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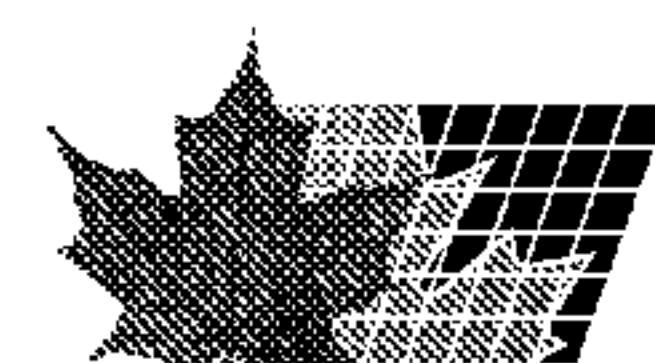
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(54) Titre : METHODE DE COMMANDE D'AMORCAGE D'UN DETONATEUR
(54) Title: METHOD FOR CONTROLLING INITIATION OF A DETONATOR

(57) **Abrégé/Abstract:**

A method for controlling the initiation of an electronic detonator when located in surrounding ground, the method comprising the steps of: measuring the actual spatial position of the said detonator in relation to one or more adjacent detonators; and calculating the time of initiation of the said detonator based upon its actual spatial position.



ABSTRACT**METHOD FOR CONTROLLING INITIATION OF A DETONATOR**

A method for controlling the initiation of an electronic
5 detonator when located in surrounding ground, the method
comprising the steps of: measuring the actual spatial
position of the said detonator in relation to one or more
adjacent detonators; and calculating the time of initiation
of the said detonator based upon its actual spatial
10 position.

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METHOD FOR CONTROLLING INITIATION OF A DETONATOR

Field of the Invention

The present invention relates to the control of explosive detonators. In particular the invention relates to controlling the initiation of an electronic detonator for use in a mining process, and will primarily be described with reference to this context.

10

Background Art

In mining processes an explosive blast is conducted to fracture an orebody to enable recovery of the broken rock to obtain its associated minerals. Explosive material and a detonator for initiating the explosion are placed into a series of pre-drilled narrow elongate holes (blast holes) in the orebody, the area is cleared of people and equipment, and an explosion is set off.

The optimisation of an explosive blast involves trying to obtain certain physical results from the explosion at minimum cost of explosive, which is a significant expense in many mining operations. The specific positioning of sufficient explosive to achieve a successful blast is a complex task. This task is complicated by a need to: avoid over-fragmentation of the rock; heave (or move) as much ore as possible into an accessible position; avoid over-vibration of the ground around the area being mined; and to protect the working face (high wall of the orebody) and nearby floor of the area from collapse.

30

In general the desired physical outcomes of an explosive blast are determined by the initiation time between adjacent blast holes, and by matching the initiation time to the response time of the particular

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rock. The rock response time is related to the speed which cracks are generated around a blast hole by the stress/strain waves created by initiation of an explosion therein. Very hard rock usually has a fast response time
5 (typically 1.5 milliseconds/metre of rock away from the hole), whereas very soft rock usually has a very slow response time (soft sandstone could be 6 milliseconds/metre of rock away from the hole). Blasting at above or below the actual response time can result in a
10 less than optimal physical rock breakage performance.

Pyrotechnic detonators are typically used to initiate an explosion and can have a scatter (or error) of approximately 5% of the initiation time. More recently electronic detonators have been developed and have a
15 scatter of approximately 0.1% so enable a much more optimal performance. Electronic detonators have a programmable microchip which replaces the traditional pyrotechnic delay element. As well as total timing accuracy, electronic detonators can be timed to initiate
20 at intervals of typically anywhere from 0 to 20,000ms in 1ms steps. Such flexibility has provided blast design engineers with the ability to create complex blast timing designs.

In order to optimise the physical results of an
25 explosive blast, blasting engineers usually create blast timing designs based on an assumed position of drill holes and a desired blast outcome. This design is typically done prior to drilling of any blast holes and, out of necessity, assumes certain characteristics of the rock.
30 Detonators are then programmed to go off at a fixed time and in a set sequence. However during drilling of blast holes, complications can arise and a hole may not be able to be drilled in a pre-determined location because of

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varying ground conditions. Thus the pre-determined or designed blast hole pattern and the actual blast hole pattern may be very different. Production constraints mean that operators are under pressure to load, set and fire a
5 blast as quickly as possible. Changes from the original blast design may cause major changes to the timing design, which can be very difficult for operators to implement at the time of blasting. The operators sometimes need to make new timing estimates (milliseconds/metre of rock away from
10 the hole), and replace a pre-timed detonator, but an incorrect new estimate by an operator can result in poor physical rock breakage performance. The alternative method is for an accurate off-site redesign of the timing plan by the blast engineer, however modifications to the blast once
15 the detonators have been programmed may require several hours for redesigning and reprogramming, which is typically not available in a production situation.

