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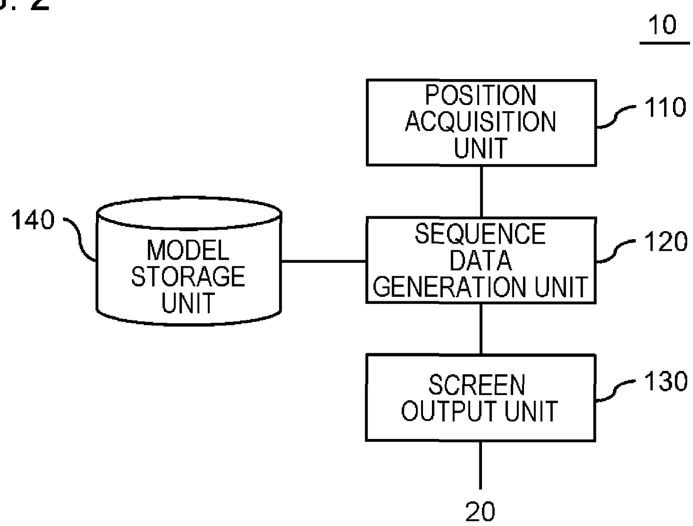
(54) DRILLING SEQUENCE DATA GENERATION DEVICE, DRILLING SEQUENCE DATA GENERATION METHOD, AND PROGRAM

(57) A drilling sequence data generation device (10) includes a position acquisition unit (110), a sequence data generation unit (120), and a screen output unit (130) . The position acquisition unit (110) acquires drilling position data. The drilling position data indicates a position of each of a plurality of blast holes to be formed in a face in the face. The sequence data generation unit (120) generates first sequence data indicating a recommended sequence of forming the plurality of blast holes using the drilling position data. The sequence data generation unit (120) uses a model stored in a model storage unit (140) when generating the first sequence data. The screen output unit (130) generates screen data indicating the recommended sequence and outputs the screen data.

FIG. 2



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Description

TECHNICAL FIELD

[0001] The present invention relates to a drilling sequence data generation device, a drilling sequence data generation method, and a program.

BACKGROUND ART

[0002] In tunnels and mine shafts, when blasting is performed in a face, blast holes for inserting explosives are formed. As a technique for assisting a process of forming the blast holes, for example, there is a technique described in Patent Document 1. Patent Document 1 discloses a technique that, when a tunnel is excavated using a drilling machine provided on a boom, calculates the position of a blast hole formed in a face using information related to the position, posture, and orientation of a mobile carriage and information related to the position of the drilling machine and displays the calculated position on a monitor.

RELATED DOCUMENT

PATENT DOCUMENT

[0003] Patent Document 1: Japanese Unexamined Patent Publication No. 2018-197445

SUMMARY OF THE INVENTION

TECHNICAL PROBLEM

[0004] In general, a plurality of blast holes are formed in a face. Therefore, labor required to form the blast holes varies depending on a formation sequence of the plurality of blast holes. However, it is difficult to optimize the formation sequence of the blast holes. An example of an object of the invention is to facilitate the determination of a formation sequence of a plurality of blast holes in a case in which the plurality of blast holes are formed in a face.

SOLUTION TO PROBLEM

[0005] According to the invention, there is provided a drilling sequence data generation device including: a position acquisition unit that acquires drilling position data indicating a position of each of a plurality of blast holes to be formed in a face in the face; a sequence data generation unit that generates first sequence data indicating a recommended sequence of forming the plurality of blast holes using the drilling position data; and a screen output unit that generates screen data indicating the recommended sequence and outputs the screen data.

[0006] According to the invention, there is provided a drilling sequence data generation method executed by a computer, the drilling sequence data generation method including: a position acquisition process of acquiring drilling position data indicating a position of each of a plurality of blast holes to be formed in a face in the face; a sequence data generation process of generating first sequence data indicating a recommended sequence of forming the plurality of blast holes using the drilling position data; and a screen output process of generating screen data indicating the recommended sequence and outputting the screen data.

[0007] According to the invention, there is provided a program that causes a computer to implement: a position acquisition function of acquiring drilling position data indicating a position of each of a plurality of blast holes to be formed in a face in the face; a sequence data generation function of generating first sequence data indicating a recommended sequence of forming the plurality of blast holes using the drilling position data; and a screen output function of generating screen data indicating the recommended sequence and outputting the screen data.

ADVANTAGEOUS EFFECTS OF INVENTION

[0008] The invention facilitates the determination of a formation sequence of a plurality of blast holes in a case in which the plurality of blast holes are formed in a face.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The above and other objects, advantages, and features of the invention will be more apparent from the following description of certain preferred embodiments taken in conjunction with the accompanying drawings.

[0010]

[Fig.1] Fig. 1 is a diagram showing a usage environment of a drilling sequence data generation device according to a first embodiment.

[Fig.2] Fig. 2 is a diagram showing an example of a functional configuration of the drilling sequence data generation device.

[Fig.3] Fig. 3 is a diagram showing an example of a screen displayed by a screen output unit.

[Fig.4] Fig. 4 is a diagram showing an example of a hardware configuration of the drilling sequence data generation device.

[Fig.5] Fig. 5 is a diagram showing an example of a functional configuration of a drilling sequence data generation device according to a second embodiment.

[Fig.6] Fig. 6 is a diagram showing an example of data stored in a drilling data storage unit.

[Fig.7] Fig. 7 is a diagram showing an example of a functional configuration of a drilling sequence data generation device according to a third embodiment.

[Fig.8] Fig. 8 is a diagram showing an example of a screen according to screen data output by a screen output unit.

[Fig. 9] Fig. 9 is a diagram showing a first example of a process performed by a drilling sequence data generation device according to a fourth embodiment.

[Fig.10] Fig. 10 is a diagram showing a second example of the process performed by the drilling sequence data generation device according to the fourth embodiment.

[Fig.11] Fig. 11 is a diagram showing functions of a drilling sequence data generation device according to a fifth embodiment.

[Fig.12] Fig. 12 is a diagram showing an example of a screen output by a screen output unit.

[Fig.13] Fig. 13 is a diagram showing functions of a drilling sequence data generation device according to a sixth embodiment.

[Fig.14] Fig. 14 is a diagram showing functions of a drilling sequence data generation device according to a seventh embodiment.

[Fig.15] Fig. 15 is a diagram showing functions of a drilling sequence data generation device according to an eighth embodiment.

DESCRIPTION OF EMBODIMENTS

[0011] Hereinafter, embodiments of the invention will be described with reference to the drawings. In addition, in all of the drawings, the same components are denoted by the same reference numerals, and the description thereof will not be repeated.

(First Embodiment)

[0012] Fig. 1 is a diagram showing a usage environment of a drilling sequence data generation device 10 according to this embodiment. The drilling sequence data generation device 10 is used together with a drilling machine 20. The drilling machine 20 forms a plurality of blast holes in a face of a tunnel, a mine shaft, or the like. For example, the plurality of blast holes are used to charge explosives. Positions where the plurality of blast holes are formed are determined, for example, by a worker. The drilling sequence data generation device 10 generates data (hereinafter, referred to as first sequence data) indicating a recommended sequence of forming the plurality of blast holes whose positions have already been determined.

[0013] The drilling sequence data generation device 10 generates screen data that indicates the recommended sequence indicated by the first sequence data and outputs the screen data. For example, the drilling sequence data generation device 10 may transmit the screen data to a display which is provided in an operator's seat of the drilling machine 20 such that the screen data is displayed.

[0014] Further, in a case in which an operator of the drilling machine 20 wears an augmented reality head-mounted display, the drilling sequence data generation device 10 may generate augmented reality screen data and transmit the augmented reality screen data to the head-mounted display such that the augmented reality screen data is displayed. In this case, an example of the screen data is data for displaying the positions and recommended sequence of the plurality of blast holes in the face on an augmented reality screen. Then, the head-mounted display displays the screen data and an image which has been obtained by superimposing marks indicating the positions of the plurality of blast holes in the face and numerical values indicating the formation sequence of the plurality of blast holes on an image of the face generated by a camera provided in the head-mounted display and on which the marks have been superimposed.

[0015] Further, in a case in which the drilling machine 20 includes a projection device that projects an image onto the face, the drilling sequence data generation device 10 generates, as the screen data, data for projecting the positions of the plurality of blast holes onto the face together with the recommended sequence indicated by the first sequence data and transmits the data to the projection device. The projection device projects the positions of the blast holes onto the face together with the recommended sequence indicated by the first sequence data, using the screen data.

[0016] In addition, the screen data output by the drilling sequence data generation device 10 may include a moving image (for example, animation) showing the movement of a boom 22 of the drilling machine 20 according to the formation sequence indicated by the first sequence data together with the positions of the plurality of blast holes and the formation sequence.

[0017] In the example shown in Fig. 1, the drilling sequence data generation device 10 is provided outside the drilling machine 20. However, the drilling sequence data generation device 10 may be mounted on the drilling machine 20.

[0018] Fig. 2 is a diagram showing an example of a functional configuration of the drilling sequence data generation device 10. The drilling sequence data generation device 10 includes a position acquisition unit 110, a sequence data generation unit 120, and a screen output unit 130.

[0019] The position acquisition unit 110 acquires drilling position data. The drilling position data indicates the position of each of the plurality of blast holes to be formed in the face in the face. The drilling position data is formed by, for example, a person who performs the work of forming a tunnel or a mine shaft or a person who makes a plan for the work and is input to the position acquisition unit 110 by the user of the drilling sequence data generation device 10. The drilling position data indicates, for example, the coordinates of each of the plurality of blast holes on a two-dimensional plane indicating the face. In addition, the drilling position data may be the coordinates of a digging start point (hole top) of each of the plurality of blast holes in a three-dimensional space. In addition, the drilling position data may further include the angle (desired digging angle) of each of the blast holes. Further, the drilling position data may include the coordinates of each of a digging start point (hole top) and a digging end point (hole bottom) of each of the plurality of blast holes in the three-dimensional space. In this case, the position acquisition unit 110 can calculate the angle of a straight line connecting the coordinates of the hole top and the hole bottom to calculate the angle (desired digging angle) of the blast hole.

