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ELECTRICAL SAFETY DETONATOR

Filed June 4, 1962

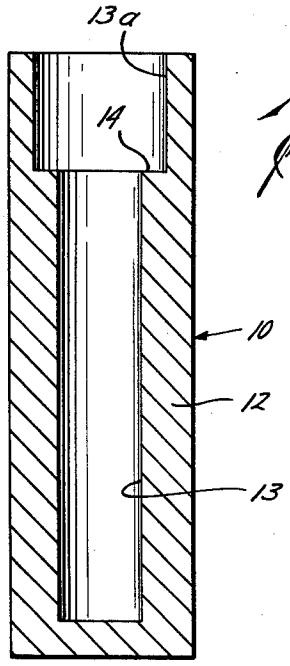


Fig. 1

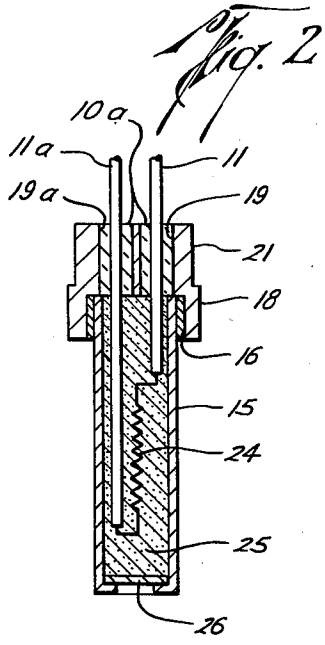


Fig. 2

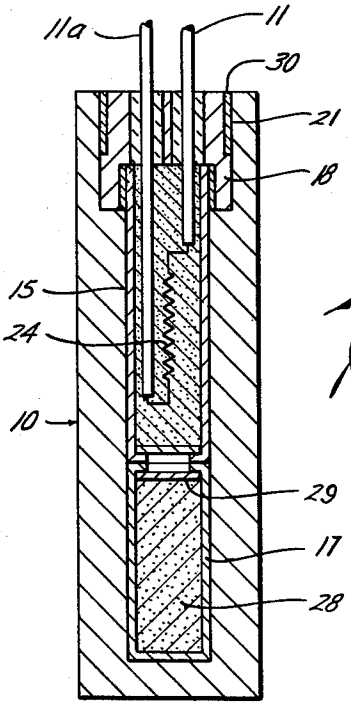


Fig. 3

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ELECTRICAL SAFETY DETONATOR

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The invention relates to electrical safety detonators for use in well bores to detonate explosives or shaped charges which provide a penetration in earth formations. In particular, this invention relates to detonators which are useful where well bore pressures and temperatures are very high.

Perforating apparatus for use in well bores typically includes a shaped charged device which is detonated by a blasting cord. The blasting cord is in turn detonated by a blasting cap or detonator. Detonators or blasting caps in this type of use are often exposed to the fluids in the well bore and consequently, the pressures and temperature of the fluid in the well bore. Conventional detonators are not practical for use where the pressures exceed about 14,000 p.s.i. and the temperatures exceed about 200° C. Moreover, in well bores where gas is present under considerable pressures, conventional detonators, which generally have rubber or neoprene seals, are not gas-tight so that their operation is frequently faulty.

Also, detonators of known types are normally fitted with low-resistance igniter wires to ensure their very quick ignition. In order to protect these detonators from being prematurely detonated by stray currents and voltages, resistors of appreciable value are coupled to the outside of the detonators in an electrical series connection with the igniting wire. These additional exterior resistors are sometimes inadvertently shorted or opened to cause a detonator failure. Igniting compounds of a very low sensitivity are sometimes used to avoid premature detonation of a detonator from such things as atmospheric electrical discharges. Such igniting compounds like aluminothermic mixtures (25% Al+75% Fe_2O_3 or 20% Al+80% CuO for instance) react only at temperatures from 1000° C. and require ignition currents of several amperes. Cables conventionally used in well bores are not designed to carry such currents so such igniting compounds of low sensitivity are not usually used in well bores. Moreover, in conventional detonators it is possible to develop relatively high static charges on the detonator as a result of friction with the metal walls. Hence, it is possible for a spark to leap between the detonator jacket or wall and one of the terminals of the heating resistor to prematurely ignite the detonator. This, of course, can be eliminated by a high loss insulator, such as rubber of high carbon content covering the detonator but nonetheless, the hazard is still present.