Summary of the Invention

20 In a first aspect the present invention provides a method for controlling the initiation of a plurality of electronic detonators when located in surrounding ground, the method comprising the steps of:

- 25 - locating said detonators and one or more adjacent detonators in the ground using a pre-determined planned positional relationship, this pre-determined planned positional relationship having an associated planned timing design for an initiator of each of the plurality of detonators;
- 30 - measuring the deviation between an actual located position and the pre-determined planned position of each of said detonators in the ground; and

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- calculating the time of initiation of each of said detonators based upon the deviation and modifying the planned timing design accordingly.

By knowing the deviation in the position of the detonators
5 in the actual blast hole pattern from the pre-determined
planned blast hole pattern, and using this property to
manipulate the time for the detonator to initiate, the
timing design of an explosion can be readily modified by a
blast operator immediately prior to a blast.

10 Preferably the determination of both the pre-determined
planned positional relationship and the actual located
position of each of the electronic detonators is made in
relation to a coordinate reference point.

Preferably the deviation is measured with respect to the
15 coordinate reference point.

Preferably the pre-determined planned positional
relationship and the actual located position of each of the
electronic detonators is measured using an electronic
positioning system.

20 Preferably the electronic positioning system is one of an
inertial positioning device or a global positioning system.

Preferably the step of calculating is carried out by a
computing device capable of receiving an input.

Preferably said computing device is a calculator, a laptop
25 computer, or a palm device.

Preferably the said detonators and the adjacent detonators
are arranged substantially in one or more rows, the latter
arrangement forming a grid. Most preferably the row or rows
forming a grid are substantially parallel to a working or
30 excavation face of a mine.

In a second aspect the present invention provides a system
for controlling the initiation of a plurality of electronic

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detonators when located in surrounding ground with one or more adjacent detonators, the system comprising:

- measuring means for measuring the deviation distance between an actual located position of each of said detonators and a pre-determined planned position of each of the detonators in the ground, this pre-determined planned positional relationship having an associated planned timing design for an initiator of each of the plurality of detonators; and
- calculating means for calculating a modified time of initiation of each of the said detonators based upon the deviation and the planned timing design.

Preferably the measuring means is arranged to measure both the pre-determined planned position and the actual located position of each of the electronic detonators in relation to a coordinate reference point.

Preferably the measuring means is arranged to work in conjunction with an electronic positioning system.

Preferably the calculating means is a computing device capable of receiving an input.

Preferably said computing device is a calculator, a laptop computer, or a palm device.

In a third aspect the present invention provides a computer program arranged to instruct a computing system to operate in accordance with the above methods of the first and second aspects.

In a further aspect the present invention provides a computer program arranged to instruct a computing system to operate as a system in accordance with the aspects above.

In a still further aspect the present invention provides a computer readable medium carrying a computer program according to the above aspects.

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The invention also provides a computer readable memory in which is recorded instructions for execution by a computing system to operate in accordance with the method of the invention.

5 The invention also provides a computer readable memory in which is stored instructions for execution by a computing system to operate as a system in accordance with the invention.

10 **Brief Description of the Drawing**

Notwithstanding any other forms which may fall within the scope of the present invention, preferred forms of the invention will now be described, by way of example only, with reference to the accompanying drawing in which:

15 Figure 1 shows a block flow diagram of one method for controlling the initiation of an electronic detonator in accordance with the invention.

Modes for Carrying out the Invention

20 To locate explosives and detonators in surrounding ground, for example in a bench at the working face of an open cut mine, typically a blast plan is made by a blast design engineer using assumed parameters of orebody hardness, distance between drilled blast holes for insertion of
25 explosive, depth of hole and other input data. A drilling crew subsequently mark out the blast pattern and drill the blast holes as per the design, but the position of those holes may need to be adjusted to take into account on-site variations such as unexpected orebody hardness, breakage of
30 the drill or crumbling or collapse of the hole requiring a new hole to be drilled. Typically the drilled blast holes for loading of explosive and a detonator are arranged

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substantially in a row or rows within a grid which are generally parallel to a working or excavation face of a mine, and the mine workings thus advance in a direction orthogonal to the row(s).

