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(54) **AN EXPLOSIVE CARTRIDGE AND A METHOD OF ARRANGING AN EXPLOSIVE CARTRIDGE IN A BLAST HOLE**

SPRENGPATRONE UND VERFAHREN ZUR ANORDNUNG EINER SPRENGPATRONE IN EINEM SPRENGLOCH

CARTOUCHE D'EXPLOSIF ET PROCÉDÉ DE POSITIONNEMENT D'UNE CARTOUCHE D'EXPLOSIF DANS UN TROU DE MINE

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## Description

**[0001]** The invention relates to an explosive cartridge.

**[0002]** Beyond this, the invention relates to a method of arranging an explosive cartridge in a blast hole.

**[0003]** Furthermore, the invention relates to the use of an explosive cartridge for material fragmentation, particularly for any type of rock, rock mass, concrete or comparable material fragmentation.

**[0004]** Explosive cartridges may be used in many technical fields for any type of rock, rock mass, concrete or comparable material fragmentation.

**[0005]** US 3,323,455 discloses a container for explosives for use in an expansible explosive cartridge having structurally weak rupturable portions formed by chemical action in situ on the container. These weak rupturable portions help to break the cartridge at predefined positions when tamped inside a borehole.

**[0006]** WO 2000/79212 discloses a method for setting and igniting a charge of explosives for geological investigations, comprising the following steps: a hole is drilled in the ground which is to be investigated; an explosion chamber is hollowed out, whereby said explosion chamber has an expanded form in relation to the bore hole at the end of said bore hole; an ignition element and an explosive container containing an explosive in a protective blister surrounding the ignition element are lowered down into the explosion chamber; the explosive is pressed out of the explosive container into the explosive chamber and the ignition element is ignited. Thus, a pump and a small diameter hose are replaced through which a borehole enlarged at the bottom could be completely filled as well.

**[0007]** US 3,696,703 discloses a water-proof package for water-sensitive bulk-loaded blasting agents comprising an inner and outer plastic tube and mounted between them a liner folded up onto the inner tube in concertina fashion, said tubes being fitted with a constriction to retain the liner within the tubes and with a cap to protect the bottom end of the assembly, wherein the package is attachable to a loading hose for blasting agent and the liner is pushed out through the bottom end of the outer tube by the loading hose or the blasting agent, when charging commences.

**[0008]** US 4,813,358 discloses an inflatable wand for positioning within an upward oriented, mining borehole and near a lower collar opening thereof wherein the wand provides a conduit for introducing and retaining liquid explosive materials within the borehole. The wand includes a flexible tube with longitudinally oriented reinforcing fibers embedded in an elastic composition such as rubber. The tube is constructed to permit radial elongation in response to a force arising within the tube and directed radially outward, but to restrain against axial elongation during use. Such radial elongation arises because of back pressure developed by the flowing explosive as it is impeded at a valve outlet at the distal end of the wand. Enlargement of the wand seals the opening of the bore-

hole without destruction of the elastic material on sharp points and edges of the borehole collar.

**[0009]** GB 1 403 975 A, which forms the starting point for the subject-matter of independent claims 1 and 13, discloses a cartridge for compacting matter within a confined region. The cartridge relates to placing non-explosive materials in a bore-hole, combining the materials in place to make an explosive mixture and automatically compacting the explosive mixture within the bore-hole.

**[0010]** However, conventional explosive cartridges for any type of rock, rock mass, concrete or comparable material fragmentation do in many cases not allow to entirely fill up a blast hole formed in the ground. This would be desired to obtain an efficient fragmentation result.

**[0011]** It is an object of the invention to enable to fill up the bottom of a blast hole with an explosive material in an efficient manner.

**[0012]** In order to achieve the object defined above, an explosive cartridge, a method of arranging an explosive cartridge in a blast hole, and the use of an explosive cartridge for material fragmentation according to the independent claims are provided.

**[0013]** According to the invention, an explosive cartridge for generating an explosion in a blast hole is provided, the explosive cartridge comprising a flexible casing for containing an explosive, and a mechanism for expanding the casing in a first direction and for simultaneously contracting the casing in a second direction which differs from the first direction.

**[0014]** According to the invention, a method of arranging an explosive cartridge for generating an explosion in a blast hole is provided, the method comprising inserting the explosive cartridge in the blast hole, and expanding a casing of the explosive cartridge in a first direction and simultaneously contracting the casing in a second direction which differs from the first direction.

**[0015]** According to still another exemplary embodiment of the invention, an explosive cartridge having the above mentioned features may be used in the field of material fragmentation (particularly for any type of rock, rock mass, concrete or comparable material fragmentation).

**[0016]** The term "casing" may particularly denote the portion of the explosive cartridge which portion has a (for instance continuous) inner surface surrounding the explosive (such as a non-loose explosive sealed by a surrounding flexible casing) entirely. Thus, the casing may define a sealed space accommodating explosive material, particularly accommodating explosive material of a fixed and defined amount.

**[0017]** According to an exemplary embodiment of the invention, an explosive cartridge (or a bullet) is provided for use in mining applications or the like, wherein the explosive cartridge can be lowered in a previously formed blast hole and can be installed at the bottom of the borehole, that is to say in a deepest portion, of the blast hole. Due to the necessity to lower the explosive cartridge, the lowest part of the blast hole is not entirely filled with the

explosive cartridge in a lateral direction directly after insertion. In contrast to this, a distance between the explosive cartridge and the walls delimiting the blast hole remains in many cases. To overcome such problems, according to an exemplary embodiment of the invention, a cartridge-internal mechanism may be activated which expands an outer lower portion of the explosive cartridge so that the lower portion of the activated cartridge fills a larger or even the entire lateral space at the deepest portion of the blast hole. Simultaneously, an extension of the explosive cartridge in lowering (or length) direction is reduced by contracting the explosive cartridge when expanding the cartridge in the other direction, so that the density of explosive contained within the cartridge is not reduced by the lateral extension. This may make it possible to efficiently install the explosive cartridge in a blast hole, and to enable an efficient force transmission in a subsequent detonation.

**[0018]** Thus, embodiments of the invention may make it possible that essentially the entire cross-section of a bore hole is filled with the cartridge. Therefore, material crushing in the deepest portion of the blast hole during a detonation may be promoted.

**[0019]** Thus, even with a non-loose explosive charge, and therefore with a high explosive density, an efficient blasting may be made possible.