It is an object of this invention to provide new and improved detonators which operate satisfactorily at temperatures in excees of 200° C. and at pressures in excess of about 14,000 p.s.i.

Another object of this invention is to provide new and improved detonators which are hermetically sealed.

It is a further object of this invention to provide new and improved detonators whose safety in the presence of stray currents or of static charges is excellent.

It is another object of this invention to provide a new and improved safety detonator needing a low igniting current.

Still another object of this invention is to provide new and improved detonators which are easy and safe to use.

An electrical detonator according to the invention, comprises a hollow metal receptacle with a suitable wall thickness. Sealed in the receptacle by a metal cover are a detonating or explosive charge, an inflaming or igniting compound wherein the igniter is connected to at least one conductor traversing the cover closing the receptacle. The conductor is sealed in the cover by an insulating glass bead. The igniting compound is more particularly a sensitive mixture of the aluminothermic type.

According to another feature of the invention, the electrical igniter is made of a helically wound wire whose resistance is of some few dozen ohms which prevents untimely operation of the detonator in the presence of interference currents or charges.

The novel features of the present invention are set forth with particularly in the appended claims. The present invention, both as to its organization and manner of operation together with further objects and advantages thereof, may best be understood by way of illustration and example of certain embodiments when taken in conjunction with the accompanying drawings in which:

FIG. 1 is a view in cross-section of the detonator casing of the present invention;

FIG. 2 is a view in cross section of the igniter subassembly for the detonator; and

FIG. 3 is a view in cross section of the assembled detonator.

According to FIG. 1, a hollow, cylindrically shaped receptacle **10** is shown constructed, for example, of steel of sufficient thickness to withstand high pressures. The receptacle can, for example, be 1.97 inches long with a wall **12** of 0.12 inch thickness and a central bore **13** which is 0.24 inch in diameter. The opening of the receptacle has a counterbore **13***a* which forms a shoulder **14**.

A metal cylindrical closure member **18** (shown in FIGS. 2 and 3) is sized for reception in the counterbore **13***a* and has two passages **19**, **19***a* extending therethrough. The lower end of the member **18** is counterbored to receive a thin, tubular tube **15** constructed of brass which is brazed to the member **18** as shown at numeral **16**.

Each of the passages **19**, **19***a* receives a bare wire conductor **11**, **11***a* made of an iron-cobalt (15–20%) and nickel (25–30%) alloy which is hermetically sealed therein by a glass bead **10***a*. The beads **10***a* are obtained by a well-known technique in electronics, by inserting a little glass tube into each passage with a conductor and melting the glass which by dissolving alloy oxides forms hard welding. While cooling, the passage **19** hoops the glass bead. Within the tube **15**, the ends of conductors **11**, **11***a* are attached to the ends of a helically wound wire resistor **24** which has an electrical resistance of 50 ohms. Resistor **24** lies approximately along the center line of tube **15**. The tube **15** is filled with an alumino-thermic igniting mixture **25**, for example, a weakly compressed homogeneous mixture of aluminum and barium peroxide powder in roughly stoichiometric proportions (Al:20% and BaO_2:80%). A lid **26** is provided for the lower end of tube **15**.

In the bottom of receptacle **10** is a thin-walled container **17** enclosing a booster explosive **28** such as lead nitride. Container **17** is closed at its upper end by a thin-walled crimped disc **29**.