[0020] The sequence data generation unit 120 generates the first sequence data using the drilling position data. When generating the first sequence data, the sequence data generation unit 120 determines the recommended sequence indicated by the first sequence data, for example, such that the time (work time) required to form all of the blast holes or a path is the shortest.

[0021] The sequence data generation unit 120 generates the first sequence data, using a model stored in a model storage unit 140, in addition to the drilling position data. The model stored in the model storage unit 140 generates the first sequence data using at least the drilling position data. The model may be generated by machine learning, such as a neural network, or may be a program based on an algorithm (for example, a 2-opt method) that searches for the shortest path. In the case of the machine learning, training data includes the drilling position data and the work time (or the path) in past cases.

[0022] In addition, the model stored in the model storage unit 140 may be adjusted such that the blast holes located in a specific region (for example, outside) in the first sequence data are formed first. This can be implemented, for example, by giving a weighting coefficient in the algorithm that searches for the shortest path.

[0023] Further, the input of the model stored in the model storage unit 140 may include information related to the drilling machine 20, for example, the number of booms 22 forming the blast holes. In this case, the user of the drilling sequence data generation device 10 also inputs the information related to the drilling machine 20 to the position acquisition unit 110.

[0024] The screen output unit 130 generates the screen data indicating the recommended sequence and outputs the screen data. A specific example of the output destination of the screen data or the like is as described with reference to Fig. 1.

[0025] Fig. 3 is a diagram showing an example of the screen displayed by the screen output unit 130. On the screen shown in Fig. 3, the positions of the plurality of blast holes are displayed together with numerical values indicating the formation sequence of each of the blast holes. In addition, a line indicating the formation sequence is also displayed. This line connects one blast hole and the next blast hole to be formed.

[0026] After viewing this screen, the worker (for example, the operator of the drilling machine 20) may skip any blast hole or may change a drilling sequence of some blast holes during actual drilling as necessary. Further, the operator of the drilling sequence data generation device 10 may input instructions indicating the skip and the change to the drilling sequence data generation device 10. In this case, the sequence data generation unit 120 corrects the first sequence data in response to this input.

[0027] In addition, the formation sequence of the blast holes may be displayed in a tabular form on the screen output by the screen output unit 130.

[0028] Fig. 4 is a diagram showing an example of a hardware configuration of the drilling sequence data generation device 10. The drilling sequence data generation device 10 includes a bus 1010, a processor 1020, a memory 1030, a storage device 1040, an input/output interface 1050, and a network interface 1060.

[0029] The bus 1010 is a data transmission path through which the processor 1020, the memory 1030, the storage device 1040, the input/output interface 1050, and the network interface 1060 mutually transmit and receive data. However, a method for connecting the processor 1020 and the like is not limited to the bus connection.

[0030] The processor 1020 is a processor that is implemented by a central processing unit (CPU), a graphics processing unit (GPU), or the like.

[0031] The memory 1030 is a main storage device that implemented by a random access memory (RAM) or the like.

[0032] The storage device 1040 is an auxiliary storage device that is implemented by a hard disk drive (HDD), a solid state drive (SSD), a memory card, a read only memory (ROM), or the like. The storage device 1040 stores program modules that implement each function (for example, the position acquisition unit 110, the sequence data generation unit 120, and the screen output unit 130) of the drilling sequence data generation device 10. The processor 1020 reads each of the program modules onto the memory 1030 and executes the program modules to implement each of the functions corresponding to the program modules. In addition, the storage device 1040 also functions as the model storage unit 140.

[0033] The input/output interface 1050 is an interface for connecting the drilling sequence data generation device 10 and various input/output devices.

[0034] The network interface 1060 is an interface for connecting the drilling sequence data generation device 10 to a network. This network is, for example, a local area network (LAN) or a wide area network (WAN). A method for connecting the network interface 1060 to the network may be a wireless connection or a wired connection.

[0035] As described above, this embodiment causes the drilling sequence data generation device 10 to generate, when acquiring the drilling position data indicating the positions of the plurality of blast holes to be formed in the face, the first sequence data indicating the recommended sequence of forming the plurality of blast holes and outputs the screen data indicating the recommended sequence. Therefore, it is easy for the worker to determine the formation sequence of the plurality of blast holes. As a result, labor is reduced both when the formation of the blast holes is planned and when drilling is performed.

(Second Embodiment)

[0036] Fig. 5 is a diagram showing an example of a functional configuration of a drilling sequence data generation device 10 according to this embodiment. The drilling sequence data generation device 10 shown in Fig. 5 has the same configuration as the drilling sequence data generation device 10 according to the first embodiment except for the following points.

[0037] First, the drilling sequence data generation device 10 includes a drilling data storage unit 150. The drilling data storage unit 150 stores drilling data for the tunnel or the mine shaft that is currently being formed. The drilling data stores data related to the operation of the drilling machine 20 when the blast holes that have already been formed are drilled.

[0038] Then, the sequence data generation unit 120 uses at least a portion of the drilling data in addition to the drilling position data when generating the first sequence data. This is because the drilling data reflects the geology of a region in which the tunnel or the mine shaft is formed. The formation time of the blast holes also changes depending on the geology. Therefore, in this embodiment, the model stored in the model storage unit 140 also uses the drilling data as an input.

[0039] Fig. 6 is a diagram showing an example of the data stored in the drilling data storage unit 150. The drilling data stores data that specifies the position in the extension direction of the tunnel or the mine shaft (for example, data indicating how many times blasting is performed to form the blast hole: described as a face number in Fig. 6) and drilling data when the blast hole is drilled at that position. A plurality of blast holes are formed in one face, and the drilling data is stored for each blast hole together with data indicating the positions of the blast holes in the face.

[0040] In the example shown in Fig. 6, the drilling data includes time required per unit length, vibration data, operation data, output data, and image data.

[0041] The time required per unit length is the time required to dig the blast hole by a unit length (for example, 50 cm) . The vibration data indicates a chart of at least one of vibration and sound generated during drilling. These data items directly indicate the difference between strata.

[0042] The operation data indicates the history of operations (for example, mechanical operations for levers and the like) performed on the drilling machine 20 by the operator during drilling. The operation data indicates whether the operator was struggling during drilling and indirectly indicates the length of the time required for drilling.

[0043] The output data indicates the history of the magnitude of the output from the drilling machine 20. In a case in which the drilling machine 20 is a hydraulic device, the output is indicated by, for example, oil pressure or oil temperature. In addition, in a case in which the drilling machine 20 is an electric device, the output is indicated by, for example, a power consumption value (or a current value) . In a case in which the stratum is hard, energy required for drilling increases. Therefore, the output data also indirectly indicates the length of the time required for drilling.

[0044] The image data is an image of the face. Further, instead of the image data or together with the image data, roughness data indicating a distribution of the roughness of the surface of the face may be used. The roughness data is generated using, for example, 3D-LiDAR. The image data can be analyzed to understand the roughness of the face. The roughness of the face indicates the state of the stratum in the region in which the face is located or the face. In addition, in a case in which the image data includes color data, it is also possible to estimate a distribution of the hardness of the face from the distribution of colors. Therefore, the image data (or roughness data) also affects the formation sequence of the blast holes.

[0045] In addition, it is preferable that the drilling data used by the sequence data generation unit 120 is data a predetermined number of operations before (for example, data in the previous operation, data within two operations before, or data within three operations before) .

[0046] In this embodiment, as in the first embodiment, labor is reduced both when the formation of the blast holes is planned and when drilling is performed. Further, the sequence data generation unit 120 uses the drilling data when generating the first sequence data indicating the recommended sequence of forming the plurality of blast holes. The drilling data indicates the state of the face or the state of the strata surrounding the face. Therefore, the reliability of the first sequence data increases.

(Third Embodiment)

[0047] Fig. 7 is a diagram showing an example of a functional configuration of a drilling sequence data generation device 10 according to this embodiment. The drilling sequence data generation device 10 shown in Fig. 7 has the same configuration as the drilling sequence data generation device 10 according to the second embodiment except for the following points.

[0048] First, the drilling sequence data generation device 10 includes a second sequence data acquisition unit 160. The second sequence data acquisition unit 160 acquires second sequence data. The second sequence data is different from the first sequence data and indicates a formation sequence of the plurality of blast holes. The second sequence data is formed by, for example, a worker (the worker may be the operator of the drilling machine 20 or another person) and indicates a sequence according to the worker's rule of thumb.

[0049] Then, the screen output unit 130 generates, as the screen data, data for visually checking the formation sequence indicated by the first sequence data and the formation sequence indicated by the second sequence data. In addition, the screen data may include at least one of a predicted value of the work time according to the first sequence data and a predicted value of the work time according to the second sequence data, and a difference between the two predicted values. Further, the predicted values and the difference therebetween may be output by voice.

[0050] Furthermore, in a case in which the screen data includes animation showing the movement of the boom 22, the screen data may show only the movement of the boom 22 according to the first sequence data, may show the movement of the boom 22 according to the first sequence data and the movement of the boom 22 according to the second sequence data to be superimposed in a semi-transmissive state, or may show the movement of the boom 22 according to the first sequence data and the movement of the boom 22 according to the second sequence data in different display regions.

[0051] Fig. 8 is a diagram showing an example of a screen according to the screen data output by the screen output unit 130. In Fig. 8, the screen includes a region showing the first sequence data and a region showing the second sequence data. The content of display in each region is as described with reference to Fig. 3.

[0052] In addition, a button for selecting one of the first sequence data and the second sequence data may be displayed on this screen. The operator of the drilling machine 20 uses this button to select the sequence data to be actually applied. Then, the drilling sequence data generation device 10 guides the formation of a plurality of blast holes according to the selected sequence data.

