



(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
31.12.2014 Bulletin 2015/01

(51) Int Cl.:
F42B 3/16 (2006.01) F42C 19/12 (2006.01)

(21) Application number: **12869339.7**

(86) International application number:
PCT/RU2012/000124

(22) Date of filing: **22.02.2012**

(87) International publication number:
WO 2013/125975 (29.08.2013 Gazette 2013/35)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

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(54) **DETONATOR CAPSULE**

(57) What is proposed is: a detonator capsule comprising a casing, which contains an ignition charge, a primary explosive and a secondary explosive, which are arranged in such a way that the ignition charge ignites the primary explosive, which in turn detonates the secondary explosive, an electronic delay timer for the ignition of the primary explosive and an explosion initiation means, which is connected to said delay means for the ignition of the primary explosive, wherein the explosion initiation means comprises a shock tube, one end of which is fixed in the inlet part of said casing, a cylindrical case which is mounted coaxially to the shock tube and the inlet into the cavity of the case is directed towards the shock tube, wherein a magnetic armature is mounted in the cavity of said cylindrical case in such a way as to be capable to move along the axis of said cylindrical case, and said cylindrical case is covered on the outside by an induction coil.

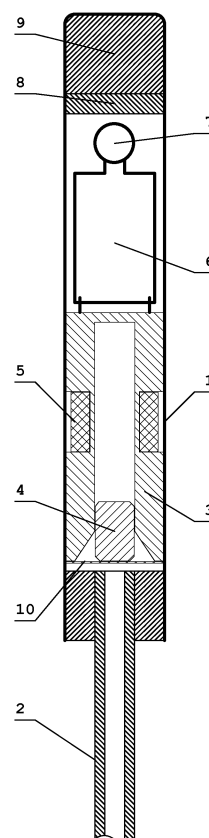


Fig. 1

Description

Technical field

[0001] This invention relates to means designed for conducting explosions.

Background of the Invention

[0002] Modern technologies of development of mountain massifs by explosions are based on the principle of short-delay explosion. This technology provides alternate explosions of charged wells drilled in a big, specially prepared mountain massif. Common means for providing sequence of explosions are detonator capsules with non-electric initiation - using shock tubes with internal delaying element. Such an element is pyrotechnic delaying tube which provides the delay of explosion. Delay capsules are assembled in chain - so called surface network. Every capsule is placed near its own wellhead. After igniting of the first detonator, the second detonator ignites after a certain delay time, then - the third, etc. Initiating pulse is transmitted into well by a well detonator which is connected with surface detonator. Triggered surface detonator transmits initiating pulse inside well detonator, which initiates well explosive charge. In order to prevent the destruction of surface network by the first exploding well, delay detonators are also used in wells, and the well delay exceeds the delay of surface detonators.

[0003] Delay accuracy when using pyrotechnical means is low. Usually this value is $\pm 10\%$. Very low accuracy of well delay can disrupt the sequence of well explosions. This leads to a necessity of an increase of the consumption of explosives, and to an occurrence of so-called outsized stone fractions, the elimination of which requires additional, heavy expenses.

[0004] Practically, the only possibility to get capsules with high igniting accuracy is to use capsules with electronic delay, which provides higher accuracy compared to the pyrotechnic delay. However, capsules with electronic delay, available on the market - EDE3, I-kon, Hot/QuickShot, Deltadet - have many design flaws. Firstly, all of them are electrical - in these devices initiating signal goes through wires, which requires highly qualified personnel. Furthermore, a special controller, which is programmed directly at the explosion area, is required. Therefore training of the personnel and changing traditional explosion circuits are needed. Secondly, they cost higher exceeding several times the cost of capsules with pyrotechnical delay. For these reasons, implementation of capsules with electronic delay is slow. Fast implementation of this capsule depends on its similarity to traditional ones both in terms of network installation and handling, and in terms of designing the explosions. So, currently there is a need for detonator capsule with electronic delay and non-electric initiating system.

[0005] A detonating device is known which comprises: a casing, containing a charge of compacted blasting sub-

stance, a charge of blasting substance of bulk density, a charge of initiating substance, ignition charge, which is made of a metal spiral connected to electronic module, which comprises a detecting module, connected to two-wire line, shunted by first and second diode from the central device, first storage capacitance is connected to the first output of detection unit and to the first input of microprocessor with crystal oscillator, which is connected also through a second input by the connection of the first and second diodes to the two-wire line, second storage capacitance is connected to the second output of the detection unit, connected to consequently connected ignition unit and first switch, the connection point of which is connected to third input of microprocessor through divider, a second switch is additionally attached to the second capacitance, control inputs of the two switches are connected to first and second outputs of the microprocessor, and the microprocessor has personal identification number programmed during the manufacturing (Patent of Russia No2147365 MPC F42B3/18). Required delay time is programmed directly before explosion and the accuracy of time intervals is about 1 ms, ranging from 0 to 20 s. This device requires personnel with high qualification because there is a necessity to control digitally programmable and blasting devices.