The assembly comprising the tube **15** of alumino-thermic powder and the cover **18** practically occupies all of the free space within the receptacle **10** above the lead nitride booster charge **28** and is jammed into tight contact with the case **17**. Cover **18** has an outer recessed surface **21** to form an annular recess with the receptacle **10** which permits a metal seal **30** to be made between the cover **18** and the receptacle **10**. Seal **30** is thus a hermetic seal. Cover **18** is brazed onto receptacle **10** by high frequency

or induction heating which does not affect explosive mixture **25** since the explosive mixture requires higher temperatures for detonation.

With such an embodiment the metal seal **30** and the wire-welded glass beads **10***a* seal the detonator very tightly so that the assembly is gas proof and fluid tight, even for hydrocarbon gases under very high pressures, since these external high pressures are transmitted by the metal seal **30** to the cover body thereby increasing the hooping of the glass beads against the wall of the passages **19** and **19***a*. In electronics, glass beads and iron-cobalt-nickel conductors ensure insulation of the said conductors but a high degree of fluid-tightness is neither required nor obtained. But, by a good choice of the cover shape and the seal position one obtains an increasing of the bead hooping by the high pressures applied on the detonator, thereby allowing the said detonator to withstand the said pressures without any drawback.

Furthermore, the steel wall of receptacle **10** has a thickness of ample dimensions to withstand any high pressures.

Operation of the detonator acocrding to the invention at temperatures in excess of 200° C. is ensured. Indeed, the alumino-thermic mixture is perfectly stable at a temperature up to 677–700° C. and lead nitride **28** withstands without detonating, a temperature of 270° C. The safety margin thus is great compared with ambient temperatures encountered in a well bore.

During the lowering of a perforating apparatus into the well bore, heavy vibrations occur. Because the alumino-thermic mixture **25** and the lead nitride **28** are separately enclosed, abrasive contact of the explosive with metal parts is prevented. Hence, the detonator is insensitive to any such vibrations.

With regard to stray electrical currents and static charges, the protection of the detonator according to the invention, is directly ensured by the high resistance of the igniter resistor **24**. While in the instance described, the resistor **24** has a resistance of 50 ohms, its value may vary according to cases, from 15 to 80 ohms. Static voltages typically found in well bores generate in resistor **24** only currents which are too weak to develop sufficient temperature to ignite the explosive mixture **25**. The same holds true with respect to stray currents which may be induced by adjacent electrical conductors passing the detonator.

Another advantage of a detonator according to the invention, in the presence of static charges which have been stored by friction against the outer sides of the detonator, results from the alumino-thermic mixture which itself provides a low resistance path to discharge static charges as they occur.

If a control voltage of 25 volts is applied from a power source (not shown), a 0.5 amp. current flows through resistor **24**. The resistor **24** is heated slowly and after approximately 1 second, its temperature rises to some 700° C. At the same time, the alumino-thermic mixture **25** and the lead nitride **28** still remain at the pressure conditions of the assembly because the thickness of wall **12** of the receptacle prevents the external pressure from significantly alerting the internal pressure, and, of course, no gas or liquid under high pressure can enter the receptacle. As soon as the critical temperature of 600–700° C. for igniting the mixture **25** of aluminium and barium peroxide is reached, a reaction occurs at the surface of the resistor **24**. This reaction is quickly transmitted to the remainder of the mixture **25** releasing a great quantity of heat energy. This great quantity of heat is confined in receptacle **10** and detonates the lead nitride mass **28**. It is well-known that the barium peroxide BaO_2 is an unstable product which easily becomes barium oxide (BaO) and oxygen. This feature explains why an aluminum-barium peroxide mixture reacts from 600–700° C. instead of 1000° C. like usual alumino-thermic mixtures, needing thus a low igniting current.

Thus, a detonator according to the invention, is capable of operation under very severe temperature and pressure conditions encountered in well bores.

It is well understood that the invention is not limited to the examples described and illustrated above which have solely been used as non-restrictive examples, but on the contrary the invention may be made in other alternative manners.

