



(51) International Patent Classification:

E21B 44/00 (2006.01) *E21D 9/00* (2006.01)
E21B 7/02 (2006.01)

(21) International Application Number:

PCT/SE2016/050929

(22) International Filing Date:

29 September 2016 (29.09.2016)

(25) Filing Language:

Swedish

(26) Publication Language:

English

(30) Priority Data:

1551253-6 30 September 2015 (30.09.2015)

SE

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(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, DJ, 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, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, 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))

(54) Title: SYSTEM AND METHOD FOR DRILLING PLAN GENERATION

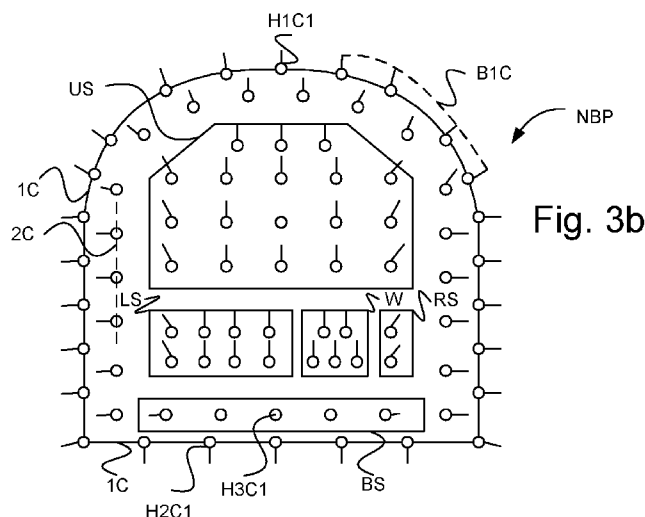


Fig. 3b

(57) Abstract: The invention relates to a method for drilling plan generation where a drilling plan is specifying a number of drilling holes having a starting point and an end point, which drilling holes are distributed within specified sectors of the drilling plan, which sectors comprise a first sector (W) specifying a so called wedge and at least one second sector (LS; RS; US; BS) adjacent to said first sector, comprising the steps of: - on the basis of an existing drilling plan (PBP), automatically generating a new drilling plan (NBP) where said first sector (W) is positioned in a new position compared to said existing drilling plan (PBP); and - adapting dimensions and position of said at least one second sector (LS; RS; US; BS) to said new position of said first sector in said new drilling plan (NBP). The invention also relates to a computer program product comprising program code (P) for a computer (200; 210) for implementing a method for drilling plan generation according to the invention. The invention also relates to a system and a drilling rig (100) being equipped with the system.

SYSTEM AND METHOD FOR DRILLING PLAN GENERATION

TECHNICAL FIELD

The present invention relates to a method for drilling plan generation. The invention also relates to a computer program product comprising program code for a computer for implementing a method according to the invention. The invention also relates to a system and a drilling rig being equipped with the system.

BACKGROUND

Electronic drilling plans are today used in for example the mining industry. These drilling plans are used as instructions and means for per segment drilling a number of holes in the body which is to be blasted and emptied on material. Said drilling plans comprise information about for example where starting points and end points are positioned and which diameter each said drilling hole shall present. Hereby such start points for drilling holes and direction, length and diameter of each drilling hole are specified. Hereby is also presented the distribution of said drilling holes in said body. An operator of a drilling rig may hereby use a sequence of different predetermined drilling plans so as to subsequently drill a number of predefined holes for blasting, whereby a desired tunnel or drift may be created in for example a mountain or a mine.

Said electronic drilling plans are today developed in advance at for example a planning centre, whereby said drilling plans are stored on a portable memory and brought by the operator to the drilling rig which is to be used for drilling. Thereafter said electronic drilling plans are loaded into a computer arranged at the drilling rig for use during operation of the drilling rig.

A drilling plan may be presented in two or three dimensions on a presentation screen of said computer. The drilling plan may comprise a number of different sectors which may be presented as a surface in two dimensions or as a volume in three dimensions. One such sector is denoted wedge. A number of adjacent sectors are also specified. Other sectors in the drilling plan are denoted stopes. A common set of stopes of a drilling plan defines a left and right stope, which are positioned to the left and right of said wedge, respectively. Further, a sector positioned adjacently above said left stope, wedge and right stope usually is denoted upper stope. In a similar way a sector beneath said left stope, wedge and right stope is denoted lower stope. Said four sectors may be surrounded by a so called inner contour and an outer contour. Said outer contour is defining an outermost boundary for

starting points of drilling holes. A part of said outer contour may be denoted bottom row, defining a lowest boundary, i. e. corresponding to the ground.

5 After drilling holes have been drilled in accordance with a provided drilling plan these are filled with explosives, whereby a suitable blast is performed. Typically sections are blasted in a sequence regarding said sectors and contours, where said wedge is blasted first, thereafter side stopes, upper wedge and lower wedge are blasted. Said inner and outer contour are blasted in a suitable way.

10 These drilling plans are today static and do not allow for an operator to adapt the same to prevailing circumstances, paying regard to for example characteristics, such as cracks of the material in the body of the section to be drilled and blasted. Hereby it may be necessary to develop a new drilling plan at said planning centre, which leads to undesired delays of the drilling procedure, which delays are associated with high costs.

15 SUMMARY OF THE INVENTION

There is thus a need to, in a reliable and user-friendly way, adapt existing drilling plans for a drilling rig. There is hereby a need to, in a time-effective and user-friendly way, allow adaption of existing drilling plans for a drilling rig on site of said drilling rig in connection with the operation thereof.

20 An object of the present invention is to provide a new and advantageous method for drilling plan generation.

Another object of the invention is to provide a new and advantageous system for drilling plan generation and a new and advantageous computer program for drilling plan generation.

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Another object of the invention is to provide an alternative method for drilling plan generation, an alternative system for drilling plan generation and an alternative computer program for drilling plan generation of a drilling rig.

Yet another object on the invention is to provide a method, a system and a computer program for flexible drilling plan generation wherein a new drilling plan may be generated, which new drilling plan hereby may be adapted to existing circumstances during operation of a drilling rig.

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Another object of the invention is to provide a method, a system and a computer program for drilling plan generation so as to achieve a more time-effective, and hereby cost-effective, operation of a drilling rig.

- 10 Some of said objects are achieved with a method for drilling plan generation according to claim 1. Other objects are achieved by a system for drilling plan generation according claim 6. Advantageous embodiments are specified in the depended claims.

According to an aspect of the present invention there is provided a method for drilling plan
15 generation where a drilling plan is specifying a number of drilling holes having a starting point and an end point, which drilling holes are distributed within sectors specified in the drilling plan, which sectors comprise a first sector specifying a so called wedge and at least one second sector adjacent to said first sector, comprising the steps of:

- on the basis of an existing drilling plan, automatically generating a new drilling plan where said first
20 sector is positioned in a new position compared to said existing drilling plan;
- determining rules specifying drilling holes of said existing drilling plan; and
- applying the thus determined rules in said new drilling plan and adapting dimensions and position of said at least one second sector to said new position of said first sector in said new drilling plan.

25 Said existing drilling plan and said new drilling plan are electronic drilling plans. Said existing drilling plan is an in advanced specified drilling plan. Said new drilling plan may be generated on site for drilling of a drilling rig. By allowing generation of said new drilling plan on site for drilling an operator of the drilling rig may adapt positioning of said first sector to prevailing circumstances. Hereby

position of a wedge of said existing drilling plan may be changed, wherein an adaptation of said at least one second sector may be performed dynamically in dependence thereof.

Advantageously, an operator may hereby, by means of for example a presentation screen where said
5 existing drilling plan is presented, change position, and potentially dimensions, of said first sector in a desired way, whereby a new drilling plan automatically may be generated where adaptations are performed in relation to said changed position. It may be desired to change position of said first sector of the existing drilling plan considering cracks of the body where drills are to be positioned to start a hole. It may also be desired to change position of said first sector of the existing drilling plan
10 when the surface of the body where drills are to be positioned to start a hole is presenting a non-favourable surface structure which make starting a hole and initial drilling more difficult. It may be desired to change position of said first sector of the existing drilling plan when an operator wishes to alternate the position of the wedge horizontally for successive segments of the body, corresponding to successive drilling plans. Hereby, a more advantageous position of said wedge in successive drilling
15 plans may be achieved in a time-effective and user-friendly manner.

Hereby, an operator may for various reasons decide to change position of said first sector of the existing drilling plan so as to adapt the same to prevailing circumstances. Hereby, a flexible method for generation of drilling plans according to the invention is provided.

