

SINGLE-CAPACITOR ELECTRONIC DETONATOR AND SYSTEM FOR FIRING
SUCH SINGLE-CAPACITOR ELECTRONIC DETONATORS

The present invention relates to a single-capacitor electronic detonator and a system for firing such single-capacitor electronic detonators.

5 The present invention generally applies to the field of mines and quarries and public works sites using programmable electronic detonators fired remotely according to a predetermined firing plan.

10 The electronic detonators are used to initiate an explosive. An electronic detonator thus comprises an explosive-initiating means, formed for example by a fusehead, connected to electronic control means. The electronic detonator also comprises means for connection to an external energy source to supply the electronic detonator with energy.

15 The main function of the electronic control means is to delay firing. In this way, a countdown is implemented when the electronic detonator receives a firing command, the firing of the explosive-initiating means being triggered at the end of the countdown. The electronic control means must be able to operate autonomously, without supplying energy to
20 the electronic detonator, once the firing command has been received.

To this end, an electronic detonator has one or two energy storage capacitors.

25 In the embodiments in which the electronic detonator comprises two energy storage capacitors, a first energy storage capacitor is designed to store the energy required to supply the electronic control means, in particular for implementing the delay countdown, and a second capacitor is designed to store the energy required to fire the explosive-
30 initiating means.

In the embodiments in which the electronic detonator comprises a single energy storage capacitor, the latter is designed, firstly, to supply the electronic control means

with energy and, secondly, to supply the explosive-initiating means when the electronic detonator is fired.

The lower cost of an electronic detonator with a single capacitor (hereinafter a single-capacitor electronic
5 detonator) is a clear advantage.

However, electronic detonators with two energy storage capacitors are safer for operators than single-capacitor electronic detonators.

Indeed, in principle, an electronic detonator with two
10 capacitors allows the first energy storage capacitor dedicated to supplying the electronic control means to be charged when the electronic detonator is connected to an external energy source, for example through conductive wires.

The second energy storage capacitor dedicated to firing
15 the explosive-initiating means is only charged with energy when a charging command is received, before a firing command is sent and received.

The electronic detonator with two capacitors therefore operates safely, preventing accidental firing of the
20 explosive-initiating means before the initiation of a blast.

In a single-capacitor electronic detonator, the single energy storage capacitor is charged once the electronic detonator is connected to an external energy source by connection means.

25 The energy or some of the energy required to supply the explosive-initiating means when the single-capacitor electronic detonator is fired is therefore stored in the single-capacitor electronic detonator once it is connected to an external energy source.

30 If a blasting switch located between the explosive-initiating means and the energy storage capacitor is accidentally closed, accidental firing may occur.

In order to ensure a reliable level of safety for operators when handling single-capacitor electronic
35 detonators, these are operated by equipment (programming console, firing console) which are designed to limit the

electrical voltage that can be supplied on the connection lines of the single-capacitor electronic detonators.

In this way, the external energy source always has an electrical voltage lower than a non-firing voltage value of the explosive-initiating means integrated into each single-capacitor electronic detonator.

The non-firing voltage corresponds to a voltage value below which it is impossible to fire the explosive-initiating means.

By selecting a non-firing voltage value of the explosive-initiating means, it is ensured that the electrical voltage of the external energy source is always sufficiently lower than the firing voltage, known as the all-fire voltage.

The all-fire voltage corresponds to the voltage above which the explosive-initiating means is systematically fired.

Such a single-capacitor electronic detonator has a very high level of safety when it is operated with the dedicated equipment.

However, this level of safety can deteriorate and be lower than that provided by an electronic detonator with two capacitors if the single-capacitor electronic detonator is connected to an electrical voltage source and equipment other than that supplied and recommended by the firing system.

The object of the present invention is to overcome at least one of the aforementioned drawbacks and propose a single-capacitor electronic detonator with an improved level of safety.