Thus, one can use a single bead traversed either by both conductors or only one, as in the case where one end of the igniter is connected to the jacket or wall of the detonator.

Likewise, the attachment of cover **18** to receptacle **10** may be made in another way than by brazing, for example, an autogenous soldering or a metal-to-metal seal which can be accomplished by pressure setting or shrink-fitting methods.

As for the composition of the igniting compound, black powder which is stable up to 300° C. can be also used if the detonator is carefully made. With special cables which can withstand large currents, usual alumino-thermic mixtures can be used.

Likewise, the lead nitride **28** may be replaced by another primary blasting agent, or even by a secondary one, if sufficient quantities, provided the the explosives be stable at temperatures in excess of 200° C.

As for the receptacle **10**, it can be made of material other than steel, provided its resistance to the pressure is great enough and its dimensions are not excessive.

Furthermore, instead of being made of an alloy of iron-cobalt and nickel, wires **11** and **11***a* can be made of tungsten or molybdenum oxides of which are also dissolved by melting of a suitable glass, and thus form a hard welded bond.

An alternative concerning the receptacle **10** is employed when a detonator according to the invention is used as a detonator for a quick fuse or a shaped charge. In these cases, the bottom of receptacle **10** is machined for direct attachment to the tip of said quick fuse or shaped charge.

While particular embodiments of the present invention have been shown and described, it is apparent that changes and modifications may be made without departing from this invention in its broader aspects and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

What is claimed is:

1. A detonator comprising: a hollow metal receptacle having an open and a closed end; a booster explosive received in said closed end of said receptacle, said explosive being stable up to a temperature substantially not less than 200° C.; and means for detonating said booster explosive including an igniting composition separately disposed in said receptacle proximate to said booster explosive, said igniting composition being stable up to a temperature substantially not less than 600° C., an electrical resistor disposed within said igniting composition, said resistor having an electrical conductor leading from one end thereof, a metal cover having a glass tubular electrical insulator sealingly engaged therein, said conductor being passed through said tubular insulator and sealingly engaged therein, said cover being sealingly engaged with said receptacle to hermetically close said open end thereof; said receptacle, cover and insulator being adapted and engaged one to the other to withstand high pressures external thereto, the resistance of said resistor being in the range of 15–80 ohms and capable of being heated to temperatures in excess of 600° C. in approximately one second in response to a sustained application of electrical current, yet being insensitive to stray electrical currents.

2. A detonator comprising: a hollow metal receptacle having an open and a closed end; a first hollow case received in said closed end of said receptacle; a booster

explosive disposed in said first hollow case, said explosive being stable up to a temperature substantially not less than 200° C.; means for detonating said booster explosive including a second hollow case received in said receptacle and disposed with one end thereof in detonating proximity to said booster explosive, an igniting composition disposed in said hollow case, said igniting composition being stable up to a temperature substantially not less than 600° C., an electrical resistor disposed within said igniting composition, a metal cover received in said open end, means for conducting current through said resistor including a metal electrical conductor passed through said metal cover and attached to said resistor, electrical insulation means sealing said conductor relative to said metal cover, and means sealing said cover relative to said receptacle; the resistance of said resistor being in the range of 15–80 ohms and capable of being heated to temperatures in excess of 600° C. in approximately one second in response to a sustained application of electrical current, yet being insensitive to stray electrical currents.

3. The detonator of claim 2 wherein said resistor has a resistance of 50 ohms.

4. An igniter for a blasting cap including an enclosure member for receipt within a blasting cap container, an igniting composition disposed in said enclosure member, said igniting composition being stable up to a temperature

substantially not less than 600° C., an electrical resistor disposed within said igniting composition, an electrical conductor means attached to said resistor for conducting current through said resistor, the resistance of said resistor being in the range of 15–80 ohms and capable of being heated to temperatures in excess of 600° C. in approximately one second in response to a sustained application of electrical current, yet being insensitive to stray electrical currents.

5. The igniter of claim 4 wherein said resistor has a resistance of 50 ohms.

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