(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
29 December 2016 (29.12.2016)

(10) International Publication Number
WO 2016/205935 Al

(51) **International Patent Classification:**
***F42D 1/05*** (2006.0 1) ***F42D 1/02*** (2006.0 1)
***E21C 37/00*** (2006.01) ***F42D 1/04*** (2006.01)
***F42B 3/02*** (2006.01) ***F42D 3/00*** (2006.01)

(21) **International Application Number:**
PCT/CA20 16/050726

(22) **International Filing Date:**
2 1 June 2016 (21 .06.2016)

(25) **Filing Language:** English

(26) **Publication Language:** English

(30) **Priority Data:**
62/182,715 22 June 2015 (22.06.2015) US

(71) **Applicant: NORVENT MINE SYSTEMS INC.** [CA/CA]; 189 Allan Street, P.O. Box 400, Coniston, Ontario POM 1M0 (CA).

(72) **Inventor: RADKE, Edgar Helge Fred;** 189 Allan Street, P.O. Box 400, Coniston, Ontario POM 1M0 (CA).

(74) **Agent: MILTONS IP/P.L;** 15 Fitzgerald Rd., Suite 200, Ottawa, Ontario K2H 9G1 (CA).

(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available):* AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG,

*[Continued on next page]*

(54) **Title:** CONTROLLED DIRECTIONAL BLASTING

**(57) Abstract:** A method of loading a borehole for directional blasting comprises placing two or more cartridges containing a primary explosive into the borehole, the cartridges being spaced evenly apart and abutting 10% to 50% of the borehole perimeter on a desired direction of blasting; securing wiring to a detonator in each cartridge, the wiring connectable to a controller that can activate all of the detonators simultaneously; and filling a remainder of the borehole with an emulsion or ANFO having a lower velocity of detonation (VOD) than the primary explosive. A system of interlocking cartridges for use in the method and a method of loading a borehole for main field blasting are also disclosed.

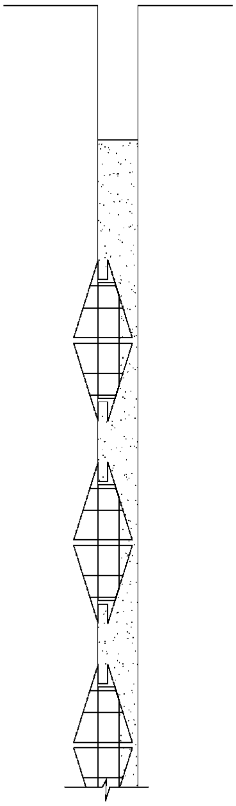

FIG. 2A

MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available):* ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

**Published:**

— *with international search report (Art. 21(3))*

# CONTROLLED DIRECTIONAL BLASTING

## Technical Field

**[001]** The present disclosure relates to a method and system for controlled directional blasting.

## Background

**[002]** Vertical mining has been employed for some time. Though it has proven to be cost effective, problematic areas still persist as in maintaining ground integrity. Major equipment loss and stope loss due to falls of ground are a couple of examples. Ground integrity and wall stabilization are also factors when dealing with large open pit mining operations.

**[003]** Long borehole blasting is an economical method of mining with several engineering variables such as drill and blast patterns, blasting methods, longer blasthole configurations, larger diameter holes with more powerful explosives and numerous methodologies for controlled blasting. Pre-splitting, Cushion and Buffer Blasting have played an important part in controlled blasting in open pit operations. In open pit mining, if backbreak is not controlled properly there is remedial action which can take place, though costly and time consuming. This is not so in underground longhole blasting where ground conditions are a high priority, especially when successive blasting takes place within a stope or body of ore. This mining method results in high energy concentration in the blast area that can result in severe backbreak problems for stope walls leading to unsafe ground conditions and possible stope wall or fill failure if blasting at a fill perimeter. Unstable conditions lead to higher costs due to equipment loss, ore loss, higher dilution and control problems as mining operations move to new and deeper depths. Backbreaking, unstable stope and wall conditions are a direct result of the properties of current blasting methods utilized throughout the mining industry.

**[004]** At present, each borehole when blasted has a burn reaction in a linear direction along the center axis of the loaded borehole. The detonation, typically initiated from the toe (bottom up), creates shock waves and high pressure gases that begin the sequence which will ultimately fracture a rock mass. As the charge is fired a sequence of events commences. A detonation wave travels up the explosive column from the detonator/primer and a high-pressure stress wave travels out into the rock mass. Tensile radial fractures are caused by expanding compressive waves that proceed outwards in a right angle direction to the wave front followed by high pressure explosive gases that expand the borehole fractures causing failure. The reason for limited ground control or ground instability is primarily due to energy which is released in a uniform radial direction radiating outward from the center axis of the borehole.