According to a first aspect, the present invention relates to a single-capacitor electronic detonator, comprising an explosive-initiating means, electronic control means, a single energy storage capacitor designed to supply said electronic control means and said explosive-initiating means with energy when said single-capacitor electronic detonator is fired, and means for connection to an energy

source for supplying said single energy storage capacitor with energy.

According to the invention, the single-capacitor electronic detonator also has means for clipping the voltage applied to the terminals of said single energy storage capacitor, said clipping means having a threshold clipping value lower than a non-firing voltage value of said explosive-initiating means, said clipping means being controlled by said electronic control means between an activated position, in which said clipping means limit said voltage to a value lower than said threshold clipping value, and a deactivated position, in which said clipping means are inactive.

In this way, the voltage at the terminals of the single energy storage capacitor can be limited by default at the electronic detonator itself: whatever the voltage applied to the connection means of the electronic detonator, the voltage at the terminals of the energy storage capacitor remains lower than the non-firing voltage value of the explosive-initiating means of the electronic detonator.

Non-accidental firing of the electronic detonator is provided by the design of the single-capacitor electronic detonator itself, and is not dependent on the equipment to which it is connected during use.

According to a second aspect, the present invention also relates to a single-capacitor electronic detonator, comprising an explosive-initiating means, electronic control means, a single energy storage capacitor designed to supply said electronic control means and said explosive-initiating means with energy when said single-capacitor electronic detonator is fired, and means for connection to an energy source for supplying said single energy storage capacitor with energy.

According to the invention, the single-capacitor electronic detonator also comprises voltage regulation means connected to said means for connection to an energy source,

said voltage regulation means being controlled by said electronic control means between at least one high-voltage position, in which the output voltage of the voltage regulation means is greater than a non-firing voltage value of said explosive-initiating means, and a low-voltage position, in which the output voltage of the voltage regulation means is lower than said non-firing voltage value of said explosive-initiating means.

In this way, the voltage at the terminals of the single energy storage capacitor can be limited by default at the electronic detonator itself: whatever the voltage applied to the connection means of the electronic detonator, the voltage at the terminals of the energy storage capacitor remains lower than the non-firing voltage value of the explosive-initiating means of the electronic detonator.

Non-accidental firing of the electronic detonator is provided by the design of the single-capacitor electronic detonator itself, and is not dependent on the equipment to which it is connected during use.

According to one embodiment of the invention, the single-capacitor electronic detonator comprises voltage regulation means as described above connected between the means for connection to an energy source and clipping means as described above.

The combination of the voltage regulation means and clipping means further enhances the safety of the single-capacitor electronic detonator, by virtue of its very design.

According to an alternative embodiment of the invention, the clipping means are connected between the means for connection to an energy source and said voltage regulation means.

In one practical embodiment, said electronic control means are designed to control both said clipping means in said activated position and said voltage regulation means in said low-voltage position.

The two protection means, clipping means and voltage regulation means are thus active at the same time.

Advantageously, when the electronic control means are powered up, said electronic control means are designed to
5 control said clipping means in said activated position and/or said voltage regulation means in said low-voltage position.

Whatever the voltage applied to the bus line or supply line to which the single-capacitor electronic detonator is connected, the voltage at the terminals of the energy storage
10 capacitor is lower than the non-firing voltage value of said explosive-initiating means.

In practice, and in order to further improve the operational safety of the single-capacitor electronic detonator, when said electronic control means detect an
15 interruption in the power supply to said single-capacitor electronic detonator for a predefined period, said electronic control means are designed to control said clipping means in said activated position and/or said voltage regulation means in said low-voltage position.

According to one embodiment, when said electronic control means receive a dedicated command before said single-capacitor electronic detonator is fired, said electronic control means are designed to control said clipping means in
20 said deactivated position and/or said voltage regulation means in said high-voltage position.
25

Upon receiving a dedicated command before firing, the energy storage capacitor can be charged by an energy source to an adequate voltage to then enable the explosive-initiating means to be fired.

30 In practice, the dedicated command can be a command for charging the energy storage capacitor.

Alternatively, the dedicated command can be a command for deactivating the protection means, i.e. the clipping means and the voltage regulation means, a command for
35 charging the energy storage capacitor being received later by the single-capacitor electronic detonator.