**[0020]** By means of a contraction of the cartridge in a length direction, a lateral expansion of the cartridge may be triggered in a controlled manner. Therefore, it may be ensured that the cartridge fills essentially the entire cross-section of the blast hole, particularly in a deepest portion of a blast hole, that is to say in a blind hole of the blast hole. This functionally combined length contraction and lateral expansion of the cartridge may be performed before the actual detonation, in other words when preparing or installing the cartridge for an efficient subsequent detonation. By taking this measure, the available cross-section of the bore hole may be essentially completely be used to be filled with the cartridge. This may improve the force transmission between explosive and surrounding rock material during the detonation.

**[0021]** An explosive cartridge according to an exemplary embodiment of the invention may be used in single or multiple hole and single or multiple row blasting. For instance, in a rectangular drill hole pattern with a certain distance of the holes from the next free face (burden) and with a certain distance between the holes (side spacing) a number of blast holes may be drilled in the ground. A number of blast holes (for instance one hundred) may then be filled with explosive cartridges. Using the cartridges, the ignition of the holes may be carried out sequentially and/or simultaneously. By providing a mechanism for expanding the cartridge in the deepest portion of the blast hole without an undesired reduction of the density of explosive charge, particularly by expanding the cartridge in a lateral direction and by contracting the cartridge in a longitudinal direction at the same time, the explosive force may be improved or optimized and the

specific explosives energy input into the blasted material maybe increased.

**[0022]** Particularly, the functional coupling or combination of the radial expansion and the longitudinal contraction may enable to obtain these and other advantages.

**[0023]** An outer casing of the explosive cartridge may be manufactured of a mechanically flexible material so as to allow the expansion and simultaneous contraction to be carried out without being destroyed. In this context, the skilled person will understand that this purpose requires a certain flexibility which allows a sufficiently large expansion/contraction of at least a part of the casing without being damaged. The skilled person will further understand that this purpose may require a flexibility which is not too pronounced, so as to hold the components contained within the casing without a significant deformation of the casing. For instance, polyethylene with a thickness of 0.5 mm may be appropriate for these purposes. An alternative material for the casing may be a rubber-type material.

**[0024]** The thickness of a material of the casing may vary in a vertical direction, so that a high flexibility may be obtained in the deepest portion of the bore hole and a larger rigidity may be obtained at an upper portion of the cartridge in the bore hole. Additionally or alternatively, plastics or other materials having a varying, that is to say spatially dependent rigidity, may be used. For example, a polyethylene foil may be used for the casing having a thickness of 1 mm in an upper portion of the cartridge, and 0.5 mm in the deepest portion of the cartridge.

**[0025]** Thus, a highly efficient expansion cartridge may be provided. Such an expansion cartridge may comprise an explosive cartridge covered by a flexible plastic material. Triggered by a chemical reaction or by compressed air or a mechanical mechanism, the length of the cartridge may be reduced, and at the same time an expansion of the explosive cartridge in a radial direction may be carried out. Thus, an expansion cartridge according to an exemplary embodiment of the invention does not use an isolated lateral swelling or expansion of the cartridge triggered by a chemical reaction, which would result in a reduction of the density of the explosive charge. In contrast to such a one-dimensional approach, embodiments of the invention combine such an expansion of the cartridge in a lateral direction with a contraction of the cartridge in a length direction, thereby providing a two-dimensional solution for maintaining a high density of the explosive charge. Thus, a system for manufacture of an explosive charge with a reduced length and a simultaneous expansion in a radial direction may be provided.

**[0026]** In the following, recognitions, investigations and considerations will be presented based on which embodiments of the invention have been developed.

**[0027]** For blasting in the field of surface mining and quarry, vertical or inclined blast holes may be drilled in the rock mass typically parallel to a wall to be broken.

These blast holes can be subdrilled to a certain extent of for instance 1/3 of the burden (the burden may be the distance between the bore hole and the wall to be broken).

**[0028]** Due to the drilling procedure and due to a possible water flow from the rock mass, the deepest portion of the blast hole is in many cases filled with water and/or with muddy water.

**[0029]** Subsequently, loose explosive material or explosive material contained in a cartridge is inserted into such a bore or blast hole. When inserting a cartridge in the bore hole, it usually has a smaller diameter than the blast hole. Consequently, the explosive cartridges do not entirely fill the blast hole in many cases. As a result, only a part of the blast hole volume can be effectively used for the blasting. When employing cartridged emulsion explosive for blasting with a density of close to 1 g/cm<sup>3</sup>, this may also result in problems during loading. Namely, the cartridges may sink to the deepest portion of the blast hole only in an insufficient or very slow manner. The density of muddy water in the deepest portion of the blast hole is in many cases above 1 g/cm<sup>3</sup>. Thus, due to the small density difference between the explosive cartridges and the muddy water, only a very slow sinking of the cartridge to the deepest portion of the bore hole is obtained.

**[0030]** However, a properly fitting loading of the deepest portion of the blast hole and a reliable sinking of the explosive cartridges to the deepest portion of the blast hole is important for achieving a proper blasting result with regard to a reliable breaking of the lowest portion of a wall to be broken.

**[0031]** When employing gelatinous explosive with a slightly higher density for loading the deepest portion of the blast hole, the cartridges reliably sink to the deepest portion of the blast hole. However, in such a situation, the deepest portion of the blast hole is only insufficiently used with regard to the blast hole cross-section.

**[0032]** Forming slits in the explosive cartridges does not solve this problem entirely: When the cartridge to be lowered hits a water surface in the blast hole, a lateral expansion of the cartridge may occur, so that it will be prevented that the entire bore hole cross section is filled by the cartridge.

**[0033]** Each increase of the loading density (with regard to the density of the explosive as well as to the degree of using the cross-section of the bore hole) results in an improved blasting quality and enables to select a larger burden, that is to say a larger distance between the bore hole and the wall to be broken by the explosion. Particularly, increasing the burden has a large economical importance for blasting, since this may result in a significantly increased amount of rock per blast hole. In combination with an increase of the burden, usually an increase of the lateral side distance between the blast holes occurs. Therefore, an increase of the burden may in principle depend (for example with a square function) from an increase of the drill pattern, and thus with a larger

amount of rock per blast hole.

**[0034]** Apart from employing cartridged explosive for loading the deepest portion of the bore hole, it is also possible to use loose explosive which can be pumped via a tube into the deepest portion of the bore hole. In such a configuration, an initiation charge (booster charge) is first inserted into the deepest portion of the bore hole with a detonator fixed thereto. This booster charge (for instance TNT, i.e. Trinitrotoluene, or PETN, i.e. Pentaerythritol Tetranitrate) is then lowered along the ignition wires or the ignition tube to the deepest portion of the blast hole. Due to the high density of such initial explosives, in many cases there is no problem that the booster sinks directly to the deepest portion of the blast hole. When subsequently loading loose explosive charge, the inserted explosive material may be mixed in a strong manner with the mud in the water in the deepest portion of the blast hole. This may result in the fact that between the pumped or inserted explosive and the booster charge in the deepest portion of the bore hole, only an insufficient contact is obtained. This may result in a non-successful ignition and/or to a bad initiation of the inserted main explosive.