[0006] A detonator capsule with electronic delay is known, comprising a casing, containing ignition charge, electronic unit for delay of explosion, primary explosive and secondary explosive, initiating unit and sensor, that are placed in front of the electronic delay unit, herewith the sensor is made with ability to convert pulse from initiating unit and to transmit this pulse to electronic delay unit, which is programmed for a certain time delay, the sensor is made with the ability to switch on the electronic delay unit by photo-sensor and thermo-sensor (Patent RF No2349867 MPC F42B3/10). Time delay of this capsule is set in manufacturing which is an undoubted advantage of this device.

[0007] The detonator capsule's main disadvantage is that it is operable only by using galvanic power suppliers. These power suppliers have limited working temperature range and storage life. Moreover detonator capsule with permanently active power supply is very dangerous during transportation and preparatory works.

Description of the invention

[0008] The invention solves the problem of creating a detonator capsule which has high igniting accuracy, is non-active before putting into operation by initiating pulse, that's why it is safe during storage and transportation and has great, almost non-limited storage life.

[0009] The detonator capsule comprises a casing, which contains an ignition charge, a primary explosive and a secondary explosive, which are arranged in such a way that the ignition charge ignites the primary explosive, which detonates the secondary explosive, an electronic delay timer of primary explosive and an explosion

initiation means, which is connected to said delay means for the ignition of the primary explosive, wherein the explosion initiation means comprises a shock tube, one end of which is fixed in the inlet of said casing, a cylindrical case mounted coaxially to the shock tube and the inlet into the cavity of the case is directed towards the shock tube, and a magnetic armature is mounted in the cavity of said cylindrical case with the ability to move along the axis of said cylindrical case, and said cylindrical case is covered on the outside by an induction coil.

[0010] The cavity of cylindrical case may be closed by a membrane, to which a magnetic armature is attached (e.g. glued) in order to eliminate armature movements during transportation, vibration impacts, and hits.

[0011] The cavity of cylindrical case may be closed by a fixing washer made of magnetically soft material, the washer also eliminates armature movements during transportation, vibration impacts, and hits.

[0012] Auxiliary magnet or return spring can be mounted in the cylindrical case.

[0013] The bottom of the cylindrical case can be solid or may have draining channels.

[0014] Induction coil resistance is $R \approx T/\pi C$, where T - time needed by the magnetic armature to pass through the inner cavity of the case, which is covered by induction coil from the outside, C - capacitance of storage capacitors.

[0015] Induction coil inductance is $L \approx TR/\pi$, where T - time needed by the magnetic armature to pass through the inner cavity of the case, which is covered by induction coil from the outside, R - resistance of the induction coil.

[0016] The means of primary explosive ignition delay is electronic delay timer.

[0017] Electronic delay timer comprises storage capacitors, at least one of them provides power supply to its elements, and at least the other one provides power supply to ignition charge.

[0018] Storage capacitors are charged by same or different voltage signs depending on the rectifier circuit.

[0019] The proposed detonator capsule is shown in Fig.1 and Fig.2. Fig.1 shows detonator capsule with magnetic armature fixed to the fixing membrane, Fig.2 shows detonator capsule with magnetic armature fixed to the fixing washer made of magnetically soft material, where: 1 - capsule casing, 2 - shock tube, 3 - cylindrical case, 4 - magnetic armature, 5 - induction coil, 6 - means of delay of the ignition of primary explosive, 7 - ignition charge, 8 - primary explosive, 9 - secondary explosive, 10 - fixing membrane, 11 - fixing washer.

[0020] The detonator capsule works as follows. Input element of detonator capsule is shock tube 2. It can be for example a plastic tube with external diameter of about 3.5 mm and internal diameter of about 1 mm. A fine explosive substance is sprayed on the inner surface of the tube, for example - 10-20 mg per meter of tube length. When the tube is actuated at one end, the shock wave begins to spread along its axis with a speed of 2000 m/s. The tube can be actuated by detonator capsule, detonat-

ing cord or special trigger device. When shock wave reaches the end of the tube, it ejects jet of hot gases. The total energy (thermal and kinetic) of this jet is about 1-2 J. When the jet of gases from shock tube 2 burst in casing 1, it tears off the magnetic armature from the fixing element (membrane 10 or fixing washer 11) and puts it into motion. Initially the magnetic armature is fixed in such a way that its immobility is provided. For instance, it can be fixed on fixing membrane by glue, wherein the fixing membrane is also glued to the cylindrical case's edge. Also the magnetic armature can be connected magnetically to the fixing washer in order to remain its initial position.

[0021] Magnetic armature, when flying along the axis of the cavity of the cylindrical case 4, induces an EMF in induction coil 5, which covers said cylindrical case 3 from the outside.

[0022] Induced voltage goes from induction coil's pins to means of delay of the ignition of primary explosive 6. A sample voltage oscillogram on induction coil's pins is shown in Fig. 7.