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Hereby, a suitable adaptation of positioning and orientating of drilling holes in said new drilling plan may be determined in a time-effective and user-friendly manner. According to an embodiment drilling holes of different sectors in the original drilling plan may be specified according to unique rules for each sector. By automatically determining which rules are valid for said at least one second
25 sector these rules may be applied and implemented on a corresponding sector in the new drilling plan. Said rules may for example relate to desired row distances (burden) and hole distances as well as which dimension drilling holes within said sector shall have. It should be noted that rows of holes do not necessarily need to be horizontal and vertical even if this is often the case. Determination of said rules may be initiated manually by an operator of a drilling rig where said new drilling plan is
30 generated. Hereby predetermined rules may be used for adaptation of a drilling plan to prevailing circumstances on site for drilling.

The method may comprise the steps of:

- specifying said existing drilling plan in such a way that it comprises said first sector and four more sectors, comprising a sector on each side of said first sector and an upper sector, positioned above said first sector and the sectors on each side of said first sector, and a lower sector positioned under said first sector and the sectors on each side of said first sector; and
- in said existing drilling plan, specifying said sectors within the frame of an outer contour;
- specifying said new drilling plan in a corresponding way.

Hereby an existing drilling plan may be used as basis for specifying a new drilling plan, which is both time-effective and user-friendly.

The method may comprise the steps of:

- specifying said new drilling plan in such a way that said first sector is moved horizontally to the right or to the left;
- adapting dimensions and positions of sectors on each side of the new position of said first sector.

Hereby a user-friendly, flexible and automatic generation of the new drilling plan is achieved. If said first sector is moved horizontally to the right or to the left only the dimensions and positions of the sectors on each side of the new position of said first sector are affected. This means that dimensions and position of a provided upper stope and the dimensions and position of a lower stope do not need to be affected by such a movement. Hereby a method for generating a new drilling plan which is not associated with a heavy computational burden is achieved.

The method may comprise the steps of:

- specifying said new drilling plan in such a way that said first sector is moved vertically in a direction upwards or downwards;
- adapting dimensions of and positions of all sectors surrounding said first sector and its new position.

Hereby a user-friendly, flexible and automatic generation of the new drilling plan is achieved. If said first sector is moved vertically upwards or downwards the dimensions and positions of sectors adjacent to the new position of said first sector may be affected. This means that the dimensions and positions of the provided upper and lower stopes as well as dimensions and positions of said side stopes may be affected by such a move. Hereby a flexible and user-friendly method according to an aspect of the present invention is provided.

It should be noted that the first sector of the existing drilling plan may be moved both horizontally and vertically, i. e. diagonally. During a diagonal movement dimensions and positions of a provided upper and lower stope and dimensions and positions of said side stopes may be affected. Hereby a flexible and user-friendly method according to an aspect of the present invention is provided.

The method may comprise the steps of:

- on the basis of said existing drilling plan, generating said new drilling plan wherein said first sector has new dimensions compared to said existing drilling plan; and

- adapting dimensions and position of said at least one second sector to the new dimensions of said first sector in said new drilling plan.

According to an embodiment dimensions of said first sector may be changed, i.e. the size of the first sector represented in two dimensions may be made larger or smaller. Hereby, the rules which have been determined for drilling holes of the first sector in the existing drilling plan may be used for generating a new set of drilling holes for the first sector in the new drilling plan. Hereby the number of drilling holes associated with the first sector which has been changed in size in the new drilling plan may be larger or smaller. A flexible method according to an embodiment of the invention is hereby achieved. Sectors defining adjacent stopes in the new drilling plan may hereby be adapted dynamically to the new dimensions and position of the first sector.

According to an embodiment a wedge being defined of a first sector in the existing drilling plan may be replaced by another wedge, which hereby may have a different size than the wedge in the existing drilling plan. This new wedge, and hereto associated rules for drilling holes, may hereby be introduced in new drilling plan, whereby adaptation of positions and dimensions of the other sectors of the new drilling plan may be performed automatically. This new wedge may have predetermined dimensions and a predetermined drilling hole distribution, where the new wedge thus may be based

on predetermined rules. Alternatively, rules for a new wedge may be determined and applied on site at the drilling rig.

According to an aspect of the present invention there is provided a method for drilling plan

5 generation where a drilling plan is specifying a number of drilling holes having starting points and end points, which drilling holes are distributed within sectors specified in the drilling plan, which sectors comprise a first sector specifying a so called wedge and at least one second sector adjacent said first sector. The method comprises the steps of:

- 10 - on the basis of an existing drilling plan, generating a new drilling plan where said first sector is positioned in a new position compared to said existing drilling plan; and
- adapting dimensions and position of said at least one second sector to said new position of said first sector in said new drilling plan.

The method may comprise the steps of:

- 15 - determining rules specifying drilling holes of said existing drilling plan; and
- applying the thus determined rules in said new drilling plan.

According to an aspect of the present invention there is provided a system for drilling plan generation, wherein a drilling plan is specifying a number of drilling holes having starting points and
20 end points, which drilling holes are distributed within sectors specified in said drilling plan, which sectors comprise a first sector specifying a so called wedge and at least one second sector adjacent said first sector, comprising:

- means arranged to, on the basis of an existing drilling plan, automatically generate a new drilling plan where said first sector is positioned in a new position compared to said existing drilling plan;
- 25 - means arranged to determine rules specifying drilling holes of said existing drilling plan;
- means arranged to apply the thus determined rules in said new drilling plan; and
- means arranged to adapt dimensions and position of said at least one second sector to the new position of said first sector in said new drilling plan.

According to an aspect of the present invention there is provided a system for drilling plan generation, wherein a drilling plan is specifying a number of drilling holes with starting points and end points, which drilling holes are distributed within sectors specified in the drilling plan, which sectors comprise a first sector specifying a so called wedge and at least one second sector adjacent said first sector, comprising:

- means arranged to, on the basis of an existing drilling plan, generate a new drilling plan wherein said first sector is positioned in a new position compared to said existing drilling plan; and
- means arranged to adapt the dimensions and position of said at least one second sector to the new position of said first sector in said new drilling plan.

Said means for generating a new drilling plan may be denoted first drilling plan generating means.

Said means for adapting dimensions and position may be denoted first adaptation means.

The system may comprise:

- means arranged to determine rules specifying drilling holes of said existing drilling plan; and
- means arranged to apply the thus determined rules in said new drilling plan.

Said means for determining rules may be denoted rule determining means.

Said means for applying the thus determined rules may be denoted rule application means.

The system may comprise:

- means arranged to specify said existing drilling plan in such a way that it comprises said first sector and four additional sectors, comprising a sector on each side of said first sector and an upper sector, positioned above the first sector and the sectors on each side on said first sector, and a lower sector

positioned under said first sector and a sector on each side of said first sector, which means may be denoted first specifying means;

- means arranged to, in said existing drilling plan, specify said sectors within the frame of an outer contour, which means may be denoted second specifying means; and

- 5 - means arranged to specify said new drilling plan in a corresponding way, which means may be denoted third specifying means.

The system may comprise:

- 10 - means arranged to specify said new drilling plan in such a way that said first sector is moved horizontally to the right or to the left, which means may be denoted fourth specifying means; and
- means arranged to adapt dimensions and positions of the sectors on each side of the new position of said first sector, which means may be denoted second adaptation means.

The system may comprise:

- 15 - means arranged to specify said new drilling plan in such a way that said first sector is moved vertically upwards or downwards, which means may be denoted fifth specifying means; and
- means arranged to adapt dimensions and positions of all sectors surrounding said first sector and its new position, which means may be denoted third adaptation means.

- 20 The system may comprise:

- means arranged to, on the basis of said existing drilling plan, generate said new drilling plan where said first sector has new dimensions compared to said existing drilling plan, which means may be denoted second drilling plan generation means; and
- means arranged to adapt dimensions and position of said at least one second sector to the new dimensions of said first sector in said new drilling plan, which means may be denoted fourth adaptation means.
- 25

According to an aspect of the present invention there is provided a drilling rig comprising a system for drilling plan generation according to what is disclosed herein.

5 According to an aspect of the present invention there is provided a drilling rig comprising a system for drilling plan generation according to what is disclosed herein.

Said drilling rig may also be denoted drifting configuration or drifting drilling rig.

10 According to an aspect of the present invention there is provided a computer program for drilling plan generation, wherein said computer program comprises program code for causing an electronic control unit or another computer connected to the electronic control unit to perform the steps according to anyone of the claims 1-5.

