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(54) **METHOD FOR INSTALLING A SET OF ELECTRONIC DETONATORS AND ASSOCIATED IGNITION METHOD**

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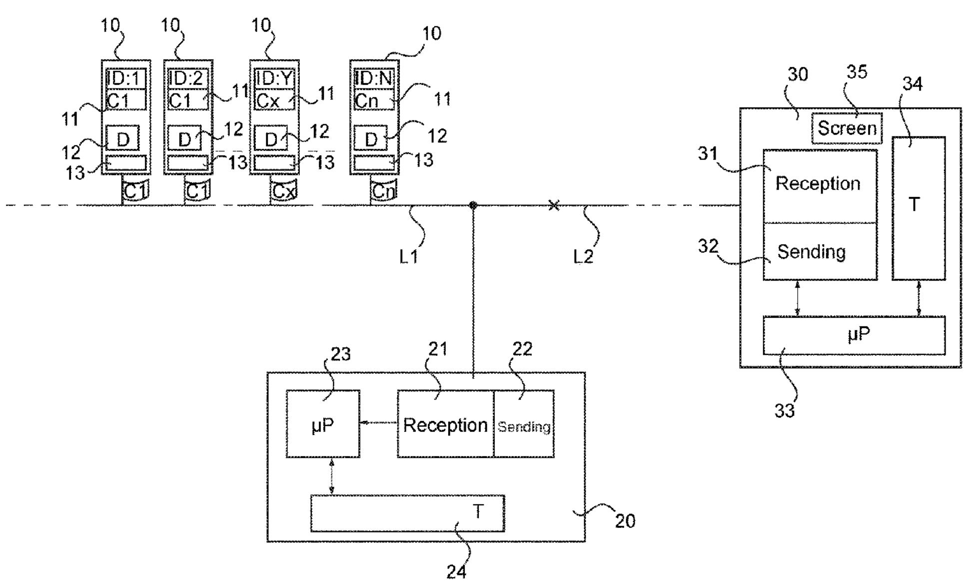
(57) **ABSTRACT**

A method for installing a set of electronic detonators in blast holes of a mining face includes the following steps: connecting detonators, charged into the blast holes, to a movable test device; receiving, by the movable test device, a message sent by each detonator; determining, from that message, a set of values, representing the total number of detonators connected to the movable test device; sending, to one or more detonators of the set, a data set to store including the set of values representing the total number of detonators connected to the movable test device; and storing the data set in the memory of one or more detonators of the set of electronic detonators. Use for later verification of the connection of the detonators before firing.

20 Claims, 4 Drawing Sheets



(58) **Field of Classification Search**
USPC 102/200, 301, 311, 221, 313, 322, 401, 102/403, 426; 89/1.11
See application file for complete search history.

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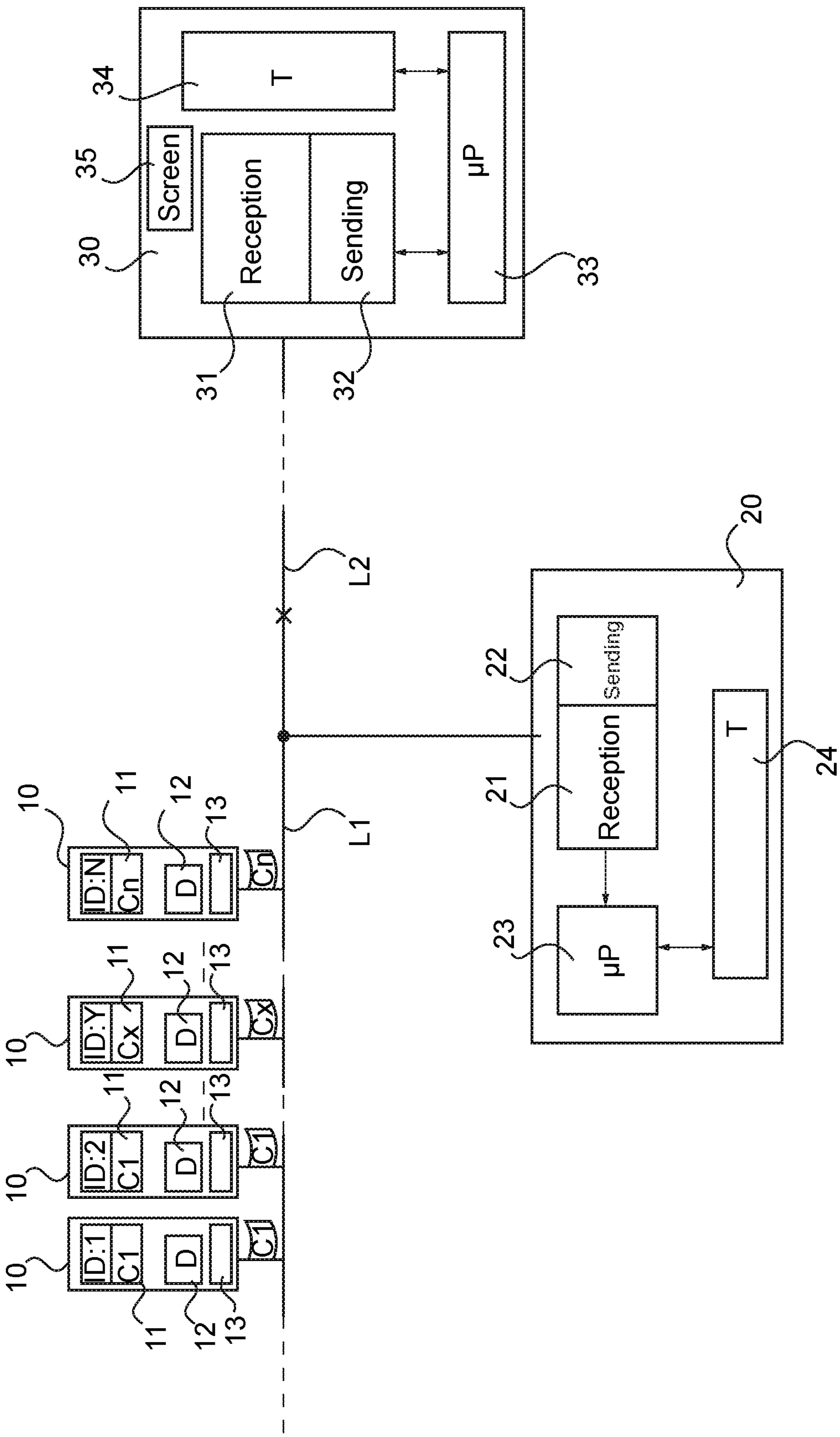

30
31
32
33
34
35
Screen
Reception
Sending
T
µP
L1
L2
20
21
22
23
24
Reception
Sending
µP
T
10
11
12
13
ID:1
ID:2
ID:Y
ID:N
C1
Cx
Cn
D