[0053] In this embodiment, the same effect as that in the second embodiment is obtained. Further, the screen according to the screen data includes the second sequence data as well as the first sequence data. Therefore, the worker can visually understand how the formation sequence of the blast holes has changed as compared to the rule of thumb up to now.

(Fourth Embodiment)

[0054] In this embodiment, a drilling machine 20 has a plurality of booms 22 and operates the plurality of booms 22 in parallel. Then, the drilling sequence data generation device 10 generates the first sequence data corresponding to each of the plurality of booms 22.

[0055] Specifically, when the position acquisition unit 110 acquires the drilling position data, the sequence data generation unit 120 allocates, to each of the plurality of blast holes, the booms 22 which can reach the blast hole (hereinafter, referred to as allocation data) . In this case, a plurality of the booms 22 may be allocated to one blast hole. Then, the sequence data generation unit 120 acquires information indicating an allocation balance. This information indicates the number of blast holes to be allocated to each of the plurality of booms 22 (or the ratio of the number of blast holes to be allocated to the total number of blast holes) and is input to the drilling sequence data generation device 10 by, for example, the worker.

[0056] Then, the sequence data generation unit 120 calculates the number of blast holes to be drilled by each of the plurality of booms 22. In this case, the sequence data generation unit 120 uses the above-described allocation data. Then, the sequence data generation unit 120 generates the first sequence data corresponding to each of the plurality of booms 22 using the calculated number of blast holes. Then, the sequence data generation unit 120 checks whether or not the plurality of booms 22 physically interfere with each other when the plurality of booms 22 are operated according to the first sequence data and confirms the first sequence data when there is no problem. On the other hand, in a case in which the plurality of booms 22 are expected to interfere with each other, the sequence data generation unit 120 generates another first sequence data item and repeats the same process as described above.

[0057] In addition, when calculating the number of blast holes to be drilled by each of the plurality of booms 22, the sequence data generation unit 120 may use data indicating the hardness of a portion in which each blast hole is formed. This data is, for example, drilling data (for example, time required for drilling) for each blast hole in the past (for example, in the previous operation). Then, the sequence data generation unit 120 reduces the number of blast holes allocated to the boom 22 to which a relatively hard spot has been allocated.

[0058] Fig. 9 is a diagram showing a first example of a process performed by the drilling sequence data generation device 10 according to this embodiment. In the example shown in Fig. 9, the drilling machine 20 has three booms 22 (a left boom, a middle boom, and a right boom) . As shown in Fig. 9(A), the drilling position data has positional information of the blast holes, but does not have information indicating by which boom 22 each blast hole has to be drilled. Then, as shown in screen data of Fig. 9(B), the sequence data generation unit 120 generates the first sequence data for each of the three booms 22.

[0059] Fig. 10 is a diagram showing a second example of the process performed by the drilling sequence data generation device 10 according to this embodiment. In the example shown in Fig. 10, the drilling machine 20 has three booms 22 (a left boom, a middle boom, and a right boom). As shown in Fig. 10(A), the drilling position data includes information indicating by which boom 22 each blast hole has to be drilled, in addition to the positional information of the blast holes . Then, as shown in screen data of Fig. 10 (B), the sequence data generation unit 120 generates the first sequence data for each of the three booms 22. In this case, the sequence data generation unit 120 also changes the number of blast holes to be handled by each boom 22. For example, in a case in which the geology of the region to be handled by the left boom is hard, the sequence data generation unit 120 reduces the number of blast holes to be handled by the left boom and increases the number of blast holes to be handled by the middle boom.

[0060] As described above, this embodiment allows, in a case in which the drilling machine 20 has a plurality of booms 22, the drilling sequence data generation device 10 to generate the first sequence data for each of the booms 22. In addition, the sequence data generation unit 120 reduces the number of blast holes allocated to the boom 22 to which a hard spot has been allocated. Therefore, the time required to form the plurality of blast holes is reduced.

(Fifth Embodiment)

[0061] Fig. 11 is a diagram showing the functions of a drilling sequence data generation device 10 according to this embodiment. In this embodiment, a drilling machine 20 has a plurality of booms 22 and operates the plurality of booms 22 in parallel. Then, the sequence data generation unit 120 of the drilling machine 20 makes the relative distances of the plurality of booms 22 satisfy a predetermined standard when generating the first sequence data. Hereinafter, this standard is referred to as a first standard. The first standard indicates, for example, the lower limit of the relative distances of the plurality of booms 22. In this case, the sequence data generation unit 120 generates the first sequence data such that a relative distance L of the plurality of booms 22 during drilling is equal to or greater than the first standard. In this case, the sequence data generation unit 120 generates the first sequence data for each of the plurality of booms 22.

[0062] In addition, the first standard is a value at which adjacent booms 22 do not physically interfere with each other during drilling and is set by, for example, the operator of the drilling sequence data generation device 10 or a manager of a construction site. The drilling sequence data generation device 10 may store only one first standard or may store a plurality of different first standards. In the latter case, the sequence data generation unit 120 may generate the first sequence data for each of the plurality of first standards and for each of the plurality of booms 22.

[0063] Fig. 12 is a diagram showing an example of the screen output by the screen output unit 130 of the drilling sequence data generation device 10. In the example shown in Fig. 12, the sequence data generation unit 120 generates the first sequence data for each of the plurality of first standards and for each of the plurality of booms 22. Then, the screen output unit 130 generates screen data such that the first sequence data can be displayed on one screen. Specifically, the screen output unit 130 displays the recommended sequence for each of the plurality of booms 22 in one display region for each of the plurality of first standards. In addition, a display aspect of each display region is the same as that in the example shown in Fig. 9(B).

[0064] This embodiment also allows, in a case in which the drilling machine 20 has a plurality of booms 22, the drilling sequence data generation device 10 to generate the first sequence data for each of the booms 22. In addition, in a case in which the blast holes are drilled according to the first sequence data, the possibility of interference between the plurality of booms 22 is reduced. Further, in a case in which the screen output unit 130 displays the screen shown in Fig. 12, the operator of the drilling sequence data generation device 10 can understand how the drilling sequence changes depending on a change in the first standard.

(Sixth Embodiment)

[0065] Fig. 13 is a diagram showing the functions of a drilling sequence data generation device 10 according to this embodiment. The sequence data generation unit 120 of the drilling sequence data generation device 10 sequentially selects a plurality of blast holes to sequentially determine the formation sequence of the plurality of blast holes. Further, in this embodiment, a standard for the movement direction of the boom during the formation of the plurality of blast holes is preset. Hereinafter, this standard is referred to as a second standard. Then, the sequence data generation unit 120 of the drilling machine 20 generates the first sequence data using the second standard.

[0066] For example, the second standard indicates a direction. Then, when selecting a blast hole to be drilled after a certain blast hole, the sequence data generation unit 120 sets the amount of movement of the boom in the direction indicated by the second standard to be equal to or greater than 0 as much as possible. In other words, when generating the first sequence data, the sequence data generation unit 120 prevents the boom from being moved backward with respect to the direction indicated by the second standard as much as possible. In addition, the sequence data generation unit 120 may correct the first sequence data generated using the second standard as necessary such that the movement distance of the boom is shortened (for example, minimized).

[0067] For example, the sequence data generation unit 120 generates the first sequence data as follows. First, as shown in Fig. 13, the sequence data generation unit 120 generates a pattern that reciprocates in a direction substantially perpendicular to the second standard (for example, such that an angle θ of a traveling direction with respect to the second standard is equal to or greater than 75°). Then, the blast holes are selected in an order in which the blast holes are superimposed on this pattern to generate initial data of the first sequence data. Then, the sequence data generation unit 120 corrects the initial data such that the movement distance of the boom is shortened (for example, minimized).

[0068] In addition, the drilling sequence data generation device 10 may store only one second standard or may store a plurality of different second standards. In the latter case, the sequence data generation unit 120 may generate the first sequence data for each of the plurality of second standards. Then, the screen output unit 130 of the drilling sequence data generation device 10 may display the first sequence data for each of the plurality of second standards on one screen.

[0069] Further, in a case in which the drilling machine 20 has a plurality of booms 22, the drilling sequence data generation device 10 may store the second standard for each of the plurality of booms 22. In this case, the sequence data generation unit 120 may generate the first sequence data for each of the plurality of second standards and for each of the plurality of booms 22. Then, the screen output unit 130 of the drilling sequence data generation device 10 may display the first sequence data generated for each of the plurality of second standards and for each of the plurality of booms 22 on one screen. An example of this screen is the same as that in the example shown in Fig. 12.

[0070] This embodiment allows the manager or the user of the drilling sequence data generation device 10 to set the standard for the movement direction of the boom 22.

(Seventh Embodiment)

[0071] Fig. 14 is a diagram showing the functions of a drilling sequence data generation device 10 according to this embodiment. The sequence data generation unit 120 of the drilling sequence data generation device 10 sequentially selects a plurality of blast holes to sequentially determine the formation sequence of the plurality of blast holes . Some rules may be established when the drilling sequence of the blast holes is determined. An example of this rule is the first standard described in the fifth embodiment. In this case, this rule may be satisfied until a certain blast hole is selected, but may not be satisfied when the next blast hole (hereinafter, referred to as a first blast hole) is selected. In this case, the screen output unit 130 outputs information indicating the first blast hole.

[0072] For example, in the example shown in Fig. 14 (A), the screen output unit 130 displays data indicating a drilling sequence up to the first blast hole on the screen indicating the positions of the plurality of blast holes. In this case, the screen output unit 130 displays the first blast hole in an aspect different from the other blast holes. Here, an example of the different aspect is that at least one of a color, a pattern, and an outline is different.

[0073] In addition, the sequence data generation unit 120 may generate the first sequence data assuming that there is no first blast hole. In this case, as shown in Fig. 14(B), the screen output unit 130 may display the position of the first blast hole on a screen showing the recommended sequence indicated by the first sequence data.