15 According to an aspect of the present invention there is provided a computer program for drilling plan generation, wherein said computer program comprises program code for causing an electronic control unit or another computer connected to the electronic control unit to perform the steps according to anyone of the claims 1-5, when said program code is run on said control unit or said computer.

20 According to an aspect of the present invention there is provided a computer program for drilling plan generation, wherein said computer program comprises program code stored on a, by a computer readable, medium for causing an electronic control unit or another computer connected to the electronic control unit to perform the steps according to anyone of the claims 1-5.

25 According to an aspect of the present invention there is provided a computer program for drilling plan generation, wherein said computer program comprises program code stored on a, by a computer readable, medium for causing an electronic control unit or another computer connected to the electronic control unit to perform any of the steps according to anyone of the claims 1-5, when said program code is run on said control unit or said computer.

According to an aspect of the present invention there is provided a computer program product comprising a program code stored on a, by a computer readable, medium for performing the method steps according to anyone of claims 1-5, when said computer program is run on an electronic control unit or another computer connected to the electronic control unit.

According to an aspect of the present invention there is provided a computer program product comprising a program code non-volatile stored on a, by a computer readable, medium for performing the method steps according to anyone of claims 1-5, when said program code is run on an electronic control unit or another computer connected to the electronic control unit.

Further objects, advantages and novel features of the present invention will become apparent to one skilled in the art from the following details, and also by putting the invention into practice. Whereas the invention is described below, it should be noted that it is not restricted to the specific details described. One skilled in the art having access to the teachings herein will recognise further applications, modifications and incorporations in other fields, which are within the scope of the invention.

BREIF DESRIPTION OF THE DRAWINGS

For fuller understanding of the present invention and further objects and advantages of it, the detailed description should be read together with the accompanying drawings, in which the same reference notation denote similar items in the various diagrams, and in which:

Figure 1 schematically illustrates a drilling rig, according to an embodiment on the invention;

Figure 2 schematically illustrates a system of the drilling rig presented in Figure 1, according to an embodiment of the invention;

Figure 3a schematically illustrates an existing drilling plan;

Figure 3b schematically illustrates a changed drilling plan, according to an aspect of the invention;

Figure 3c schematically illustrates a changed drilling plan, according to an aspect of the invention;

Figure 3d schematically illustrates a changed drilling plan, in according to an aspect of the invention;

Figure 3e schematically illustrates a side view of a drilling plan;

Figure 4a schematically illustrates a flowchart of a method, according to an embodiment of the invention;

- 5 Figure 4b in greater detail schematically illustrates a flowchart of a method, according to an embodiment of the invention; and

Figure 5 schematically illustrates a computer, according to an embodiment of the invention.

DETAILED DESCRIPTION OF THE DRAWINGS

- 10 With reference to Figure 1 there is illustrated a side view of a drilling rig 100. The illustrated drilling rig 100 may be a so called drifting configuration or drifting drilling rig. The drilling rig 100 is arranged with a number of arms. According to the presented embodiment said drilling rig is arranged with three arms, namely a first arm 110a, a second arm 110b and a third arm 110c, which are arranged to hold a respective drilling arrangement comprising a drilling machine and a thereto associated feeder
- 15 arrangement. It should be noted that said drilling rig 100 may be equipped with an arbitrary number of arms having a drilling arrangement, for example one, two, three or four arms. Said drilling arrangements may be arranged to drill holes with a determined length, for example two, five or ten meters. Said holes may be intended to in a suitable way at least partially be filled with explosives for mining of desired determined drifts.

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The drilling rig 100 may be arranged for operation in a tunnel under ground or in mountains. Said arms and drilling arrangements may according to an example be operated substantially independently of each other. Operation of said drilling rig 100 may be performed manually by an operator. Operation of said drilling rig 100 may according to an embodiment be performed

25 automatically or semi-automatically.

Herein the term "link" refers to a communications link which may be a physical wire, such as an opto-electronic communication wire, or a non-physical wire, such as a wireless connection, such as a radio link or microwave link.

With reference to Figure 2 there is presented a system 299 for drilling plan generation at the drilling rig 100. The system 299 is arranged at the drilling rig 100. The system 299 may hereby constitute a part of the herein inventive system for drilling plan generation in accordance with an aspect of the present invention. The system 299 comprises a first control unit 200. One example embodiment is disclosed with reference to Figure 5.

A sensor configuration 220 is arranged for communication with the first control unit 200 via a link 220. Said sensor configuration 220 may comprise a number of different sensors, which are required for operating said drilling rig 100. Said sensor configuration 220 may for example comprise distance readers for determining distances between said drilling arrangements and the body which is to be drilled in. Said distance readers may for example comprise laser devices for measuring relevant distances for manoeuvring said arms of said drilling rig and/or said drilling arrangements. Said sensor configuration 220 may also comprise position determining means for determining positions regarding said drilling rig 100. Said sensor configuration 220 is arranged to continuously or intermittently send signals S200 comprising relevant and detected information to the first control unit 200 via said link L220. Hereby the first control unit 200 is arranged to use said received information for operating said drilling rig 100.

Manoeuvre means 230 is arranged for communication with said first control unit 200 via a link L230. An operator can hereby control operation of said drilling rig 100 by means of said manoeuvre means 230. Said manoeuvre means 230 may for example comprise at least one of control sticks (for example a so called joystick), buttons, handles, steering wheel, paddles, accelerator pedal, breaking pedal, transmission control devices, etc. Hereby said operator of the drilling rig 100 may manoeuvre, propel, operate and control said drilling rig 100 in a desired way. Hereby said operator for example may position, direct and operate said arms 110, 110b, 110c, drilling arrangements and feeder devices of said drilling rig 100. Hereby said manoeuvre means 230 is arranged to send control signals S230 to different systems of said drilling rig 100 for operator requested affection of said system, for example hydraulic systems for said feeder devices.

Presentation means 240 is arranged for communication with said first control unit 200 via a link L240. Said presentation means 240 may comprise a presentation screen. Said presentation means 240 may according to an embodiment comprise a touch screen. Said presentation means 240 is arranged to present information for said operator for allowing adequate operation of said drilling rig 100. For example information relevant for positioning and orientation of said drilling arrangements may be presented. An operator may by suitable means, for example a so called mouse or by means of the screen as such, choose different views. Hereby said presentation means 240 is arranged to present information regarding for example the different drilling arrangements of the drilling rig 100, for example drilled length for a certain drilling arrangement, rotational speed of said drilling arrangement, etc.

Said first control unit 200 is arranged to present a drilling plan by means of said presentation means 240. Examples of said drilling plan are described in greater detail with reference to Figures 3a-e.

An operator of the drilling rig 100 may hereby change an existing drilling plan by for example affecting said presentation means 240 or by suitable means associated with said presentation means 240. Hereby a new drilling plan may be generated. This is described in greater detail with reference to for example Figures 3a-e and 4a and 4b.

The first control unit 200 is arranged to receive existing drilling plans intended as instructions for operation of said drilling rig 100. This may for example be performed by loading said existing drilling plans from a detachable USB-memory. Said first control unit 200 is hereby arranged to receive said USB-memory, or any other suitable means serving as carrier of information comprising existing drilling plans.

A communication means 250 is arranged for communication with the first control unit 200 via a link L250. Said communication means is arranged for wireless communication with a service centre from which existing drilling plans may be loaded into a memory of said first control unit 200. Hereby relevant existing drilling plans may be sent from said service centre to said first control unit 200 continuously, intermittently or when necessary. An operator of said drilling rig 100 may handle said downloading of relevant drilling plans by means of for example said presentation means 240.

A second control unit 210 is arranged for communication with the first control unit 200 via a link L210. The second control unit 210 may be detachably connected to the first control unit 200. The second control unit 210 may be a to the vehicle 100 external control unit. The second control unit 210 may be arranged to perform the inventive method steps. The second control unit 210 may be used for loading program code to the first control unit 200, in particularly program code for executing the inventive method. The second control unit 210 may alternatively be arranged for communication with the first control unit 200 via an internal network of the drilling rig 100. The second control unit 210 may be arranged to perform substantially similar functions as the first control unit 200.

Figure 3a schematically illustrates an example of an electronic drilling plan PBP. Said drilling plan PBP is hereby an existing drilling plan. Said existing drilling plan PBP is generated in advance. Typically said drilling plan PBP may be generated at a planning centre which is located remotely from the site of drilling with said drilling rig 100. Said drilling plan PBP may be provided to said first control unit 200 in any suitable way, for example by means of a portable memory or via a link communication, such as a wireless link or a physical wire.