Fig. 1

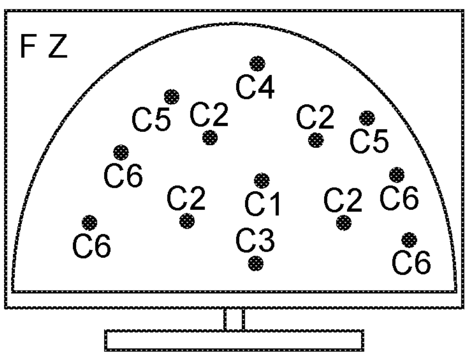

Fig. 2

	T
Cat.	(ms)
C1	0
C2	250
C3	500
C4	750
C5	1000
C6	1250

Fig. 3

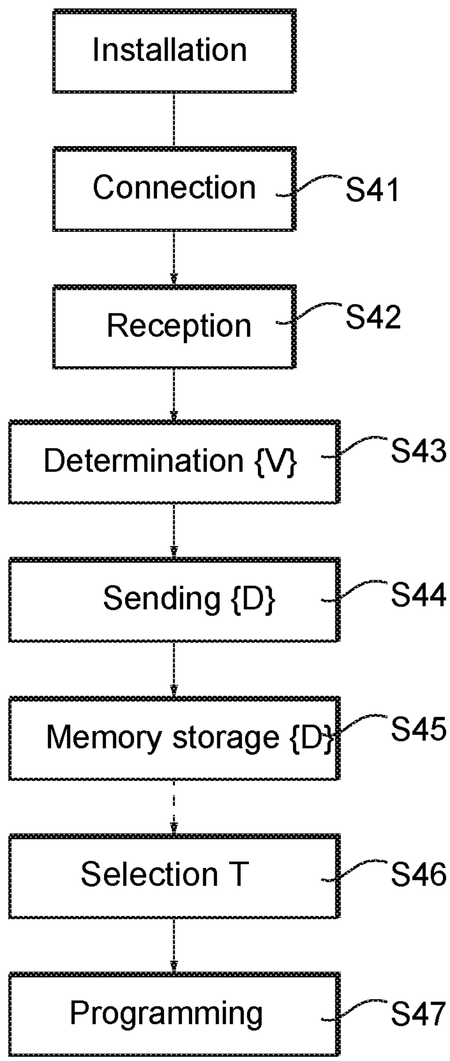
Installation
Connection
S41
Reception
S42
Determination {V}
S43
Sending {D}
S44
Memory storage {D}
S45
Selection T
S46
Programming
S47

Fig. 4

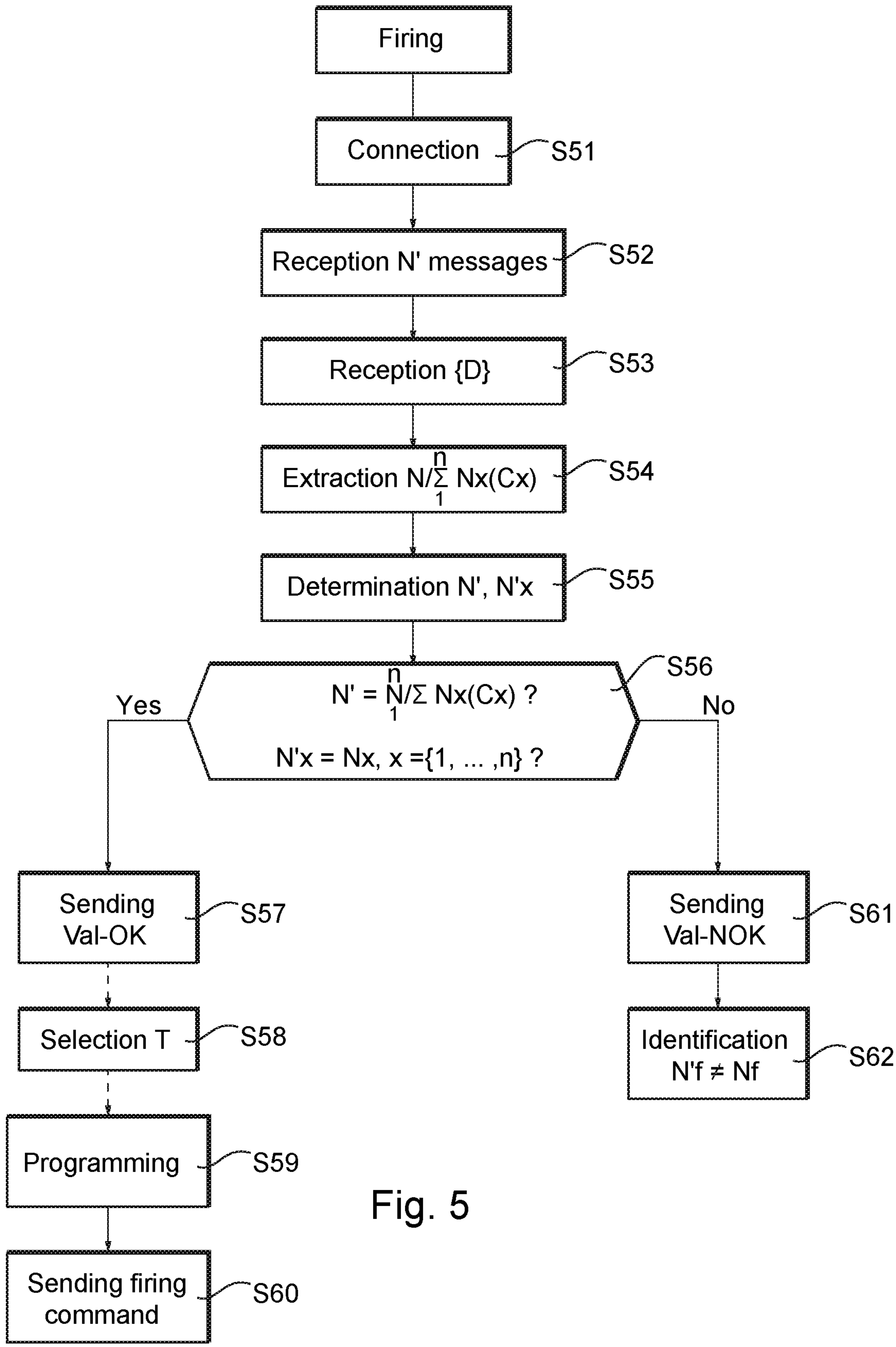
Firing
Connection
S51
Reception N' messages
S52
Reception {D}
S53
Extraction N/Σ Nx(Cx)
S54
Determination N', N'x
S55
N' = N/Σ Nx(Cx) ?
N'x = Nx, x ={1, ... ,n} ?
S56
Yes
No
Sending Val-OK
S57
Selection T
S58
Programming
S59
Sending firing command
S60
Sending Val-NOK
S61
Identification N'f ≠ Nf
S62

Fig. 5

METHOD FOR INSTALLING A SET OF ELECTRONIC DETONATORS AND ASSOCIATED IGNITION METHOD

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is the U.S. national phase of International Application No. PCT/FR2021/052319 filed Dec. 14, 2021, which designated the U.S. and claims priority to FR 2013388 filed Dec. 17, 2020, the entire contents of each of which are hereby incorporated by reference.

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to an installation method for installing a set of electronic detonators at a mining face.

It also relates to a method for firing a set of electronic detonators installed at a mining face according to the installation method in accordance with the invention.

The present invention furthermore relates to a movable test device for the implementation of the installation method in accordance with the invention as well as to a system for firing a set of electronic detonators installed at a mining face according to the installation method in accordance with the invention.

Description of the Related Art

The present invention applies in general to the field of mines and quarries and to the sites of public works employing programmable electronic detonators and remote firing according to a predetermined firing layout.

The firing layout defines, at the mining face, the location of blast holes each configured to receive an electronic detonator associated with an explosive, as well as the firing sequence, that is to say the delay associated with each electronic detonator, according to its location in each blast hole of the mining face.

The firing of the electronic detonators according to a firing layout is conventionally implemented based on two main phases, one at the mining face, the other at a distance from the mining face.

Firstly, the electronic detonators are charged into the blast holes defined by the firing layout, then are identified one by one by means of a movable test device, at the mining face.

The movable test device is generally designed to read, send, test, program one or more electronic detonators simultaneously or individually, with contact or contactless.