**[0035]** A further circumstance which may be observed when pumping the explosive in the blast hole is the fact that strong currents of the water and the explosive may be formed in the deepest portion of the bore hole. By such dynamic streaming phenomena, the booster which has been previously inserted in the blast hole may be pressed out of the deepest portion of the blast hole when pumping the explosive in the blast hole. In some cases, the booster may buoy upwards several metres during the pumping. This upwardly buoying of booster charges inserted into the bore hole may also be the origin for many insufficient blast results, yielding a bad fragmentation result in the lowest portion of the bottom of the wall to be broken.

**[0036]** Summarizing, due to the presence of water in the deepest portion of the blast hole and due to the relatively high mud content in this water, problems with a correct loading of the deepest portion of the bore hole may occur.

**[0037]** Furthermore, when inserting cartridges or booster charges in a conventional manner, only a part of the cross-section of the blast hole is used for the loading. This may result in the effect that, with a certain blast hole diameter, only a small burden may be blasted, so that effectiveness is lost compared to an entirely filled blast hole cross-section.

**[0038]** In view of the above considerations, an exemplary embodiment of the invention provides a system for manufacture of a bottom charge to be positioned in a deepest portion of a blast hole. A corresponding cartridge may therefore fill essentially the entire cross-section of the blast hole.

**[0039]** According to an exemplary embodiment of the invention, a loading system for introducing an explosive charge in a bottom portion of a blast hole may include at

least a part of the following components:

- A cartridge comprising an explosive material (for instance an emulsion explosive and/or a gelatinous explosive and/or a gel explosive and/or a single component explosive, for instance Nitropenta (Pentaerythritol Tetranitrate), TNT (Trinitrotoluene), Hexogen (Cyclotrimethylene trinitramine), etc.), preferably having a diameter of up to at the most essentially 2/3 of a diameter of the blast hole and/or of a density of larger than 1.4 g/cm<sup>3</sup>.
- The length of the explosive cartridge may be more than 500 mm, for example essentially 1000 mm.
- An enclosure of the cartridge may comprise an unbreakable elastic material, for instance made of a plastics.
- A mechanism for reducing the length of the explosive cartridge and for increasing the diameter of the explosive cartridge up to the diameter of the blast hole. This can be achieved, for instance, by means of a mechanically controlled pull or a push system (for instance using a spring), by means of a chemically activated system, by means of a vacuum (or low pressure) controlled system and or by means of a pneumatically controlled system.
- A device for lowering the cartridge into the deepest portion of a blast hole and for actuating the mechanism for reducing the length and for increasing the diameter of the cartridge.

**[0040]** According to an exemplary embodiment, a bore hole charging system may be provided comprising an explosive cartridge embedded in a flexible plastic cover with a mechanism (for example provided with a chemical reaction system or a compressed air system or a mechanical device) for reducing the length of the explosive cartridge while simultaneously expanding the explosive cartridge in radial direction.

**[0041]** The expansion of the explosive cartridge to the diameter of the blast hole may be effected by a mechanical device or by a reaction initiated by a chemical process or using compressed air.

**[0042]** The activation of the expansion mechanism after the insertion of the cartridge in the deepest portion of the blast hole may occur by a mechanism to be activated from outside of or from an upper end of the bore hole (for instance using an igniter wire or a string, using a timing mechanism, by means of a delayed mechanical activation of a contraction spring, or by means of a delayed activated chemical reaction process). Beyond this, embodiments of the invention may also perform a contraction of the explosive cartridge in longitudinal direction by a compressed fluid (like air).

**[0043]** In a lower part of the explosive cartridge, a small hole may be provided in which an electrical, or a non-electrical or an electronic detonator may be inserted.

**[0044]** After charging of one, two or more such expansion cartridges in the deepest portion of a blast hole, a

main mass of explosive charge may be deposited onto this bottom charge.

**[0045]** Embodiments of the invention may allow to fill a bore hole in an improved manner, may allow to design the burden of the blast holes to the limit of the surrounding rock and may further ensure that the drilled bore hole volume is filled substantially entirely with explosive material. Thus, a ratio between a used portion of the bore hole and of the bore hole of almost 100% may be obtained. Embodiments of the invention may contribute to design a drill pattern for blast work with an efficiency which may be increased by 20 to 30 %, or more. Implementing embodiments of the invention may enable to increase the filling degree of the blast holes when charging cartridge explosives from approximately 80% to essentially 100%.

**[0046]** According to an exemplary embodiment of the invention, the expansion of the cartridge may be achieved by a corresponding shortening of the length of the cartridge, thereby engaging the walls of the bore hole by the laterally expanded cartridge and by simultaneously maintaining a high density of the explosive material.

**[0047]** Next, further exemplary embodiments of the explosive cartridge will be explained. However, these embodiments also apply for the method and for the use.

**[0048]** The flexible casing may comprise a plastic, particularly polyethylene, or may comprise a rubber-type material. However, other plastic or non-plastic materials may be used if such a material allows the expansion in a radial and the compression in a longitudinal direction without being destroyed.

**[0049]** The flexible casing may comprise a flexible portion and a rigid portion. The flexible portion may be located adjacent to a bottom of the casing and may be adapted to be positioned in a deepest part of the blast hole. By taking this measure, it may be securely ensured that the deepest portion of the blast hole is really filled up essentially entirely with the expanded cartridge, whereas an upper portion may be free of an expansion or may experience a smaller expansion.

**[0050]** The flexible portion may have a smaller thickness than the rigid portion. By taking one and the same material for the flexible portion and for the rigid portion and by designing the rigid portion from a thicker material (for instance 1 mm) as compared to the flexible portion (for instance 0.5 mm), the different elastic properties may be obtained with low effort.

**[0051]** Additionally or alternatively, the flexible portion may be made of a material being more flexible than a material of which the rigid portion is made. Thus, by selecting the material properties of the rigid portion and of the flexible portion, the elasticity requirements may be met.

**[0052]** In this context, the term "flexible" may particularly denote a portion of the casing having a value of the modules of elasticity which is smaller than a value of the modules of elasticity of a "rigid" portion of the casing.

**[0053]** The mechanism may be adapted in such a man-

ner that the first direction is essentially perpendicular to the second direction. In other words, a lateral expansion may be functionally combined with a longitudinal compression, the longitudinal axis being perpendicular to the lateral direction.

