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(54) **PULSE DRILLING APPARATUS**

(57) Disclosed is a pulse drilling device, including: a plurality of drill rods (100), a plurality of drill bits, a plurality of energy storage capacitors (300) and a plurality of discharge switches (400). Each of the drill rods is correspondingly connected to the energy storage capacitor, the energy storage capacitor is configured to charge the drill rod connected to the energy storage capacitor, the drill bit is connected to the drill rod, the discharge switch is connected to the drill rod to control the drill rod to discharge to the drill bit to break rocks, and the plurality of the drill rods are configured to continuously and alternately charge and discharge. The discharge switch can control the charging state of each of the drill rods correspondingly. When one of the drill rods is in the discharging state, the other drill rods are in the charging state. The drill rod in the discharging state switches to the charging state after the electric energy is exhausted, and at the same time, the drill rod in the fully charged state is continuously discharged. As a result, the plurality of drill rods can be continuously charged and discharged alternately, thereby greatly improving the drilling efficiency.

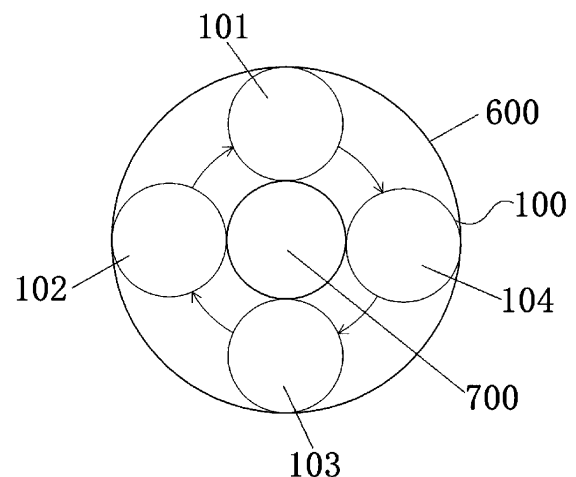


FIG. 1

Description

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims priority to Chinese Patent Application No. 202110653591.2, filed on June 11, 2021, the entire contents of which are incorporated herein by reference.

TECHNICAL FIELD

[0002] The present application relates to the technical field of drilling equipment, and in particular to a pulse drilling device.

BACKGROUND

[0003] Breaking the ore by the pulse discharge is a new breaking technology developed in the past few decades, which uses the mechanical effects of shock waves, jets or plasma channels generated by the pulse discharge to break ores. There are no flying stones or harmful substances during the breaking process, and the discharge process is easy to control.

[0004] However, the pulse drilling devices currently used are all in the form of single charge and discharge, and cannot truly realize the function of continuous discharge drilling, thus the efficiency of drilling and breaking is relatively low.

SUMMARY

[0005] The present application provides a pulse drilling device, aiming to solve the problem in the related art that the pulse drilling device cannot continuously charge and discharge and has low drilling efficiency, so as to realize the continuous charging and discharging of the pulse drilling device and improve the drilling efficiency.

[0006] The pulse drilling device provided by the present application includes: a plurality of drill rods, a plurality of drill bits, a plurality of energy storage capacitors and a plurality of discharge switches; each of the drill rods is correspondingly connected to the energy storage capacitor, the energy storage capacitor is configured to charge the drill rod connected to the energy storage capacitor, the drill bit is connected to the drill rod, the discharge switch is connected to the drill rod to control the drill rod to discharge to the drill bit to break rocks, and the plurality of the drill rods are configured to continuously and alternately charge and discharge.

[0007] In an embodiment, the drill bit includes an integrated drill bit, and each of the drill rods is connected to the integrated drill bit.

[0008] In an embodiment, the drill bit includes a plurality of split drill bits, and each of the drill rods is connected to one of the split drill bits.

[0009] In an embodiment, the drill bit is detachably connected to the drill rod through a drill bit connector.

[0010] In an embodiment, each of the drill rods is equipped with the discharge switch to control a working state of each of the drill rods.