The identifying step consists of reading a unique identifier associated with each electronic detonator by the movable test device progressively with the wired or wireless connection of each electronic detonator of the movable test device. A delay is then associated with each electronic detonator according to the chosen firing layout, which associates a predefined delay with each blast hole according to its location in the mining face This delay associated with each electronic detonator is stored in memory in the movable test device.

In some applications, it is provided at this stage to program and store in memory, in each electronic detonator, the firing delay which is associated with it according to the chosen firing layout.

Usually, the movable test device carries out a test of the electronic detonators connected to the bus line in order to verify the proper connection of the set of electronic detonators identified individually.

Once the preceding step has been carried out, the bus line on which are connected the electronic detonators is connected to a firing line and the latter is itself connected to a remote firing device.

The step of remote firing may then be implemented.

This step of firing may be launched several days, or possibly weeks, after the step of installing electronic detonators at a mining face.

Before the actual remote firing, the remote firing device carries out carries out a test step in order to verify that all the electronic detonators of the firing layout are properly connected to the firing line and that the conditions of firing the electronic detonators at the mining face are still satisfactory for setting off the firing.

For this, the remote firing device compares the individual identification information sent to it by each electronic detonator with the data saved by the movable test device at the test and installation step of the electronic detonators at the mining face.

Thus, the data saved by the movable test device at the installation step, that is to say the number of electronic detonators placed at the mining face and connected to the bus line, the unique identification associated with each electronic detonator as well as the delay associated with each electronic detonator (possibly programmed in each electronic detonator), are transferred from the movable test device to the remote firing device and are stored in memory to enable the implementation of the test before firing.

This data transfer may be carried out using a memory medium such as a USB key or possibly by a transmission using a wireless communication protocol between the movable test device and the remote firing device.

In practice, it is then necessary to move the movable test device and/or the memory medium over a large distance, between the mining face and the remote firing device.

SUMMARY OF THE INVENTION

The present invention is directed to solving at least one of the aforementioned drawbacks and to provide a simplified installation for a set of electronic detonators, then their firing according to a predefined firing layout.

To that end, according to a first aspect, the present invention relates to an installation method for installing a set of electronic detonators in blast holes of a mining face.

The installation method comprises the following steps:

connecting electronic detonators charged into the blast holes to a movable test device;

receiving, by the movable test device, a message sent by each detonator of said set of electronic detonators;

determining, by the movable test device from said message sent by each detonator, a set of values representing the total number of electronic detonators connected to the movable test device;

sending, by said movable test device to one or more detonators of said set of electronic detonators, a data set to store in memory comprising said set of values representing the total number of electronic detonators connected to the movable test device; and

storing said data set in memory saving means of one or more detonators of said set of electronic detonators.

Thus, at least one detonator of the set of electronic detonators stores in memory at least some of a set of values representing the total number of electronic detonators connected to the movable test device at the time of the installation of the detonators at the mining face.

These items of information may thus be sent by at least one detonator once the electronic detonators have been connected to a remote firing device to enable the validation of the whole of the installation and of the proper connection, and in particular verify that there are no leakages of current on the line for connecting the electronic detonators to the remote firing device.

The storage in memory of information useful for the validation test in at least one electronic detonator makes it possible to dispense with the transfer of data between the movable test device and a remote firing device.

Therefore, it is not necessary to physically transfer the data, obtained at the time of the installation of the electronic detonators at the mining face, to the remote firing device.

According to one embodiment, at the sending step, said data set to store in memory is sent to all the detonators of the set of electronic detonators, said data set being stored in saving means of each detonator of the set of electronic detonators.

The redundant storage in memory of the data set in all the electronic detonators makes it possible to ensure the transfer of that data set later to a remote firing device, even in case of a fault in one or other of the detonators or its connection to the remote firing device.

Advantageously, said data set to store in memory further comprises a reference of the mining face.

Thus, when several firings are envisioned over a same period of time, the mining face reference makes it possible to verify the correct attribution of a stored data set to a particular mining face.

In a practical embodiment, said set of values comprises the total number of electronic detonators connected to the movable test device.

The total number of electronic detonators connected at the time of the installation method at the mining face makes it possible later to verify that the correct number of electronic detonators is connected to the remote firing device, prior to triggering the firing

In a particular embodiment, each detonator comprises memory means for storing at least one reference of delay category chosen from among a predefined set of delay categories.

In one embodiment, the installation method further comprises, for each delay category, a step of issuing a test command by said movable test device to a sub-set of electronic detonators comprising a same reference of delay category stored in memory and, at the determining step, said set of values comprises, for each delay category, the number of electronic detonators comprising that same reference of delay category stored in memory.

This information on the number of electronic detonators of each delay category later makes it possible to verify that the correct number of electronic detonators, of each delay category according to the chosen firing layout, is connected to the remote firing device, before triggering firing.

In another embodiment, in addition to or alternatively to the preceding embodiment, at the step of receiving, by said movable test device, a message sent by each detonator of said set of electronic detonators, said message comprises at least the reference of delay category stored in said memory storage means of said detonator, and at the determining step, said set of values comprises, for each delay category, the number of electronic detonators comprising that same reference of delay category stored in memory.

Preferably, in order to verify that the detonators of all the delay categories implemented at the time of the installation at the mining face are properly connected, the data set to store in memory comprises the number of delay categories of said predefined set of delay categories.

In practice, at the memory storage step, the number of electronic detonators comprising said saved reference of delay category is stored respectively in the saving means of at least one electronic detonator comprising said stored reference of delay category.

In one embodiment, the installation method further comprises the following steps:

- selecting, in the movable test device, a template of associations of each delay category with a predefined delay according to a predetermined firing layout; and
- programming a firing delay in each detonator of the set of electronic detonators based on said template of associations and the reference of delay category stored in the memory means of said detonator.

This programming of the delay at the movable test device is simplified thanks to the use of a template of associations. The firing delay may be programmed automatically according to the delay category stored in memory at each detonator. All the detonators may be programmed simultaneously and not one by one.

According to a second aspect, the present invention also relates to a method for firing a set of electronic detonators installed at the mining face according to the installation method described above, implemented in a firing device.

The firing method comprises the following steps:

- connecting said set of electronic detonators to the firing device;
- receiving a message sent by each detonator of said set of electronic detonators;
- receiving said data set stored in said saving means of one or more detonators of said set of electronic detonators;
- extracting, from said stored data set, said set of values representing the total number of electronic detonators connected to the movable test device at the time of installing said set of electronic detonators at the mining face;
- determining the current number of electronic detonators of said set of electronic detonators connected to the firing device based on the message sent by each detonator of said set of electronic detonators;
- comparing said current number with said set of values representing the total number of electronic detonators connected to the movable test device; and
- issuing a validation message for a test if said current number is consistent with said set of values representing the total number and a non-validation message if said current number is not consistent with said set of values representing the total number.

Verifying proper connection of the set of detonators may thus be carried out based on the data set sent by one or more electronic detonators to the remote firing device and does not require the transfer of data between the movable test device used at the time of installing the detonators at the mining face and the firing device, remote from the mining face.

According to one embodiment, the method for firing a set of electronic detonators that is installed at the mining face comprises the following steps:

- connecting said set of electronic detonators to the firing device;
- receiving a message sent by each detonator of said set of electronic detonators, said message comprising at least

the reference of delay category stored in said memory storage means of said detonator;

receiving said data set stored in said saving means of one or more detonators of said set of electronic detonators;

extracting, from said stored data set, said set of values comprising, for each delay category, the number of electronic detonators comprising said stored reference of delay category;

determining, for each delay category, the current number of electronic detonators comprising said stored reference of delay category, from said message sent by each detonator of said set of electronic detonators;

comparing, for each delay category, said current number with said number of electronic detonators comprising said stored reference of delay category; and

issuing a test validation message if said current number is equal to said number of electronic detonators comprising said stored reference of delay category for all the delay categories, and a message of non-validation if said current number is different from said number of electronic detonators comprising said stored reference of delay category for at least one delay category.