A drilling plan is a model presenting how a number of holes are to be drilled in a segment of a tunnel. A segment may for example be 5 meters long, and hereby corresponds to a length of a body which is desired to first be drilled, then blasted and thereafter emptied of material.

The illustrated drilling plan PBP is hereby illustrated in a view in a main direction of a thought tunnel. The drilling plan PBP is presented in a vertical view (comprising a local 2D projection). In a drilling plan starting points of a number of drilling holes and how each such drilling hole is to be directed are presented. A starting point is presented as a circle in a drilling plan. Further, an end point is illustrated by a projection of a drilling hole running from said starting point. Such a projection of a drilling hole is illustrated as a line projecting from said circle regarding entry position of a drilling hole. Hereby a direction and end point of a certain drilling hole may be read out from said drilling plan. In a case where a drilling hole is running orthogonally to said vertical plan, i. e. straight in to the body, said projection is not presented, hereby only the starting point (the circle) is presented.

The existing drilling plan PBP is presenting a first sector W, a so called wedge. Said first sector W presents a number of drilling holes to be drilled. In this case said first sector comprises five drilling holes. The respective projections of the drilling holes are showing that all drilling holes of the first sector are directed slightly obliquely upwards at a certain angle.

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Herein is disclosed that a drilling plan, existing or generated, is presenting at least one second sector. Herein four such sectors are presented, according to below.

10 The drilling plan PBP comprises a left stope LS. Said left stope LS is presenting four drilling holes, where two are to be drilled obliquely upwards and two are to be drilled obliquely upwards to the left. The drilling plan comprises a right stope RS. Said right stope RS is presenting four drilling holes, where two are to be drilled obliquely upwards and two are to be drilled obliquely upwards to the right.

15 According to this example embodiment said left stope LS and said right stope RS have substantially the same height as said first sector W. Alternatively said left stope LS and said right stope RS may have mutually different shapes, which also are different from said first sector W.

20 The drilling plan comprises an upper stope US. Said upper stope US comprises a number of drilling holes. A drilling plan comprises a lower stope BS. Said lower stope BS comprises a number of drilling holes.

25 Hereby said first sector W is adjacent the left stope LS and the right stope RS as presented in Figure 3a. Said upper stope US is defined by a sector which is positioned above said first sector W, said left stope LS and said right stope RS. Said lower stope BS is positioned under said first sector W, said left stope LS and said right stope RS.

Further is presented an outer first contour 1C in said drilling plan PBP. At said first outer contour 1C a number of drilling holes comprising hole starting points and said respective drilling hole projection are defined. Inside said first outer first contour 1C an inner second contour 2C is presented. At said

inner second contour 2C a number of hole start points and said respective drilling hole projection are defined. A part of said second contour 2C is illustrated with a broken line. The part of said outer first contour 1C, which is running horizontally under said lower stope BS may be denoted bottom row.

- 5 The illustrated existing drilling plan is according to an aspect of the invention subject for a change meaning that an operator who is using drilling plans for operating said drilling rig 100 wants to move said first sector W to a more suitable position in the drilling plan. The operator may also change dimensions of said first sector W and hereby achieve a new drilling plan, according to an aspect of the present invention. Alternatively the operator may exchange said first sector W of the existing
- 10 drilling plan and hereby achieve a new drilling plan, according to an aspect of the present invention. According to this example a so called wedge of the original drilling plan is exchanged with a new, different wedge in the new drilling plan.

- Within each said sector and at each of said contour of the original drilling plan a distribution,
- 15 positioning, dimension and orientation of a number of drilling holes are specified according to unique rules for each such sector or contour. Such different rules may be predetermined.

- Hereby drilling holes of said first sector are specified according to a certain set of rules WR. Hereby drilling holes of said left stope are specified according to a set of rules LSR. Hereby drilling holes of
- 20 said right stope are specified according to a set of rules RSR. Hereby drilling holes of said upper stope are specified according to a set of rules USR. Hereby drilling holes of said lower stope are specified according to a set of rules BSR. Hereby drilling holes of said first outer contour 1C are specified according to a set of rules 1CR. Hereby drilling holes of said inner contour 2C are specified according to a set of rules 2CR.

25

With reference to the Figures 3b-3d below it is described how new generated drilling plans may look like after an operator of said drilling rig 100 has moved the first sector.

- Figure 3b is schematically illustrating a changed, new, drilling plan NBP, according to an aspect of the
- 30 invention. Hereby said first sector W has been moved in a horizontal direction to the right in the

original drilling plan PBP. This movement may be performed by the operator at the drilling rig 100 by means of said presentation means 240. Hereby it is determined which rules are associated with said left stope LS and with rules are associated with said right stope RS, namely LSR and RSR. These rules may be the same rules.

- 5 Hereby a new left stope LS and a new right stope RS are generated on the basis of said new position of said first sector W where drilling holes for said new left stope LS and said new right stope RS are generated on the basis of said respective determined rules.

- 10 In Figures 3b-3d it is illustrated a part of a contour B1C which will define the first outer contour in a subsequent segment of the body, which contour B1C may define an outer contour 1C for said subsequent segment of the body. This is also illustrated in Figure 3e in greater detail.

- 15 Figure 3c schematically illustrates a changed, new, drilling plan NBP, according to an aspect of the invention. Hereby said first sector W has been moved in a vertical direction upwards in the original drilling plan PBP. This movement may be performed by the operator at the drilling rig 100 by means of said presentation means 240. Hereby it is determined which rules are associated with said left stope LS and which rules are associated with said right stope RS, namely LSR and RSR. It is further determined which rules are associated with said upper stope US and which rules are associated with said lower stope BS, namely USR and BSR.

20

- Hereby a new left stope LS and a new right stope RS are generated on the basis of said new position of said first sector W where drilling holes of said new left stope LS and said new right stope RS are generated on the basis of said respective determined rules. Hereby it is generated a new upper stope US and a new lower stope BS on the basis of said new position of said first sector W where drilling
25 holes for said new upper stope US and said new lower stope BS are generated on the basis of said respective determined rules.

Figure 3d schematically illustrates a changed, new, drilling plan NBP, according to an aspect of the invention. Hereby said first sector W has been moved in a diagonal direction obliquely upwards to

the right in the original drilling plan PBP. Hereby corresponding relevant steps which have been described with reference to Figure 3b and Figure 3c are performed.

Figure 3e schematically illustrates a side view of a drilling plan NBP. Hereby drilling holes H1C1, H2C1
5 and H3C1 which have been illustrated with reference to Figure 3b are illustrated. The distance between 1C defining a start plane for drilling and B1C defining an end plane for drilling may be an arbitrarily suitable distance, for example 5 meters. It is thus the length of the segment of the body to be drilled and blasted. Hereby is illustrated that said drilling hole H1C1 has a direction to some extent inclined upwards. Hereby is illustrated that said drilling hole H2C1 has a direction to some extent
10 inclined downwards. Hereby it is illustrated that said drilling hole H3C1 has a direction running orthogonally to said start plan (which in this case is vertical) in to the body.

It should be noted that said start plane and said end plane may present an orientation which is not vertically orientated. Hereby, an electronic drilling plan may relate to a segment where said start
15 plane and said end plan are not vertically oriented.

Figure 4a schematically illustrates a flowchart of a method for drilling plan generation where a drilling plan is specifying a number of drilling holes having starting points and end points, which drilling holes are distributed within sectors specified in the drilling plan, which sectors comprise a
20 first sector W specifying a so called wedge and at least one second sector adjacent to said first sector W. The method comprises a first method step s401. The step s401 comprises the steps of:

- on the basis of an existing drilling plan PBP, automatically generating a new drilling plan NBP where said first sector W is positioned in a new position compared to said existing drilling plan PBP; and
- adapting dimensions and position of said at least one second sector to said new position of said first
25 sector in said new drilling plan NBP.

After the method step s401 the method is ended/returned.

Figure 4b schematically illustrates a flowchart of a method for drilling plan generation where a drilling plan is specifying a number of drilling holes having starting points and end points, which

drilling holes are distributed within sectors specified in the drilling plan, which sectors comprise a first sector specifying a so called wedge and at least one second sector adjacent to said first sector.