[0011] In an embodiment, the pulse drilling device further includes a control unit electrically connected to each of the discharge switches to control a working state of each of the discharge switches to control a discharge time and a discharge sequence of each of the drill rods.

[0012] In an embodiment, an insulating layer is provided between a low-voltage end and a high-voltage end at a connecting port of the drill rod and the drill bit connector.

[0013] In an embodiment, each of the drill rods is connected to at least one of the energy storage capacitors, and each of the energy storage capacitors is connected to a high-voltage power supply electrically connected to the control unit.

[0014] In an embodiment, the pulse drilling device further includes a casing, and the plurality of the energy storage capacitors and the plurality of the drill rods are installed in the casing.

[0015] In an embodiment, a slag discharge channel is provided in the casing, and the plurality of drill rods are provided in an annular array inside of the casing with a center point of the slag discharge channel as a center point of the annular array.

[0016] In the pulse drilling device provided by this application, each of the drill rods is correspondingly connected to the energy storage capacitor, and the energy storage capacitor can charge the connected drill rod. The drill bit is connected to the drill rod, and the discharge switch is connected to the drill rod to control the drill rod to discharge to the drill bit and break the rock, and a plurality of drill rods can continuously alternate charge and discharge.

[0017] Compared with the related art, the pulse drilling device is provided with a plurality of drill rods, and each of the drill rods is correspondingly connected to the energy storage capacitor. The discharge switch can control the charging state of each of the drill rods correspondingly. When one of the drill rods is in the discharging state, the other drill rods are in the charging state. The drill rod in the discharging state switches to the charging state after the electric energy is exhausted, and at the same time, the drill rod in the fully charged state is continuously discharged. As a result, the plurality of drill rods can be continuously charged and discharged alternately, thereby greatly improving the drilling efficiency.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] In order to illustrate the technical solutions in the embodiments of the present application or in the related art more clearly, the following briefly introduces the accompanying drawings required for the description of the embodiments or the related art. Obviously, the drawings in the following description are only part of embodiments of the present application. For those skilled in the art, other drawings can also be obtained according to the

structures shown in these drawings without any creative effort.

FIG. 1 is a schematic structural view of a pulse drilling device according to the present application.

FIG. 2 is a schematic structural view of a pulse drilling device equipped with an integrated drill bit according to the present application.

FIG. 3 is a schematic view of a working state of the pulse drilling device equipped with the integrated drill bit.

FIG. 4 is a schematic structural view of a pulse drilling device equipped with a split drill bit according to the present application.

FIG. 5 is a schematic view of a working state of the pulse drilling device equipped with the split drill bit.

Reference signs:

[0019]

100: drill rod; 101: first drill rod;
102: second drill rod; 103: third drill rod;
104: fourth drill rod; 201: integrated drill bit;
202: split drill bit; 300: energy storage capacitor;
400: discharge switch; 500: drill bit connector;
600: casing; 700: slag discharge channel.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0020] The embodiments of the present application will be further described in detail below with the accompanying drawings and examples. The following examples are used to illustrate the present application but cannot be used to limit the scope of the present application.

[0021] In the description of the embodiments of the present application, it should be noted that the orientations or positional relationships indicated by the terms "center", "longitudinal", "lateral", "upper", "lower", "front", "back", "left", "right", "vertical", "horizontal", "top", "bottom", "inside", "outside", etc. are based on the orientations or positional relationships shown in the accompanying drawings and are only for the convenience to describe the embodiments of the present application and to simplify the description, but does not indicate or imply that the device or element referred to must have a specific orientation, be constructed and operated in a specific orientation, and therefore cannot be understood as a limitation on the embodiments of the present application. In

addition, the terms "first" and "second" are used for descriptive purposes only and are not to be understood as indicating or implying relative importance.