The firing methods thus makes it possible to validate or not validate the installation of the electronic detonators and their connection before firing, based on the knowledge of the number of electronic detonators of each delay category.

According to another embodiment, the method for firing a set of electronic detonators that is installed at the mining face comprises the following steps:

connecting said set of electronic detonators to the firing device;

sending, for each delay category, a test command by said firing device to a sub-set of electronic detonators comprising a same stored reference of delay category;

receiving, for each delay category, a message sent by each detonator of said sub-set of electronic detonators comprising said same stored delay category;

receiving said data set stored in said saving means of one or more detonators of said set of electronic detonators;

extracting, from said stored data set, said set of values comprising, for each delay category, the number of electronic detonators comprising said stored reference of delay category;

determining, for each delay category, the current number of electronic detonators comprising said stored reference of delay category, from said message sent by each detonator of said subset of electronic detonators comprising said same stored delay category;

comparing, for each delay category, said current number with said number of electronic detonators comprising said stored reference of delay category; and

issuing a test validation message if said current number is equal to said number of electronic detonators comprising said stored reference of delay category for all the delay categories, and a message of non-validation if said current number is different from said number of electronic detonators comprising said stored reference of delay category for at least one delay category.

In practice, at said step of issuing a non-validation message, the delay category or categories of which the current number is different from said number of electronic detonators comprising said stored reference of delay category is or are identified.

The operator can thus identify the defective detonators among the set of electronic detonators, and decide, according to the delay category concerned, to suspend the firing or trigger it.

In an advantageous embodiment, the firing method further comprises the following steps:

selecting a template of associations of each delay category with a predefined delay according to a predetermined firing layout; and

programming a firing delay in each detonator of said set of electronic detonators based on said template of associations and the reference of delay category stored in the memory storage means of said detonator.

Programming the delay can thus be carried out from the remote firing device, and is simplified through the use of a template of associations. The firing delay may be programmed automatically according to the delay category stored at each detonator. All the detonators may be programmed simultaneously and not one by one.

According to a third aspect, the present invention also relates to a movable test device for the implementation of the installation method described above.

The movable test device comprises:

receiving means for receiving a message sent by each detonator of said set of electronic detonators charged into blast holes;

determining means for determining, from said message sent by each detonator, a set of values representing the total number of electronic detonators connected to said movable test device; and

sending means for sending, to one or more detonators of said set of electronic detonators, a data set to store comprising said set of values representing the total number of electronic detonators connected to said movable test device.

The movable test device has features and advantages similar to the installation method it implements.

Lastly, according to a fourth aspect, the present invention relates to a firing system for a set of electronic detonators installed at the mining face according to the installation method described above.

The firing system comprises a movable test device configured to be connected to a bus line, the electronic detonators being connected to said bus line, and a firing device configured to be remotely connected via a firing line to said bus line.

In practice, each detonator of said set of electronic detonators comprises means for storing a reference of delay category chosen from among a predefined set of delay categories, each delay category being identified by a predefined combination of a numerical code and a color code, said numerical code being stored as reference of delay category in said storage means of each detonator.

Advantageously. said numerical code and said color code of each predefined combination are visible on at least one location chosen from among a connection cable of the electronic detonator or a connector of said electronic detonator to the bus line.

The combination of a number and of a color makes it possible to simply and visually define the delay category to which the electronic detonator belongs and thereby to facilitate its installation at the mining face.

In practice, said predefined set of delay categories comprises between 16 and 32, or even 64 different delay categories.

The firing system has features and advantages similar to the firing method described above.

BRIEF DESCRIPTION OF THE DRAWINGS

Still other particularities and advantages of the invention will appear in the following description with reference to the accompanying drawings which are given by way of non-limiting examples:

FIG. **1** is a diagrammatic view of a firing system in accordance with one embodiment of the invention;

FIG. **2** is a diagram illustrating the programming of a firing layout for a firing system of FIG. **1**;

FIG. **3** is a diagram illustrating a template of associations of delay categories with predefined delays according to the example of the firing layout of FIG. **2**;

FIG. **4** is an algorithm of an installation method for installing a set of electronic detonators according to one embodiment of the invention; and

FIG. **5** is an algorithm of a method for firing a set of electronic detonators according to one embodiment of the invention;

DETAILED DESCRIPTION

A description will first of all be given with reference to FIG. **1** of a system for firing a set of electronic detonators installed at the mining face.

The firing system comprises several electronic detonators **10** each provided to be installed in a blast hole at the mining face.

In usual manner, each electronic detonator **10** is placed with a predetermined amount of explosive in a blast hole bored in a mining face.

The set of electronic detonators **10** so installed at the mining face are next configured to be fired in a single volley.

Such a firing system is used for example in particular in applications for mines, quarries and public works.

In this embodiment, the firing system comprises a mobile test device **20** configured to be connected to a bus line L**1**.

The electronic detonators **10** are also connected to the bus line L**1** and thus connected to the mobile test device **20**.

The mobile test device **20** may thus communicate with one or more electronic detonators **10**, simultaneously or individually, in order to read information or data stored in memory by the electronic detonators **10**, issue information to those electronic detonators **10** and test their connection and their operating state.

In some embodiments, the mobile test device **20** is also designed to program the electronic detonators **10**, and for example program a firing delay as will be described in more detail below.

The mobile test device **20** comprises, in conventional manner, receiving means **21** and sending means **22** making it possible to communicate with the electronic detonators **10**, simultaneously or individually.

The receiving means **21** are configured in particular to receive a message issued by each electronic detonator **10**, simultaneously or individually. The sending means **22** are configured to issue messages and/or information to store or program in each electronic detonator **10**.

The receiving means **21** and sending means **22** may be formed by a bi-directional emitter/receiver, known to the person skilled in the art in the field of wired communication networks.

Although, in the example embodiment illustrated in FIG. **1**, the electronic detonators **10** and the mobile test device **20** are connected by a wired connection by means of the bus line L**1**, the invention is not limited to that type of connection.

In particular, the mobile test device **20** and the electronic detonators **10** could communicate via a wireless connection, for example by radio link. The receiving means **21** and sending means **22** may then be formed by a bi-directional emitter/receiver antenna, known to the person skilled in the art in the field of wireless communication networks.

The movable test device **20** further comprises a microprocessor **23** making it possible to implement different data processing operations, computations and parameterizations as will be described later with reference to the installation method for installing electronic detonators at the mining face.

The movable test device **20** also comprises a memory of EEPROM type (EEPROM being an acronym for Electrically Erasable Programmable Read Only Memory).

The role and the operation of the movable test device **20** will be described in more detail with reference to the installation method for installing electronic detonators **10** at the mining face.

The firing system further comprises a firing device **30** provided to be remotely connected to electronic detonators **10**.

As illustrated in FIG. **1**, the firing device **30** is connected via a firing line L**2**, itself connected to the bus line L**1**.

The firing device **30** is provided to be placed at a long distance from the mining face to enable triggering of the firing in full safety for the operator actuating firing from the firing device **30**.

The firing device **30** comprises receiving means **31** and sending means **32** enabling bi-directional communication between the electronic detonators **10** and the firing device **30**, simultaneously or individually.

The receiving means **31** and sending means **32** are similar to those described earlier in connection with the mobile test device **20**.