- 5 The method comprises a first method step s410. The method step s410 may comprise the step of providing an existing drilling plan PBP. This may be performed by loading said existing drilling plan PBP into the first control unit 200 and presenting said existing drilling plan PBP by means of said presentation means 240. Such an existing drilling plan PBP is described in greater detail with reference to Figure 3a. After the method step s410 a subsequent method step s420 is performed.
- 10 The method step s420 may comprise the step of determining rules specifying drilling holes of said existing drilling plan PBP. Hereby said first sector W in the existing drilling plan PBP is identified and thereto associated rules for drilling holes of said first sector W are determined. According to an alternative said rules for drilling holes of said first sector W does not need to be determined.
- 15 Hereby said at least one second sector in the existing drilling plan PBP is identified and thereto associated rules for drilling holes of said second sector are determined.
- 20 Hereby said existing drilling plan is specified in such a way that it comprises a first sector as well as four additional sectors, comprising an sector of each side of said first sector and an upper sector, positioned above said first sector and the sectors on each side of said first sector, and a lower sector positioned under said first sector and the sectors on each side on the first sector. The step s420 comprises to determine rules of drilling holes of respective identified sector of the existing drilling plan PBP. After the method step s420 a subsequent method step s430 is performed.
- 25 The method step S430 may comprise the step of changing position of said sector W in the existing drilling plan. This may be performed by the operator by means of said presentation means 240. Hereby said first sector W in the existing drilling plan PBP may be moved in any way specified in Figure 3b-3d, i. e., to the right or left, vertically upwards or downwards, or in a diagonal direction.

The method step s430 may comprise the step of exchanging said first sector W in the existing drilling plan PBP with another first sector with determined rules for drilling holes in said first sector. The method step s430 may comprise the step of changing size of said first sector W in the existing drilling plan PBP.

- 5 After the method step s430 a subsequent method step s440 is performed.

The method step s440 may comprise the step of applying the thus determined rules and generating a new drilling plan on the basis of said existing drilling plan PBP and the determined rules for each and one of the identified sectors in the existing drilling plan and the identified sectors in said existing
10 drilling plan. The method step s440 comprises the step of, where applicable, adapting the identified sectors of the existing drilling plan to dimensions and position of said first sector in the new drilling plan and hereby generating a new drilling plan NBP. Hereby said new drilling plan is specified in a corresponding way as the existing drilling plan, but with a moved (and potentially dimension
15 holes of said contours 1C and 2C does not need to be adapted to said change regarding said first sector W. After the method step s440 the method is ended. Alternatively the method returns to method step s410 for application on a subsequent segment of the body where drilling may be performed. Hereby the inventive method is performed for a new existing drilling plan PBP.

20 Figure 5 shows a diagram of one version of a device 500. The control units 200 and 210 described with reference to Figure 2 may in one version comprise the device 500. The device 500 comprises a non-volatile memory 520, a data processing unit 510 and a read/write memory 550. The non-volatile memory 520 has a first memory element 530 in which a computer program, e.g. an operating system, is stored for controlling the function of the device 500. The device 500 further comprises a
25 bus controller, a serial communication port, I/O means, an A/D converter, a time and date input and transfer unit, an event counter and an interruption controller (not shown). The non-volatile memory 520 has also a second memory element 540.

There is provided a computer program P for drilling plan generation where a drilling plan is specifying
30 a number of drilling holes each having a start point and an end point, which drilling holes are distributed within specified sectors of the drilling plan, which sectors comprise a first sector W specifying a so called wedge and at least one second sector adjacent to said first sector.

The computer program P may comprise routines for on the basis of an existing drilling plan PBP, automatically generating a new drilling plan NBP where said first sector W is positioned in a new position compared to said existing drilling plan PBP. The computer program P may comprise routines
5 for determining rules specifying drilling holes of said existing drilling plan PBP. The computer program P may comprise routines for applying the thus determined rules in said new drilling plan NBP. The computer program P may comprise routines for adapting dimensions and position of said at least one second sector to said new position of said first sector in said new drilling plan NBP.

10 The computer program P may comprise routines for specifying said existing drilling plan PBP in such a way that it comprises said first sector W and four more sectors comprising an sector on each side of said first sector and an upper sector, positioned above said first sector and the sectors on each side of said first sector, and a lower sector positioned under said first sector and the sectors on each side of said first sector. The computer program P may comprise routines for, in said existing drilling plan,
15 specifying said sectors within the frame of an outer contour 1C.

The computer program P may comprise routines for specifying said new drilling plan NBP in a corresponding way.

The computer program P may comprise routines for specifying said new drilling plan NBP in such a
20 way that said first sector is moved horizontally to the right or to the left. The computer program P may comprise routines for adapting dimensions and positions of sectors on each side of the new position of said first sector.

The computer program P may comprise routines for specifying said new drilling plan NBP in such a
25 way that said first sector is moved vertically in a direction upwards or downwards. The computer program P may comprise routines for adapting dimensions of and positions of all sectors surrounding said first sector and its new position.

The computer program P may comprise routines for, on the basis of said existing drilling plan PBP, generating said new drilling plan NBP wherein said first sector has new dimensions compared to said
30 existing drilling plan PBP. The computer program P may comprise routines for adapting dimensions

and position of said at least one second sector to the new dimensions of said first sector in said new drilling plan NBP.

The program P may be stored in an executable form or in compressed form in a memory 560 and/or
5 in a read/write memory 550.

Where it is stated that the data processing unit 510 performs a certain function, it means that it conducts a certain part of the program which is stored in the memory 560 or a certain part of the program which is stored in the read/write memory 550.

10 The data processing device 510 can communicate with a data port 599 via a data bus 515. The non-volatile memory 520 is intended for communication with the data processing unit 510 via a data bus 512. The separate memory 560 is intended to communicate with the data processing unit via a data bus 511. The read/write memory 550 is arranged to communicate with the data processing unit 510
15 via a data bus 514. The links L210, L220, L230, L240 and L250, for example, may be connected to the data port 599 (see Fig. 2).

When data are received on the data port 599, they are stored temporarily in the second memory element 540. When input data received have been temporarily stored, the data processing unit 510
20 will be prepared to conduct code execution as described above. According to an embodiment the signals received on the data port 599 comprises information about an existing drilling plan. According to an embodiment the signals received on the data port 599 comprises information about by an operator requested changes regarding an existing drilling plan, e.g. information regarding how a wedge of the existing drilling plan is desired to be moved, changed regarding dimensions or
25 exchanged to a different wedge.

Parts of the methods herein described may be conducted by the device 500 by means of the data processing unit 510 which runs the program stored in the memory 560 or the read/write memory 550. When the device 500 runs the program, method steps and process steps herein described are executed.

30 The foregoing description of the preferred embodiments of the present invention is provided for illustrative and descriptive purposes. It is not intended to be exhaustive, nor to limit the invention to the variants described. Many modifications and variations will obviously suggest themselves to one

skilled in the art. The embodiments have been chosen and described in order to best explain the principles of the invention and their practical applications and thereby make it possible for one skilled in the art to understand the invention for different embodiments and with the various modifications appropriate to the intended use.

Claims

1. A method for drilling plan generation where a drilling plan is specifying a number of drilling holes having a starting point and an end point, which drilling holes are distributed within sectors specified in the drilling plan, which sectors comprise a first sector (W) specifying a so called wedge and at least one second sector (LS; RS; US; BS) adjacent to said first sector, comprising the steps of:

- on the basis of an existing drilling plan (PBP), automatically generating a new drilling plan (NBP) where said first sector (W) is positioned in a new position compared to said existing drilling plan (PBP);

- determining rules (LSR; RSR; USR; BSR) specifying drilling holes of said existing drilling plan (PBP); and

- applying the thus determined rules (LSR; RSR; USR; BSR) in said new drilling plan (NBP) and adapting dimensions and position of said at least one second sector (LS; RS; US; BS) to said new position of said first sector (W) in said new drilling plan (NBP).

2. The method according to claim 1, comprising the steps of:

- specifying said existing drilling plan (PBP) in such a way that it comprises said first sector and four more sectors (LS; RS; US; BS), comprising a sector on each side of said first sector (W) and an upper sector (US), positioned above said first sector (W) and the sectors (LS; RS) on each side of said first sector (W), and a lower sector (BS) positioned under said first sector (W) and the sectors (LS; RS) on each side of said first sector (W); and

- in said existing drilling plan (PBP), specifying said sectors (LS; RS; US; BS) within the frame of an outer contour (1C);

- specifying said new drilling plan (NBP) in a corresponding way.

3. The method according to anyone of claims 1-2, comprising the steps of:

- specifying said new drilling plan (NBP) in such a way that said first sector (W) is moved horizontally to the right or to the left;

- adapting dimensions and positions of sectors (LS; RS) on each side of the new position of said first sector.

4. The method according to anyone of claims 1-3, comprising the steps of:

- 5 - specifying said new drilling plan in such a way that said first sector (W) is moved vertically in a direction upwards or downwards;
- adapting dimensions of and positions of all sectors surrounding said first sector (W) and its new position.