## Summary

**[005]** In one aspect, there is provided a method of loading a borehole for directional blasting, the method comprising: placing two or more cartridges containing a primary explosive into the borehole, the cartridges being spaced evenly apart and abutting 10% to 50% of the borehole perimeter on a desired direction of blasting; securing wiring to a detonator in each cartridge , the wiring connectable to a controller that can activate all of the detonators simultaneously; and filling a remainder of the borehole with a secondary explosive in form of an emulsion or ammonia nitrate fuel oil (ANFO) having a lower velocity of detonation (VOD) than the primary explosive.

**[006]** In another aspect, there is provided a method of loading a borehole for main field blasting, the method comprising: placing two or more detonators into a first borehole containing a primary explosive, the detonators being spaced evenly apart at an interval I and connected with a first cable; placing two or more detonators into a second borehole containing the primary explosive, the detonators of the second borehole being spaced evenly apart at interval I with a topmost detonator of the second borehole being placed at a depth of ½ of interval I lower than a topmost detonator of the first borehole and the detonators of the second borehole being connected by a second cable; securing wiring to the first cable and the second cable, the wiring connectable to a controller that can activate all of the detonators simultaneously.

**[007]** In another aspect, there is provided a system for implementing the method.

## Brief Description of the Drawings

**[008]** Figures 1A and IB are line drawings of in accordance with one example embodiment of the present disclosure;

**[009]** Figure 2A and 2B is a line drawing of a blast trajectory from a borehole loaded according to one example embodiment of the present disclosure.

**[0010]** Figure 3 shows a multi-hole embodiment of the present disclosure.

## Detailed description

**[0011]** To the accomplishment of the foregoing and related ends, certain illustrative aspects are described herein in connection with the following description and the annexed drawings. These aspects are indicative of the various ways in which the principles disclosed herein can be practiced. Other advantages and novel features will become apparent from the following detailed description when considered in conjunction with the drawings.

**[0012]** The proposed changes involve the loading of long boreholes and the properties associated with the blast sequence of individual boreholes. The disclosed method and system should achieve measurable control of individual borehole blasts, that is to direct the fracturing properties of the blast sequence to a specified direction instead of radially, as well as, reducing ground vibration associated with the individual blast sequence. This will lead to a calculable tool for control on large borehole blasting and allow for greater ground stability, better control of stope perimeter walls and slot raise blasts and will be highly advantageous when mining at greater depths with higher pressures.

**[0013]** Control can be gained by using a dual phase, multi-stage blasting sequence. The disclosed technique utilizes two types of explosives, primary and secondary, with different characteristics and physical properties. The disclosed method and system utilizes the detonation characteristics of one explosive to initiate fracturing of host rock while simultaneously initiating the secondary explosive, in a uniform controlled detonation pattem, to achieve extremely high pressure gas production to compliment directional fracturing as well as aligning wave patterns to mitigate seismic magnitude. This methodology allows for variances to control gas pressure production and magnitude of associated wave propagation.

**[0014]** The "Dual Phase" expression relates to the burn or oxidation of two separate classes of explosives with different physical detonation velocities that are utilized within the blast hole detonation sequence (as shown in Figure 1A). "Multi-Stage" refers to the stacking or decoupling of primary charges within the individual blast hole (as shown in Figure IB). Primary explosive charges are decoupled to minimize the magnitude of various wave formations associated with the primary charge and to eliminate the propagation of a detonation head and associated Shockwaves that would develop within the secondary explosive. The design will be different depending on the borehole size. For example, some underground mines use 4 1/2 "bore boles while large open pits use 20" and 24"bore holes.

**[0015]** Properties sought for the primary explosive would be speed, high VOD, which is directly related to compression wave formation and first stage fracturing. In some embodiments, the primary explosives are packaged in plastic carriers. In some embodiments, the primary explosives are packaged in carriers that are of crescent shape. In some embodiments, the carriers for the primary explosives have a length between one and two meters depending of host rock density and desired attributes to the borehole blast. Length of primary explosive charge is a direct factor in initial primary fracturing and the production of extreme gas pressure production.

**[0016]** In some embodiments, the primary explosives are in interlocking cartridges, using a male / female snap type connection, with two male and one female on one end and two female and one male on the other. The borehole periphery would be the lock guard to keep them from detaching during positioning. In some embodiments, the cartridges containing the primary explosives are skeleton style structures that protect the explosives when lowering or raising in bore holes and allows the primary charge direct contact with the borehole periphery to be cast. In some embodiments, each cartridge has three to four plastic rings incorporated within it that hold the cartridge in place within the borehole. In some embodiments, the rings are equally spaced. In some embodiments, the rings are 1.25 to 2 times the borehole diameter. The rings, due to the diameter are directional and will only allow travel in one direction.

**[0017]** Interlocking the cartridges allows for charge alignment, different configurations and ease in loading the hole. In some embodiments, when placed in the borehole, the primary charge will abut 10% to 50% of the borehole periphery which is also the desired direction of casting. A small booster may be housed mid-point of the cartridge that will accept the detonators on the inner (concave) side of the cartridge. The concave cartridge wall has small plastic clips for securing detonator tubing or wires.