The firing device **30** further comprises a microprocessor **33** making it possible to implement different data processing operations, computations and parameterizations as will be described later with reference to the firing method as described later.

A programmable memory **34** of EEPROM memory type is also provided in the firing device **30**.

A display screen **35** may also equip the firing device **30** to communicate with the operator.

The role and the operation of the firing device **30** will be described in more detail with reference to the firing method.

Each electronic detonator **10** comprises bidirectional communication means **13** configured for the communication of the electronic detonator **10** with the movable test device **20** and/or the firing device **30** The bidirectional communication means **13** of the electronic detonators are similar to the receiving means **21** and sending means **22** described earlier with reference to the movable test device **20**.

Furthermore, each electronic detonator **10** comprises memory storage means **11** configured to store identification information specific to each electronic detonator **10**.

These memory means **11** are formed for example by a ROM or Read Only Memory or by a writable memory of EEPROM type.

In particular, each electronic detonator **10** is associated with a unique identifier ID parameterized in the electronic detonator **10** at the time of its manufacture.

The value IDY of this identifier ID is comprised here, purely by way of example, between ID**1** and IDN, N corresponding to the total number of electronic detonators **10** installed at the mining face for performing firing.

In the illustrated embodiment, and without being limiting, each electronic detonator **10** also comprises a reference x of delay category Cx saved in the memory means **11**.

In its principle, the implementation of a delay category Cx consists of pre-categorizing the electronic detonators **10** according to their delay category Cx, all the electronic detonators **10** associated with the same delay category Cx then being programmed with a same firing delay according to a predetermined firing layout.

Each delay category Cx is preferably identified by a predefined combination of a numerical code x and of a color code.

The numerical code or number x is stored in memory as a reference of delay category Cx in the memory means **11** of each electronic detonator **10**.

In order to facilitate the installation of the electronic detonators **10** in the blast holes at the mining face, the delay category Cx with which is associated the electronic detonator is visible on each electronic detonator **10**.

The use of a numerical code or number x and of a color code makes it possible to facilitate, in combination, the identification by the operator at the mining face, of each electronic detonator **10** to install.

Preferably, the number x and the color that is associated with each combination are visible on the electronic detonator **10**.

The number x and/or the color code may be visible for example on the cable for connecting the electronic detonator **10** to the bus line L**1**.

This embodiment has been illustrated in FIG. **1** in which a different color label, bearing the number **1**, x, . . . , n, is attached to the connection cable for each electronic detonator **10**.

Of course, other types of location could be chosen to make visible the delay category Cx with which is associated the electronic detonator **10**.

For example, the combination of the numerical code and of the color code identifying each delay category Cx could also be visible on a connector (not shown) connecting the electronic detonator **10** to the bus line L**1**.

Moreover, a label of RFID type may be fastened to an outside face of the casing of the electronic detonator **10**. This label may thus comprise not only the color code and the numerical code x of the delay category Cx but also the identifier IDY of the electronic detonator **10**.

The advantage of the categorization of the electronic detonators **10** will appear in more detail below, with reference to the method for installation and firing the electronic detonators.

Lastly, each electronic detonator **10** further comprises saving means **12** formed by an EEPROM type writable memory.

In practice, the saving means **12** may be distinct from the memory means **11** of each electronic detonator **10** or be formed from a same EEPROM memory with separate registers for the storage of the different data.

As will appear in the description below, the saving means **12** make it possible to store locally, at each of or some of the electronic detonators **10**, data in connection with the firing layout in which are implemented those electronic detonators **10**.

An illustration is provided in FIG. **2** of a firing layout associated with a mining face identified by a reference FZ

When a firing layout is defined, the programmer defines, at the mining face, the location of the various electronic detonators **10**, which are diagrammatically illustrated by dots in FIG. **2** and associates with them a firing delay.

An associations template T such as illustrated in FIG. **3**, is then defined in parallel, enabling a firing delay (in millisecond) to be associated with each delay category Cx.

By way of non-limiting example, FIGS. **2** and **3** illustrate the implementation of six delay categories C**1**, C**2**, C**3**, C**4**, C**5**, C**6** respectively associated with 0, 250, 500, 750, 1000, 1250 ms of firing delay.

Of course, this example embodiment is purely illustrative.

In practice, the predefined set of delay categories Cx comprises between 16 and 32 different delay categories for the creation of a conventional firing layout. This number may be raised to 64 for larger firing layouts. Typically, the use of 20 to 25 different delay categories makes it possible to produce a firing layout for a given mining face FZ.

The use of an associations template T avoids having to know the value of the firing delay in the firing layout as illustrated not FIG. **2**.

Indeed, the firing layout may be carried out by locating the electronic detonators **10** having the same firing delay by attributing to them a delay category Cx, this being for each different firing delay of the firing layout. The associations model T next makes it possible to define the firing delay for each delay category Cx.

In the firing layout as illustrated in FIG. **2**, each electronic detonator **10** may thus be viewed by a dot of color and a number x, corresponding to the color code and the numerical code characterizing its delay category Cx.

A description will now be given with reference to FIG. **4** of an installation method for installing a set of electronic detonators **10** according to one embodiment of the invention.

As described above with reference to FIG. **1**, each electronic detonator **10** is placed in a blast hole of a mining face.

This placement of the electronic detonators is made according to the firing layout such as that given as an example in FIG. **2**.

To that end, the installer may have a charge map, available for example on the movable test device **20**, making it possible to identify the location of each electronic detonator and its delay category Cx, seen by the associated color code and numerical code x.

This charge map simplifies the placement of each electronic detonator **10** in the dedicated blast hole.

The installer may, for a given mining face FZ, take the required number of electronic detonators **10** of each delay category Cx, then dispose them at the mining face FZ by just complying with the color code and/or the numerical code of the charge map.

The installation method next comprises a step S**41** of connecting the electronic detonators **10** to the movable test device **20**.

In the example embodiment described with reference to FIG. **1**, and without being limiting, the electronic detonators **10** are connected via a bus line L**1**, itself connected to the movable test device **20**.

The installation method next comprises a step S**42** of receiving, by the movable test device **20**, a message sent by each electronic detonator **10**.

The issuing of a message by each electronic detonator **10** may be carried out spontaneously.

For example, the issuing of a message by each detonator may take place as of its connection to the bus line L**1**, itself connected to the movable test device **20**.

Each electronic detonator **10** is thus configured to issue a message to the movable test device **20** as of its powering-up.

The messages at the receiving step S**42** are thus received in succession, progressively with the connection of the electronic detonators to the bus line L**1**.

Alternatively, in another embodiment, the movable test device **20** sends, in an issuing step, a test command to all the electronic detonators **10**, after their connection to the bus line L**1**.

The receiving step S**42** then makes it possible to receive, simultaneously or individually, a message in response, sent by each electronic detonator **10** to the movable test device **20**.

The receiving step S**42** is implemented by the receiving means **21** of the movable test device **20**.

The installation method next comprises a step S**43** of determining, from the message sent by each electronic detonator **10**, a set of values V representing the total number of electronic detonators **10** connected to the movable test device **20**.

The determining step S**43** is implemented by the determining means formed by the microprocessor **23**, from messages received at the receiving step S**42**.

In particular, this set of values V determined by the movable test device **20** may comprise the total number N of electronic detonators **10** connected to the movable test device **20**.

The total number N of electronic detonators **10** may be determined from the number of messages received at the receiving step S**42**.

More particularly, in the embodiment illustrated in FIG. **1**, in which each electronic detonator **10** is associated with a delay category Cx, at the determining step S**43**, the set of values V comprises, for each delay category Cx, the number Nx of electronic detonators **10** comprising the reference x of delay category Cx stored in the memory means **11**.