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Example

An example according to the present invention will now be described.

Referring to Figure 1, in one form of the method of the present invention, there is no planned blast pattern provided and the time of initiation of an electronic detonator was controlled by a blast operator once the placement of the explosive and detonator in surrounding ground has occurred.

10 The blast operator measured the actual spatial position of the detonator(s) in relation to one or more adjacent detonators by first identifying and logging a known coordinate reference point, which can be one of a survey position, another blast hole or a physical feature such as
15 the corner of the blast pattern area. Then the actual drilled blast hole spatial position was identified relative to that reference point. Each hole was also identified by a unique identity code or name, and its position was entered or logged into a recordal system.
20 The order of identification of the blast holes in a blast pattern was irrelevant.

The spatial position of the blast holes was measured using a measuring means in the form of an electronic positioning system, usually an inertial positioning device
25 (IPD) but a global positioning system (GPS) could also be used. The spatial position of each of the detonators was determined using a hand-held IPD (or GPS) unit which recorded a detonator identity and its location when the IPD (or GPS) unit was placed in communication with the
30 detonator (by physical contact, infrared reader, or electronic identification tag) when the detonator was positioned in the surrounding ground. The data from the hand-held unit was then transferred to a computer system

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for subsequent analysis, calculation of time of detonator initiation and archival.

In another variation, the detonators included an electronic positioning unit which was a transponder in communication with a local positioning system or an IPD or GPS which was itself in communication with the computer system.

The electronic positioning system alternatively included a laser theodolite tool (or other laser tape measures or electronic tape measures) which was used to manually survey the position of the blast holes for entry (manually or electronically) into a computer or other recording device. Any means of measuring the spatial position of the detonators when in position is within the scope of the invention.

A computer program was then used to calculate the time of initiation of any detonator based upon its logged actual spatial position in the blast pattern. Knowledge of the spatial position of the detonators in the actual blast hole pattern was used to manipulate the time for the detonator to initiate, rather than pre-programming the initiation time of any given detonator. Whereas the known methodology involved reading the unique identity of a detonator and assigning an initiation time to its assumed position or order of identification (or coding a unique identity and initiation time onto a microchip in the electronic detonator), prior to the actual blast hole pattern being developed, in the present method the timing design of the blast can be calculated (and substantially changed) by the blast operator immediately prior to the blast. In one instance the initiation time was assigned and coded, either by laser scanner or by actively connecting with and interrogating the chip.

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The step of calculating the initiation time of the detonator was carried out by a calculating means in the form of a computing device capable of receiving inputs including actual position coordinate data. Devices
5 employed included one of a calculator, laptop computer, palm or similar portable digital assistant, enabled mobile telephone or other computing device. The coordinate data was entered directly from the electronic positioning system or by manual entry. A computer program was used to
10 instruct the computing device. The computer program was provided on a computer readable medium such as a CD-Rom, computer disc or the like.

In another variation where there was a pre-determined planned blast pattern provided by a blast design engineer,
15 for each particular blast hole in the ground the blast operator located a detonator along with explosives in the hole and then measured the deviation between the actual located position and the pre-determined planned position of the detonator in the ground. The operator then
20 calculated the time of initiation of the detonator(s) based upon the deviation.

As previously described, the blast operator measured both the pre-determined planned positional relationship and the actual spatial position of the detonator(s) by first
25 identifying and logging a known coordinate reference point, and then the actual drilled blast hole spatial position was identified relative to that reference point. As previously described, each hole was also identified by a unique identity code or name, and its position was
30 entered or logged into a recordal system. The order of identification of the blast holes in a blast pattern was irrelevant. The pre-determined planned position of the

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blast holes used by the blast design engineer was usually developed by the use of proprietary computer software.

The deviation was measured with respect to the coordinate reference point, so that vector details (x, y and z
5 coordinate positional details) were recorded. This meant that both the distance and the direction that the actual spatial position of the detonator was spaced from the pre-determined planned positional relationship of that detonator was measured.

10 The spatial position of the blast holes was measured using a measuring means in the form of an electronic positioning system, embodiments of which are described above.

A computer program was then used to calculate the time of
15 initiation of any detonator based upon its deviation from the pre-determined planned position of that detonator in the blast pattern. This deviation was used to manipulate the time for the detonator to initiate, rather than pre-programming the initiation time of the detonator. The
20 planned timing design of an explosion was readily modified by a blast operator immediately prior to a blast by knowing the deviation in the position of the detonators in the actual blast hole pattern from the pre-determined planned blast hole pattern, and using this property to
25 manipulate the time for the detonator to initiate.

