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A New Safety Electric Initiating System

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Abstract: Based on the analysis of weakness on the safety of traditional electric detonators, a BJ-1 safety electric detonator initiating system and its corresponding safe examination technique were successfully developed. By leading false foot wires and taking advantage of the transmitting frequency band of Mo-Zn ferrite, detonators in this new system can completely impede the direct induction of outside crosstalk that may cause casual firing in the ordinary as well as electromagnetic ones. Possible causality by lightning was discussed. Results are presented, of its safety tests on resistance to direct and alternating current, electrostatic, and crosstalk induced by damp leakage in saturated salty water.

Key words: electric detonator; blasting engineering; electric initiating system; safety

In last twenty or thirty years, blasting technology developed rapidly. Because of safety problems, as a tendency, electric detonators and the electric detonator initiating method have been disused [1–4]. However, through systematic research into the safety problems of electric detonators for many years, this paper developed successfully a new safety electric initiating system, and solved its safety examination problems.

1 Safety Evaluations on Traditional Electric Detonators

1.1 Ordinary electric detonators

Ordinary electric detonators' foot wires are exposed outside of the shells, which lead directly to bridge thread. The foot wires must be shorted before detonators leave factories in order to avoid accidents. This is widely accepted as the best safety measure, but it is inappropriate [1,3].

Because the condition of a blasting site can be very complex, it will form an equivalent circuit if the insulation at points a or b is damaged (as shown in **figure 1**). Usually, each foot wire is 2 m long and its resistivity is 0.6 Ω/m. As a result, the total resistance of two foot wires in series r = 2.4 Ω. The resistance of an average 8# electric detonator R = 2.5–3.3 Ω. If some unexpected factors invade and the voltage between a and b is big enough, the current which flows through the bridge thread will initiate the detonator. The longer the foot wires are, the more dangerous it will be. In experiment, 100V direct current voltage was exerted between a and b, and all the detonators were initiated. Same result was produced in a series of experiment conducted in the former Soviet Union under other conditions. In another case, the shorted foot wires form a circuit, which surround an area. If the outer magnetic field is changed, the detonator can also be initiated. For example, the inductive fields of high voltage wire, low voltage wire or thunder may induce current, which may be big enough to initiate the detonator unexpectedly. Thus it can be seen the safety of ordinary detonators, even if their foot wires are shorted, are still not assured.

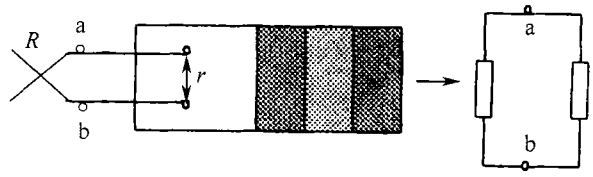

Figure 1 A ordinary electric detonator and its equivalent circuit.

1.2 Electromagnetic detonators

The safety of electromagnetic detonators is assured when crosstalk currents are induced into their elementary circuit. However, if their secondary circuit was taken into account, electromagnetic detonators, when insulation on their foot wires failed, will be equivalent to ordinary ones while their foot wires are shorted (as shown in **figure 2**). An electromagnetic detonator whose foot wires have no juncture is better insulated than the ordinary ones. Even though it's safer, Loopholes still exist [1].

2 BJ-1 safety electric detonators

BJ-1 safety electric detonators have both advantages of electromagnetic ones and ordinary ones.

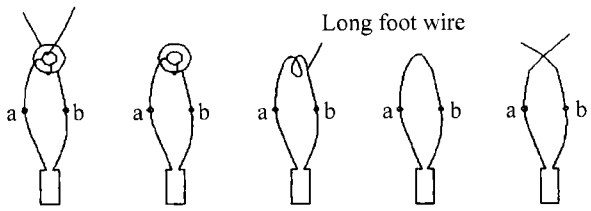

Figure 2 A simplified electromagnetic detonator and its equivalent loop.

After minimization, soft magnetic loops are enclosed in metallic shells of electric detonators or at plastic plugs outside tubes. The two wires, leaded from a BJ-1 safety electric detonator, are symbolic false foot wires rather than real foot wires. Thus the direct induction of outside crosstalk currents are completely impeded, *i.e.*, it is radically out of dangers from foot wires by avoiding exposure (as shown in **figure 3**).

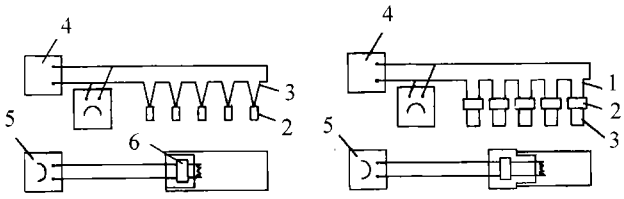

Figure 3 BJ-1 safety electric detonator system: Near-Nozzle (left) and Inner (right) initiating. 1–BJ-1 key component, 2–BJ-1 electric detonator, 3–False foot wire, 4–Initiating device, 5–AZ-1 detector, and 6–Detecting element.

By taking advantage of the transmitting frequency band characteristics of Mo-Zn ferrite, it can not only obstruct direct current, miscellaneous pulse current, electrostatic, and thunder pulse current from initiating electric detonator, but also attenuate crosstalks from electromagnetic waves with high frequency, as shown in **figure 4**.