**[0054]** The mechanism may comprise at least one of the group consisting of a mechanical pull mechanism, a mechanical push mechanism, a spring mechanism, a pneumatically activatable mechanism, a chemically activatable mechanism, a magnetically activatable mechanism, and an electrically activatable mechanism. Mechanical, spring-based, pneumatic and chemically activatable embodiments are illustrated in the figures explained below. A magnetically activatable mechanism may comprise, for instance, a permanent magnet and an electromagnet, wherein activation of the electromagnet by applying an appropriate current may generate a magnetic force which generates a repulsive force acting on the permanent magnet, forcing the permanent magnet to be moved in a downward direction. Thus, the contraction in a longitudinal direction may be initiated by such a magnetic trigger. Alternatively, electric forces may be used to initiate the longitudinal compression, for instance using a capacitor. The plates of the capacitor may be charged with electric charges of the same polarity, thereby forcing a lower capacitor plate to go downward under the influence of an electric force, resulting in a compression in the longitudinal direction.

**[0055]** The combined contraction-expansion mechanism may be activated from a remote position. In other words, a human operator standing outside of the bore hole may operate the mechanism of the explosive cartridge even in an operation state in which the explosive cartridge is inserted into a blast hole. This may allow to trigger the mechanism in a wired or wireless manner. A wired triggering may include the transmission of a control signal via a wire, or a direct activation energy. A wireless transmission may include the transmission of electromagnetic waves as a trigger signal for initiating the activation. Thus, the term "remotely" may particularly denote the fact that the mechanism can be activated by a user being positioned far away from the cartridge, since the mechanism does not make it necessary for the user to directly touch or contact the cartridge.

**[0056]** The mechanism may be activatable by a priming wire (an ignition wire), a string, a time switch, a delayed chemical reaction, and a delayed spring mechanism. Also a remote control may be used to trigger the activation from a remote position.

**[0057]** A lowering unit may be provided and may be adapted for lowering the explosive cartridge into the blast hole. This may be performed using strings or the like.

**[0058]** An explosive material may be contained in the casing. For instance, TNT or any other explosive material which may cause a detonation may be contained in the casing. An explosive charge accommodated in the cartridge may also comprises one of or a mixture of nitroglyceral, gun cotton, ammonium nitrate, cellulose and

barium sulphate.

**[0059]** The explosive cartridge may have a density of more than  $1 \text{ g/cm}^3$ , particularly of at least  $1.5 \text{ g/cm}^3$ , more particularly of at least  $2 \text{ g/cm}^3$ . With such density values, it may be ensured that the explosive cartridge sinks in water (having a density of  $1 \text{ g/cm}^3$ ), or even in muddy water which usually have a density of less than  $1.5 \text{ g/cm}^3$ . More generally, the average density of the explosive cartridge may be larger than the density of the surrounding material (usually water and/or muddy water). This may ensure that the explosive cartridge securely sinks to the deepest portion of a blast hole without any external activity. When the explosive cartridge has a density of more than  $1.5 \text{ g/cm}^3$ , it may be guaranteed that the cartridge reliably sinks to a deepest portion of the blast hole, even when the blast hole is at least partially filled with water and/or muddy water.

**[0060]** A bottom portion of the explosive cartridge may comprise a small hole (for instance having a size of 6.9 mm) in which a detonator is inserted. This may allow to start the ignition and the blasting at the lowest portion of the blast hole which allows for an efficient detonation.

**[0061]** The aspects defined above and further aspects of the invention are apparent from the examples of embodiment to be described hereinafter and are explained with reference to these examples of embodiment.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0062]** The invention will be described in more detail hereinafter with reference to examples of embodiment but to which the invention is not limited.

**[0063]** Fig. 1 to Fig. 4 illustrate explosive cartridges according to exemplary embodiments of the invention.

## DESCRIPTION OF EMBODIMENTS

**[0064]** The illustration in the drawing is schematically. In different drawings, similar or identical elements are provided with the same reference signs.

**[0065]** In the following, referring to **Fig. 1**, an explosive cartridge 100 according to an exemplary embodiment of the invention will be explained.

**[0066]** The explosive cartridge 100 is adapted for initiating, contributing or generating an explosion in a blast hole 101, that is to say in a hole extending along an essential longitudinal (for example vertical) direction 102 in a surrounding rock 103 which is indicated schematically in Fig. 1.

**[0067]** The explosive cartridge 100 comprises a flexible casing 104 containing an explosive indicated schematically with reference numeral 105. The flexible casing 104 comprises a plastic foil made of polyethylene.

**[0068]** Furthermore, a mechanism for expanding the casing 104 in a first direction 106 and for simultaneously contracting the casing 104 in a second direction 107 which is oriented essentially perpendicular to the first direction 106 is provided. The mechanism described is ac-

tivable from a remote position, that is to say from a position outside of the blast hole 101.

**[0069]** A bottom portion of the explosive cartridge 100 comprises a small hole in which a detonator 108 is inserted.

**[0070]** According to the embodiment shown in Fig. 1, the activation of the mechanism is performed using a compressed air tube.

**[0071]** As can be taken from Fig. 1, a fixation 109 is shown which allows to fix a compressed air tube which is directed towards the blast hole opening. By taking this measure, an air pressure of 3 bar to 5 bar may be generated.

**[0072]** Furthermore, a chamber 110 is provided into which the compressed air is injected and which forces an injection cartridge 111 to move in a downward direction 107. Reference numeral 111 denotes a double walled injection cartridge which is pressed inside of an expansion cartridge 112. A sliding direction of the injection cartridge 111 is indicated by the reference numeral 107.

**[0073]** Furthermore, a thread guide or a groove guide is indicated with reference numeral 113.

**[0074]** The expansion cartridge 112 is filled with a plastified explosive and is surrounded with a resilient, soft or elastic foil 104.

**[0075]** As indicated in Fig. 1, a diameter of the explosive cartridge 100, d, may be in the order of magnitude of 80 mm, whereas a bore hole diameter, D, may be in the order of magnitude of 100 mm.

**[0076]** In the following, referring to **Fig. 2**, an explosive cartridge 200 according to another exemplary embodiment of the invention will be explained.

**[0077]** The explosive cartridge 200 differs from the explosive cartridge 100 essentially in that, according to Fig. 2, the activation is initiated via a chemical reaction. For this purpose, a fixation 201 for a string for pulling out a cap after expanding the explosive cartridge 200 is provided. Furthermore, a chamber 202 is provided which is filled with two or more (solid, liquid or gaseous) components which generate a gas like carbon dioxide (CO<sub>2</sub>) by a chemical reaction, and move the injection cartridge 111 in a downward direction due to the pressure of the generated gas.

**[0078]** In the following, referring to **Fig. 3**, an explosive cartridge 300 according to another exemplary embodiment of the invention will be explained.