The electronic control means can deactivate the two protection means, i.e. the clipping means and the voltage regulation means, when the single-capacitor electronic detonator receives a single dedicated command before firing
5 or a firing command.

Alternatively, the electronic control means can deactivate only one of the two protection means, i.e. the clipping means or the voltage regulation means, when the single-capacitor electronic detonator receives a dedicated
10 command before firing.

The dedicated command can be a command for charging the energy storage capacitor or a specific command for deactivating one of the two protection means.

In practice, the electronic control means can
15 deactivate a first protection means, for example the clipping means, upon receipt of a first deactivation command, then a second protection means, for example the voltage regulation means, upon receipt of a second deactivation command. Of course, the order in which the two protection means are
20 deactivated can be reversed.

Deactivation of the two protection means then requires that the single-capacitor electronic detonator receives two dedicated commands in succession before firing.

According to a third aspect, the invention also relates
25 to a system for firing one or more single-capacitor electronic detonators according to the invention.

The firing system comprises a firing console designed to transmit, to said electronic control means of one or more single-capacitor electronic detonators, a command to switch
30 said clipping means from said activated position to said deactivated position and/or a command to switch said voltage regulation means from said low-voltage position to said high-voltage position.

Said firing console is advantageously designed to
35 transmit separately said command to switch said clipping means from said activated position to said deactivated

position and said command to switch said voltage regulation means from said low-voltage position to said high-voltage position.

5 This separate control of the clipping means and voltage regulation means enhances the level of safety in the event of failure of one or other of the two switching commands.

Said electronic control means are advantageously designed, upon receiving a first command to switch said clipping means from said activated position to said deactivated position, or said voltage regulation means from said low-voltage position to said high-voltage position, to cancel said first switching command if, within a predetermined time period, a second command to switch said voltage regulation means from said low-voltage position to said high-voltage position, or said clipping means from said activated position to said deactivated position, is not received.

20 Other features and advantages of the invention will become apparent in the description below.

In the appended drawings, provided by way of non-limiting example:

- Figure 1 shows a block diagram of a single-capacitor electronic detonator according to one embodiment of the invention; and

- Figure 2 shows a block diagram of a firing system according to one embodiment of the invention.

30 With reference to Figure 1, a single-capacitor electronic detonator according to one embodiment of the invention will first of all be described.

Conventionally, an electronic detonator is used in mines, quarries and public works to initiate the explosive.

Typically, such an electronic detonator can be used in a firing plan with numerous other electronic detonators. As a general principle, an electronic detonator comprises an

explosive-initiating means, hereinafter referred to in a non-limiting manner as fusehead, connected to an electronic control circuit. The electronic control circuit of each electronic detonator includes a firing delay function, triggering the firing of each electronic detonator after a pre-programmed delay countdown. This function of electronic detonators is known and does not need to be described in detail in the present description.

As shown schematically in Figure 1, a single-capacitor electronic detonator 10 comprises a fusehead 11 connected to an electronic control circuit supplied with electric current.

The single-capacitor electronic detonator 10 comprises means 13 for connection to an energy source 12 to supply the electronic control circuit with energy. The connection means 13 comprise, for example, conductive wires and a connection box (not shown) enabling the single-capacitor electronic detonator 10 to be connected to the energy source 12, via a power supply line, for instance.

The energy source 12 can be formed by an electric battery, for example.

At the input of the electronic control circuit, the single-capacitor electronic detonator 10 comprises means for filtering and rectifying the current 14. These means for filtering and rectifying the current 14 are common and enable the electronic control circuit of the single-capacitor electronic detonator 10 to be supplied with direct current.

In this way, the electronic control circuit can be supplied with direct current via the conductive wires of the means 13 for connection to an energy source 12, consisting of an external alternating current supply.

However, the electronic control circuit has to be able to operate autonomously, without any electrical energy being supplied by the means 13 for connection to the energy source 12, in particular when a firing command is received by the single-capacitor electronic detonator 10.