[0074] This embodiment causes, in a case in which a predetermined rule is not satisfied while the sequence data generation unit 120 is determining the recommended sequence of the blast holes, the screen output unit 130 to output the position of the first blast hole which is the cause of the dissatisfaction. Therefore, the manager or the user of the drilling sequence data generation device 10 can easily recognize the first blast hole. In addition, the manager or the user can recognize the recommended sequence when the blast holes are formed assuming there is no first blast hole.

(Eighth Embodiment)

[0075] Fig. 15 is a diagram showing the functions of a drilling sequence data generation device 10 according to this embodiment. The drilling sequence data generation device 10 according to this embodiment has the same configuration as the drilling sequence data generation device 10 according to any of the above-described embodiments except for the following points.

[0076] First, the drilling position data includes attribute data. The attribute data indicates attributes of at least one blast hole and is set, for example, by a person who determines the position of the blast hole. For example, the attribute data indicates that it is preferable to form the blast hole last. This blast hole is, for example, a blast hole that is located at the bottom. The reason is that, in a case in which the blast hole located at the bottom is formed first, when a blast hole located above the blast hole is formed, bedrock debris is likely to be accumulated in front of or near the blast hole located at the bottom.

[0077] Then, the sequence data generation unit 120 generates the first sequence data using this attribute data. For example, in a case in which the attribute data indicates that it is preferable to form the blast hole last, the first sequence data is generated such that the blast hole is formed last.

[0078] In addition, the attribute data may indicate the attributes of all of the blast holes. For example, the attribute data may indicate the relative positions of all of the blast holes (for example, the bottom, the middle, or the top) . In this case, when generating the first sequence data, the sequence data generation unit 120 generates the first sequence data such that the blast hole whose attribute indicates the "bottom" is formed last.

[0079] In addition, it is preferable that the attributes to be included in the attribute data are preset. For example, a plurality of candidates for the attributes are preset. Then, the person who generates the attribute data selects the attributes of each of the blast holes from the plurality of candidates.

[0080] This embodiment makes it easy for the worker to determine the formation sequence of a plurality of blast holes. In addition, the drilling position data includes the attribute data. Then, the drilling sequence data generation device 10 generates the first sequence data using this attribute data. Therefore, the validity of the first sequence data is high.

[0081] The embodiments of the invention have been described above with reference to the drawings. However, these embodiments are examples of the invention, and various configurations other than the above-described configurations can also be adopted.

[0082] In addition, in the plurality of flowcharts used in the above description, a plurality of steps (processes) are described in order. However, the execution order of the steps in each of the embodiments is not limited to the above-described order. In each of the embodiments, the order of the steps shown in the flowcharts can be changed within a range that the content is consistent. Further, the above-described embodiments can be combined as long as the contents do not contradict each other.

[0083] This application claims priority based on Japanese Patent Application No. 2020-211080 filed on December 21, 2020, and the entire disclosure thereof is incorporated herein.

REFERENCE SIGNS LIST

[0084]

10 drilling sequence data generation device
20 drilling machine
22 boom
110 position acquisition unit
120 sequence data generation unit
130 screen output unit
140 model storage unit
150 drilling data storage unit
160 second sequence data acquisition unit

Claims

1. A drilling sequence data generation device comprising:

   a position acquisition unit that acquires drilling position data indicating a position of each of a plurality of blast holes to be formed in a face in the face;
   a sequence data generation unit that generates first sequence data indicating a recommended sequence of forming the plurality of blast holes using the drilling position data; and
   a screen output unit that generates screen data indicating the recommended sequence and outputs the screen data.

2. The drilling sequence data generation device according to claim 1,

   wherein the face is provided in a tunnel or a mine shaft, and
   the sequence data generation unit acquires drilling data which is data when blast holes that have already been formed at a time of digging the tunnel or the mine shaft are formed and generates the first sequence data using the drilling position data and the drilling data.

3. The drilling sequence data generation device according to claim 2,
   wherein the drilling data includes time required to form the blast holes.

4. The drilling sequence data generation device according to claim 2 or 3,
   wherein the drilling data includes vibration data indicating a vibration or a sound generated during the formation of the blast holes.

5. The drilling sequence data generation device according to any one of claims 2 to 4,
   wherein the drilling data includes operation data indicating an operation performed by an operator on a machine used to form the blast holes.

6. The drilling sequence data generation device according to any one of claims 2 to 5,
   wherein the drilling data includes output data indicating a magnitude of an output of a machine used for the blast holes.

7. The drilling sequence data generation device according to any one of claims 1 to 6,
   wherein the sequence data generation unit generates the first sequence data further using at least one of roughness data indicating roughness of a surface of the face and an image of the face.

8. The drilling sequence data generation device according to any one of claims 1 to 7, further comprising:

   a second sequence data acquisition unit that acquires, from an outside, second sequence data which is different from the first sequence data and which indicates a formation sequence of the plurality of blast holes,
   wherein the screen output unit generates, as the screen data, data for visually checking the formation sequence indicated by the first sequence data and the formation sequence indicated by the second sequence data.

9. The drilling sequence data generation device according to any one of claims 1 to 8,

   wherein a plurality of booms are used to form the plurality of blast holes, and
   the sequence data generation unit allocates, to each of the plurality of booms, the blast holes to be formed by the boom and generates the first sequence data for each of the plurality of booms.

10. The drilling sequence data generation device according to any one of claims 1 to 9,
wherein the screen output unit includes, in the screen data, a moving image showing movement of a boom that performs drilling when the drilling is performed according to the first sequence data.

11. The drilling sequence data generation device according to any one of claims 1 to 10,

wherein the screen data is data for projecting the positions of the plurality of blast holes onto the face together with the recommended sequence indicated by the first sequence data, and
the screen output unit outputs the screen data to a projection device that projects an image onto the face.

12. The drilling sequence data generation device according to any one of claims 1 to 10,

wherein the screen data is data for displaying the positions of the plurality of blast holes in the face on an augmented reality screen, and
the screen output unit outputs the screen data to an augmented reality display.

13. The drilling sequence data generation device according to any one of claims 1 to 12,

wherein a plurality of booms are used to form the plurality of blast holes,
a first standard to be satisfied by a relative distance of the plurality of booms during the formation of the plurality of blast holes is set, and
the sequence data generation unit generates the first sequence data for each of the plurality of booms such that the relative distance of the plurality of booms satisfies the first standard.

14. The drilling sequence data generation device according to claim 13,

wherein a plurality of the first standards are set,
the sequence data generation unit generates the first sequence data for each of the plurality of first standards and for each of the plurality of booms, and
the screen data is data for displaying the first sequence data generated for each of the plurality of first standards and for each of the plurality of booms on one screen.

15. The drilling sequence data generation device according to claim 13 or 14,

wherein the sequence data generation unit sequentially selects the plurality of blast holes to sequentially determine the formation sequence of the plurality of blast holes, and
when the first standard is not satisfied at a time of selecting a first blast hole, the screen output unit outputs information indicating the first blast hole.

16. The drilling sequence data generation device according to claim 15,
wherein the sequence data generation unit generates the first sequence data assuming that the first blast hole is not present.

17. The drilling sequence data generation device according to any one of claims 1 to 16,

wherein a second standard indicating a standard for a movement direction of a boom during the formation of the plurality of blast holes is set, and
the sequence data generation unit generates the first sequence data using the second standard.

18. The drilling sequence data generation device according to claim 17,

wherein a plurality of the second standards are set,
the sequence data generation unit generates the first sequence data for each of the plurality of second standards, and
the screen data is data for displaying the first sequence data generated for each of the plurality of second standards on one screen.

19. The drilling sequence data generation device according to any one of claims 1 to 18,

wherein the drilling position data further includes attribute data indicating an attribute of at least one of the blast holes, and
the sequence data generation unit generates the first sequence data further using the attribute data.

20. A drilling sequence data generation method executed by a computer, the drilling sequence data generation method comprising:

a position acquisition process of acquiring drilling position data indicating a position of each of a plurality of blast holes to be formed in a face in the face;
a sequence data generation process of generating first sequence data indicating a recommended sequence of forming the plurality of blast holes using the drilling position data; and

a screen output process of generating screen data indicating the recommended sequence and outputting the screen data.

21. A program that causes a computer to implement:

a position acquisition function of acquiring drilling position data indicating a position of each of a plurality of blast holes to be formed in a face in the face;
a sequence data generation function of generating first sequence data indicating a recommended sequence of forming the plurality of blast holes using the drilling position data; and
a screen output function of generating screen data indicating the recommended sequence and outputting the screen data.