[0022] In the description of the embodiments of the present application, it should be noted that, unless otherwise explicitly stipulated and limited, the terms "connection" and "connected" should be understood in a broad sense. For example, it can be a fixed connection or a removable connection, a detachable connection or an integrated connection, a mechanical connection or an electrical connection, and a direct connection or an indirect connection through an intermediate medium. For those skilled in the art, the specific meanings of the above terms in the embodiments of the present application can be understood in specific situations.

[0023] In the embodiments of the present application, unless otherwise clearly stated and limited, the first feature "on" or "below" the second feature may be that the first feature is directly connected to the second feature, or the first feature is indirectly connected to the second feature through an intermediate medium. Furthermore, the first feature "above" or "beneath" the second feature may be that the first feature is directly above or diagonally above the second feature or the first feature is directly beneath or diagonally beneath the second feature, or simply means that the first feature is higher in level than the second feature or the first feature is lower in level than the second feature.

[0024] In the description of this specification, reference to the description of the terms "one embodiment", "some embodiments", "examples", "specific examples" or "some examples" is intended to describe that the specific features, structures, materials or characteristics of the embodiments or the examples are included in at least one embodiment or example of the embodiments of the present application. In this description, the schematic expressions of the above terms are not necessarily directed to the same embodiment or example. Furthermore, the specific features, structures, materials or characteristics described may be combined in any suitable manner in any one or more embodiments or examples. In addition, those skilled in the art can combine different embodiments or examples and features of different embodiments or examples described in this specification to achieve the purpose and technical solutions of the embodiments of this application unless they are inconsistent with each other. The technical solutions of the embodiments of the present application will be described in more detail below with reference to the accompanying drawings. It is obvious that the embodiments to be described are only some rather than all of the embodiments of the present application. All other embodiments obtained by persons skilled in the art based on the embodiments of the present application without creative efforts shall fall within the scope of the present application.

[0025] A pulse drilling device according to an embodiment of the present application will be described below with reference to FIG. 1 to FIG. 5. It should be understood

that the following descriptions are only illustrative embodiments of the present application and do not constitute any special limitations to the present application.

[0026] In an embodiment, the present application provides a pulse drilling device, as shown in FIG. 1, FIG. 2 and FIG. 4. The pulse drilling device includes: a plurality of drill rods 100, a plurality of drill bits, a plurality of energy storage capacitors 300 and a plurality of discharge switches 400.

[0027] Each of the drill rods 100 is correspondingly connected with the energy storage capacitor 300. The energy storage capacitor 300 can charge the drill rod 100 connected thereto. The drill bit is connected to the drill rod 100, and the discharge switch 400 is connected to the drill rod 100 to control the drill rod 100 to discharge to the drill bit and break the rock. Moreover, the plurality of drill rods can be charged and discharged continuously and alternately.

[0028] Compared with the related art, the pulse drilling device is provided with the plurality of drill rods 100, and each of the drill rods 100 is correspondingly connected with the energy storage capacitor 300. The discharge switch 400 can control a charging state of each of the drill rods 100 correspondingly. When one of the drill rods 100 is in a discharging state, the other drill rods 100 are in a charging state. The drill rod 100 in the discharging state switches to the charging state after an electric energy is exhausted, and at the same time, the drill rod 100 in the fully charged state is continuously discharged. As a result, the plurality of drill rods 100 can be charged and discharged continuously and alternately, thereby greatly improving a drilling efficiency.

[0029] In an embodiment, as shown in FIG. 1, the drill rod 100 includes a first drill rod 101, a second drill rod 102, a third drill rod 103 and a fourth drill rod 104. The first drill rod 101, the second drill rod 102, the third drill rod 103 and the fourth drill rod 104 are all correspondingly connected with the energy storage capacitors 300. Assuming that the discharge switch 400 firstly controls the first drill rod 101 to discharge to the drill bit to break the rock, then the second drill rod 102, the third drill rod 103 and the fourth drill rod 104 are all in the charging state. When the electric energy of the first drill rod 101 is exhausted, the discharge switch 400 can control any one of the second drill rod 102, the third drill rod 103 and the fourth drill rod 104 to discharge to the drill bit to break the rock. At the same time, the energy storage capacitor 300 charges the first drill rod 101. According to this regular cycle, the first drill rod 101, the second drill rod 102, the third drill rod 103 and the fourth drill rod 104 can realize continuous and alternate charging and discharging, thereby greatly improving the drilling efficiency.

