner which will likewise withstand the rigors of high temperature without impairing the sealed relation between the plug and the case.

In the accompanying drawings:

Figure 1 is a longitudinal sectional view of a typical barrel type oil well perforating gun equipped with an electric blasting cap, constructed in accordance with the present invention; and

Figure 2 is a longitudinal sectional view of a blasting cap constructed and charged in accordance with the present invention.

Referring now to Figure 1 of the drawings, the oil well perforating gun shown consists of a tubular barrel **1** having the upper end thereof closed by a cap **2** and the lower end thereof enclosed by a similar cap **3**. Located in spaced relationship within the barrel **1** is a plurality of shaped explosive charges **4** each addressed toward a window **5** in the the barrel **1**. The several shaped charges **4** are interconnected by a fuse **6** (of detonating explosive), the lower end of which is associated with an electric blasting cap **7** as by being taped thereto. A pair of lead wires **8** extend from the cap **7** through a suitable sealing plug **9** to the exterior of the barrel, it being understood that said lead wires usually extend to a control station located at the surface of the ground so that, when the barrel **1** and its contents have been lowered to the desired horizon, detonation of the charges **4** may be initiated by properly energizing the firing circuit, including lead wires **8**.

The cap **7** is located in the bottom of barrel **1**, and is preferably of the character hereinbefore referred to wherein some one or more components of the cap are rendered non-functioning when well liquids leak into the barrel **1**. By disposing the cap **7** in the bottom of the barrel, leaked-in liquids will surround the cap before a sufficient volume thereof is present to surround the lowermost of the explosive charges **4**.

The electric blasting cap **7** is shown in detail in Figure 2 and consists of a metallic cup **11**, having appropriate explosive charges in the bottom thereof, and the open end being closed by a plug **12** which is precast or molded of such high temperature resistant materials as those hereinbefore mentioned.

The cup **11** is provided with a crimp **13** which extends about the lower end of plug **12** and serves to position the latter with reference to the bottom of case **11**. The open end of case **11** is inturned, as shown at **14**, to retain the plug **12** in position.

Lead wires **8** extend through plug **12**, being preferably molded in position therein, and terminate in bridge wire **15**.

The explosive train in the blasting cap may consist of a base charge **16**, an initiator charge **17**, and an igniter charge **18**, the latter surrounding bridge wire **15**. As clearly shown in Figure 2, a substantial space exists between the igniter charge **18** and the initiator charge **17**. In order to permit well liquids, which may have leaked into the barrel **1** and surrounded the blasting cap **7**, to have access to the space between the initiator **17** and the igniter charge **18**, the case **11** is provided with a plurality of vent holes **19**. Accordingly, when such



space becomes filled with well liquids, the latter constitute a protective film which prevents propagation of the explosion wave from ignition charge **18** to charges **16** and **17**. Thus the cap is rendered non-functioning when the space between the charges **17** and **18** becomes filled with liquid. In order to assure that the explosive train will remain sensitive at the temperatures encountered in deep wells, the base charge **16** may consist of about 4.5 grains of cyclonite, the initiator charge **17** may consist of about 3.5 grains of lead azide, and the igniter charge **18** may be a pellet consisting of about .5 grain of lead styphnate incorporated with about 1% gum Arabic as a binder. Lead azide may be substituted for cyclonite in base charge **16** or, if desired, a confined body of trinitrotoluene may be used, it being understood, however, that the trinitrotoluene is confined within a suitable container, such as a capsule (itself stable at high temperature), which will prevent migration of the trinitrotoluene when the latter becomes melted at temperatures less than those expected to be encountered. Where the cap is provided with vent holes **19** as above described, the several charges in the explosive train are either pressed into the case or preformed into pellets so as to remain intact and avoid leakage through the vents **19**. Where the vent holes **19** are not provided, the igniter charge may consist of three grains of loose lead styphnate surrounding the bridge wire, and the initiator charge may consist of loose lead azide or loose lead styphnate—indeed the three-component explosive train may be replaced by a single charge of loose lead azide, the case being sufficiently filled that the loose azide surrounds at the bridge wire **15**. With the components in the explosive train selected from the materials mentioned, the explosive train will retain its sensitivity upon prolonged exposures to temperatures in the neighborhood of 350° F.

In situations where it is not important to render the blasting cap non-functioning in the event of leakage, and in any case where the blasting cap is intended to be submersed in liquid, the vent holes **19** are eliminated and the plug **12** provided with a suitable water-proofing seal, which is likewise physically stable at temperatures of 350° F. The sealing material may be silicone cement, for example. Where the plug **12** is formed of plastic materials, such as neoprene, and the case **11** is crimped into the plug in accordance with one common practice, auxiliary sealing materials may be unnecessary.