The set of numbers Nx of electronic detonators associated with each delay category Cx thus forms a set of values V representing the total number N of electronic detonators **10** at the mining face.

In such an embodiment, the determining step S**43** may also make it possible to specifically determine the total number N of electronic detonators **10** by the following calculation:

$$N=\Sigma_1^n Nx(Cx)$$

where n is the number of delay categories used in the firing layout implemented.

In order to enable the determination of the number Nx of electronic detonators **10** associated with the delay category Cx, at the receiving step S**42**, the message comprises at least the reference x of delay category Cx stored in the memory means **11** of the electronic detonator **10**, this being for each electronic detonator **10** connected to the movable test device **20**.

In such an embodiment, the number n of delay categories Cx of the predefined set of delay categories that are used in the mining face FZ may then also be determined from the set of the messages received. For example, the microprocessor **23** is configured to compute the sum of the different references x of delay category Cx extract from the messages received.

The number n of delay categories Cx is useful for later verifying, at a test prior to triggering the firing as described below, that the electronic detonators **10** of each delay category Cx of the predefined set of delay category Cx implemented in the firing layout are indeed present.

Alternatively, it is possible for the message sent by each electronic detonator **10** not to comprise information on the delay category Cx with which each electronic detonator is associated.

In this case, the movable test device **20** queries the electronic detonators **10**, delay category by delay category, only the electronic detonators **10** associated with the same delay category Cx simultaneously issuing a message to the movable test device **20**. This latter may thus determine, at the determining step S**43**, the number Nx of electronic detonators **10** associated with the delay category Cx.

In such an embodiment, the delay categories Cx used for the mining face FZ must be stored in memory at the movable test device **20** to enable the electronic detonators **10**, to be queried, delay category by delay category.

At the determining step S**43**, the set of values V thus comprises the total number N of electronic detonators at the mining face, directly determined from the number of messages received and/or determined indirectly from the number Nx of electronic detonators of each delay category Cx.

This information determined upon the implementation of the installation method for installing for the electronic detonators **10** at the mining face is useful for verifying the proper operation and correct connection of each electronic detonator **10** at the time of triggering firing, which may occur several days, or even several weeks, after the installation of the electronic detonators **10** at the mining face.

To that end, the installation method comprises a step S**44** of sending, by the movable test device **20**, of a data set D to store at one or more electronic detonators **10**.

The receiving step S**42** is implemented by the receiving means **22** of the movable test device **20**. The data set D is received by the bi-directional communication means **13** of the electronic detonator or detonators **13**.

The data set D is configured to be stored in the saving means **12** of an electronic detonator **10**.

The electronic detonator **10** which stores the data set D may be selected in random manner by the movable test device **20** from among the set of electronic detonators **10**, or instead be selected according to the power of the message sent by each electronic detonator **10**. In this last case, the electronic detonator **10** having a response signal of greater amplitude may be selected.

The data set D to store comprises the set of values V representing the total number N of electronic detonators **10** connected to the movable test device **20**.

The installation method thus comprises a step S**45** of storing the data set D in a writable memory of at least one electronic detonator **10**.

The information such as the total number N of electronic detonators **10** connected to the movable test device **20** may thus be stored in memory at one or more electronic detonators connected to the bus line L**1**.

In one embodiment, at the sending step S**44**, the data set D to store in memory is sent to all the electronic detonators **10** of the set of electronic detonators connected to the bus line L**1**.

Therefore, the data set D is stored in the saving means **12** of each electronic detonator **10** of the set of electronic detonators.

The information thus stored in memory is then available at any one of the electronic detonators **10**.

Therefore, in case of defectiveness of one or other of the electronic detonators **10**, the redundant storage in memory of the data set D makes it possible to make secure the availability of that information at all the electronic detonators **10**.

Alternatively, at the step S**44** of storing in memory, the number Nx of electronic detonators **10** associated with the delay category Cx is stored in memory in the saving means **12** of at least one electronic detonator **10** which comprises that reference of delay category Cx stored in the memory means **11**.

Thus, the storage in memory of the number Nx of electronic detonators **10** associated with each delay category Cx is distributed among the electronic detonators **10** of each delay category Cx.

For reasons of redundancy, the number Nx of electronic detonators **10** associated with the delay category Cx may be stored in the saving means **12** of all the electronic detonators **10** that comprise that reference of delay category Cx stored in their memory means **11**.

In addition to the total number N of electronic detonators and/or the number Nx of electronic detonators **10** of each delay category Cx, the data set D to store may also comprise a reference FZ of the mining face from among a set of mining faces.

In the context of planning multiple firings, the reference FZ of the mining face, as associated with the firing layout at the time of its programming as explained earlier with reference to FIG. **2**, makes it possible to verify later, in particular before the programming of the delays for each electronic detonator, the match between the firing layout used with the mining face FZ to program.

The data set D to store in memory may also comprise the number n of delay categories Cx used in the mining face FZ.

The installation method for installing electronic detonators **10** and their reading and programming by the movable test device **20** may be finished at this stage.

However, it is also possible to provide for the programming by the movable test device **20** of the predefined delay associated with each electronic detonator **10** according to the firing layout.

In this case, the installation method further comprises a step S**46** of selecting an associations model T such as illustrated in FIG. **3**, associating each delay category Cx with a predefined delay according to a predetermined firing layout.

The selection of an associations model T is carried out by an operator, from associations models T stored in the memory **24** of the movable test device **20**.

Based on this associations model T, a programming step S**47** is implemented by the movable test device **20**: the predefined delay is sent to each electronic detonator **10** according to the delay category Cx that is associated with it. The predefined delay is then stored in the saving means **12** of each electronic detonator **10**.

The programming step S**47** is thus implemented based on the associations model T and the reference of delay category Cx stored in the memory means **12** of each electronic detonator **10**.

The use of an associations model T makes it possible to simultaneously program the predefined delay in the set of electronic detonators based on the reference of delay category Cx stored in memory.

The programming of the delay in each electronic detonator **10** according to a firing layout is thus facilitated.

A description will now be given with reference to FIG. **5** of method for firing a set of electronic detonators installed at the mining face.

The firing method is implemented in the firing device **33** as illustrated in FIG. **1**, which may be placed far from the mining face FZ and from the electronic detonators **10**.

Moreover, the method for firing the set of electronic detonators **10** may be implemented a long time after the step of installing the electronic detonators **10** in the blast holes.

It is thus of the utmost importance to test, before triggering firing, that the set of electronic detonators **10** are indeed in operational state and connected to the firing device **30** to receive the firing instruction.

To that end, the firing method first of all comprises a step S**51** of connecting the set of electronic detonators **10** to the firing device **30**.

In practice, the connection may be carried out by a firing line L**2** connected to the bus line L**1** to which have been connected the electronic detonators **10** at the time of the installation at the mining face.

The firing method next comprises a step S**52** of receiving a message sent by each electronic detonator **10**.

The firing device **30** thus receives, at the receiving means **31**, a number N' of messages sent by the set of the electronic detonators **10** connected to the firing device **30**.

The issuing of the messages by the electronic detonators **10** may be spontaneous, as of powering-up of the electronic detonators **10** at the time of the connection and/or the powering-up of the firing device **30**.

In an alternative embodiment, the firing device **30** may be configured to implement a step of sending, by the sending means **32** of a test command to the set of electronic detonators **10**.

The receiving step S**52** is then configured to receive in response the messages sent by each electronic detonator **10**.

The firing method also comprises a step S**53** of receiving the data set D stored in the saving means **12** of at least one electronic detonator **10**.

As indicated earlier, the data set D may be stored in memory in one, several or all of the electronic detonators **10** of the set of electronic detonators installed at the mining face.