**[0079]** The embodiment of Fig. 3 differs from the embodiment in Fig. 1 essentially with regard to the fact that, according to Fig. 3, the activation is initiated using a mechanical rod.

**[0080]** For this purpose, a fixation 301 for a mechanical member is provided which is guided to an outer bore hole opening and by means of which the injection cartridge 111 may be turned into the expansion cartridge 105.

**[0081]** Next, referring to **Fig. 4**, an explosive cartridge 400 according to another exemplary embodiment of the invention will be explained.

**[0082]** The embodiment of Fig. 4 differs from the embodiment of Fig. 1 essentially in that the activation is performed using a (biased) spring 401. Furthermore, a fixation 402 is provided for fixing two or more strings, one for lowering the explosive cartridge 400 and one for activating the spring 401.

**[0083]** It should be noted that the term "comprising" does not exclude other elements or features and the "a" or "an" does not exclude a plurality. Also elements described in association with different embodiments may be combined.

**[0084]** It should also be noted that reference signs in the claims shall not be construed as limiting the scope of the claims.

## Claims

1. An explosive cartridge (100, 200, 300, 400) for generating an explosion in a blast hole (101), the explosive cartridge (100, 200, 300, 400) comprising:

an at least partially flexible casing (104) for containing an explosive (105);

a mechanism for expanding the casing (104) in a first direction (106) and for simultaneously contracting the casing in a second direction (107) which differs from the first direction (106);

an injection cartridge member (111) and an expansion cartridge member (112);

wherein the expansion cartridge member (112) is filled with the explosive (105) and includes the at least partially flexible casing (104);

wherein the injection cartridge member (111) is pressed inside of the expansion cartridge member (112) filled with the explosive (105);

the mechanism being activatable by inserting the injection cartridge member (111) into the expansion cartridge member (112) in the second direction (107) to thereby expand the at least partially flexible casing (104) of the expansion cartridge member (112) in the first direction (106).

2. The explosive cartridge according to claim 1, wherein the flexible casing (104) comprises a flexible portion and a rigid portion, the flexible portion being arranged adjacent to a bottom of the casing (104) to be positioned in a deepest part of the blast hole (101).

3. The explosive cartridge according to claim 2, wherein the flexible portion of the flexible casing (104) has a smaller thickness than the rigid portion of the flexible casing (104).

4. The explosive cartridge according to claim 2 or 3, wherein the flexible portion of the flexible casing (104) is made of a first material being more flexible

than a second material of which the rigid portion is made, the first material being different from the second material.

5. The explosive cartridge according to any one of claims 1 to 4,  
wherein the mechanism is adapted in such a manner that the first direction (106) is essentially perpendicular to the second direction (107). 5
6. The explosive cartridge according to any one of claims 1 to 5,  
wherein the mechanism comprises at least one of the group consisting of a mechanical pull mechanism, a mechanical push mechanism, a spring mechanism, a pneumatic mechanism, a chemically activatable mechanism, a magnetic mechanism, and an electric mechanism. 10
7. The explosive cartridge according to any one of claims 1 to 6,  
wherein the mechanism is activatable by at least one of the group consisting of an ignition wire, a string, a time switch, a delayed chemical reaction, and a delayed spring mechanism. 15
8. The explosive cartridge according to any one of claims 1 to 7,  
comprising non-loose explosive material contained in the casing (104) in a sealed manner. 20
9. The explosive cartridge according to any one of claims 1 to 8,  
having an average density of more than 1 g/cm<sup>3</sup>, particularly of at least 1,4 g/cm<sup>3</sup>. 25
10. The explosive cartridge according to any one of claims 1 to 9,  
wherein a bottom portion of the explosive cartridge (100, 200, 300, 400) comprises a hole in which a detonator (108) is inserted. 30
11. The explosive cartridge according to any one of claims 1 to 10,  
wherein the at least partially flexible casing (104) defines a sealed space accommodating a fixed amount of the explosive (105). 35
12. The explosive cartridge (100, 200, 300, 400) according to any one of claims 1 to 11, comprising at least one of the following features: 40

the flexible casing (104) comprises at least one of the group consisting of a plastic, polyethylene, and a rubber-type material;  
the mechanism is activatable remotely;  
the explosive cartridge (100, 200, 300, 400) comprises a lowering unit adapted for lowering 45

the explosive cartridge (100, 200, 300, 400) into the blast hole (101);  
the mechanism is at least partially integrated in the casing.

13. A method of installing an explosive cartridge (100, 200, 300, 400) for generating an explosion in a blast hole (101), the method comprising:

inserting the explosive cartridge (100, 200, 300, 400) in the blast hole (101);  
expanding, by a mechanism, an at least partially flexible casing (104) of the explosive cartridge (100, 200, 300, 400) in a first direction (106) and simultaneously contracting the casing (104) in a second direction (107) which differs from the first direction (106);  
providing an injection cartridge member (111) and an expansion cartridge member (112), wherein the expansion cartridge member (112) is filled with the explosive (105) and includes the at least partially flexible casing (104);  
activating the mechanism by inserting the injection cartridge member (111) into the expansion cartridge member (112) in the second direction (107) to thereby expand the at least partially flexible casing (104) of the expansion cartridge member (112) in the first direction (106);  
pressing the injection cartridge member (111) inside of the expansion cartridge member (112) filled with the explosive (105).

14. The method according to claim 13, comprising at least one of the following features:

performing the expanding and the contracting before generating an explosion in the blast hole (101);  
expanding the casing (104) in a direction perpendicular to an extension of the blast hole (101) and simultaneously contracting the casing (104) in a direction parallel to the extension of the blast hole (101).

15. A method of using an explosive cartridge according to any one of claims 1 to 12 in the field of material fragmentation.