[0030] It should be noted that the above embodiment is only an illustrative embodiment of the present application and does not constitute any limitation on the present application. The number of drill rods 100 can be determined according to actual needs.

[0031] In an embodiment, the drill bit includes an inte-

grated drill bit 201, and each of the drill rods 100 is connected to the integrated drill bit 201.

[0032] As shown in FIG. 2 and FIG. 3, the pulse drilling device includes the integrated drill bit 201. The plurality of drill rods 100 are connected to the integrated drill bit 201. Any drill rod 100 can be discharged to the integrated drill bit 201 to break rocks. The pulse drilling device equipped with the integrated drill bit 201 can realize continuous drilling work under a same energy condition as small diameters.

[0033] In an embodiment, the drill bit includes a plurality of split drill bits 202, and each of the drill rods 100 is connected with the split drill bit 202.

[0034] As shown in FIG. 4 and FIG. 5, the pulse drilling device includes the plurality of split drill bits 202. A number of the split drill bits 202 is equal to a number of the drill rods 100. That is, each of the drill rods 100 is connected with the split drill bit 202. Each of the drill rods 100 can discharge to the corresponding split drill bit 202 connected thereto to break rocks. The pulse drilling device equipped with the split drill bit 202 can realize continuous drilling work with small energy and large diameter.

[0035] In an embodiment, the drill bit is detachably connected to the drill rod 100 through a drill bit connector 500.

[0036] According to the above-described embodiments, it can be seen that by changing a type of the drill bit, the pulse drilling device can be suitable for continuous drilling work under different working conditions, which greatly improves the flexibility and versatility of the pulse drilling device.

[0037] In an embodiment, each of the drill rods 100 is provided with the discharge switch 400 to control the working status of each of the drill rods 100.

[0038] For example, the first drill rod 101 is connected with a first discharge switch. The second drill rod 102 is connected with a second discharge switch. The third drill rod 103 is connected with a third discharge switch. The fourth drill rod 104 is connected with a fourth discharge switch. When the first drill rod 101 is required to discharge, the first discharge switch is in a conductive state, and the first drill rod 101 discharges to the drill bit to break the rock. At this time, the second discharge switch, the third discharge switch and the fourth discharge switch are all in an off state, and the second drill rod 102, the third drill rod 103 and the fourth drill rod 104 are all in the charging state. When the electric energy of the first drill rod 101 is exhausted, the first discharge switch, the third discharge switch and the fourth discharge switch are in the off state, the second discharge switch is in the on state, and the second drill rod 102 is discharged to the drill bit to breaking rocks, and the rest of the drill rods are in the charging state.

[0039] In an embodiment, an insulating layer is provided between a low-voltage end and a high-voltage end at a connecting port of the drill rod 100 and the drill bit connector 500. The insulation layer is configured to isolate a connection among the high-voltage electrode drill bit,

the low-voltage electrode drill bit and the casing to prevent a leakage of electrical energy and safety problems.

[0040] In an embodiment, the pulse drilling device further includes a control unit electrically connected to each of the discharge switches 400 to control a discharge time and a discharge sequence of each of the drill rods 100 by controlling the working state of each of the discharge switches 400.