[0023] Fig. 3 shows a detonator capsule with fixation of magnetic armature to fixing washer made of magnetically soft material and containing an auxiliary magnet in the cavity of the cylindrical case 3. The same poles of magnetic armature and auxiliary magnet are oriented towards each other. In case of tearing off of the magnetic armature from the fixing washer because of transport vibrations, the auxiliary magnet restores the armature in its initial position.

[0024] Fig. 4 shows detonator capsule with draining channel 13, which prevents air compression in front of the armature, which increases armature speed and, as a result - induction coil's EMF.

[0025] Fig. 5 shows detonator capsule with magnetic armature fixed on fixing washer made from magnetically soft material and containing a return spring 14 in the cavity of the case 3. The return spring plays the same role as auxiliary magnet - it returns magnetic armature to its initial position in case of tearing off of the magnetic armature from the washer caused by transportation vibrations of the capsule.

[0026] In some cases it is advisable to divide the detonator casing into two parts. One part contains the cylindrical case with induction coil and magnetic armature, while the other part contains the electronic timer with ignition charge. The two parts are connected by flexible electrical cable 15 as shown in Fig. 6.

[0027] Fig. 8 shows circuit diagram of electronic delay timer which can be used in proposed detonator as means of delay of the ignition of primary explosive, where: 7 - ignition charge, 16 - wires going to induction coil, 17 - electronic switch, 18 - microprocessor, C1 - first storage capacitor, C2 - second storage capacitor, D1 - first rectifying diode, D2 - second rectifying diode. In such rectifying circuit the capacitor C1 is charged with positive voltage, while the capacitor C2 is charged with negative voltage.

[0028] Fig. 9 shows circuit diagram of electronic delay timer, which can be used in proposed detonator as means of delay of the ignition of primary explosive, where: 7 - ignition charge, 16 - wires going to induction coil, 17 - electronic switch, 18 - microprocessor, C1 - first storage capacitor, C2 - second storage capacitor, D1, D2, D3, D4 - rectifying diodes. The pairs of diodes D1, D2 and D3, D4 form two rectifying bridges. In such rectifying circuit both capacitors C1 and C2 are charged with positive voltage.

[0029] Fig. 10 shows circuit diagram of electronic delay timer, which can also be used in proposed detonator as means of delay of the ignition of primary explosive, where: 7 - ignition charge, 16 - wires going to induction coil, 17 - electronic switch, 18 - microprocessor, C1 - first storage capacitor, C2 - second storage capacitor, D1, D2, D3, D4 - rectifying diodes. In such rectifying circuit both capacitors C1 and C2 are charged with positive voltage. This circuit is supplemented by a booster diode D5. Use of the booster diode D5 increases the energy of the ignition charge.

[0030] When means of ignition delay is made in the form of an electronic delay timer, which is shown in Fig. 8, the voltage goes from induction coil's pins to storage capacitors C1 and C2 through rectifying diodes D1 and D2. Capacitor C1 through diode D1 is charged by a positive half-wave voltage from induction coil's pins. Capacitor C2 through diode D2 is charged by a negative half-wave voltage from induction coil's pins. The inductance of the coil is calculated in accordance with the relation $L/R \approx RC \approx T/\pi$, where L - coil inductance, R - coil resistance, C - capacitance of storage capacitors, T - time needed by the magnetic armature to fly through the induction coil. Inductance is given by the number of coil turns, resistance is given by the choice of wire diameter and capacitance of capacitors C1 and C2 is given by energy requirements of ignition charge.

[0031] As soon as the voltage appears at the capacitor C1, the microprocessor 18 switches on and starts countdown of the delay time, which was set up in manufacturing. After the countdown ends, the microprocessor opens the electronic switch 17 and ignites the ignition charge 7. Electrical energy of the capacitors is spent on the work of timer during the countdown of the delay and on the igniting of the ignition charge. The delay time may be from 10 up to 10000 milliseconds. Ignition charge 7 ignites primary explosive 8, the burning of which goes to a detonation in less than 50 microseconds. Primary explosive detonation wave actuates secondary explosive 9. Its explosion occurs and the process ends.

[0032] When means of ignition delay is made in the form of electronic delay timer shown in Fig. 9, the detonator capsule operates in the same manner. The difference is that the storage capacitors are charged by only positive voltage because of usage of rectifying half-bridges D1, D2, D3, and D4. This simplifies the circuit of electronic switch.

[0033] Fig 10 shows another embodiment of means of

ignition delay. It differs from the previous one by presence of a booster diode D5. When electronic switch is triggered, the diode D5 passes the remaining charge of the capacitor C1 into circuit of ignition charge increasing its energy and reliability of operation.

[0034] Described detonator capsule's design allows for high triggering accuracy, and this is valid for both explosions with short delay time and explosions with long delay time. Its delay time accuracy does not exceed 10 milliseconds and it is completely ready for use immediately after manufacturing. In addition detonator capsule is non-active during storage, transportation and preparatory explosion works. It comes in a working state only when initiating pulse is applied to it, that's why detonator capsule is safe during transportation and storage, and has almost non-limited storage life.