FIG. 1

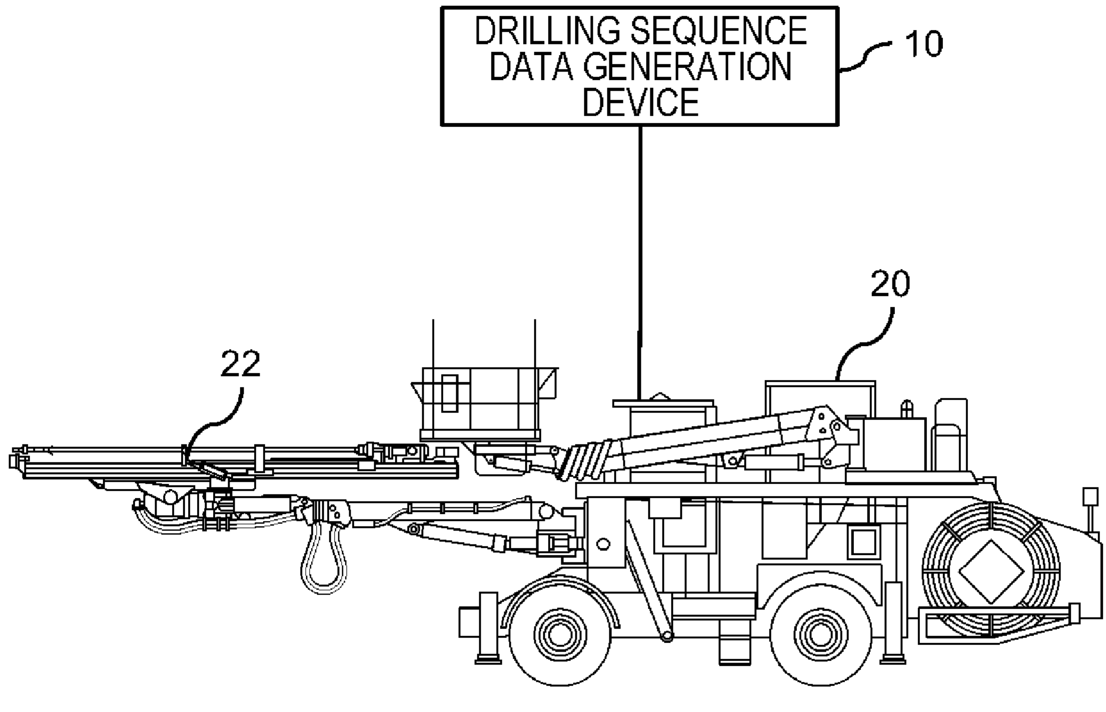


FIG. 2

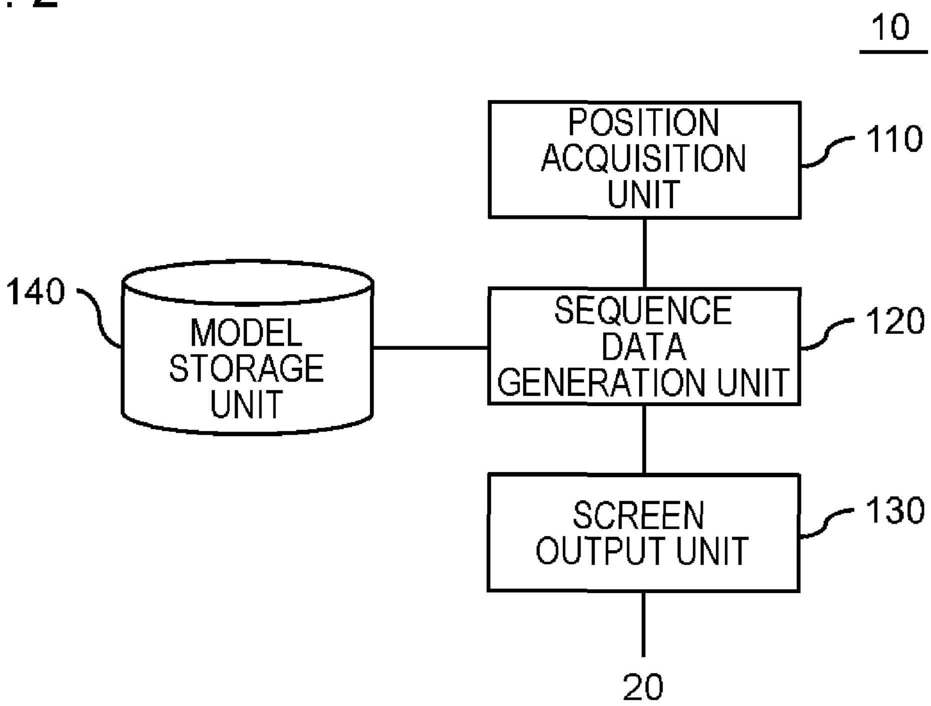
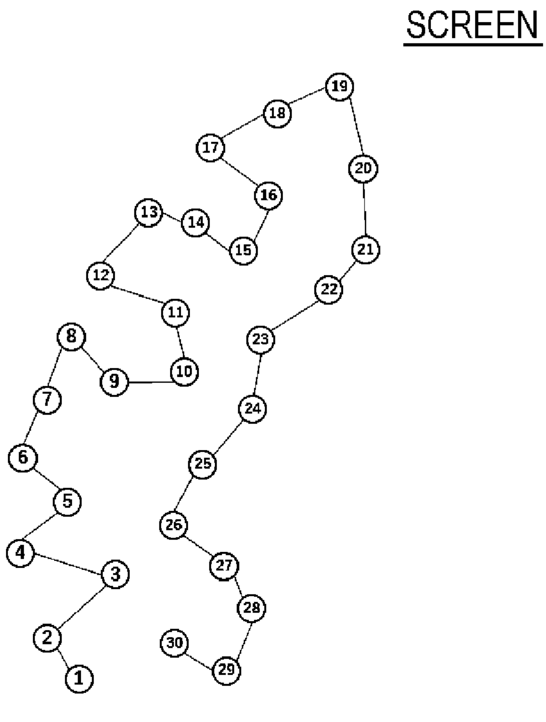

10
POSITION ACQUISITION UNIT
110
140
MODEL STORAGE UNIT
SEQUENCE DATA GENERATION UNIT
120
SCREEN OUTPUT UNIT
130
20

FIG. 3


SCREEN
1
2
3
4
5
6
7
8
9
10
11
12
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29
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FIG. 4

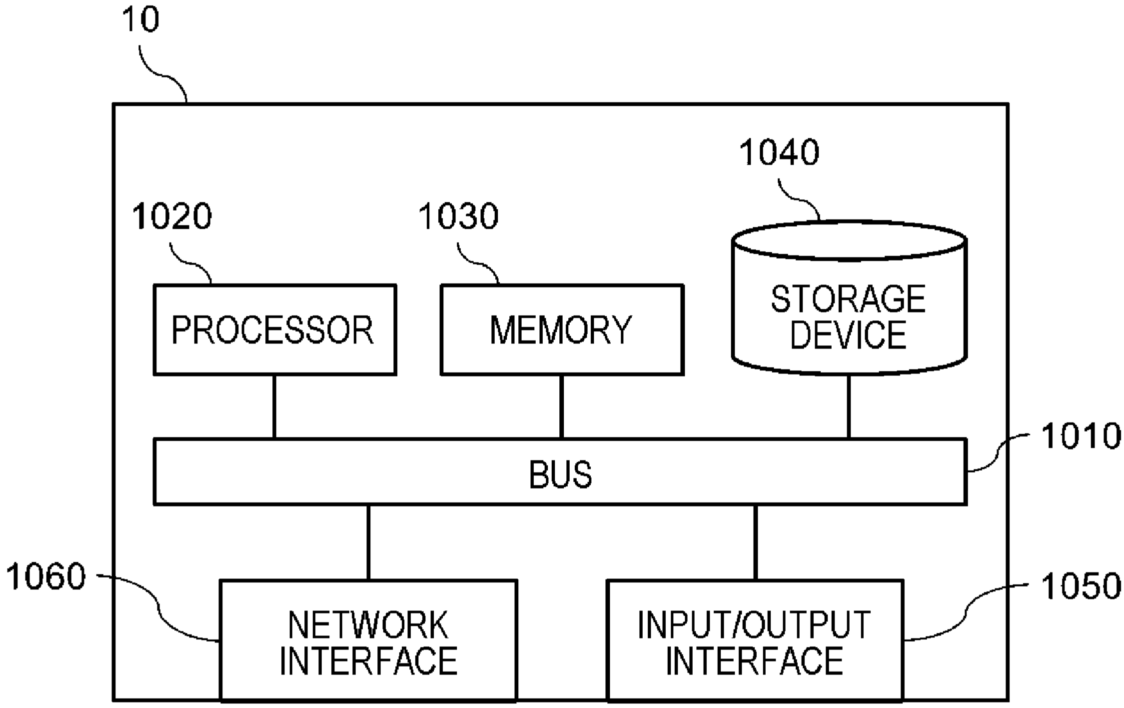
10
1040
1020
1030
PROCESSOR
MEMORY
STORAGE DEVICE
BUS
1010
1060
1050
NETWORK INTERFACE
INPUT/OUTPUT INTERFACE

FIG. 5

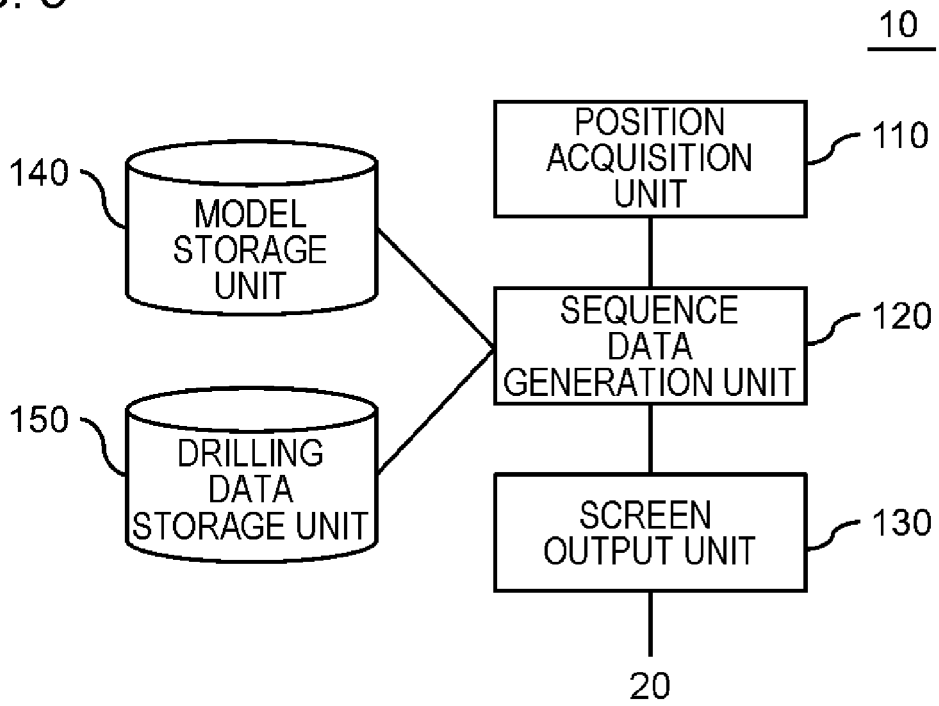
10
140
MODEL
STORAGE
UNIT
150
DRILLING
DATA
STORAGE UNIT
POSITION
ACQUISITION
UNIT
110
SEQUENCE
DATA
GENERATION UNIT
120
SCREEN
OUTPUT UNIT
130
20