More particularly, and without being limiting, in the implementation illustrated in FIG. **1** for which each electronic detonator **10** is associated with a delay category Cx, at the step S**52** of receiving a message sent by each electronic detonator **10**, the message further comprises at least the reference of delay category Cx stored in the memory means **11** of the electronic detonator **10**.

Alternatively, the firing device **30** may be configured to implement a step of sending, for each delay category Cx, a test command sent to the sub-set of electronic detonators **10** comprising the same stored reference of delay category Cx.

The number of messages received thus directly corresponds to the current number of electronic detonators **10** that are associated with that delay category Cx.

The firing method next comprises a step S**54** of extracting, from the data set D, a set of values V representing the total number N of electronic detonators **10** that are connected to the movable test device **20** at the time of the installation of the set of electronic detonators **10** at the mining face.

The extracting step S**54** is implemented by the microprocessor **33** of the firing device **30**.

The set of values representing the total number of electronic detonators may, as indicated earlier, correspond to the total number N of electronic detonators **10** that are connected to the bus line L**1** and/or to the numbers Nx of electronic detonators **10** that are associated with each delay category Cx, this being for the predefined set $\{1, \ldots, x, \ldots, n\}$ of delay categories Cx.

At the extracting step S**54**, it is also possible to extract, from the data set D, the reference FZ of the mining face concerned as well as the number n of delay categories Cx used in the mining face at the time of the installation of the electronic detonators **10**.

The firing method further comprises a step S**55** of determining, based on the step S**52** of receiving messages sent by each electronic detonator **10**, the current number N' of electronic detonators **10** connected to the firing device **30**.

The determining step S**55** is implemented by a calculating device of the microprocessor **33** of the firing device **30**.

The current number N' may thus be calculated from the sum of the messages received at the receiving step S**52**.

In the embodiment in which the message received at the receiving step S**52** comprises the reference of delay category Cx stored in memory in each electronic detonator **10**, the determining step S**55** is configured to determine, for each delay category Cx, the current number N'x of electronic detonators **10** associated with that delay category Cx.

In the embodiment in which the electronic detonators **10** are queried, delay category by delay category, by the firing device **30**, the number of messages received in response to each sending of a test command corresponds to the current number N'x of electronic detonators **10** associated with that delay category Cx.

The current number N'x of electronic detonators **10** associated with each delay category Cx also makes it possible to determine alternatively, by sum calculation, the current number N' of electronic detonators connected to the firing device **30**.

It will thus be noted that, based on the data set D sent by the electronic detonators **10**, it is possible to know, at the firing device **30**, the installation conditions of the electronic detonators **10** at the mining face, and in particular the total number N of electronic detonators connected to the bus line L**1**, as well as the number Nx of electronic detonators **10** associated with each delay category Cx.

This information can thus be sent directly, from one or more electronic detonators **10** to the firing device **30** and avoid any information transfer by the movable test device **20** or any other information medium.

Based on the extracting and determining steps S**54** and S**55**, a comparing step S**56** is implemented by the microprocessor **33** of the firing device **30**.

At this comparing step S**56**, the current number N' of electronic detonators **10** connected to the firing device **30** is compared with the set of values representing the total number N of electronic detonators connected to the movable test device **20** at the time of the installation of the electronic detonators **10**.

As indicated earlier, the current number N' is calculated from the number of messages received at the receiving step S**52**.

At the comparing step S**56**, the current number N' is compared with the total number N of electronic detonators **10** or with the sum of the number Nx of electronic detonators **10** associated with each delay category Cx.

In practice, the current number N' is consistent with the set of values V representing the total number N when

$$N'=N$$

or

$$N' = \sum_{1}^{n} Nx(Cx)$$

where n is the number of delay categories of the set predefined at the time of the installation of the electronic detonators at the mining face.

In the embodiment in which each electronic detonator **10** is associated with a delay category Cx, the comparing step S**56** also comprises a comparison, for each delay category Cx, x belonging to {1, . . . , n}, of the current number N'x of electronic detonators **10** connected to the firing device **30** with the number Nx of electronic detonators **10** associated with the delay category Cx.

In practice, the current number N'x of electronic detonators **10** connected to the firing device **30** is consistent with the number Nx of electronic detonators **10** associated with the delay category Cx when

$$N'x=Nx,$$

this being for any delay category Cx, x belonging to {1, . . . , n}.

Depending on the result of the comparison or comparisons, a step S**57** of issuing a validation message VAL-OK is implemented if the current number N' is consistent with the set of values representing the total number N of electronic detonators connected to the movable test device **20** at the time of the installation, and if, for all the delay categories Cx, the current number N'x is consistent with the number Nx of electronic detonators **10** associated with the delay category Cx at the time of the installation of the electronic detonators **10**, when the electronic detonators associated with a delay category Cx are implemented.

This step S**57** of issuing a message may be carried out by issuing an audible message or information or warning displayed on a display screen **35** of the firing device **30**.

As indicated earlier, the programming of the predefined delay associated with each electronic detonator **10** may be implemented by the firing device **30**.

In this case, the installation method further comprises a step S**58** of selecting an associations model T such as illustrated in FIG. **3**, associating, for each delay category Cx, a predefined delay according to a predetermined firing layout. Selecting the associations model T may be implemented based on associations templates saved in the programmable memory **34** of the firing device **30**.

When several firings are programmed and are to be implemented by the firing device **30**, the reference FZ of the mining face makes it possible to select the associations model T corresponding to the selected firing layout.

By virtue of the associations model T, the predefined delay may be programmed simultaneously in all the electronic detonators **10**, in a single programming step S**59**.

The programming step S**59** is thus implemented based on the associations model T and the reference of delay category Cx stored in the memory means **11** of each electronic detonator **10**.

In practice, a general message, comprising according to the associations model T, a predefined delay associated with each delay category Cx may be sent to all the electronic detonators **10**, the programming of each predefined delay being implemented according to the reference of delay category Cx stored in the memory means **11** of each electronic detonator **10**.

The programming of the delay in each electronic detonator **10** according to a firing layout is thus facilitated.

After this procedure of testing and validating the connection of the set of electronic detonators **10** by the firing device **30**, and optionally the programming of the delay associated with each electronic detonator **10**, a step S**60** of sending a firing instruction may be implemented in full safety for triggering the firing.

On the contrary, if further to the comparing step S**56**, the current number N' of electronic detonators **10** is not consistent with the set of values V representing the total number N of electronic detonators connected to the movable test device **20** at the time of installation, a step S**61** of issuing a message of non-validation VAL-NOK is implemented.

This VAL-NOK message is sent to the operator and avoids triggering the firing when the electronic detonators **10** are not all connected, are defective or else are in greater number than those charged into the blast holes at the time of installation. This VAL-NOK message may also be an audible warning or a message displayed on the screen **35** of the firing device **30**.

In the embodiment in which each electronic detonator **10** is associated with a delay category Cx, the comparing step S**56** also comprises the comparison, for each delay category Cx, of the current number N'x of electronic detonators **10** with the number Nx of electronic detonators **10** associated with the delay category Cx.

If the current number N'x is different from the number Nx for at least one delay category Cx, the step S**61** of issuing a non-validation message VAL-NOK is implemented.

An identifying step S**62** is implemented in order to identify the delay category or categories Cf for which the current number N'f is different from the number Nf of electronic detonators **10** comprising the reference of delay category Cf stored in memory.

The identifying step S**62** thus makes it possible to indicate to the operator the delay category or categories Cf for which there are one or more additional electronic detonators for example, or one or more electronic detonators **10** that are defective, or not connected to the firing device **30**.