**[0018]** LOADING THE BOREHOLE

**[0019]** Referring to Figures 1A and IB, in some embodiments, cartridges 110 are lowered or raised into bore holes placing a detonator, all the same speed, into each cartridge securing tubing or wiring as each cartridge is added to the primary axial charge. In some embodiments a top cartridge contains no explosives as is common in the industry for stemming, capping or plugging the load hole. In some embodiments, each cartridge contains a PETN primer booster 112. Then, the remainder of the bore hole is loaded with a secondary explosive 120. The secondary explosive can comprise an emulsion or ammonia nitrate prill (ANFO (ammonia nitrate/fuel oil) such as amex) 120. Depending on the number and spacing of primary charges, a poured granular amex 120 may be of sufficient gas pressure for normal fracturing. Properties sought for secondary explosives are development of high gas pressure and ideally 50% or lower VOD than that of the primary. (See Figures 1A and IB)

**[0020]** THE DETONATION SEQUENCE

**[0021]** In an embodiment, when fired, each cartridge is detonated simultaneously with full VOD established in each direction axially within a distance of 3.5 to 3.8 times that of the primary explosive charge diameter. Upon full VOD, a detonation head is fully established that propagates a compression wave fracturing the host rock face adjacent to the primary charge periphery. As the primary explosive burns it exhibits the same properties as the conventional blast sequence, a detonation wave travels up / down the primary explosive column producing tensile radial fractures to the abutting rock surface, caused by expanding compressive waves that proceed outwards in a right angle direction to the wave front.

[0022] The secondary explosive properties should have a low VOD and should probably be a reactive agent which will produce the highest gas build-up. The secondary explosive can be granular or an emulsion. The granular, Amex, has a different density than that of the primary, which is an emulsion. Use of an emulsion secondary explosive will still work due to the difference in VOD but since the density of the emulsion and the density of the primary are virtually the same, transmission of the shock waves are easily transmitted to the rock, wherein the use of a granular secondary, the composition and density vary greatly acting as a buffer for propagating Shockwaves.

[0023] With this technique, extreme high borehole pressures will be developed due to multiple point initiation by the primary explosive, which is staged/decoupled throughout the borehole. Since, in some embodiments, the primary's VOD is minimally twice that of the secondary explosive, the direction of detonation of the secondary will be more perpendicular or angular to the borehole alignment. The creation of a full detonation head will not be possible, thus limiting host rock fracturing of the borehole wall opposing the primary charge. Fracturing of the host rock commenced with the high velocity of detonation of the primary explosive which in turn ignites the secondary charge produces gas build up that continues fracturing and fragmenting the host rock in the desired direction.

[0024] The primary explosive is connected to a detonator. In some embodiments, the detonators are electronic detonators. In some embodiments, the detonators are programmable.

[0025] PRESUMED SHOCKWAVE MITIGATION

[0026] Referring to Figures 2A and 2B, with all cartridges being fired simultaneously and developing detonation heads, the various waves will be propagating in opposing directions. This will have waves of the same size (area) of the same frequency and of the same magnitude colliding with zero degree deflection. It is presumed that these waves should have a de-escalating effect on each other thereby reducing ground vibrations associated with the propagation and normal dissipation of these waves. The magnitude (area of coverage) of the wave fronts can be controlled by the length of the primary cartridges (time for complete detonation) and their spacing, allowing control of time for wave front propagation before intersecting waves collide. Due to the difference in densities, rock and secondary explosives, it is expected that the primary explosive's propagating wave will be non- concentric with the greater concentration propagating towards the blasted face. Optimal spacing of the primary charges can be calculated to decrease costs as significant fracturing will occur between primary charges due to the elastic properties of the host rock and the convergence of two colliding detonation heads. Spacing of primary charges is designed to eliminate the propagation of a detonation head of the secondary explosive. In Fig. 2, the non-concentric rings are exaggerated for convenience of display.

**[0027]** The extreme pressure is created by reducing the time for complete detonation of the secondary explosive within the full length bore hole. Typically, in standard borehole blast, the gas production is the combination of the explosive's chemical properties and the time span for full detonation for high pressure gas production. Full detonation time can be calculated by borehole length divided by secondary's VOD.

**[0028]** The disclosed technique has each cartridge detonating simultaneously thereby igniting the secondary in multiple points of equal volume, therefore full gas production is at a fraction of the time of conventional, equating to higher gas production.

**[0029]** Since the primary charge need not be encapsulated within a uniform density of host rock as conventional blasting dictates and since the primary charge occupies under 50% of the borehole diameter, it has a partial perimeter of the less dense secondary explosive. The primary compressive wave of the primary explosive ignites the secondary explosive, via compression, that will create high borehole pressure. Properties of the primary explosive must exhibit a high potential VOD; full VOD will be accomplished due to the diameter and length of the charge. It is expected that the primary charge VOD will range in the 20,000 to 25,000 f/s range.