FIG. 6

150

FACE NUMBER	0002				
HOLE POSITION	DRILLING DATA				
	TIME REQUIRED	VIBRATION DATA	OPERATION DATA	OUTPUT DATA	IMAGE DATA (ROUGHNESS DATA)

FIG. 7

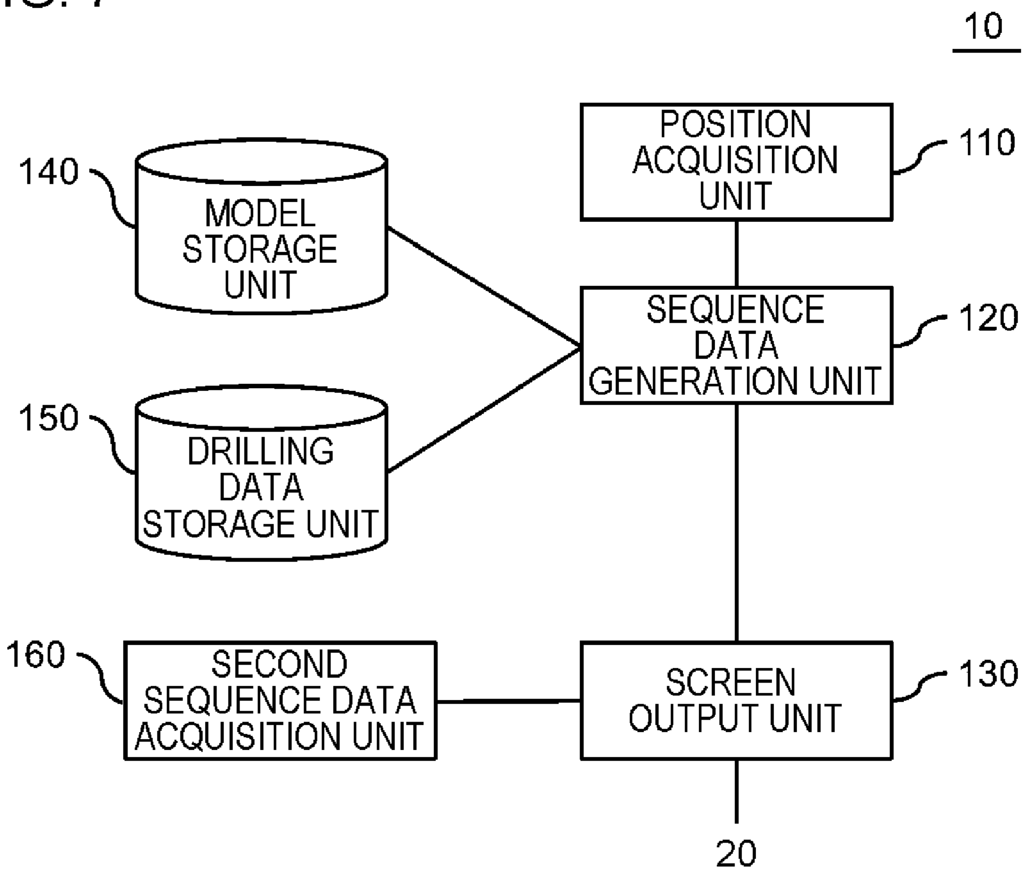
10
POSITION
ACQUISITION
UNIT
110
140
MODEL
STORAGE
UNIT
SEQUENCE
DATA
GENERATION UNIT
120
150
DRILLING
DATA
STORAGE UNIT
160
SECOND
SEQUENCE DATA
ACQUISITION UNIT
SCREEN
OUTPUT UNIT
130
20

FIG. 8

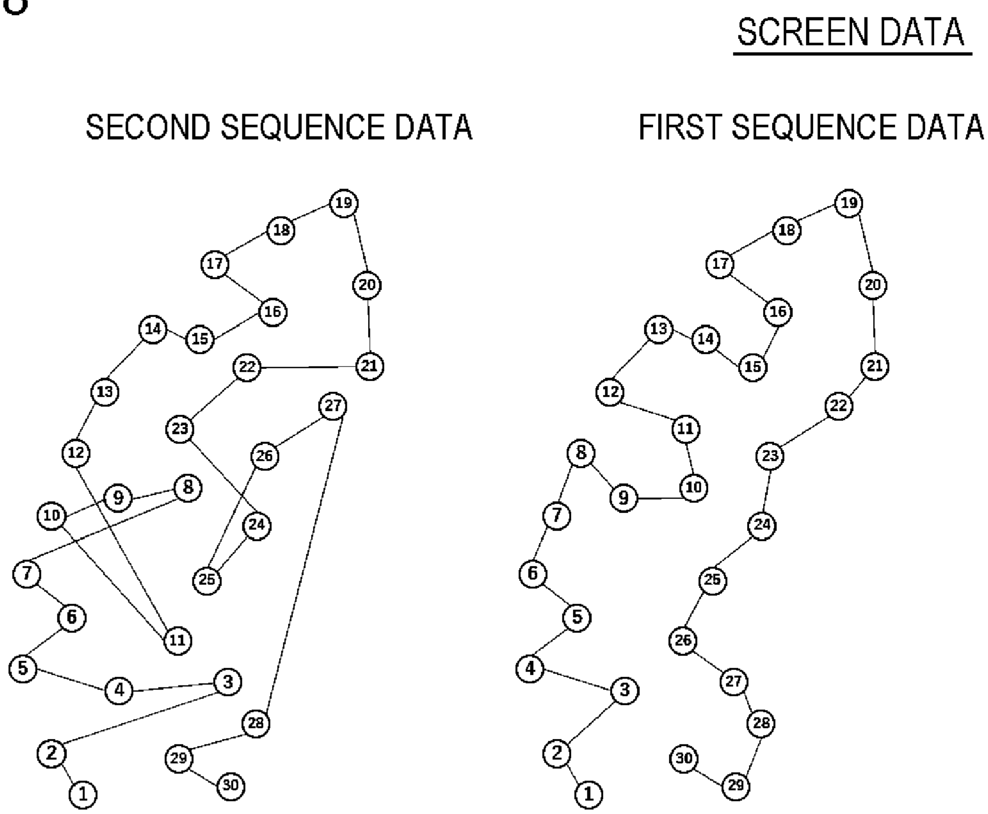
SCREEN DATA
SECOND SEQUENCE DATA
FIRST SEQUENCE DATA
1
2
3
4
5
6
7
8
9
10
11
12
13
14
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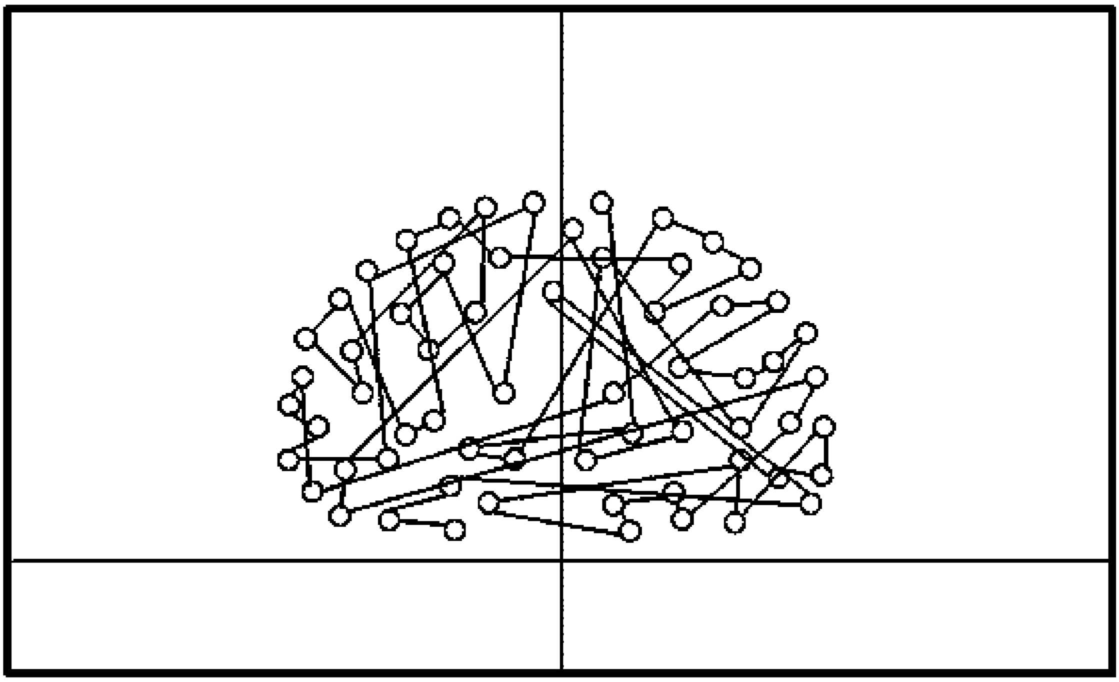
FIG. 9