According to the importance of those defective electronic detonators **10** in the course of the firing, the operator may decide to interrupt or trigger the firing.

The identifying step S**62** thus enables an improved management of the remote firing, avoiding intervention at the mining face by virtue of the identification of the defective electronic detonators **10** in the firing layout.

Naturally, the present invention is not limited to the embodiments described and illustrated.

In particular, the method for installing and firing may be implemented using electronic detonators that are not categorized according to a delay to program later.

The invention claimed is:

1. A method for installing a set of electronic detonators in blast holes of a mining face, the method comprising:

- connecting said electronic detonators charged into the blast holes to a movable test device;
- receiving, by said movable test device, a message sent by each detonator of said set of electronic detonators;
- determining, by said movable test device from said message sent by each detonator, a set of values representing the total number of electronic detonators connected to the movable test device;
- sending, by said movable test device to one or more detonators of said set of electronic detonators, a data set to store in memory comprising said set of values representing the total number of electronic detonators connected to the movable test device; and
- storing said data set in memory saving means of one or more detonators of said set of electronic detonators.

2. The installation method according to claim **1**, wherein at the sending step, said data set to store in memory is sent to all the detonators of said set of electronic detonators, said data set being stored in saving means of each detonator of said set of electronic detonators.

3. The installation method according to claim **1**, wherein said data set to store in memory further comprises a reference of said mining face.

4. The installation method according to claim **1**, wherein said set of values comprises the total number of electronic detonators connected to the movable test device.

5. The installation method according to claim **1**, each detonator comprising memory means for storing at least one reference of delay category chosen from among a predefined set of delay categories, wherein said installation method further comprises, for each delay category, a step of issuing a test command by said movable test device to a sub-set of electronic detonators comprising a same reference of delay category stored in memory and wherein, at the determining step, said set of values comprises, for each delay category, the number of electronic detonators comprising said same reference of delay category stored in memory.

6. The installation method according to claim **1**, each detonator comprising memory means for storing at least one reference of delay category chosen from among a predefined set of delay categories, wherein at the step of receiving, by said movable test device, a message sent by each detonator of said set of electronic detonators, said message comprises at least the reference of delay category stored in said memory storage means of said detonator, and wherein at the determining step, said set of values comprises, for each delay category, the number of electronic detonators comprising said same reference of delay category stored in memory.

7. The installation method according to claim **5**, wherein said data set to store in memory comprises the number of delay categories of said predefined set of delay categories.

8. The installation method according to claim **5**, wherein at said memory storage step, the number of electronic detonators comprising said stored reference of delay category is stored respectively in the saving means of at least one electronic detonator comprising said stored reference of delay category.

9. The installation method according to claim **5**, further comprising:

- selecting, in the movable test device, a template of associations of each delay category with a predefined delay according to a predetermined firing layout; and
- programming a firing delay in each detonator of said set of electronic detonators based on said template of associations and the reference of delay category stored in the memory storage means of said detonator.

10. The method for firing a set of electronic detonators installed at the mining face according to the installation method in accordance with claim **1**, implemented in a firing device, the method comprising:

- connecting said set of electronic detonators to the firing device;
- receiving a message sent by each detonator of said set of electronic detonators;
- receiving said data set stored in said saving means of one or more detonators of said set of electronic detonators;
- extracting, from said stored data set, said set of values representing the total number of electronic detonators connected to the movable test device at the time of installing said set of electronic detonators at the mining face;
- determining the current number of electronic detonators of said set of electronic detonators connected to the

firing device based on the message sent by each detonator of said set of electronic detonators;

comparing said current number with said set of values representing the total number of electronic detonators connected to the movable test device; and

issuing a validation message for a test if said current number is consistent with said set of values representing the total number and a non-validation message if said current number is not consistent with said set of values representing the total number.

11. The method for firing a set of electronic detonators installed at the mining face according to the installation method in accordance with claim **5**, implemented in a firing device, the method comprising:

connecting said set of electronic detonators to the firing device;

receiving a message sent by each detonator of said set of electronic detonators, said message comprising at least the reference of delay category stored in said memory storage means of said detonator;

receiving said data set stored in said saving means of one or more detonators of said set of electronic detonators;

extracting, from said stored data set, said set of values comprising, for each delay category, the number of electronic detonators comprising said stored reference of delay category;

determining, for each delay category, the current number of electronic detonators comprising said stored reference of delay category from said message sent by each detonator of said set of electronic detonators;

comparing, for each delay category, said current number with said number of electronic detonators comprising said stored reference of delay category; and

issuing a test validation message if said current number is equal to said number of electronic detonators comprising said stored reference of delay category for all the delay categories, and a message of non-validation if said current number is different from said number of electronic detonators comprising said stored reference of delay category for at least one delay category.

12. The method for firing a set of electronic detonators installed at the mining face according to the installation method in accordance with claim **5**, implemented in a firing device, the method comprising:

connecting said set of electronic detonators to the firing device;

sending, for each delay category, a test command by said firing device to a sub-set of electronic detonators comprising a same stored reference of delay category;

receiving, for each delay category, a message sent by each detonator of said sub-set of electronic detonators comprising said same stored delay category;

receiving said data set stored in said saving means of one or more detonators of said set of electronic detonators;

extracting, from said stored data set, said set of values comprising, for each delay category, the number of electronic detonators comprising said stored reference of delay category;

determining, for each delay category, the current number of electronic detonators comprising said stored reference of delay category, from said message sent by each detonator of said subset of electronic detonators comprising said same stored delay category;

comparing, for each delay category, said current number with said number of electronic detonators comprising said stored reference of delay category; and

issuing a test validation message if said current number is equal to said number of electronic detonators comprising said stored reference of delay category for all the delay categories, and a message of non-validation if said current number is different from said number of electronic detonators comprising said stored reference of delay category for at least one delay category.

13. Firing method according to claim **11**, wherein at the step of issuing a non-validation message, the delay category or categories of which the current number is different from said number of electronic detonators comprising said stored reference of delay category is or are identified.

14. The firing method according to claim **11**, further comprising:

selecting a template of associations of each delay category with a predefined delay according to a predetermined firing layout; and

programming a firing delay in each detonator of said set of electronic detonators based on said template of associations and the reference of delay category stored in the memory storage means of said detonator.

15. A movable test device for implementing the installation method according to claim **1**, comprising:

receiving means for receiving a message sent by each detonator of said set of electronic detonators charged in blast holes;

determining means for determining, from said message sent by each detonator, a set of values representing the total number of electronic detonators connected to said movable test device; and

sending means for sending, to one or more detonators of said set of electronic detonators, a data set to store comprising said set of values representing the total number of electronic detonators connected to said movable test device.

16. A firing system for firing a set of electronic detonators installed at the mining face according to the installation method in accordance with claim **1**, comprising a movable test device configured to be connected to a bus line, the electronic detonators being connected to said bus line, and a firing device configured to be remotely connected via a firing line to said bus line.

17. The firing system according to claim **16**, each detonator of said set of electronic detonators comprising memory means for storing a reference of delay category chosen from among a predefined set of delay categories, wherein each delay category is identified by a predefined combination of a numerical code and of a color code, said numerical code being stored in memory as a reference of delay category in said memory means of each electronic detonator.

18. The firing system in accordance with claim **17**, wherein said numerical code and said color code of each predefined combination are visible on at least one location chosen from among a connection cable of said electronic detonator or a connector of said electronic detonator to the bus line.

19. The installation method according to claim **2**, wherein said data set to store in memory further comprises a reference of said mining face.

20. The installation method according to claim **2**, wherein said set of values comprises the total number of electronic detonators connected to the movable test device.

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