The elementary circuit of this kind of tuning electromagnetic transformer is insensitive to the current whose frequency is less than 10 kHz, and the small soft Mo-Zn ferrite becomes saturated against the alternating current as its frequency ranges from 50 to 60 Hz. So all

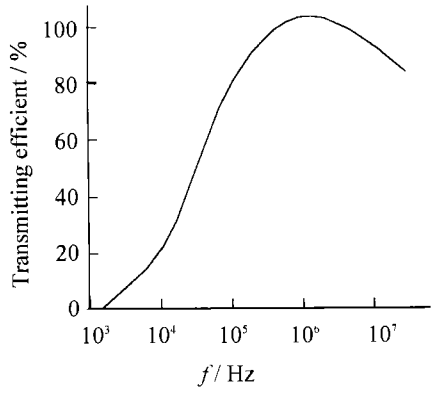

Figure 4 Relationship between the transmitting efficiency and the frequency of Mo-Zn Ferrite.

the dangers of alternating current under these values of frequency are removed. The efficiency of the electromagnetic transformer decreases rapidly as the frequency decreases. When the current frequency is 1 kHz, the efficiency is 3%, and the current can hardly be transmitted when its frequency is less than 100 Hz. As a result, BJ-1 safety electric detonators have become a new generation of widely used safety electric detonators, and their electric safety is thoroughly assured [2].

3 Safety Tests of BJ-1 Electric Detonators [1]

To electric firing of any blasting operation, safety is of utmost importance. Because crosstalk currents are very harmful to the safety of traditional electric blasting, it is always paid attention to. The major sources of crosstalk currents are:

- The returning current from an electrical hauling network via the earth;
- The leakage in alternating power and illuminating networks;
- The capacitance current of dynamic cables;
- The electrostatic produced by friction between different objects;
- The crosstalk current from the earth;
- The induction form high frequency electromagnetic waves;
- The inductive current of thunder.

(1) Test on resistance to alternating current.

Let the alternating current of 70 A with the frequency of 50 Hz flow through the elementary circuit. The conductor was melted, but the BJ-1 electric detonator was not initiated.

(2) Test on resistance to direct current.

In 1990, the experiment was conducted in the Coal Mine of Mentougou, Beijing, in which a direct current of 300 V was exerted to the BJ-1 safety electric detonator. The detonator was not initiated. This shows that its ability to resist direct current is reliable.

(3) Test on resistance to electrostatic.

The experiment in the 213 Military Institution of Xi'an showed that it is safe to exert 3 kV voltage between the two base lines or to exert 25 kV static between the shorted points of the base line and the shell.

(4) Test on resistance to leak of blasting current.

Ordinary electric detonators are likely to fail to fire under a damp environment especially when filled with turbid water. Under the condition that the insulation of

BJ-1 electric detonator's false foot wires were damaged, an experiment was done in saturated salty water, and none of the 100 detonators tested failed to fire. All these show that, compared with old electric initiating systems, the new generation of safety electric detonator initiating systems adapts better to watery and even harsher environment, such as saturated salty water and alkaline solution.

(5) Test on site with no cessation of electricity.

In the Open Coal Mine of Yongping and the Tin Mine of Heifeng, we operated with no cessation of electricity on site and none of the 1 000 BJ-1 electric detonators tested failed to fire or fire earlier.

(6) Test on resistance to thunder.

Were it directly struck by lightning, no detonator (include non-electric detonator) would be safe. When it were indirectly struck by lightning, the inductive current produced in the elementary and secondary circuit of the new generation of the new safety electric initiating system were a lightning pulse current. If this kind of current surpasses some value, the flux in the loops of electromagnetic transformer becomes saturated. According to some documents [2], even if the pulse current, whose swing value is greater than 200–400 A, enters the elementary circuit and the discharging time is 30 μs, the pulse current's swing value is only about 15 A in detonator's circuit and the time spent in discharging is 5μs. In other words, because of the saturation of the electromagnetic transformer, even if 500 A lightning pulse current enters blasting mother wires, the energy contained in the wave is less than the least initiating energy of electric detonators.

A series of experiments above-mentioned show that the new generation of safety electric initiating systems radically solves the safety problems caused by cross-talk currents.

4 Safety Examination Instrument

The network and the detonator's continuity were examined after and before the network was linked, thus malfunction was find. However, with the expansion of blasting scale, the development of blasting technology and the increase of detonator's electricity consumption, the blasting network become more and more complicated. Therefore, the examination of the network becomes complex too. Especially after the whole network has been linked, to inspect the on and off all the branches becomes more difficult. The extant blasting meter is unable to examine the new generation of electric initiating systems. In addition, traditional examination methods electrify the electric detonator in examining process, which is dangerous. Thus, there is a need for the development of new examination instruments.

Through systematic research for many years, we have developed a new examination instrument of safety electric initiating system, *i.e.*, the BWJ-2 examination instrument of electric initiating network. The major principals are:

(1) Replacing the resistance examination with the current examination.

The BWJ-2 system consists of an examination signal source and a V-shape microampere current meter. The signal source gives the elementary circuit of the blasting network a safe alternating current signal with fixed frequency. The examination meter inspects alternating current signals of related parts.

(2) Replacing the touch examination with the non-touch examination.

In a traditional electric initiating network, to define the break point when malfunction occurred, dismantling and reassembling the entire network may be unavoidable. With the replacement of non-touch current examination, the precise V-shape microampere current meter can simply show the signal current flowing in each sub-network, hence, to define the break point in a local range. This improvement not only raises the examination efficiency greatly, but also guarantees the safety of the examination process. Moreover, it alleviates the labor intensity.

5 Conclusions

The BJ-1 safety electric detonator was developed and its corresponding safe examination technique is a meaningful innovation. It not only removes the unexpected explosion dangers of electric detonators, but also enhances the safety of electric detonators to a new level. This success provides blasting engineers with a desirable initiating equipment.

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