(A) HOLE POSITION DATA



(B) SCREEN DATA

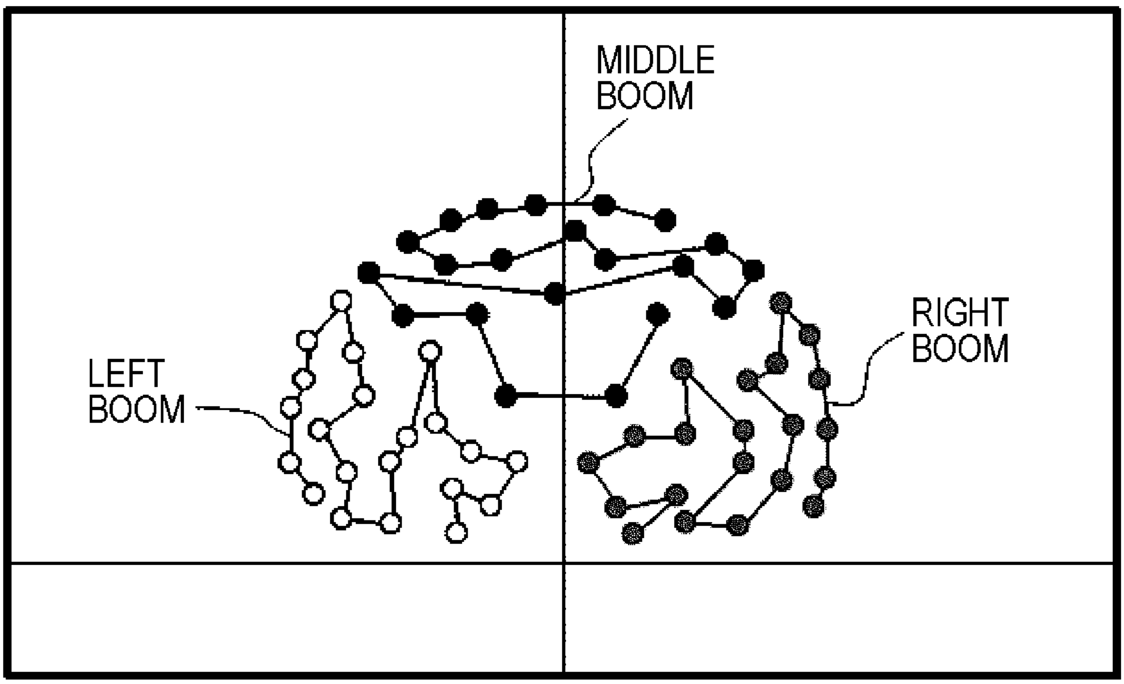
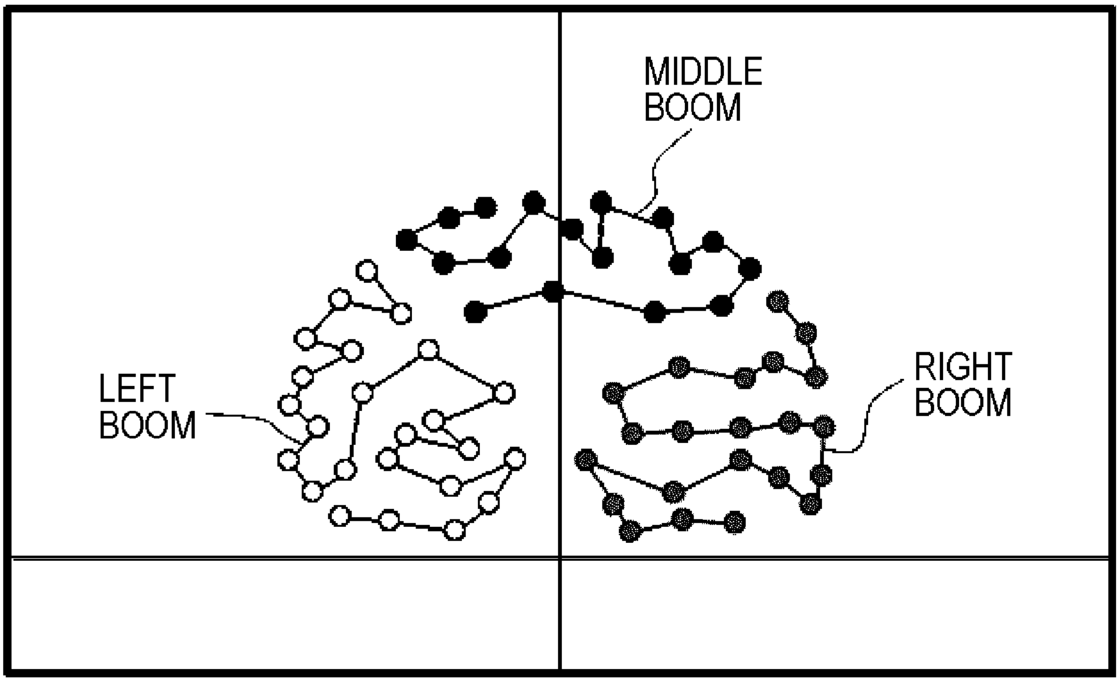


FIG. 10

(A) HOLE POSITION DATA



(B) SCREEN DATA

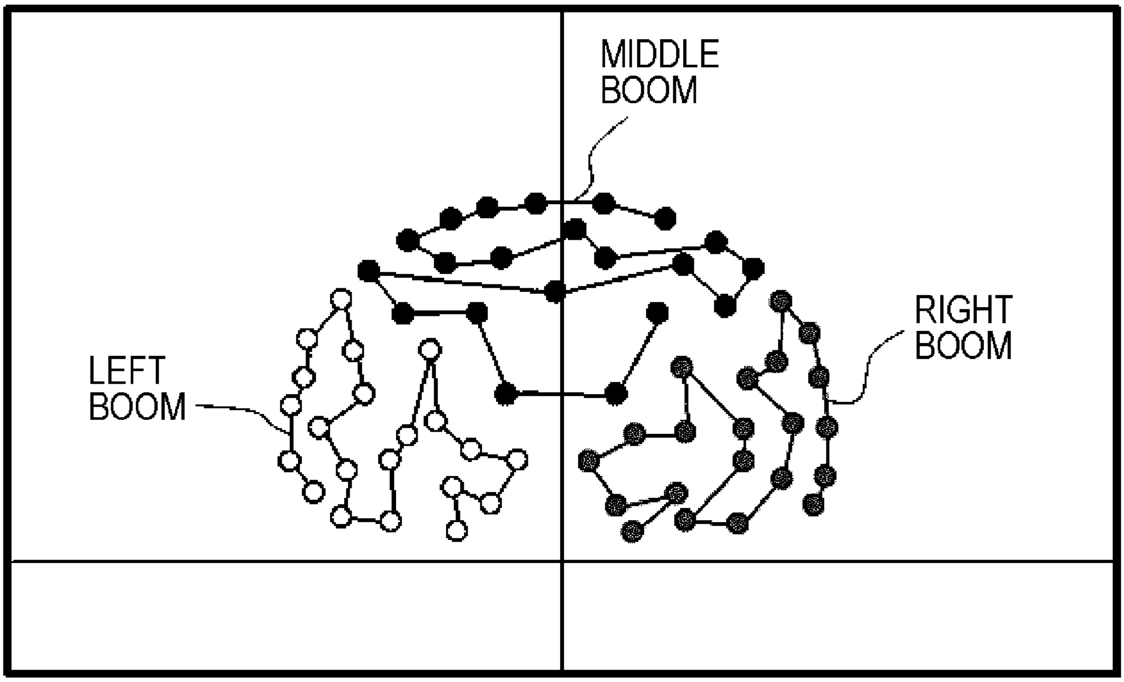


FIG. 11

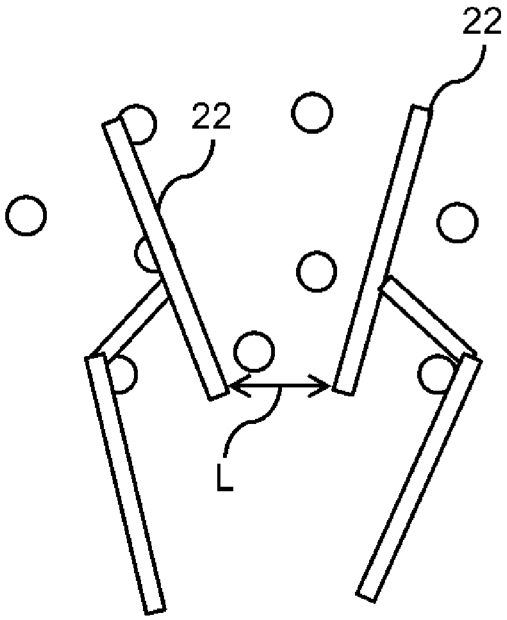
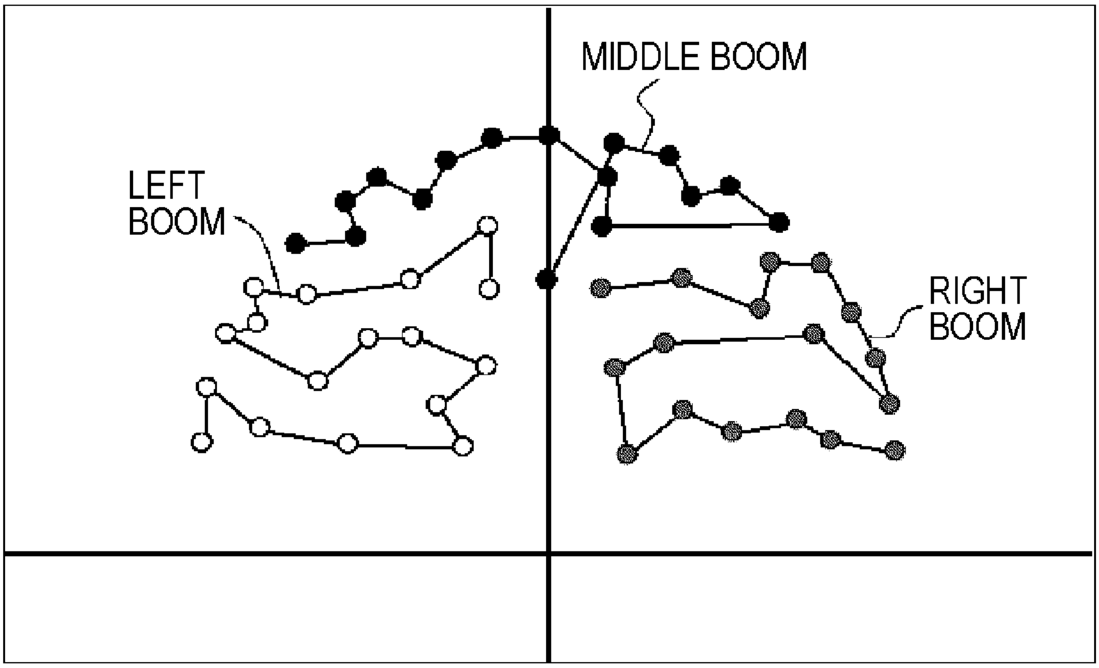