**[0030]** The primary explosive function is to initiate the fracturing of material to be blasted by wave intensity relating to VOD and initiating the secondary explosive by compressive wave. Length of the primary charges is dependent on the diameter of the hole and must be of sufficient length as to create a full detonation head from each primary charge in opposing directions; also if the diametric mass of the primary charges is too great it will reduce the maximum borehole pressure achievable. Therefore the optimum length and diameter, for various rock types must be determined. The length of primary charge also controls magnitude of wave generation.

**[0031]** In some embodiments, the secondary explosive is a reactive agent which will develop the highest gas concentration. The secondary explosive can be granular, preferred, or an emulsion. The charge diameter, detonation velocity and specific gravity (density) are key components for high pressure gas production. The secondary explosive will not produce a full detonation head and gas production will be increased by the multi point detonation and the total time required for complete detonate of the borehole. Wave fronts and vibrations created from the secondary agent have not yet been determined. The secondary explosive's key role is that of gas production to propagate the fracturing and linear cracking derived from detonation characteristics of the primary explosive.

**[0032]** Spacing of primary explosives: Primary charges are spaced to reduce the velocity of the opposing detonation heads and act as a buffer. Spacing of primary charges must be of a length to avoid the formation of a complete detonation head within the secondary. In some embodiments, the maximum spacing allowed is defined as hole diameter times 3.2 (function under 3.5) times 2 (dual wave fronts). With the multiple primary stages initiated instantly, it is the compressive wave front which ignites the secondary explosive in a lateral direction, though the lateral burn direction cannot be maintained due to the difference in detonation velocities, therefore, no full detonation head can be formulated from the secondary explosive. The multiple primary charge initiators control gas pressure. The more primary charges in the borehole, the greater the borehole pressure achieved over conventional blasting methods. This is accomplished by decreasing the time required to detonate the complete borehole. Greater control is gained by configuring the borehole charge for desired fracture and casting properties. Various lengths of spacers would allow for unique configurations to fulfill customer requirements.

**[0033]** The proposed method is predicted to result in a reduction in the size/magnitude of primary and secondary waves generated from a blast. It is expected that the outer periphery of the wave propagation as well as the bottom most detonation head to be picked up by sensors. A reduction of the ground vibration (generated waves) by 40% on a production blast would be very beneficial to the field. Energy will always be expelled from a blast in one form or another, so completely eliminating or cancelling each other out is not feasible or expected.

**[0034]** In some embodiments, the spacer is a cartridge without a primary explosive. Testing and computer programming will assist in defining the best length for various ground conditions and diameter of the borehole.

**[0035]** This technique will allow for greater control in large borehole blasting by reducing stresses on in situ ground by controlling fracturing and shock wave propagation. Since most operations develop drill blast standards for their operations and utilize common borehole diameters, it would be quite easy to manufacture the primary charges for predetermined borehole diameters and with variable spacing, allowing for control of gas production delivering scalable blast parameters. With underground mining progressing ever deeper and ground stabilization being a key factor in any mining operation, this method of blasting may become very useful in underground and open pit mining.

**[0036]** Main blast field application

**[0037]** The use of the directional methodology allows for perimeter control. However, the main body of the blast field does not require the directionality, unless utilized the methodology for casting profile. For the general field, full radial fracturing and high gas pressures are desirable, along with controlling seismicity. Thus in another embodiment of the invention, Multi-Stage Blasting, having multiple evenly spaced detonation points initiated simultaneously, thereby establishing uniform propagating wave fronts that will intersect at zero degree deflection is proposed. It is to be understood that the detonators are initiated simultaneously as no linear burning product will allow for the uniform intersecting pattern. By utilizing a two detonation cable system, "A" / "B", it is possible to utilize the wave fronts for extra fracturing while staging the fronts for intersection and lessening the seismic effects within the blast field and surrounding rock mass. These embodiments can be implemented with only one explosive.

**[0038]** With this technique, multiple variations will be possible. For instance, in one embodiment, the detonators are evenly spaced by affixing them to a rope/cable of sorts and lowered into the borehole before loading. If two variances are set up for detonator sequence, such as, detonation line "A" has spacing of 6m, 12m, 18m, 24m ( 20, 40, 60, 80 ft ) and detonation line "B" has a spacing of 3m, 9m, 15m, 21m , 27m ( 30, 50, 70, 90 ft ), then when the field is loaded with an evenly sequenced "A" , "B", "A" configuration it will allow for controlled wave fronts while initiating the Torque Theory that should allow for uniform fragmentation.

**[0039]** Referring to Figure 3, for a general blast field, cables or ropes can be used to allow for the exact spacing of detonators. In one borehole either line A or line B would be used. In the adjacent hole the opposite line would be employed. So, hole 1 would use line A , hole 2 would use line B , hole 3 would use line A and it would carry on for the number of holes in that row. A computer is used is some embodiments to lay-out the blast field firing sequence and timing of the shots.