To this end, energy storage means are provided in the single-capacitor electronic detonator 10.

As shown in Figure 1, a single energy storage capacitor 15 is provided in the single-capacitor electronic detonator 10. This energy storage capacitor 15 is designed to supply the electronic control circuit, and in particular electronic control means 16, and the fusehead 11 with energy when the single-capacitor electronic detonator 10 is fired.

In this way, the energy storage capacitor 15 provides an autonomous power supply, firstly to the electronic control means 16 during the delay countdown associated with the single-capacitor electronic detonator 10, and secondly to the fusehead 11 for firing.

As soon as the single-capacitor electronic detonator 10 is electrically connected to the energy source 12, the energy storage capacitor 15 is charged.

In this way, the energy, or at least some of the energy depending on the amplitude of the voltage applied to the conductive wires of the connection means 13, required to fire the fusehead 11 is charged and stored in the energy storage capacitor 15 of the single-capacitor electronic detonator 10.

The single-capacitor electronic detonator 10 also comprises a blasting switch 17 mounted between the energy storage capacitor 15 and the fusehead 11. Conventionally, when a firing command from a firing console is received by the single-capacitor electronic detonator 10, the electronic control means 16 control the closure of the blasting switch 17, thus initiating the firing of the fusehead 11 powered by the energy storage capacitor 15.

However, in order to ensure safe use, the single-capacitor electronic detonator 10 has protection means in order to prevent the energy storage capacitor 15 from being charged with enough electrical energy to fire the fusehead 11 until such time as a specific firing command has been

sent and received by the single-capacitor electronic detonator 10.

In the exemplary embodiment shown in Figure 1, the protection means comprise both means 18 for clipping the
5 voltage across the terminals of the energy storage capacitor 15 and voltage regulation means 19 connected to the means 13 for connection to the energy source 12.

The clipping means 18 have a threshold clipping value U_s lower than a non-firing voltage value U_a of the fusehead
10 11.

The clipping means 18 are controlled by the electronic control means 16 between an activated position, in which the clipping means 18 limit the voltage to a value lower than the threshold clipping value U_s , and a deactivated position,
15 in which the clipping means 18 are inactive.

In the embodiment shown in Figure 1, the clipping means 18 are connected in parallel with the energy storage capacitor 15. When the clipping means 18 are activated, the charging voltage of the energy storage capacitor 15 remains
20 lower than the threshold clipping value U_s , and therefore than the non-firing voltage U_a of the fusehead 11.

If the blasting switch 17 is accidentally closed, the charging voltage of the energy storage capacitor 15 is not enough to cause the fusehead 11 to be fired.

25 The clipping means 18 can consist, in a manner known to a person skilled in the art, of one or more diodes, and, for example, a Zener diode.

The voltage regulation means 19 are controlled by the electronic control means 16 between a high-voltage position, in which the output voltage of the voltage regulation means 19 is greater than the non-firing voltage value U_a of the fusehead 11, and a low-voltage position, in which the output voltage of the voltage regulation means 19 is lower than the non-firing voltage value U_a of the fusehead 11.
30

35 In the embodiment shown in Figure 1, the voltage regulation means 19 are connected in series with the energy

storage capacitor 15. When the voltage regulation means 19 are in a low-voltage position, the charging voltage of the energy storage capacitor 15 remains lower than the non-firing voltage value U_a of the fusehead 11.

5 If the blasting switch 17 is accidentally closed, the charging voltage of the energy storage capacitor 15 is not enough to cause the fusehead 11 to be fired.

 The voltage regulation means 19 can consist, in a manner known to a person skilled in the art, of a circuit of one or
10 more diodes and transistors.

 In the embodiment shown in Figure 1, the voltage regulation means 19 are connected between the means 13 for connection to the energy source 12 and the clipping means 18.

15 A resistor 18a is advantageously connected in series between the voltage regulation means 19 and the clipping means 18 in order to limit the current in the circuit of the clipping means 18 when the voltage regulation means 19 are in a high-voltage position.