Where the vent holes **19** are provided in the case **11**, it is desirable to provide a temporary seal to close the same during transportation and handling. A strip of tape is suitable for this purpose or, in lieu thereof, a closure which quickly disintegrates upon contact with liquid.

The bridge wire **15** is preferably formed of a platinum alloy containing 15% rhodium and 5% ruthenium, having a diameter of 0.0015" and an overall resistance of 455 ohms per yard at 100° F., and 498 ohms per yard at 350° F. With such a bridge wire, currents of the magnitude necessary in the control circuit for exploratory operations may be conducted through the bridge wire without heating it to an extent such as to initiate detonation of the explosive train.

From the foregoing description, those skilled in the art should readily understand that the invention accomplishes its objects and provides a dependable electric blasting cap for use in deep well bores or other situations where high temperatures are likely to occur. Moreover, where it is desired to desensitize the cap when immersed in liquids, the invention provides a cap suitable for the purpose.

While one complete embodiment of the invention has been disclosed in detail and various alternatives suggested, it is not to be understood that the invention is limited to the details described, except as indicated in the appended claims.

Having thus described the invention, what is claimed and desired to be secured by Letters Patent is:

1. In an electric blasting cap having a plurality of components including an explosive train consisting of an ignition charge, an initiator charge, and a base charge, the improvement which comprises, all explosively-active ingredients of said ignition charge consisting of lead styphnate, all explosively-active ingredients of said initiator charge being selected from the group consisting of lead styphnate and lead azide, all explosively-active ingredients of said base charge being selected from the group consisting of lead azide, cyclonite, and capsulated trinitrotoluene, and all other components of said cap being stable at a temperature of 350° F.

2. In a perforating gun of the character described, wherein spaced, shaped charges of explosive are initiated by an electric blasting cap having a plurality of components including an explosive train consisting of an ignition charge, an initiator charge, and a base charge, the improvement which comprises, all of the explosively-active ingredients of said ignition charge consisting of lead styphnate, all of the explosively-active ingredients of said initiator charge being selected from the group consisting of lead styphnate and lead azide, all of the explosively-active ingredients of said base charge being selected from the group consisting of lead azide, cyclonite, and capsulated trinitrotoluene, and all other components of said cap being stable at a temperature of 350° F.

3. In a perforating gun of the character described, wherein shaped charges of explosive are supported within a hermetically-sealed barrel with the spaces between said charges occupied by gas and the charges are arranged to be initiated by an electric blasting cap within the barrel, the improvements which comprise, said electric blasting cap having a plurality of components including an ignition charge all of the explosively-active ingredients of which consist of lead styphnate, an initiator charge all of the explosively-active ingredients of which are selected from a group consisting of lead styphnate and lead azide, and a base charge all of the explosively-active ingredients of which are selected from the group consisting of lead azide, cyclonite, and capsulated trinitrotoluene; all other components of said cap being stable at 350° F., and means within said barrel for rendering said blasting cap inoperative upon ingress of liquid into said barrel.

4. In a perforating gun of the character described, wherein spaced, shaped charges of explosive are initiated by an electric blasting cap, the improvement comprising, said electric blasting cap having a case, an explosive train in the case, and a closure plug for the case, said explosive train being composed of a plurality of explosively-active ingredients arranged to constitute an ignition charge and at least one other charge, said other charge being explosively sensitive to firing of said ignition charge and arranged to be directly detonated thereby, but spaced therefrom at a distance less than sufficient to inhibit detonation thereof directly by said ignition charge, all of the components of said blasting cap being stable at 350° F. and all ingredients of said explosive train being stable and sensitive at said temperature, and said case having vents extending from the exterior to the interior thereof adjacent the space between said ignition charge and said other charge.



5. In an electric blasting cap having a case, an explosive train in the case and a closure plug for the case, said explosive train being composed of a plurality of explosively-active ingredients arranged to constitute an ignition charge and at least one other charge, said other charge being explosively sensitive to firing of said ignition charge and arranged to be directly detonated thereby but spaced therefrom at a distance less than sufficient to inhibit detonation thereof directly by said ignition charge, the improvement which comprises, all of the explosively-active ingredients of said ignition charge consisting of lead styphnate; and all of the explosively-active ingredients of said other charge being selected from the group consisting of lead azide, cyclonite, and capsulated trinitrotoluene, all components of said cap being stable and sensitive at 350° F., and said case having vents extending from the exterior to the interior thereof adjacent the space between said ignition charge and said other charge.

6. In a perforating gun of the character described, wherein shaped charges of explosive are supported within a hermetically-sealed barrel with the spaces between said charges occupied by gas and the charges are arranged to be initiated by an electric blasting cap within the barrel, the improvement comprising, said electric blasting cap being disposed below said shaped charges and having an igniter element spaced from a base charge therein, said cap being vented at a plurality of circumferentially spaced positions at a section axially between the igniter and the base charge to admit liquid to the space between said charges on the interior of the cap.


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