## Patentansprüche

1. Sprengstoff-Patrone (100, 200, 300, 400) zum Generieren einer Sprengung in einem Sprengloch (101), wobei die Sprengstoff-Patrone (100, 200, 300, 400) aufweist:

ein zumindest teilweise flexibles Gehäuse (104) zum Aufnehmen eines Sprengstoffs (105);

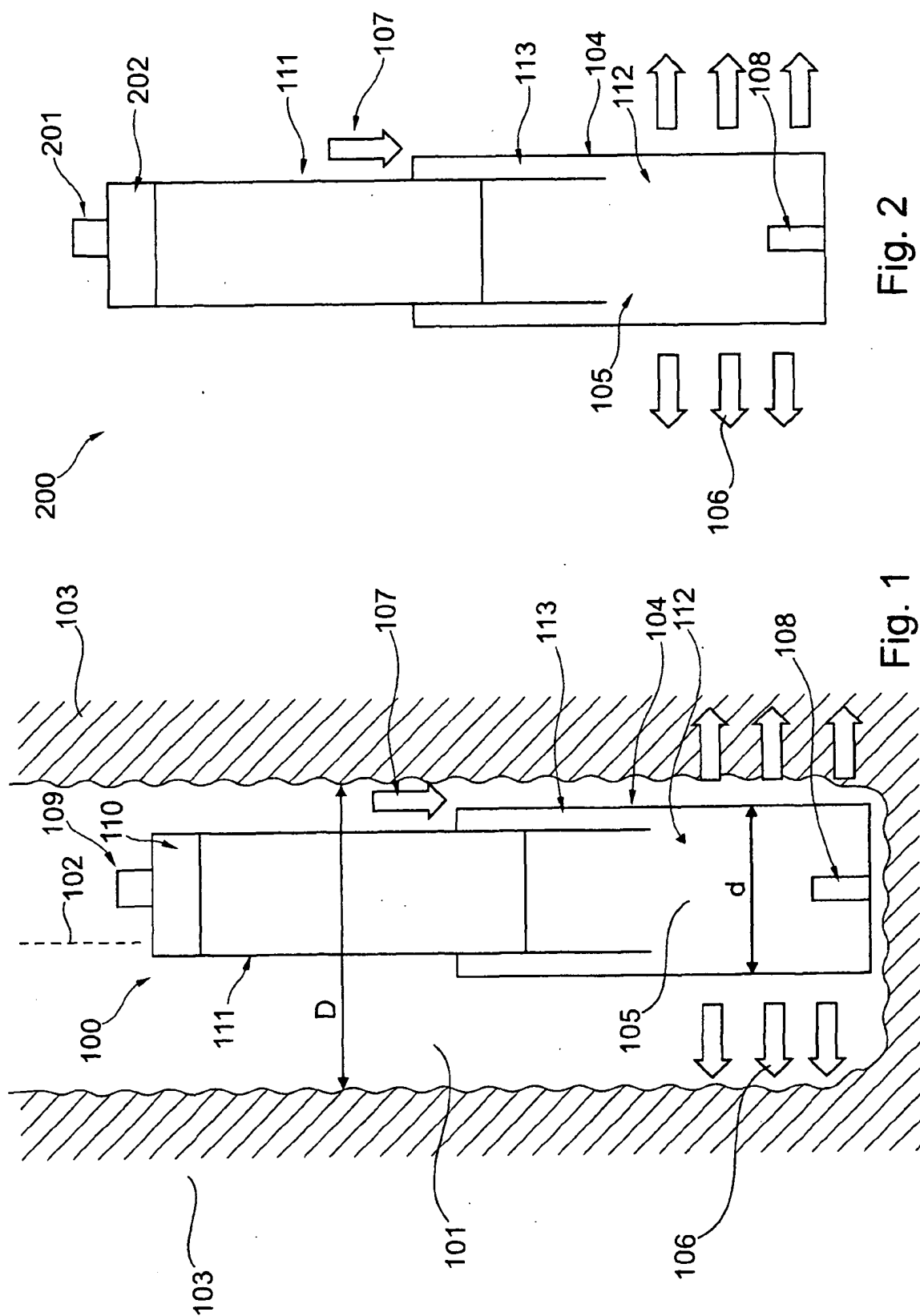
- einen Mechanismus zum Expandieren des Gehäuses (104) in einer ersten Richtung (106) und zum gleichzeitigen Kontrahieren des Gehäuses in einer zweiten Richtung (107), welche von der ersten Richtung (106) verschieden ist;  
ein Injektions-Patronenelement (111) und ein Expansions-Patronenelement (112);  
wobei das Expansions-Patronenelement (112) mit dem Sprengstoff (105) gefüllt ist und das zumindest teilweise flexible Gehäuse (104) beinhaltet;  
wobei das Injektions-Patronenelement (111) innerhalb des mit dem Sprengstoff (105) gefüllten Expansions-Patronenelement (112) gepresst ist;  
der Mechanismus, welcher aktivierbar ist mittels in der zweiten Richtung (107) Einbringens des Injektions-Patronenelements (111) in das Expansions-Patronenelement (112), um dadurch das zumindest teilweise flexible Gehäuse (104) des Expansions-Patronenelements (112) in der ersten Richtung (106) zu expandieren.
2. Sprengstoff-Patrone gemäß Anspruch 1, wobei das flexible Gehäuse (104) einen flexiblen Abschnitt und einen starren Abschnitt aufweist, wobei der flexible Abschnitt benachbart einem Boden des Gehäuses (104) angeordnet ist, welcher in einem tiefsten Teil des Sprenglochs (101) zu positionieren ist.
  3. Sprengstoff-Patrone gemäß Anspruch 2, wobei der flexible Abschnitt des flexiblen Gehäuses (104) eine kleinere Dicke als der starre Abschnitt des flexiblen Gehäuses (104) hat.
  4. Sprengstoff-Patrone gemäß den Ansprüchen 2 oder 3, wobei der flexible Abschnitt des flexiblen Gehäuses (104) aus einem ersten Material hergestellt ist, welches flexibler als ein zweites Material ist, aus welchem der starre Abschnitt hergestellt ist, wobei das erste Material verschieden von dem zweiten Material ist.
  5. Sprengstoff-Patrone gemäß einem der Ansprüche 1 bis 4, wobei der Mechanismus in einer Art und Weise eingerichtet ist, dass die erste Richtung (106) im Wesentlichen senkrecht zu der zweiten Richtung (107) ist.
  6. Sprengstoff-Patrone gemäß einem der Ansprüche 1 bis 5, wobei der Mechanismus zumindest einen von der Gruppe bestehend aus einem mechanischen Zug-Mechanismus, einem mechanischen Drück-Mechanismus, einem Federmechanismus, einem pneumatischen Mechanismus, einem chemisch aktivierbaren Mechanismus, einem magnetischen Mechanismus und einem elektrischen Mechanismus aufweist.
  7. Sprengstoff-Patrone gemäß einem der Ansprüche 1 bis 6, wobei der Mechanismus mittels zumindest einem von der Gruppe bestehend aus einem Zünddraht, einer Schnur, einem Zeitschalter, einer verzögerten chemischen Reaktion und einem verzögerten Federmechanismus aktivierbar ist.
  8. Sprengstoff-Patrone gemäß einem der Ansprüche 1 bis 7, welche ein nicht-loses Sprengstoff Material, welches in dem Gehäuse (104) in einer abgedichteten Art und Weise aufgenommen ist, aufweist.
  9. Sprengstoff-Patrone gemäß einem der Ansprüche 1 bis 8, welche eine mittlere Dichte von mehr als 1 g/cm<sup>3</sup>, insbesondere von zumindest 1,4 g/cm<sup>3</sup> hat.
  10. Sprengstoff-Patrone gemäß einem der Ansprüche 1 bis 9, wobei ein Boden-Abschnitt der Sprengstoff-Patrone (100, 200, 300, 400) ein Loch, in welchem ein Detonator (108) eingebracht ist, aufweist.
  11. Sprengstoff-Patrone gemäß einem der Ansprüche 1 bis 10, wobei das zumindest teilweise flexible Gehäuse (104) einen abgedichteten Raum, welche eine fixe Menge des Sprengstoffs (105) aufnimmt, definiert.
  12. Sprengstoff-Patrone (100, 200, 300, 400) gemäß einem der Ansprüche 1 bis 11, welche zumindest eines der folgenden Merkmale aufweist:
    - das flexible Gehäuse (104) weist zumindest eines der Gruppe bestehend aus einem Kunststoff, Polyethylen und einem gummiartigen Material auf;
    - der Mechanismus ist fern-aktivierbar;
    - die Sprengstoff-Patrone (100, 200, 300, 400) weist eine Absenk-Einheit auf, welche adaptiert ist zum Absenken der Sprengstoff-Patrone (100, 200, 300, 400) in das Sprengloch (101);
    - der Mechanismus ist zumindest teilweise in das Gehäuse integriert.
  13. Verfahren zum Installieren einer Sprengstoff-Patrone (100, 200, 300, 400) zum Generieren einer Sprengung in einem Sprengloch (101), wobei das Verfahren aufweist:
    - Einbringen der Sprengstoff-Patrone (100, 200, 300, 400) in das Sprengloch (101);