20 The voltage regulation means 19 are designed, in a high-voltage position, either to supply the current at a voltage equal to the supply voltage of the single-capacitor electronic detonator 10, or at a regulated voltage, with a value greater than the all-fire voltage value of the fusehead
25 11 of the single-capacitor electronic detonator 10.

 The single-capacitor electronic detonator 10 thus has dual protection, with the aim of preventing any accidental charging of the energy storage capacitor 15 to a voltage that is enough to fire the fusehead.

30 The non-firing voltage U_a corresponds to the voltage below which it is impossible to fire the explosive-initiating means.

 Conversely, the all-fire voltage corresponds to a voltage value above which the explosive-initiating means is
35 systematically fired.

 Firing is probable between these two voltage values.

Determining the non-firing voltage and the all-fire voltage depends on the technology of the filaments used, the pyrotechnic compositions, the substrates and the interfaces between the various components that make up the fusehead.

5 The values of these voltages can be determined by statistical test methods during the development and prototype phase of the single-capacitor electronic detonators, such as the PROBIT statistical method or BRUCETON test method.

10 By way of non-limiting example, the non-firing voltage value U_a is comprised between 6 and 10 volts, and is for example equal to 8 volts.

The all-fire voltage value of the fusehead 11 is comprised between 15 and 17 volts, by way of non-limiting example.

15 In order to ensure this dual protection, the electronic control means 16 are designed to both control the clipping means 18 in the activated position and the voltage regulation means 19 in the low-voltage position.

20 As will be described in more detail below, the control of the clipping means 18 in the activated position and the control of the voltage regulation means 19 in the low-voltage position are preferably simultaneous. They can also be sent one after the other to the single-capacitor electronic detonator 10.

25 Of course, it is possible for the single-capacitor electronic detonator 10 to only have a single protection means, and for example just clipping means 18 or just voltage regulation means 19.

30 When the single-capacitor electronic detonator 10 is connected to the energy source 12, i.e. when the electronic control means 16 are powered up, the electronic control means 16 are designed to control the clipping means 18 in the activated position and/or the voltage regulation means 19 in the low-voltage position.

35 Preferably, when the single-capacitor electronic detonator 10 is powered up, the clipping means 18 are

controlled in the activated position and the voltage regulation means 19 are controlled in the low-voltage position.

Similarly, when the electronic control means 16 detect
5 an interruption in the power supply to the single-capacitor electronic detonator 10 for a predefined period, the electronic control means 16 are designed to control the clipping means 18 in the activated position and/or the voltage regulation means 19 in the low-voltage position.

10 Thus, in the event of a loss of voltage on the supply line of the single-capacitor electronic detonator 10 for a predefined period, for example a few milliseconds, the configuration of the single-capacitor electronic detonator 10 is reinitialised at the protection means, whatever the
15 state of progress of the programming of the single-capacitor electronic detonator 10 in the firing configuration.

Preferably, in the event of loss of power to the single-capacitor electronic detonator 10, the clipping means 18 are controlled in the activated position and the voltage
20 regulation means 19 are controlled in the low-voltage position.

During the firing configuration, the electronic control means 16 receive one or more dedicated commands before the single-capacitor electronic detonator 10 is fired.

25 Upon receipt of one or more dedicated commands, the electronic control means 16 are designed to control the clipping means 18 in the deactivated position and/or the voltage regulation means 19 in the high-voltage position.

The single-capacitor electronic detonator 10 can thus
30 be controlled in order to enable charging of the energy storage capacitor 15 to a voltage that is enough to enable the fusehead 11 to be fired.

With reference to Figure 2, an exemplary embodiment will be described in more detail in a system for firing one
35 or more single-capacitor electronic detonators 10 as described above.

The single-capacitor electronic detonators 10 are each designed to be installed in a blast hole at the face.

Typically, each single-capacitor electronic detonator 10 is placed with a predetermined quantity of explosive into a blast hole drilled into a wall.