The step of calculating the initiation time of the detonator was carried out by calculating means in the form of a computing device capable of receiving an input including the deviation coordinate data, several possible
30 embodiments of which have been previously described.

Different timing plan parameters were used to calculate different blast outcomes. Different blast hole positions were able to be added or deleted to the timing plan to

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allow easy modification of a blast or even redirection or reorientation of an entire blast. The timing of initiation of each detonator was a variable and was able to be changed at any time prior to the blast, sometimes
5 even only minutes beforehand.

The practical outcome of these method and systems was that the physical results of an explosive blast were optimised by reducing the variability in explosion timing often introduced by blast operators making last minute
10 changes to an original blast design sequence. Initial experiments revealed that an increase in excavator production of around 10-15% could be achieved, both because of improved physical rock breakage performance (more even rock fragmentation, achievement of better
15 heave) as well as other operational time savings including the avoidance of blast redesign or reprogramming delays, faster ore clearing operations, and more stabilised working faces, reducing likely incidences of collapse and further production delays. At a gold mine, a 10% increase
20 in ore throughput can be worth extra revenue of many thousands of dollars per hour.

It is to be understood that, if any prior art information is referred to herein, such reference does not constitute an admission that the information forms a part of
25 the common general knowledge in the art, in Australia or any other country.

Whilst the invention has been described with reference to preferred embodiments it should be appreciated that the invention can be embodied in many
30 other forms.

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CLAIMS

1. A method for controlling the initiation of a plurality of electronic detonators when located in surrounding ground, the method comprising the steps of:

5 - locating said detonators and one or more adjacent detonators in the ground using a pre-determined planned positional relationship, this pre-determined planned positional relationship having an associated planned timing design for an initiator of each of the plurality of
10 detonators;

 - measuring the deviation between an actual located position and the pre-determined planned position of each of said detonators in the ground; and

 - calculating the time of initiation of each of said
15 detonators based upon the deviation and modifying the planned timing design accordingly.

2. A method as claimed in claim 1 wherein determination of both the pre-determined planned positional relationship and
20 the actual located position of each of the electronic detonators is made in relation to a coordinate reference point.

3. A method as claimed in claim 2 wherein the deviation is
25 measured with respect to the coordinate reference point.

4. A method as claimed in any one of claims 1 to 3 wherein the pre-determined planned positional relationship and the actual located position of each of the electronic detonators
30 is measured using an electronic positioning system.

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5. A method as claimed in claim 4 wherein the electronic positioning system is one of an inertial positioning device or a global positioning system.

5 6. A method as claimed in claim 1 wherein the step of calculating is carried out by a computing device capable of receiving an input.

7. A method as claimed in claim 6 wherein said computing
10 device is a calculator, a laptop computer, or a palm device.

8. A method as claimed in claim 1 wherein the said detonators and the adjacent detonators are arranged substantially in one or more rows, the latter arrangement
15 forming a grid.

9. A method as claimed in claim 8 wherein the row or rows forming a grid are substantially parallel to a working or excavation face of a mine.

20

10. A system for controlling the initiation of a plurality of electronic detonators when located in surrounding ground with one or more adjacent detonators, the system comprising:

- measuring means for measuring the deviation
25 distance between an actual located position of each of said detonators and a pre-determined planned position of each of the detonators in the ground, this pre-determined planned positional relationship having an associated planned timing design for an initiator of each of the plurality of
30 detonators; and

- calculating means for calculating a modified time of initiation of each of the said detonators based upon the deviation and the planned timing design.

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11. A system as claimed in claim 10 wherein the measuring means is arranged to measure both the pre-determined planned position and the actual located position of each of the electronic detonators in relation to a coordinate reference
5 point.

12. A system as claimed in claim 10 or claim 11 wherein the measuring means is arranged to work in conjunction with an electronic positioning system.

10

13. A system as claimed in claim 10 wherein the calculating means is a computing device capable of receiving an input.

14. A system as claimed in claim 13 wherein said computing
15 device is a calculator, a laptop computer, or a palm device.

15. A computer readable memory in which is recorded instructions for execution by a computing system to operate in accordance with the method of any one of claims 1 to 9.

20

16. A computer readable memory in which is stored instructions for execution by a computing system to operate as a system in accordance with any one of claims 10 to 14.

FIG. 1

Electronic Position & Timing Concept