- Expandieren, mittels eines Mechanismus, eines zumindest teilweise flexiblen Gehäuses (104) der Sprengstoff-Patrone (100, 200, 300, 400) in eine erste Richtung (106) und gleichzeitiges Kontrahieren des Gehäuses (104) in eine zweite Richtung (107), welche von der ersten Richtung (106) verschieden ist;
- Bereitstellen eines Injektions-Patronenelements (111) und eines Expansionspatronenelements (112), wobei das Expansions-Patronenelement (112) mit dem Sprengstoff (105) gefüllt ist und das zumindest teilweise flexible Gehäuse (104) beinhaltet;
- Aktivieren des Mechanismus mittels Einbringens des Injektions-Patronenelements (111) in das Expansions-Patronenelement (112) in einer zweiten Richtung (107), um dadurch das zumindest teilweise flexible Gehäuse (104) des Expansions-Patronenelements (112) die erste Richtung (106) zu expandieren;
- Pressen des Injektions-Patronenelements (111) innerhalb das mit dem Sprengstoff (105) gefüllte Expansionspatronen-Element (112).
14. Verfahren gemäß Anspruch 13, welches zumindest eines der folgenden Merkmale aufweist:
- Ausführen des Expandierens und des Kontrahierens bevor eine Sprengung in dem Sprengloch (101) generiert wird;
- Expandieren des Gehäuses (101) in eine Richtung senkrecht zu einer Erstreckung des Sprenglochs (101) und gleichzeitiges Kontrahieren des Gehäuses (104) in einer Richtung parallel zu der Erstreckung des Sprenglochs (101).
15. Verfahren zum Verwenden einer Sprengstoff-Patrone gemäß einem der Ansprüche 1 bis 12 im Bereich der Materialfragmentation.

## Revendications

1. Cartouche explosive (100, 200, 300, 400) permettant de générer une explosion dans un trou de mine (101), la cartouche explosive (100, 200, 300, 400) comprenant :
  - une douille au moins partiellement flexible (104) pour contenir un explosif (105);
  - un mécanisme permettant de dilater la douille (104) dans une première direction (106) et de contracter simultanément la douille dans une seconde direction (107) qui est différente de la première direction (106) ;
  - un organe de cartouche d'injection (111) et un organe de cartouche de dilatation (112) ;
2. Cartouche explosive selon la revendication 1, dans laquelle la douille flexible (104) comprend une portion flexible et une portion rigide, la portion flexible étant agencée de manière adjacente à un fond de la douille (104) devant être positionné dans une partie la plus profonde du trou de mine (101).
3. Cartouche explosive selon la revendication 2, dans laquelle la portion flexible de la douille flexible (104) a une épaisseur inférieure à la portion rigide de la douille flexible (104).
4. Cartouche explosive selon la revendication 2 ou 3, dans laquelle la portion flexible de la douille flexible (104) est constituée d'un premier matériau plus flexible qu'un second matériau dont la portion rigide est constituée, le premier matériau étant différent du second matériau.
5. Cartouche explosive selon l'une quelconque des revendications 1 à 4, dans laquelle le mécanisme est adapté de telle sorte que la première direction (106) est essentiellement perpendiculaire à la seconde direction (107).
6. Cartouche explosive selon l'une quelconque des revendications 1 à 5, dans laquelle le mécanisme comprend au moins un élément du groupe consistant en un mécanisme de traction mécanique, un mécanisme de poussée mécanique, un mécanisme de ressort, un mécanisme pneumatique, un mécanisme chimiquement activable, un mécanisme magnétique, et un mécanisme électrique.
7. Cartouche explosive selon l'une quelconque des revendications 1 à 6, dans laquelle le mécanisme peut être activé par au moins un élément du groupe consistant en un fil d'allumage, une corde, une minuterie, une réaction chimique retardée, et un mécanisme à ressort retardé.
8. Cartouche explosive selon l'une quelconque des re-