All of the single-capacitor electronic detonators 10 installed in this way at the front are then intended to be fired in a single blast.

In this embodiment, the firing system comprises a mobile test device 20 designed to be connected to a bus line L1.

The single-capacitor electronic detonators 10 are also connected to the bus line L1 and thus connected to the mobile test device 20.

The mobile test device 20 can thus communicate with one or more single-capacitor electronic detonators 10, either simultaneously or individually, in order to read information or data stored by the single-capacitor electronic detonators 10, send information or commands to these single-capacitor electronic detonators 10 and test their connection and their operating state.

In some embodiments, the mobile test device 20 is also designed to programme the electronic detonators 10, and for example to programme a firing delay.

The mobile test device 20 conventionally comprises receiving 21 and sending means 22 enabling it to communicate with the electronic detonators 10, either simultaneously or individually.

The receiving 21 and sending means 22 can consist of a bidirectional transmitter/receiver known to a person skilled in the art in the field of wired network communication.

Although in the exemplary embodiment shown in Figure 2 the single-capacitor electronic detonators 10 and the mobile test device 20 are connected by a wired connection by means of the bus line L1, the invention is not limited to this type of connection.

In particular, the mobile test device 20 and the single-capacitor electronic detonators 10 could communicate via a wireless connection, in particular via radio link. The receiving 21 and sending means 22 can therefore consist of
5 a bidirectional transmitting/receiving antenna known to a person skilled in the art in the field of wireless network communication.

The mobile test device 20 also comprises a microprocessor 23 for carrying out various data processing,
10 calculations and settings useful for installing single-capacitor electronic detonators 10 at the face.

The mobile test device 20 also comprises an EEPROM writable memory 24 ("Electrically Erasable Programmable Read Only Memory") and display means consisting of a screen 25 to
15 communicate with the user.

The firing system further comprises a firing console 30, forming a remote firing device, designed to communicate and transmit commands to electronic control means 16 of the single-capacitor electronic detonators.

20 The firing console 30 is designed to be remotely connected to the single-capacitor electronic detonators 10.

As shown in Figure 2, the firing console 30 is connected via a firing line L2, itself connected to the bus line L1.

The firing console 30 is designed to be placed far away
25 from the face in order to enable the operator controlling the firing from the firing console 30 to initiate firing in complete safety.

The firing console 30 comprises receiving 31 and sending means 32 enabling bidirectional communication between the
30 single-capacitor electronic detonators 10 and the firing console 30, either simultaneously or individually.

The receiving 31 and sending means 32 are similar to those described above in relation to the mobile test device 20.

The firing console 30 also comprises a microprocessor 33 for carrying out various data processing, calculations and settings required for firing.

5 An EEPROM programmable memory 34 is also provided in the firing console 30.

A display screen 35 can also be fitted to the firing console 30 in order to communicate with the operator.

Each single-capacitor electronic detonator 10 comprises bidirectional communication means 41 designed to enable
10 communication between the single-capacitor electronic detonator 10 and the mobile test device 20 and/or the firing console 30. The bidirectional communication means 41 of the single-capacitor electronic detonators 10 are similar to the receiving 21 and sending means 22 described above in relation
15 to the mobile test device 20 or to the receiving 31 and sending means 32 of the firing console 30.

The role and operation of the mobile test device 20 and the firing console 30 are known in their general principles for programming firing, the delay time associated with each
20 single-capacitor electronic detonator 10 and the actual firing, with only the particularities of communication between the firing console 30 and the single-capacitor electronic detonators 10 being described in detail below.

The firing console 30 is designed to send to each
25 single-capacitor electronic detonator 10 connected to the firing line L2 a command to switch the clipping means 18 from the activated position to the deactivated position and/or a command to switch the voltage regulation means 19 from the low-voltage position to the high-voltage position.

30 In this way, the protection means of each single-capacitor electronic detonator 10 can be remotely controlled by the firing console 30.