Brief description of the drawings

[0035]

Fig 1 shows detonator capsule with magnetic armature fixed on a fixing membrane.

Fig 2 shows detonator capsule with magnetic armature fixed on a fixing washer made from magnetically soft material.

Fig 3 shows detonator capsule with magnetic armature fixed on a fixing washer made from magnetically soft material with auxiliary magnet in the case cavity.

Fig 4 shows detonator capsule with magnetic armature fixed on a fixing washer made from magnetically soft material with draining channels.

Fig 5 shows detonator capsule with magnetic armature fixed on a fixing washer made from magnetically soft material with return spring in the case cavity.

Fig 6 shows detonator capsule with a case divided into two parts

Fig 7 shows an approximate voltage oscillogram on induction coil's pins

Fig 8 shows circuit diagram of electronic delay timer

Fig 9 shows circuit diagram of electronic delay timer

Fig 10 shows circuit diagram of electronic delay timer

[0036] The reference numbers in the figures denote the following details:

- 1 - Capsule casing
- 2 - Shock tube
- 3 - Cylindrical case
- 4 - Magnetic armature
- 5 - Induction coil
- 6 - Means of delay of the ignition of primary explosive
- 7 - Ignition charge
- 8 - Primary explosive
- 9 - Secondary explosive
- 10 - Fixing membrane
- 11 - Fixing washer

- 12 - Auxiliary magnet
- 13 - Draining channel
- 14 - Return spring
- 15 - Flexible electrical cable
- 16 - Wires going to induction coil
- 17 - Electronic switch
- 18 - Microprocessor
- C1 - first storage capacitor
- C2 - second storage capacitor
- D1 - first rectifying diode
- D2 - second rectifying diode
- D3 - third rectifying diode
- D4 - fourth rectifying diode
- D5 - booster diode

Industrial applicability

[0037] Proposed detonator capsule can be used in mining industry, construction industry, warfare and other spheres of human activity, where it is necessary to conduct blasting operations.

Claims

1. A detonator capsule comprising a casing, which contains an ignition charge, a primary explosive and a secondary explosive, which are arranged in such a way that the ignition charge ignites the primary explosive, which in turn detonates the secondary explosive, an electronic delay timer for the ignition of the primary explosive and an explosion initiation means, which is connected to said delay means for the ignition of the primary explosive, **characterized in that** the explosion initiation means comprises a shock tube, one end of which is fixed in the inlet part of said casing, a cylindrical case, which is mounted coaxially to the shock tube and the inlet into the cavity of the case is directed towards the shock tube, wherein a magnetic armature is mounted in the cavity of said cylindrical case in such a way as to be capable to move along the axis of said cylindrical case, and said cylindrical case is covered on the outside by an induction coil.
2. A detonator capsule according to claim 1, **characterized in that** the cavity of the cylindrical case is covered by a membrane, to which a magnetic armature is attached.
3. A detonator capsule according to claim 1, **characterized in that** the cavity of the cylindrical case is covered by a fixing washer, made of magnetically soft material.
4. A detonator capsule according to claim 3, **characterized in that** there is an auxiliary magnet in the cavity of the cylindrical case.

5. A detonator capsule according to claim 1, **characterized in that** the bottom of the cavity of the cylindrical case has draining channels.
- 5 6. A detonator capsule according to claim 1, **characterized in that** there is a return spring in the cavity of the cylindrical case.
- 10 7. A detonator capsule according to claim 1, **characterized in that** the casing is divided into two parts, connected by a flexible electrical cable, the cylindrical case with magnetic armature and induction coil are placed in the first part, and the electronic timer with ignition charge are placed in the second part.
- 15 8. A detonator capsule according to claim 1, **characterized in that** induction coil resistance is $R \approx T/\pi C$, where T is time needed by the magnetic armature to pass through the inner cavity of the case, which is covered by induction coil from the outside, C is capacitance of storage capacitors.
- 20 9. A detonator capsule according to claim 1, **characterized in that** induction coil inductance is $L \approx TR/\pi$, where T is time needed by the magnetic armature to pass through the inner cavity of the case, which is covered by induction coil from the outside, R is resistance of the induction coil.
- 25 10. A detonator capsule according to claim 1, **characterized in that** the means of primary explosive ignition delay is electronic delay timer.
- 30 11. A detonator capsule according to claim 10, **characterized in that** the electronic delay timer comprises storage capacitors, at least one of them provides power supply to its elements, and at least the other one provides power supply to ignition charge.
- 35 12. A detonator capsule according to claim 11, **characterized in that** storage capacitors are charged by voltage of different signs, one of them - by positive sign voltage, the other - by negative sign voltage.
- 40 13. A detonator capsule according to claim 12, **characterized in that** two diode rectifying half-bridges are used for charging storage capacitors.
- 45 14. A detonator capsule according to claim 11, **characterized in that** the electronic delay timer contains booster diode, which connects storage capacitors.
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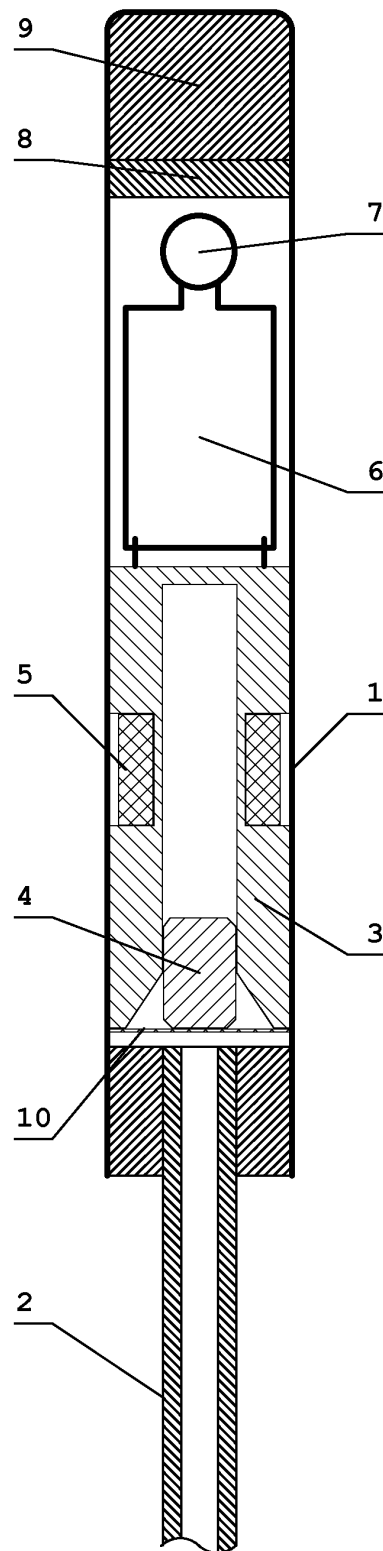