10 5. The method according to anyone of claims 1-4, comprising the steps of:

- on the basis of said existing drilling plan (PBP), generating said new drilling plan (NBP) wherein said first sector (W) has new dimensions compared to said existing drilling plan (PBP); and
- adapting dimensions and position of said at least one second sector (LS; RS; US; BS) to the new dimensions of said first sector in said new drilling plan (NBP).

15

6. A system for drilling plan generation where a drilling plan is specifying a number of drilling holes having a starting point and an end point, which drilling holes are distributed within sectors specified in the drilling plan, which sectors comprise a first sector (W) specifying a so called wedge and at least one second sector (LS; RS; US; BS) adjacent to said first sector, comprising:

- 20 - means (200; 210; 500) arranged for, on the basis of an existing drilling plan (PBP), automatically generating a new drilling plan (NBP) where said first sector (W) is positioned in a new position compared to said existing drilling plan (PBP);
- means (200; 210; 500) arranged for determining rules (LSR; RSR; USR; BSR) specifying drilling holes of said existing drilling plan (PBP);
- 25 - means (200; 210; 500) arranged for applying the thus determined rules (LSR; RSR; USR; BSR) in said new drilling plan (NBP); and
- means (200; 210; 500) arranged for adapting dimensions and position of said at least one second sector (LS; RS; US; BS) to said new position of said first sector (W) in said new drilling plan (NBP).

7. The system according to claim 6, comprising:

- means (200; 210; 500) arranged for specifying said existing drilling plan (PBP) in such a way that it comprises said first sector (W) and four more sectors (LS; RS; US; BS) comprising an sector (LS; HS) on each side of said first sector (W) and an upper sector (US), positioned above said first sector (W) and the sectors (LS; RS) on each side of said first sector (W), and a lower sector (BS) positioned under said first sector (W) and the sectors (LS; RS) on each side of said first sector (W); and
- means (200; 210; 500) arranged for, in said existing drilling plan (PBP), specifying said sectors (LS; RS; US; BS) within the frame of an outer contour (1C); and
- means (200; 210; 500) arranged for specifying said new drilling plan (NBP) in a corresponding way.

8. The system according to anyone of claims 6-7, comprising:

- means (200; 210; 500) arranged for specifying said new drilling plan (NBP) in such a way that said first sector (W) is moved horizontally to the right or to the left; and
- means (200; 210; 500) arranged for adapting dimensions and position of the sectors (LS; RS) on each side of the new position of said first sector.

9. The system according to anyone of claims 6-8, comprising:

- means (200; 210; 500) arranged for specifying said new drilling plan (NBP) in such a way that said first sector (W) is moved vertically in a direction upwards or downwards; and
- means (200; 210; 500) arranged for adapting an dimensions of and positions of all sectors (LS; RS; US; BS) surrounding said first sector (W) and its new position.

10. The system according to anyone of claims 6-9, comprising:

- means (200; 210; 500) arranged for, on the basis of said existing drilling plan (PBP), generating said new drilling plan (NBP) wherein said first sector (W) has new dimensions compared to said existing drilling plan (PBP); and

- means (200; 210; 500) arranged for adapting dimensions and position of said at least one second sector (LS; RS; US; BS) to the new dimensions of said first sector in said new drilling plan (NBP).

11. A drilling rig (100) comprising a system according to anyone of the claims 6-10.

5

12. A computer program for drilling plan generation, wherein said computer program (P) comprises program code for causing an electronic control unit or another computer connected to the electronic control unit to perform the steps according to anyone of the claims 1-5.

10 13. A computer program product comprising a program code stored on a, by a computer readable, medium for performing the method steps according to anyone of claims 1 to 5, when said computer program is run on an electronic control unit or another computer connected to the electronic control unit.

15

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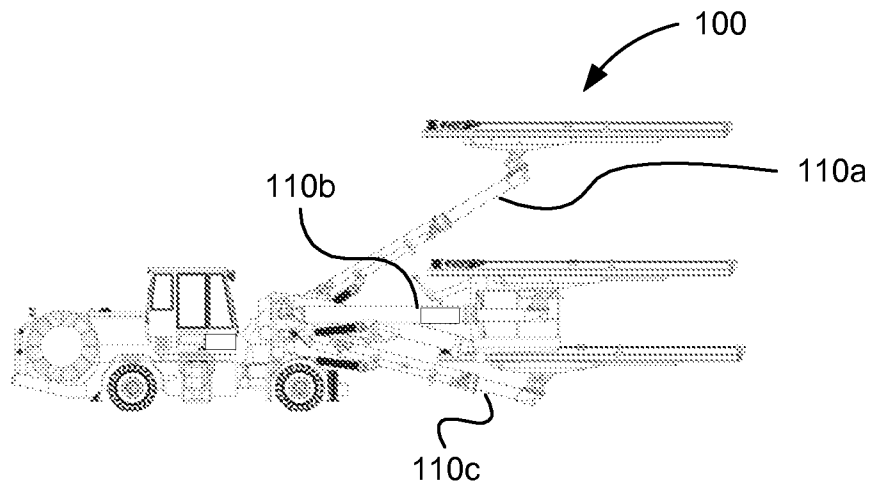