In preparation for firing, and therefore for charging the energy storage capacitor 15 of each single-capacitor
35 electronic detonator 10 with enough energy to fire the fusehead 11, the firing console 30 makes it possible to send

dedicated commands to the single-capacitor electronic detonators 10 to switch the clipping means 18 and the voltage regulation means 19 into a power supply mode at a voltage known as the full-fire voltage of the fusehead 11.

5 The firing console 30 is preferably designed to transmit separately the command to switch the clipping means 18 from the activated position to the deactivated position and the command to switch the voltage regulation means 19 from the low-voltage position to the high-voltage position.

10 Two separate dedicated commands are thus sent to each single-capacitor electronic detonator 10 to control the transition from a low-voltage level to a high-voltage level of the power supply to the single-capacitor electronic detonator 10. This dual control thus makes it possible to
15 enhance the safe use of the single-capacitor electronic detonators 10.

 In such a configuration, the electronic control means 16 of each single-capacitor electronic detonator 10 are designed, after having received a first command to switch
20 the clipping means 18 from the activated position to the deactivated position, to cancel this first switching command if, within a predetermined time period, a second command to switch the voltage regulation means 19 from the low-voltage position to the high-voltage position is not received.

25 Similarly, the electronic control means 16 of each single-capacitor electronic detonator 10 are designed, after having received a first command to switch the voltage regulation means 19 from the low-voltage position to the high-voltage position, to cancel this first switching
30 command if, within a predetermined time period, a second command to switch the clipping means 18 from the activated position to the deactivated position is not received.

 Thus, after the predetermined time period for receiving a second switching command, the single-capacitor electronic
35 detonator 10 is reconfigured in the safety position, the protection means being once again both designed to supply

the energy storage capacitor 15 at a voltage level less than the non-firing voltage value of the fusehead 11.

In practice, the firing console 30 may only have a single control key for sending the first switching command and the second switching command to the single-capacitor electronic detonators 10. This dual transmission of switching commands thus improves the safe use of the single-capacitor electronic detonators 10 without increasing the level of complexity involved for the operator of the firing console 30.

Of course, this mode of operation of the firing console 30 is not limiting. The firing console 30 can also be designed to transmit simultaneously, in the same dedicated command, the command to switch the clipping means 18 from the activated position to the deactivated position and the command to switch the voltage regulation means 19 from the low-voltage position to the high-voltage position.

These dedicated switching commands, sent by the firing console 30 to deactivate the protection means of each single-capacitor electronic detonator 10, are only sent by the firing console 30, at the very end of the firing programming procedure, and just before a command is sent to fire all of the single-capacitor electronic detonators 10.

This means that these dedicated switching commands to deactivate the protection means of each single-capacitor electronic detonator 10 cannot be sent by the mobile test device 20.

On the other hand, the mobile test device 20 or the firing console 30 can send a single dedicated command to activate the protection means of each single-capacitor electronic detonator 10, i.e. to control the clipping means 18 in the activated position and the voltage regulation means 19 in the low-voltage position.

Thus, the single-capacitor electronic detonators 10 have voltage protection devices, enabling the operator to be

protected when the single-capacitor electronic detonators 10 are connected to the bus line L1 and during the entire programming and test phase of the single-capacitor electronic detonators 10.

5 In particular, the mobile test device 20 can be used safety at the face, even if the voltage supplied by the mobile test device 20 is greater than the non-firing voltage value of the fusehead 11 of the single-capacitor electronic detonators 10. Indeed, it is sometimes useful for the mobile
10 test device 20 to supply a high voltage in order to address networks of numerous single-capacitor electronic detonators 10 connected simultaneously to the same bus line L1.

 Compared to an electronic detonator with two capacitors, such a single-capacitor electronic detonator 10
15 is thus more economical thanks to the use of a single energy storage capacitor 15, whilst guaranteeing a high level of user safety, which does not depend on the equipment to which it is connected.

 Of course, the invention is not limited to the exemplary
20 embodiments described above.

 In particular, the clipping means (18) can also be connected between the means (13) for connection to the energy source (12) and the voltage regulation means (19).