Fig. 1

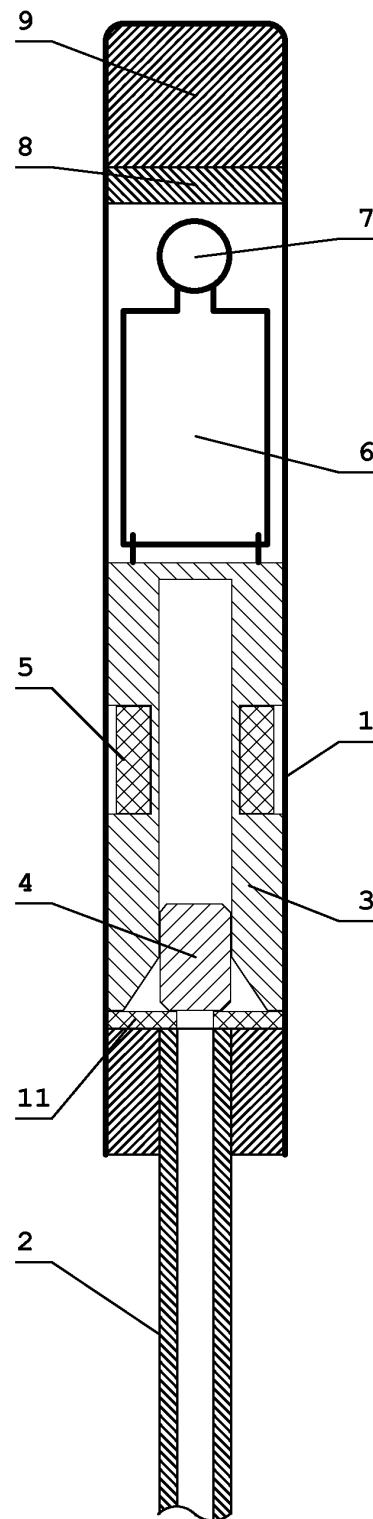


Fig. 2

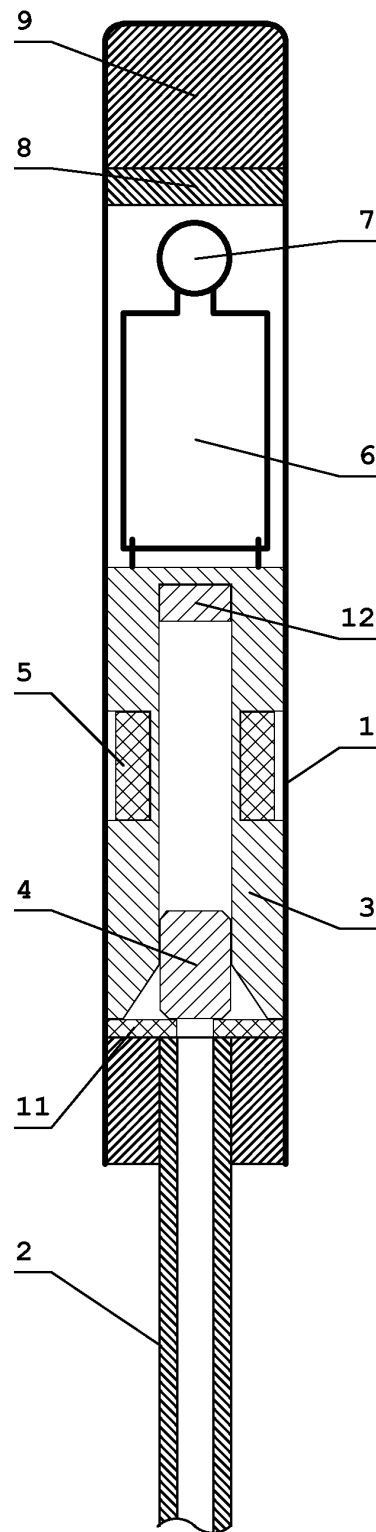


Fig. 3

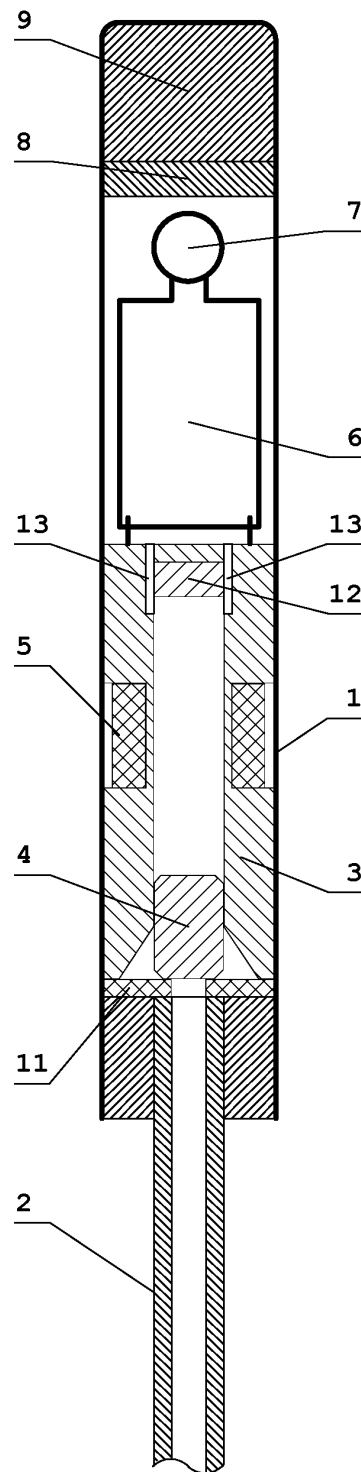


Fig. 4

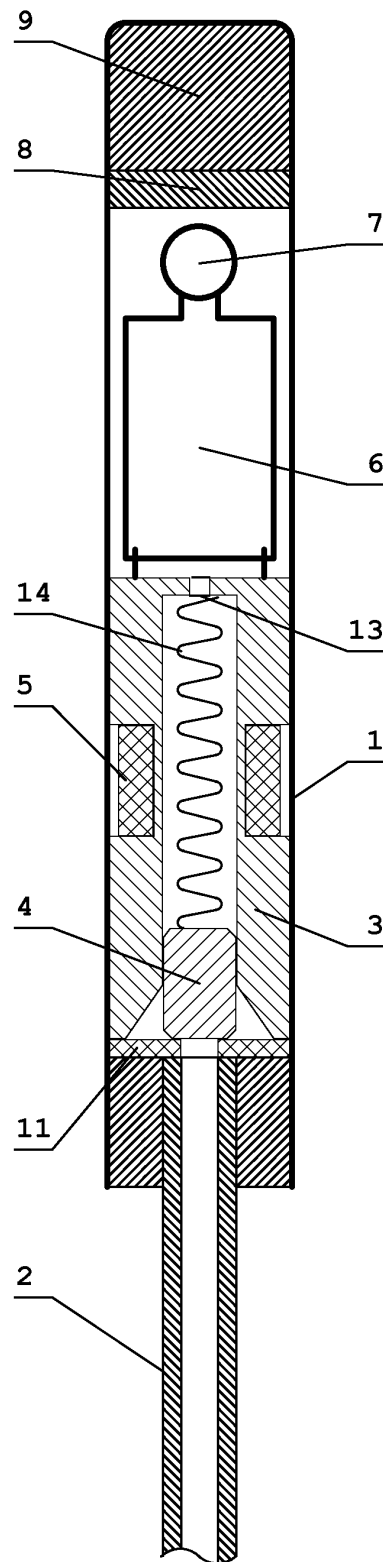


Fig. 5

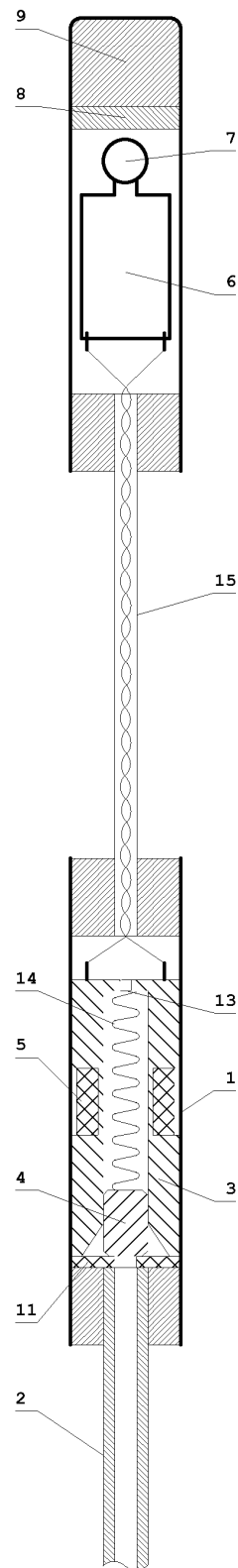


Fig. 6

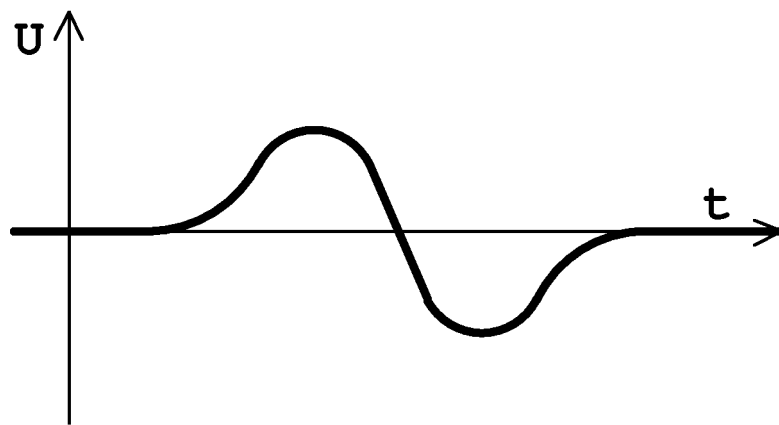


Fig. 7

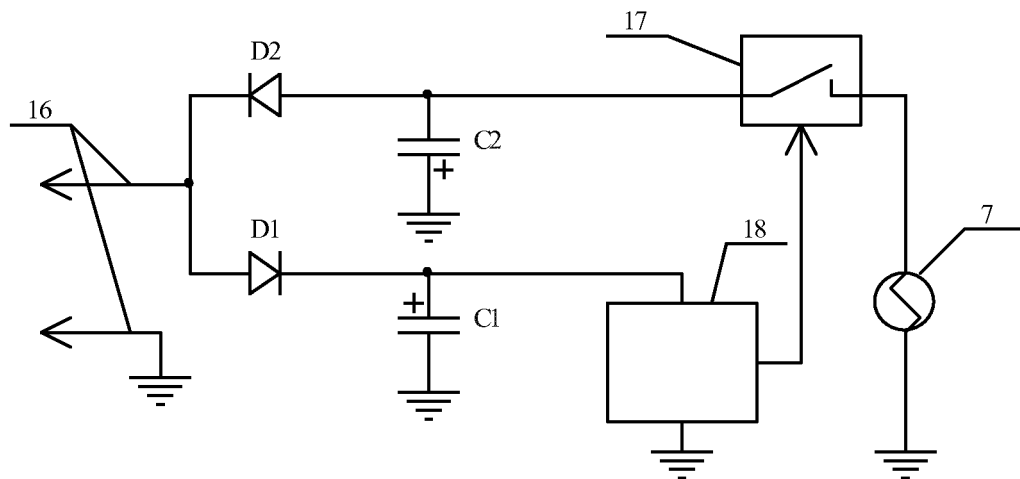


Fig. 8

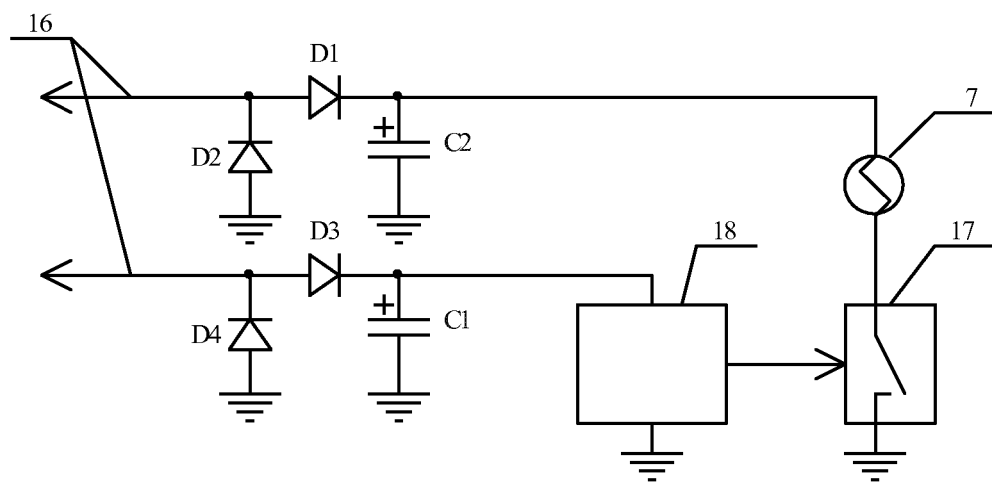


Fig. 9

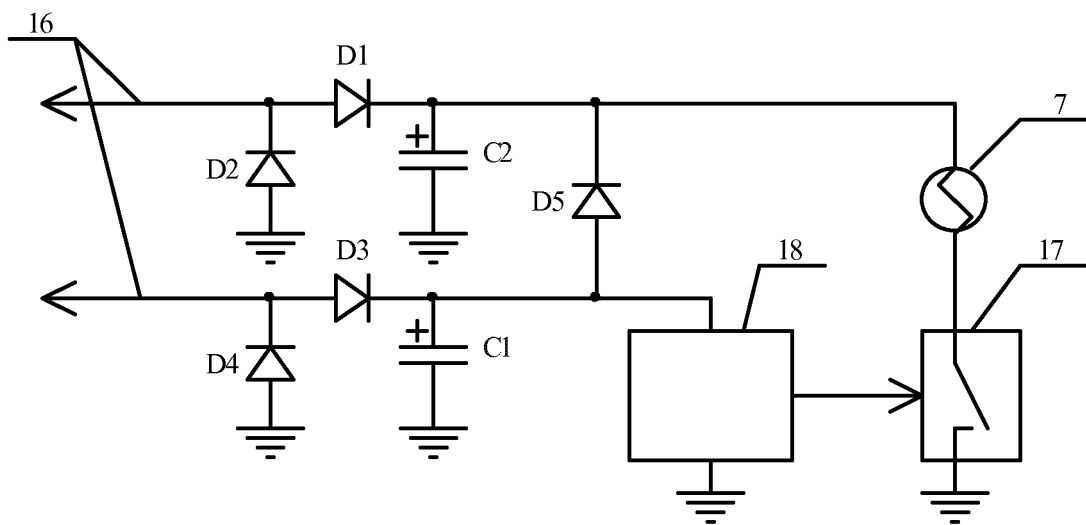


Fig. 10

INTERNATIONAL SEARCH REPORT

International application No.

PCT/RU 2012/000124

A. CLASSIFICATION OF SUBJECT MATTER <i>F42B 3/16 (2006.01)</i> <i>F42C 19/12 (2006.01)</i> According