Fig. 1

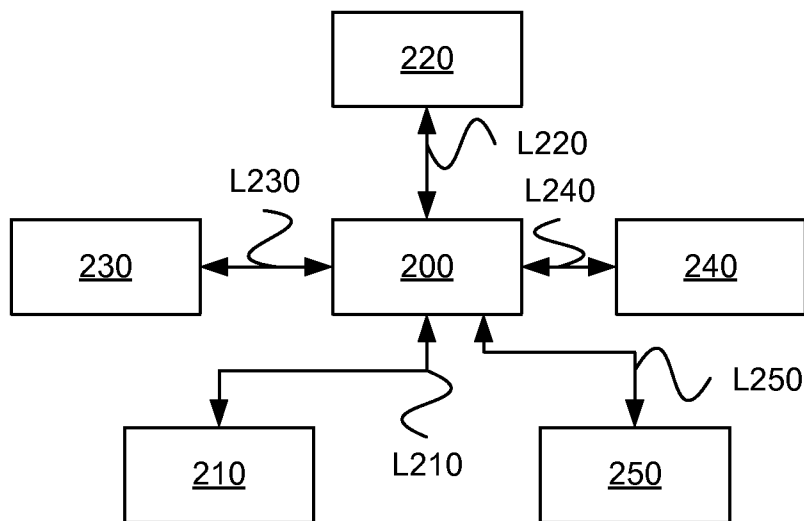


Fig. 2

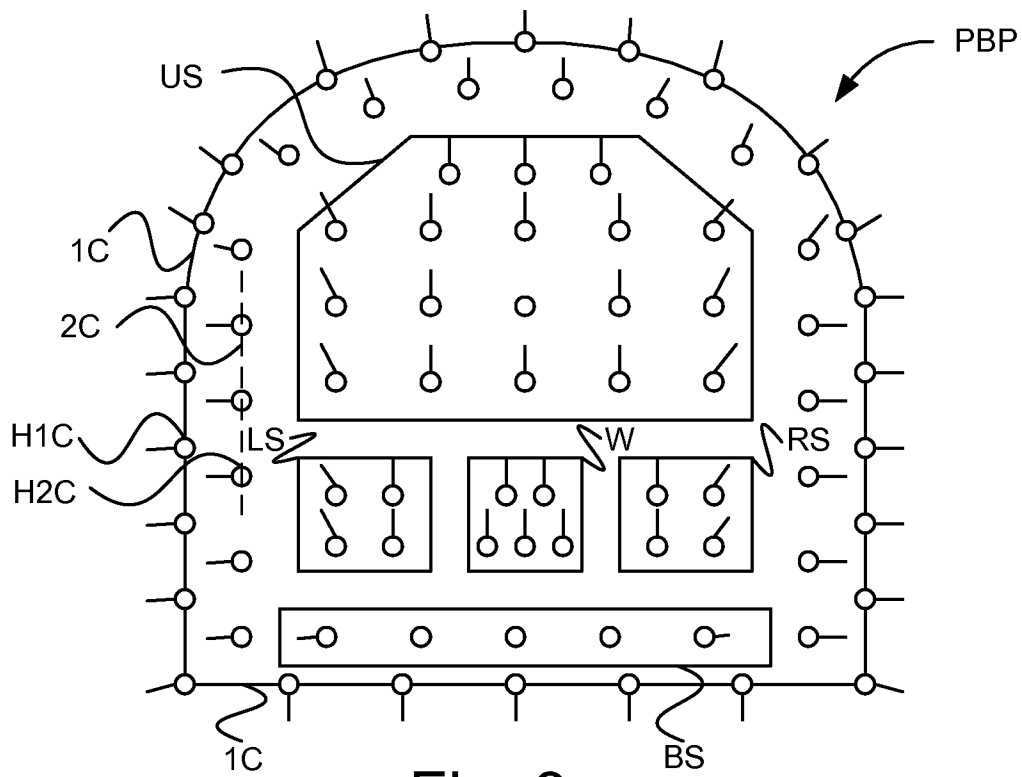


Fig. 3a

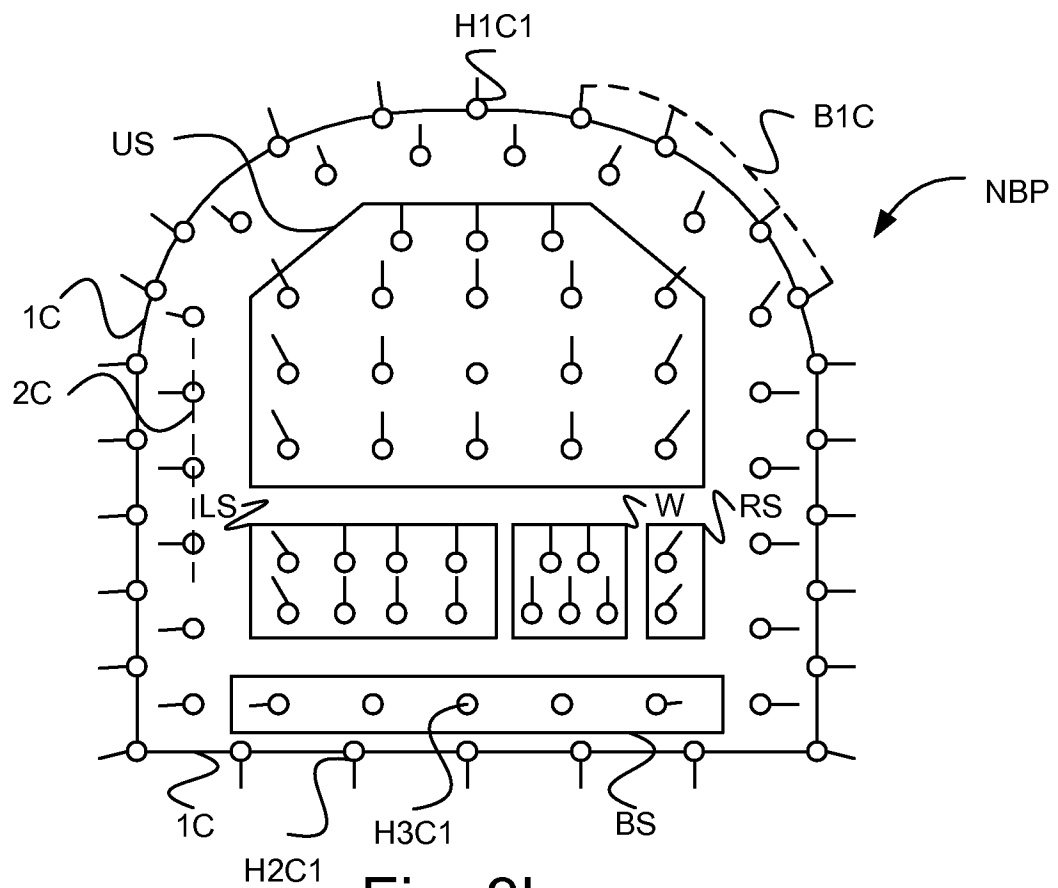


Fig. 3b

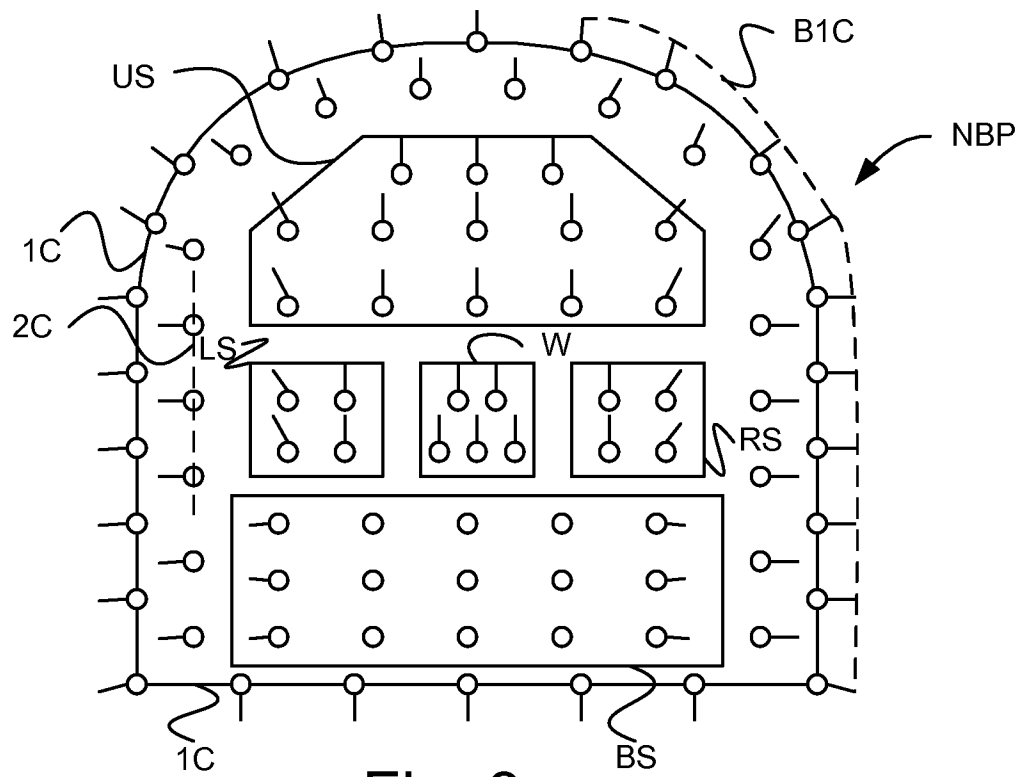


Fig. 3c

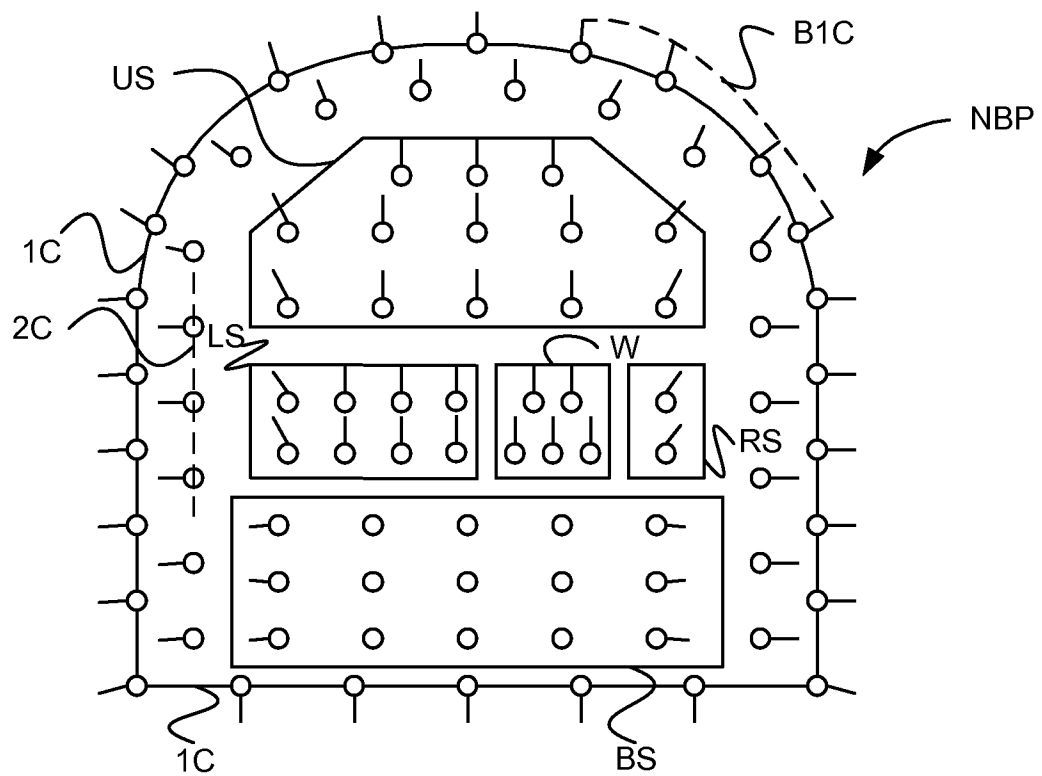


Fig. 3d

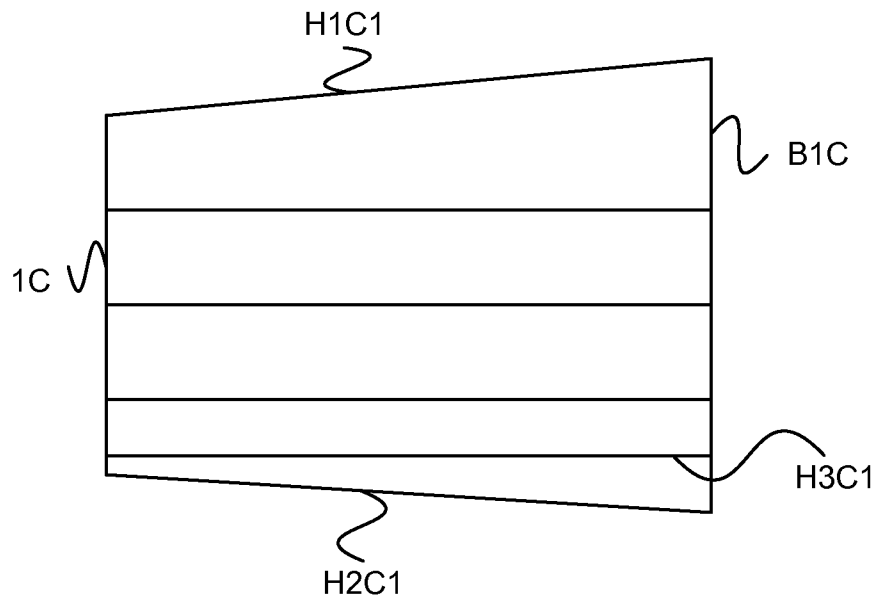


Fig. 3e

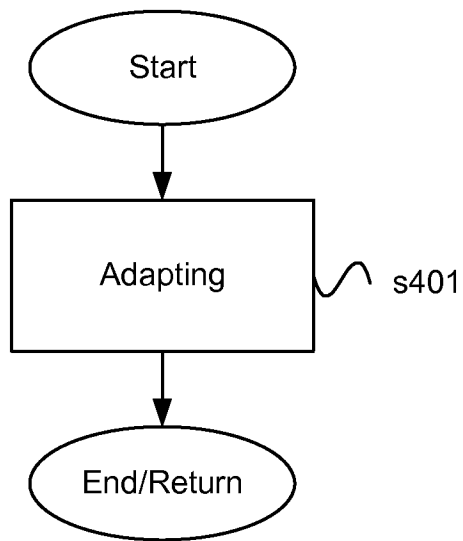


Fig. 4a

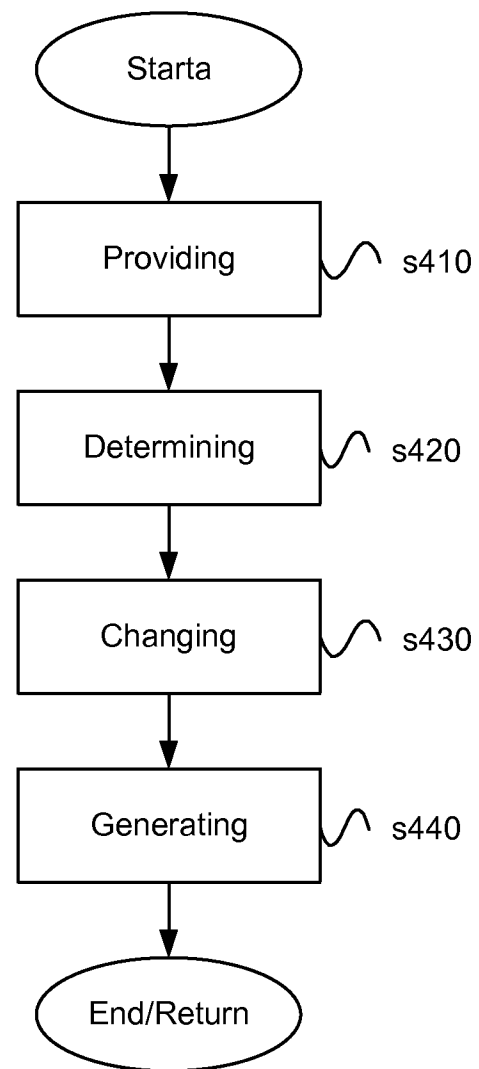


Fig. 4b

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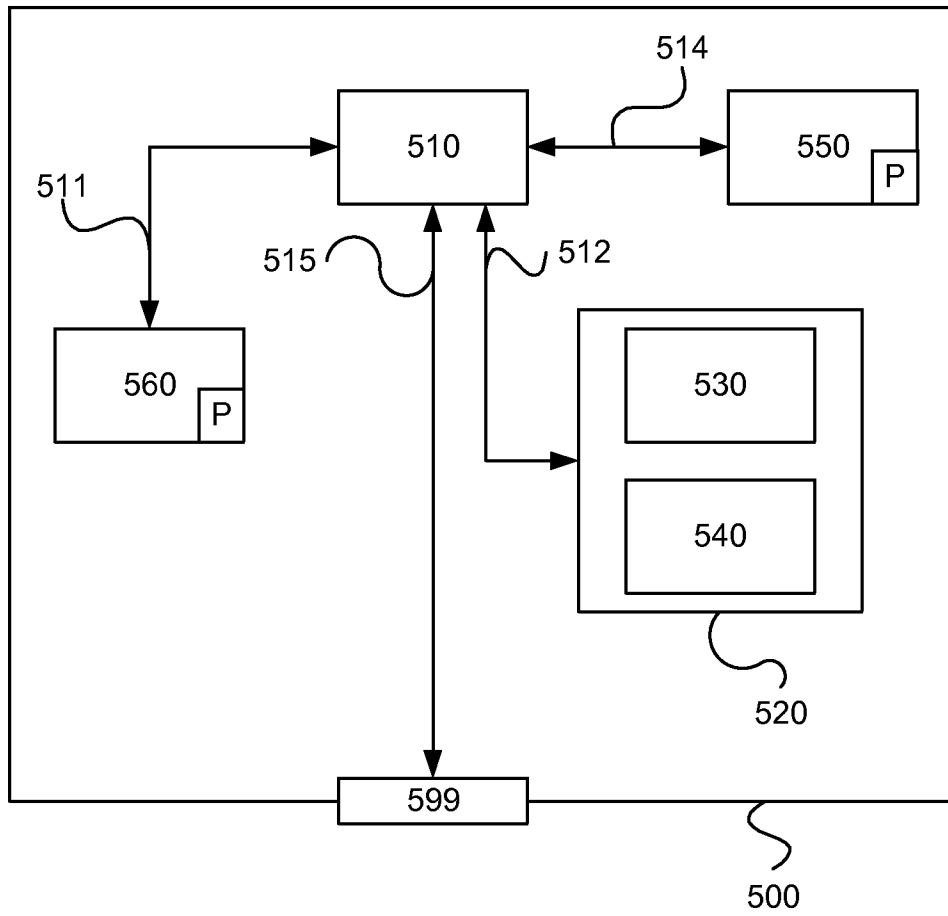


Fig. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2016/050929

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

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: E21B, E21D

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

SE, DK, FI, NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, PAJ, WPI data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	WO 2014206471 A1 (SANDVIK MINING & CONSTR OY), 31 December 2014 (2014-12-31); abstract; figures --	1-13
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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	"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
"E" earlier application or patent but published on or after the international filing date	"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
"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)	"&" document member of the same patent family
"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	

Date of the actual completion of the international search

15-12-2016

Date of mailing of the international search report

15-12-2016

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2016/050929

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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X	WO 03025341 A1 (ATLAS COPCO ROCK DRILLS AB ET AL), 27 March 2003 (2003-03-27); abstract; figures --	1-13
X	US 20040216922 A1 (KOIVUNEN PERTTI ET AL), 4 November 2004 (2004-11-04); abstract; figures -- -----	1-13

Continuation of: second sheet

International Patent Classification (IPC)

E21B 44/00 (2006.01)

E21B 7/02 (2006.01)

E21D 9/00 (2006.01)

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