CLAIMS

1. Single-capacitor electronic detonator, comprising an explosive-initiating means (11), electronic control means (16), a single energy storage capacitor (15) designed
5 to supply said electronic control means (16) and said explosive-initiating means (11) with energy when said single-capacitor electronic detonator (10) is fired, and means (13) for connection to an energy source (12) for supplying said single energy storage capacitor (15) with
10 energy, characterised in that it also comprises means (18) for clipping the voltage across the terminals of said single energy storage capacitor (15), said clipping means (18) having a threshold clipping value (U_s) lower than a non-firing voltage value (U_a) of said explosive-initiating
15 means (11), said clipping means (18) being controlled by said electronic control means (16) between an activated position, in which said clipping means (18) limit said voltage to a value lower than said threshold clipping value (U_s), and a deactivated position, in which said clipping
20 means (18) are inactive.

2. Single-capacitor electronic detonator, comprising an explosive-initiating means (11), electronic control means (16), a single energy storage capacitor (15) designed to supply said electronic control means (16) and said
25 explosive-initiating means (11) with energy when said single-capacitor electronic detonator (10) is fired, and means (13) for connection to an energy source (12) for supplying said single energy storage capacitor (15) with energy, characterised in that it also comprises voltage
30 regulation means (19) connected to said means (13) for connection to an energy source (12), said voltage regulation means (19) being controlled by said electronic control means (16) between at least one high-voltage position, in which the output voltage of the voltage
35 regulation means (19) is greater than a non-firing voltage

value (U_a) of said explosive-initiating means (11), and a low-voltage position, in which the output voltage of the voltage regulation means (19) is lower than said non-firing voltage value (U_a) of said explosive-initiating means (11).

5 3. Single-capacitor electronic detonator in accordance with claims 1 and 2, characterised in that said voltage regulation means (19) are connected between the means (13) for connection to an energy source (12) and said clipping means (18).

10 4. Single-capacitor electronic detonator according to claim 3, characterised in that said electronic control means (16) are designed to control both said clipping means (18) in said activated position and said voltage regulation means (19) in said low-voltage position.

15 5. Single-capacitor electronic detonator according to one of claims 1 to 4, characterised in that when the electronic control means (16) are powered up, said electronic control means (16) are designed to control said clipping means (18) in said activated position and/or said
20 voltage regulation means (19) in said low-voltage position.

 6. Single-capacitor electronic detonator according to one of claims 1 to 5, characterised in that when said electronic control means (16) detect an interruption in the power supply to said single-capacitor electronic detonator
25 (10) for a predefined period, said electronic control means (16) are designed to control said clipping means (18) in said activated position and/or said voltage regulation means (19) in said low-voltage position.

 7. Single-capacitor electronic detonator according
30 to one of claims 1 to 6, characterised in that when said electronic control means (16) receive a dedicated command before said single-capacitor electronic detonator (10) is fired, said electronic control means (16) are designed to control said clipping means (18) in said deactivated
35 position and/or said voltage regulation means (19) in said high-voltage position.

8. System for firing one or more single-capacitor electronic detonators (10) according to one of claims 1 to 7, characterised in that it comprises a firing console (30) designed to transmit, to said electronic control means (16) of one or more single-capacitor electronic detonators (10), a command to switch said clipping means (18) from said activated position to said deactivated position and/or a command to switch said voltage regulation means (19) from said low-voltage position to said high-voltage position.

9. Firing system according to claim 8, characterised in that said firing console (30) is designed to transmit separately said command to switch said clipping means (18) from said activated position to said deactivated position and said command to switch said voltage regulation means (19) from said low-voltage position to said high-voltage position.

10. Firing system according to claim 9, characterised in that said electronic control means (16) are designed, upon receiving a first command to switch said clipping means (18) from said activated position to said deactivated position, or said voltage regulation means (19) from said low-voltage position to said high-voltage position, to cancel said first switching command if, within a predetermined time period, a second command to switch said voltage regulation means (19) from said low-voltage position to said high-voltage position, or said clipping means (18) from said activated position to said deactivated position, is not received.