to International Patent Classification (IPC) or to both national classification and IPC																		
B. FIELDS SEARCHED																		
Minimum documentation searched (classification system followed by classification symbols) F42B 3/00-3/195, F42C 19/00-19/12																		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched																		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) PAJ, Esp@cenet, USPTO DB, CIPO, EAPO, RUPAT, DWPI, DEPATISnet																		
C. DOCUMENTS CONSIDERED TO BE RELEVANT																		
<table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>A</td> <td>RU 2349867 C2 (FEDERALNOE GOSUDARSTVENNOE UNITARNOE PREDPRIYATIE NOVOSIBIRSKII MEKHANICHESKII ZAVOD "ISKRA") 20.03.2009, the abstract, cited in the application</td> <td>1-14</td> </tr> <tr> <td>A</td> <td>RU 2129295 C1 (DZE ENSAIN-BIKFORD KOMPANI) 20.04.1999, the abstract</td> <td>1-14</td> </tr> <tr> <td>A</td> <td>EP 0601880 A2 (HALLIBURTON COMPANY) 15.06.1994, the abstract</td> <td>1-14</td> </tr> <tr> <td>A</td> <td>EP 1644694 B1 (SPECIAL DEVICES, INC.) 23.01.2008, the abstract</td> <td>1-14</td> </tr> <tr> <td>E</td> <td>RU 2451896 C1 (OTKRYTOE AKTSIONERNOE OBSHESTVO «NOVOSIBIRSKII INSTITUT PROGRAMMNYKH SISTEM" et al.) 27.05.2012, the claims</td> <td>1-4, 8-12</td> </tr> </tbody> </table>	Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	A	RU 2349867 C2 (FEDERALNOE GOSUDARSTVENNOE UNITARNOE PREDPRIYATIE NOVOSIBIRSKII MEKHANICHESKII ZAVOD "ISKRA") 20.03.2009, the abstract, cited in the application	1-14	A	RU 2129295 C1 (DZE ENSAIN-BIKFORD KOMPANI) 20.04.1999, the abstract	1-14	A	EP 0601880 A2 (HALLIBURTON COMPANY) 15.06.1994, the abstract	1-14	A	EP 1644694 B1 (SPECIAL DEVICES, INC.) 23.01.2008, the abstract	1-14	E	RU 2451896 C1 (OTKRYTOE AKTSIONERNOE OBSHESTVO «NOVOSIBIRSKII INSTITUT PROGRAMMNYKH SISTEM" et al.) 27.05.2012, the claims	1-4, 8-12
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