- vendications 1 à 7,  
comprenant le matériau explosif non libre contenu  
dans la douille (104) de façon étanche.
9. Cartouche explosive selon l'une quelconque des re- 5  
vendications 1 à 8,  
ayant une masse volumique moyenne de plus de 1  
g/cm<sup>3</sup>, en particulier d'au moins 1,4 g/cm<sup>3</sup>.
10. Cartouche explosive selon l'une quelconque des re- 10  
vendications 1 à 9,  
dans laquelle une portion de fond de la cartouche  
explosive (100, 200, 300, 400) comprend un trou  
dans lequel un détonateur (108) est inséré. 15
11. Cartouche explosive selon l'une quelconque des re-  
vendications 1 à 10, dans laquelle la douille au moins  
partiellement flexible (104) définit un espace étan-  
che logeant une quantité fixe de l'explosif (105). 20
12. Cartouche explosive (100, 200, 300, 400) selon l'une  
quelconque des revendications 1 à 11, comprenant  
au moins une des caractéristiques suivantes :
- la douille flexible (104) comprend au moins un 25  
élément d'un groupe consistant en le plastique,  
le poly(éthylène) et un matériau de type caout-  
chouc;  
le mécanisme est activable à distance ;  
la cartouche explosive (100, 200, 300, 400) 30  
comprend une unité d'abaissement adaptée  
pour abaisser la cartouche explosive (100, 200,  
300, 400) dans le trou de mine (101) ;  
le mécanisme est au moins partiellement intégré  
dans la douille. 35
13. Procédé d'installation d'une cartouche explosive  
(100, 200, 300, 400) permettant de générer une ex-  
plosion dans un trou de mine (101), le procédé con-  
sistant à : 40
- insérer la cartouche explosive (100, 200, 300,  
400) dans le trou de mine (101);  
dilater, par un mécanisme, une douille au moins  
partiellement flexible (104) de la cartouche ex- 45  
plosive (100, 200, 300, 400) dans une première  
direction (106) et contracter simultanément la  
douille (104) dans une seconde direction (107)  
qui est différente de la première direction (106) ;  
fournir un organe de cartouche d'injection (111) 50  
et un organe de cartouche de dilatation (112),  
dans lequel l'organe de cartouche de dilatation  
(112) est rempli de l'explosif (105) et comprend  
la douille au moins partiellement flexible (104) ;  
activer le mécanisme en insérant l'organe de 55  
cartouche d'injection (111) dans l'organe de car-  
touche de dilatation (112) dans la seconde di-  
rection (107) afin de dilater ainsi la douille au
- moins partiellement flexible (104) de l'organe de  
cartouche de dilatation (112) dans la première  
direction (106) ;  
presser l'organe de cartouche d'injection (111)  
à l'intérieur de l'organe de cartouche de dilata-  
tion (112) rempli de l'explosif (105).
14. Procédé selon la revendication 13, comprenant au  
moins l'une des caractéristiques suivantes :
- la réalisation de la dilatation et de la contraction  
avant la génération de l'explosion dans le trou  
de mine (101) ;  
la dilatation de la douille (104) dans une direction  
perpendiculaire à un allongement du trou de mi-  
ne (101) et la contraction simultanée de la  
douille (104) dans une direction parallèle à l'al-  
longement du trou de mine (101).
15. Procédé d'utilisation d'une cartouche explosive se-  
lon l'une quelconque des revendications 1 à 12 dans  
le domaine de la fragmentation de matériau.



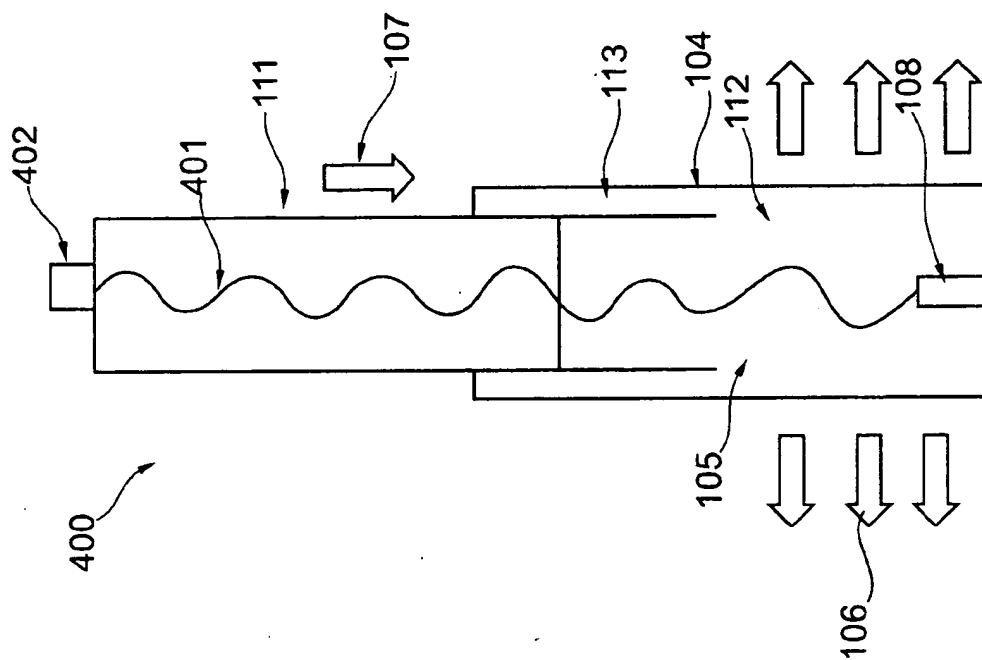


Fig. 4

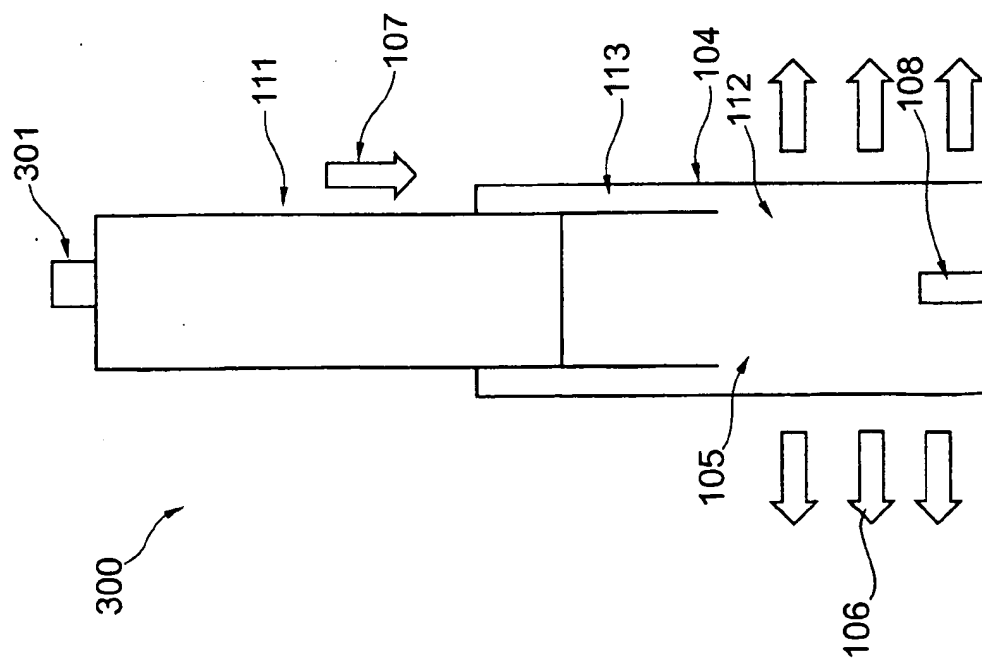


Fig. 3

**REFERENCES CITED IN THE DESCRIPTION**

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