**[0040]** Torque Theory

**[0041]** The Torque Theory states that, "When two adjacent explosive columns are initiated simultaneously from opposite ends, a compressional shock wave from each column travelling parallel but in opposing directions is formed. The greatest stress is always directed perpendicular to the primary shock front. This stress is also assumed to be greatest near the detonation head in the explosive and diminishes with distance away from the detonation head. An uneven stress distribution is formed between explosive columns when the columns are fired simultaneously and from opposite directions. This action tends to toss the fragmented rock between explosive columns in a counterclockwise motion. Reversing the primers of each explosive column will toss the material in a clockwise motion. This action is precisely what is needed to obtain uniform fragmentation and avoid tight muck piles such as in the case of in situ retorting."

**[0042]** What has been described above includes examples of the disclosed architecture. It is, of course, not possible to describe every conceivable combination of components and/or methodologies, but one of ordinary skill in the art may recognize that many further combinations and permutations are possible. Accordingly, the novel architecture is intended to embrace all such alterations, modifications and variations. Furthermore, to the extent that the term "includes" is used in either the detailed description or the claims, such term is intended to be inclusive in a manner similar to the term "comprising" as "comprising" is interpreted when employed as a transitional word in a claim.

[0043] The foregoing descriptions of specific embodiments of the present invention have been presented for purposes of illustration and description. They are not intended to be exhaustive or to limit the present invention to the precise forms disclosed, and obviously many modifications and variations are possible in light of the above teaching. The exemplary embodiment was chosen and described in order to best explain the principles of the present invention and its practical application, to thereby enable others skilled in the art to best utilize the present invention and various embodiments with various modifications as are suited to the particular use contemplated.

I Claim:

1. A method of loading a borehole for directional blasting, the method comprising:
   placing two or more cartridges containing a primary explosive into the borehole, the cartridges being spaced evenly apart and abutting 10% to 50% of the borehole perimeter on a desired direction of blasting;
   securing wiring to a detonator in each cartridge, the wiring connectable to a controller that can activate all of the detonators simultaneously; and
   filling a remainder of the borehole with a secondary explosive in form of an emulsion or ammonia nitrate fuel oil (ANFO) having a lower velocity of detonation (VOD) than the primary explosive.

2. The method of claim 1, wherein the cartridges are crescent shaped.

3. The method of claim 1 or 2 further comprising interlocking the cartridges.

4. The method of any one of claims 1 to 3 further comprising interlocking the cartridges using a skeleton structure.

5. The method of claim 4, wherein the non-explosive cartridges contains a non-explosive gel.

6. The method of any one of claims 1 to 5 wherein the cartridges are evenly spaced.

7. The method of any one of claims 1 to 6 wherein the secondary explosive is a reactive agent.

8. The method of any one of claims 1 to 7 wherein the VOD of the primary explosive is at least twice the VOD of the secondary explosive.

9. The method of any one of claims 1 to 8 further comprising determining a spacing between the cartridges that will reduce or mitigate shock wave magnitude from the primary explosive.

10. A system for implementing the method of any one of claims 1 to 9, the system comprising the two or more cartridges containing the primary explosive.

11. The system of claim 11 further comprising the wiring.

12. The system of claim 11 or 12 further comprising the secondary explosive.

13. The system of any one of claims 11 to 13 further comprising a structure for interlocking the cartridges.

14. A method of loading a borehole for main field blasting, the method comprising:

placing two or more detonators into a first borehole containing a primary explosive, the detonators being spaced evenly apart at an interval I and connected with a first cable;

placing two or more detonators into a second borehole containing the primary explosive, the detonators of the second borehole being spaced evenly apart at interval I with a topmost detonator of the second borehole being placed at a depth of ½ of interval I lower than a topmost detonator of the first borehole and the detonators of the second borehole being connected by a second cable;

securing wiring to the first cable and the second cable, the wiring connectable to a controller that can activate all of the detonators simultaneously.

15. The method of claim 14 wherein the number of detonators in the first borehole is the same as the number of detonators in the second borehole.