FIG. 12

LOWER LIMIT OF RELATIVE DISTANCE: 1000mm



LOWER LIMIT OF RELATIVE DISTANCE: 1200mm

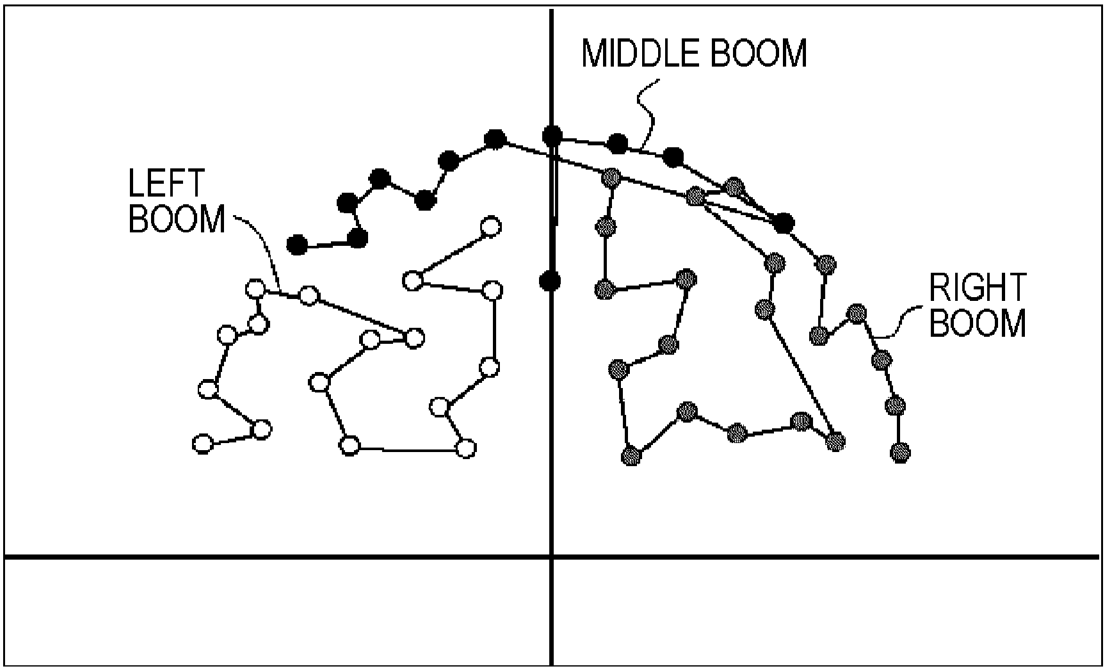


FIG. 13

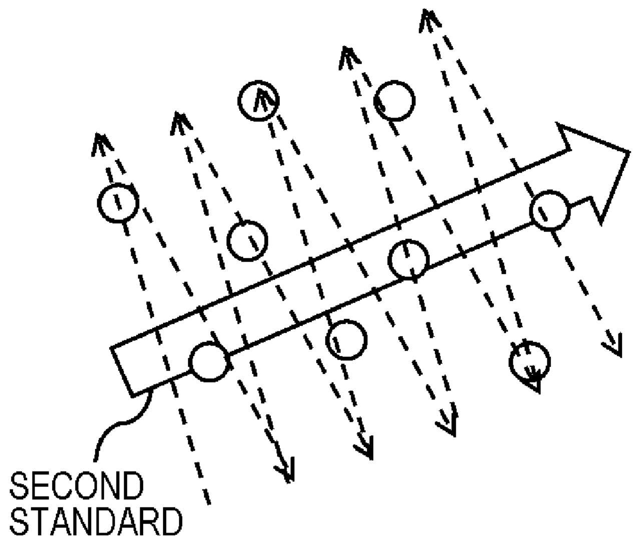
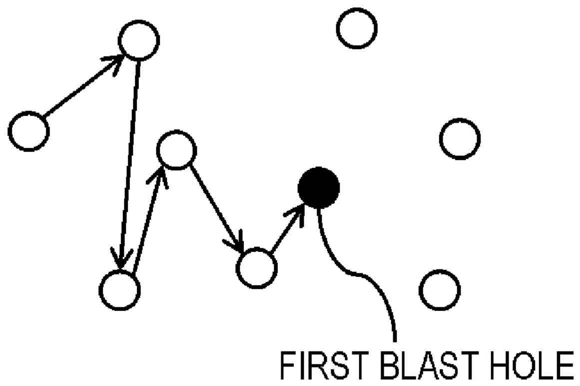


FIG. 14

(A)



(B)

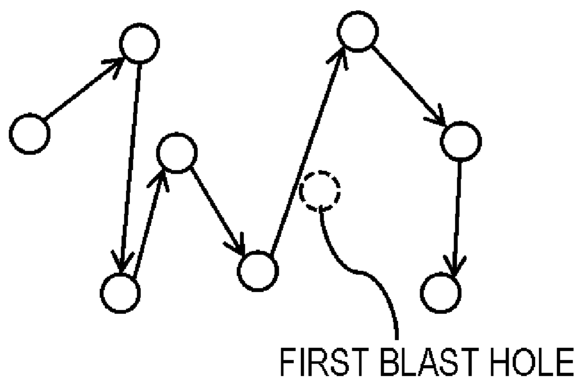
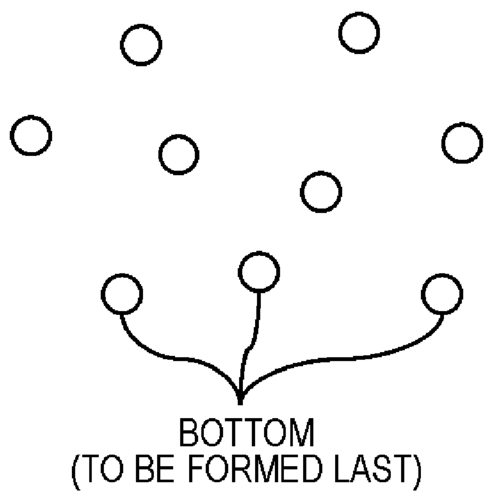


FIG. 15



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2021/045099

A. CLASSIFICATION OF SUBJECT MATTER

E21B 7/02(2006.01)i
FI: E21B7/02

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)

E21B1/00-49/10,E21D9/00

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

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2022
Registered utility model specifications of Japan 1996-2022
Published registered utility model applications of Japan 1994-2022

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2005-511930 A (SANDVIK TAMROCK OY) 28 April 2005 (2005-04-28) paragraphs [0001]-[0025], fig. 1-6	1-3, 20-21
Y	paragraphs [0001]-[0025], fig. 1-6	6-7, 9-13
A		4-5, 8, 14-19
Y	JP 2001-249186 A (FUJITA CORP) 14 September 2001 (2001-09-14) paragraph [0019]	6-7, 9-13
Y	JP 2004-171231 A (UNIV NIHON) 17 June 2004 (2004-06-17) paragraphs [0002]-[0004], [0006]	7, 9-13
Y	JP 5-202694 A (KONOIKEGUMI KK) 10 August 1993 (1993-08-10) paragraphs [0009], [0014]-[0015]	7, 9-13
Y	JP 2017-43885 A (KOMATSU MFG CO LTD) 02 March 2017 (2017-03-02) paragraphs [0065], [0118]-[0125], fig. 8	10-13
Y	JP 2017-48646 A (MAEDA CONSTRUCTION) 09 March 2017 (2017-03-09) paragraphs [0001], [0017], fig. 1-4	11, 13

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

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Date of the actual completion of the international search	Date of mailing of the international search report
18 February 2022	**08 March 2022**

Name and mailing address of the ISA/JP	Authorized officer
Japan Patent Office (ISA/JP) **3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915** **Japan**	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2021/045099

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2018-104932 A (MAEDA CONSTRUCTION) 05 July 2018 (2018-07-05) paragraphs [0025]-[0026], [0029], fig. 1-4	12-13
P, X	EP 3789579 A1 (SANDVIK MINING AND CONSTRUCTION OY) 10 March 2021 (2021-03-10) paragraphs [0001]-[0081], fig. 1-8	1-3, 9, 13, 20-21

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2021/045099

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 2005-511930 A	28 April 2005	US 2004/0216922 A1 paragraphs [0002]-[0033], fig. 1-6	
		WO 2003/048524 A1	
		EP 1470316 A1	
		CA 2468886 A1	
		NO 339999 B1	
		AT 345435 T	
		CN 1599836 A	
		ZA 200403963 B	
		AU 2002346766 A1	
JP 2001-249186 A	14 September 2001	(Family: none)	
JP 2004-171231 A	17 June 2004	(Family: none)	
JP 5-202694 A	10 August 1993	(Family: none)	
JP 2017-43885 A	02 March 2017	US 2018/0135273 A1 paragraphs [0082], [0144]-[0151], fig. 8	
		WO 2017/033623 A1	
		EP 3342937 A1	
		CN 107532401 A	
		CN 113026839 A	
JP 2017-48646 A	09 March 2017	(Family: none)	
JP 2018-104932 A	05 July 2018	(Family: none)	
EP 3789579 A1	10 March 2021	CN 112539029 A paragraphs [0001]-[0096], fig. 1-8	

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2018197445 A **[0003]**
- JP 2020211080 A **[0083]**