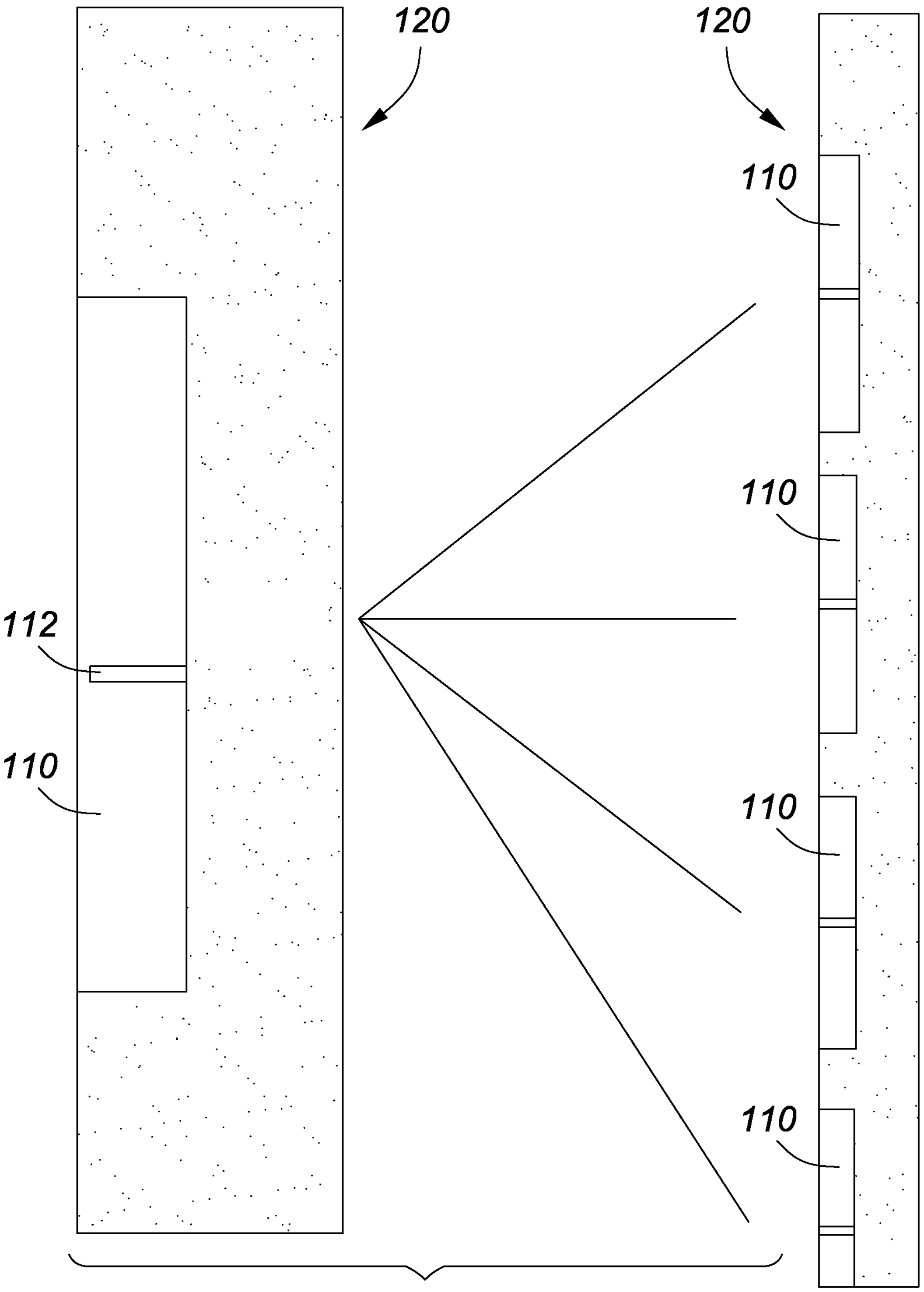

FIG. 1A

FIG. 1A

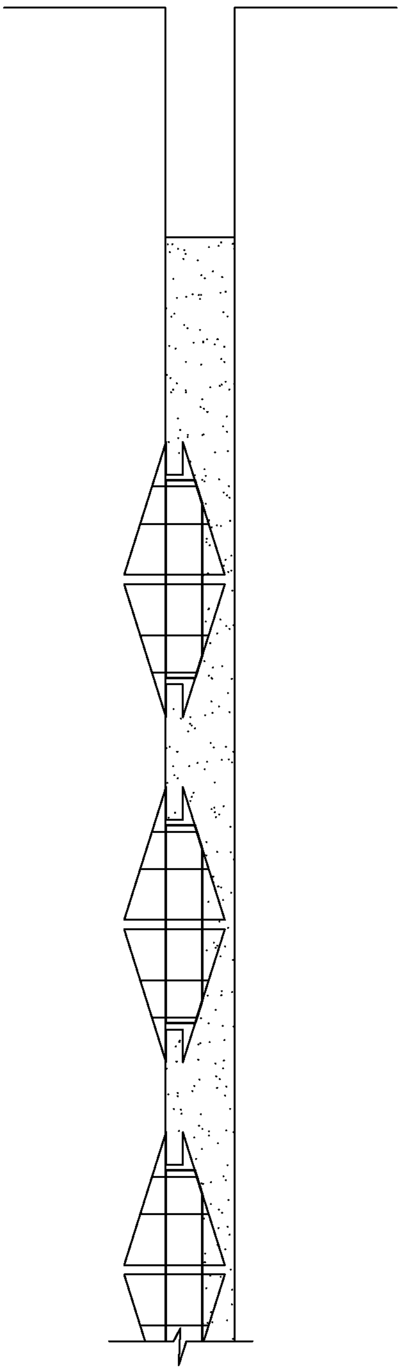

FIG. 2A

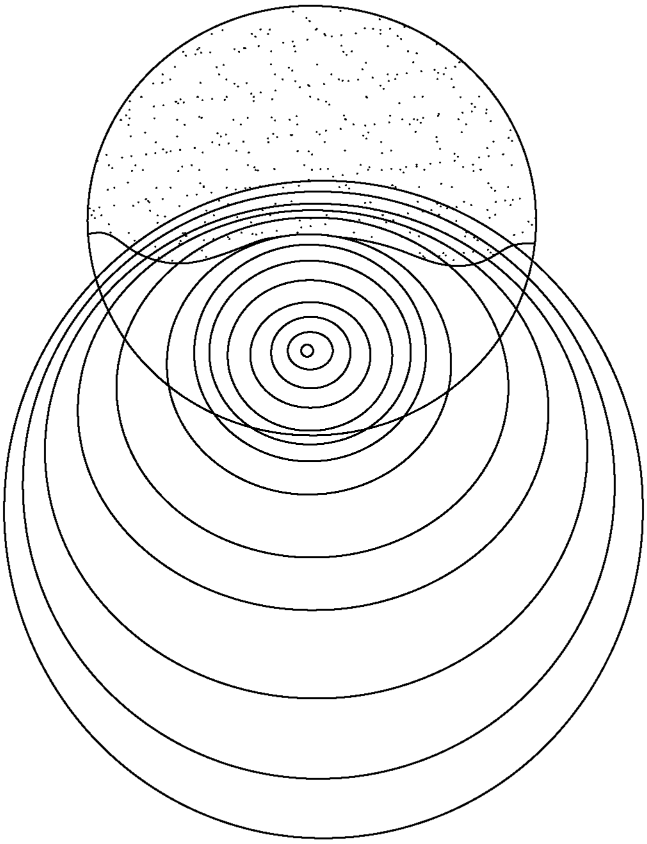

FIG. 2B

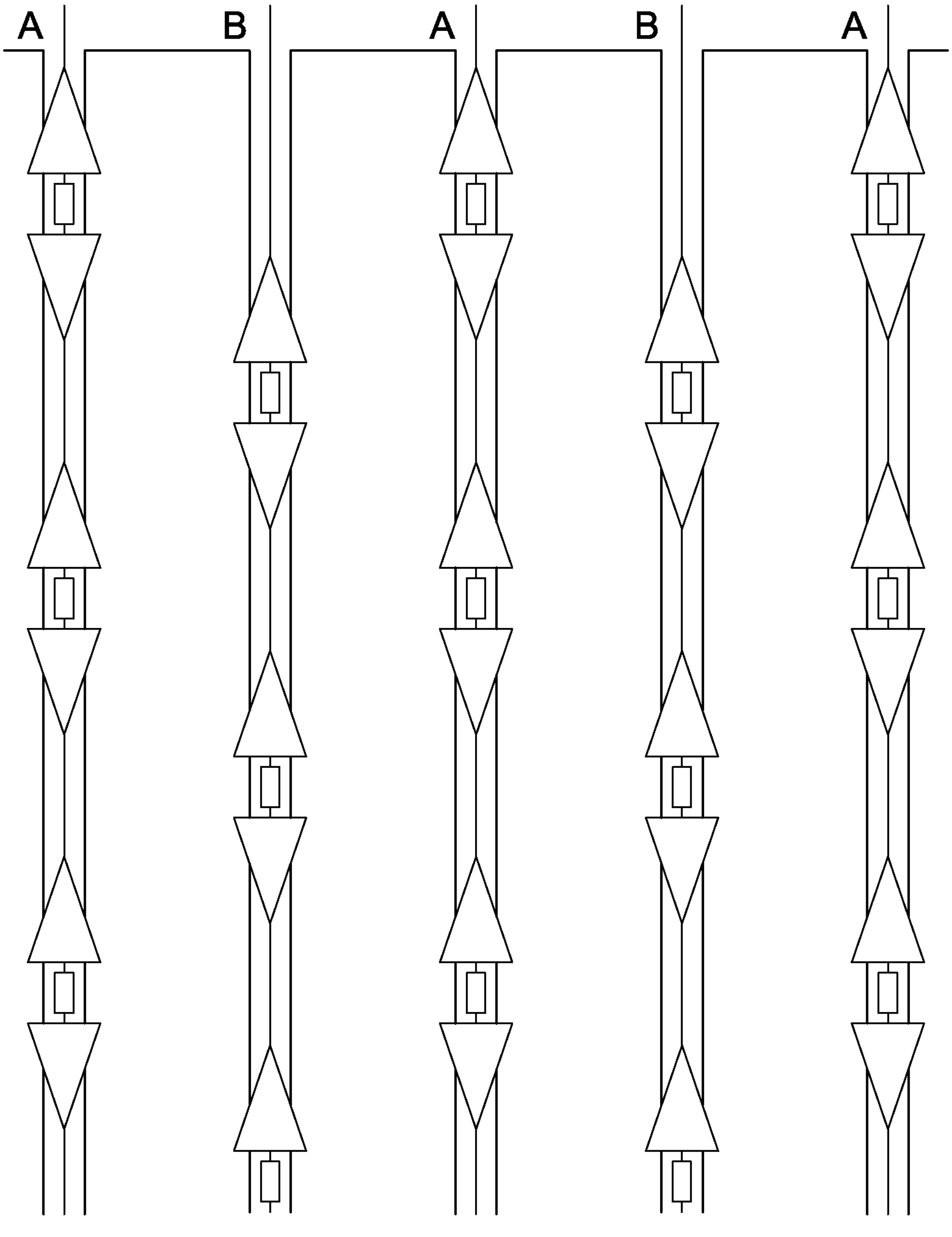

FIG. 3

**INTERNATIONAL SEARCH REPORT**

International application No.
**PCT/CA2016/050726**

A. CLASSIFICATION OF SUBJECT MATTER
IPC: ***F42D 1/05*** (2006.01) , ***E21C 37/00*** (2006.01) , ***F42B 3/02*** (2006.01) , ***F42D 1/02*** *(2006.01)* ,
***F42D 1/04*** (2006.01) , ***F42D 3/00*** (2006.01)

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)
IPC (2006.01): F42D 1/15, E21C 37/00, F42B 3/02, F42D 1/02, F42D 1/04, F42D 3/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
N/A

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
Canadian Patent Database, Questel
Keywords: primary, secondary, high, cartridge, explosive, borehole, crescent, interlock, detonator

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X<br>Y | US5596165 A (CARNEY, P.) 21 January 1997 (21-01-1997)<br>*Column 1, lines 42-54* | 1, 6-12<br>2, 3, 13 |
| Y | US4090447 A (JOHNSEN, O. A.) 23 May 1978 (23-05-1978)<br>*abstract* | 2 |
| Y | WO2008/092282 A1 (MATTSON, T.) 7 August 2008 (07-08-2008)<br>*abstract* | 3, 13 |
| A | US2770312 A (Silverman, D.) 13 November 1956 (12-11-1956)<br>*Whole document* | |

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

| | | | |
|---|---|---|---|
| * | Special categories of cited documents: | "T" | later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention |
| "A" | document defining the general state of the art which is not considered to be of particular relevance | | |
| "E" | earlier application or patent but published on or after the international filing date | "X" | document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone |
| "L" | document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) | "Y" | document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art |
| "O" | document referring to an oral disclosure, use, exhibition or other means | | |
| "P" | document published prior to the international filing date but later than the priority date claimed | "&" | document member of the same patent family |

| | |
|---|---|
| Date of the actual completion of the international search<br>20 September 2016 (20-09-2016) | Date of mailing of the international search report<br>23 September 2016 (23-09-2016) |
| Name and mailing address of the ISA/CA<br>Canadian Intellectual Property Office<br>Place du Portage I, C114 - 1st Floor, Box PCT<br>50 Victoria Street<br>Gatineau, Quebec K1A 0C9<br>Facsimile No.: 819-953-2476 | Authorized officer<br>Victoria Dempster (819) 639-4506 |

**Box No. II** **Observations where certain claims were found unsearchable (Continuation of item 2 of the first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claim Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claim Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claim Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

**Box No. III** **Observations where unity of invention is lacking (Continuation of item 3 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:
The claims are directed to a plurality of inventive concepts as follows:

Group A - Claims 1-13 are directed to a method of loading a borehole for directional blasting and system for the same; and
Group B - Claims 14-15 are directed to a method of loading a borehole for main field blasting.

The claims must be limited to one inventive concept as set out in PCT Rule 13.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☑ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claim Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim Nos.:

**Remark on Protest**

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

| Patent Document Cited in Search Report | Publication Date | Patent Family Member(s) | Publication Date |
|---|---|---|---|
| US5596165A | 21 January 1997 (21-01-1997) | US5596165A | 21 January 1997 (21-01-1997) |
| | | EP0582702A1 | 16 February 1994 (16-02-1994) |
| | | EP0582702A4 | 27 July 1994 (27-07-1994) |
| | | US5261327A | 16 November 1993 (16-11-1993) |
| | | W09315365A1 | 05 August 1993 (05-08-1993) |
| US4090447A | 23 May 1978 (23-05-1978) | US4090447A | 23 May 1978 (23-05-1978) |
| | | AU499296B2 | 12 April 1979 (12-04-1979) |
| | | AU1030876A | 21 July 1977 (21-07-1977) |
| | | CA1055308A | 29 May 1979 (29-05-1979) |
| | | GB1519671A | 02 August 1978 (02-08-1978) |
| WO2008092282A1 | 07 August 2008 (07-08-2008) | WO2008092282A1 | 07 August 2008 (07-08-2008) |
| | | AT506595T | 15 May 2011 (15-05-2011) |
| | | DE602007014108D1 | 01 June 2011 (01-06-2011) |
| | | EP2108103A1 | 14 October 2009 (14-10-2009) |
| | | EP2108103B1 | 20 April 2011 (20-04-2011) |
| | | US2010089270A1 | 15 April 2010 (15-04-2010) |
| | | US8028624B2 | 04 October 2011 (04-10-2011) |
| US2770312A | 13 November 1956 (13-11-1956) | None | |