[0041] Further, in an embodiment, at least one energy storage capacitor 300 is connected to each of the drill rods 100. Each of the energy storage capacitors 300 is connected to a high-voltage power supply. The high-voltage power supply is electrically connected to the control unit. With reference to the above embodiment, the pulse drilling device further includes the control unit. The control unit is electrically connected to the first discharge switch, the second discharge switch, the third discharge switch and the fourth discharge switch. Each of the drill rods 100 can be equipped with a plurality of energy storage capacitors 300, and each of the energy storage capacitors 300 is connected to the high-voltage power supply. The high-voltage power supply can convert a conventional 220V commercial power or a 380V industrial power into a high-voltage direct current, and transfer it to the energy storage capacitor 300 to charge the first drill rod 101, the second drill rod 102, the third drill rod 103 and the fourth drill rod 104. The control system can control the high-voltage power supply to charge the energy storage capacitors 300 corresponding to the first drill rod 101, the second drill rod 102, the third drill rod 103 and the fourth drill rod 104.

[0042] At the same time, the control system can also set a certain discharge time and a certain discharge sequence. For example, the control system may set the discharge sequence to be the first drill rod 101, the second drill rod 102, the third drill rod 103 and the fourth drill rod 104. The discharge time of each of the drill rods 100 is 30 minutes.

[0043] At the beginning, the control system controls the first discharge switch to be in the on state, and the second discharge switch, the third discharge switch and the fourth discharge switch to be in the off state. At this time, the first drill rod 101 is discharged to the drill bit to break. At the same time, the control system controls the high-voltage power supply to charge the second drill rod 102, the third drill rod 103 and the fourth drill rod 104. After the first drill rod 101 is discharged for 30 minutes, the control system controls the first discharge switch, the third discharge switch and the fourth discharge switch to be in the off state, and the second discharge switch is in the on state. At this time, the second drill rod 102 is discharged to the drill bit to break. At the same time, the control system controls the high-voltage power supply to charge the first drill rod 101, the third drill rod 103 and the fourth drill rod 104. After the second drill rod 102 is discharged for 30 minutes, the first discharge switch, the second discharge switch and the fourth discharge switch are in the off state, and the third discharge switch is in

the on state. At this time, the third drill rod 103 is discharged to the drill bit to break. At the same time, the control system controls the high-voltage power supply to charge the first drill rod 101, the second drill rod 102 and the fourth drill rod 104. After the third drill rod 103 is discharged for 30 minutes, the first discharge switch, the second discharge switch and the third discharge switch are in the off state, and the fourth discharge switch is in the on state. At this time, the fourth drill rod 104 is discharged to the drill bit to break. At the same time, the control system controls the high-voltage power supply to charge the first drill rod 101, the second drill rod 102 and the third drill rod 103. According to this rule, a next cycle of the continuous charging and discharging work is carried out.

[0044] It should be understood here that at least one energy storage capacitor 300 is connected to each of the drill rods 100. The energy storage capacitor 300 connected to each of the drill rods 100 can be adjusted according to actual needs. All energy storage capacitors can be connected to the same high-voltage power supply.

[0045] In an embodiment, the pulse drilling device further includes a casing 600. Each of the energy storage capacitors 300 and each of the drill rods 100 are installed in the casing 600.

[0046] Furthermore, in an embodiment, as shown in FIG. 1 to FIG. 5, a slag discharge channel 700 is provided in the casing 600. The plurality of drill rods 100 are provided in an annular array inside the casing 600 with a center point of the slag discharge channel 700 as a center point of the annular array.

[0047] As shown in FIG. 1, the slag discharge channel 700 is located at a center of the plurality of drill rods 100, which is configured to suppress a mud and flush out the slag from broken rocks to discharge the slag in a positive circulation. Or the broken slag can be sucked out from the slag discharge channel 700 to discharge the slag in a reverse circulation.

[0048] According to the above-described embodiments, it can be seen that the pulse drilling device has a simple and compact structure and is easy to operate. Compared with traditional mechanical breaking methods, its breaking efficiency is greatly improved and the working cost is lower. At the same time, the device can be applied to drilling work under different working conditions and has the high flexibility and versatility. In addition, compared with the existing pulse drilling device, this device can truly realize continuous charging and continuous discharge, thereby achieving continuous drilling work, and the drilling work efficiency is greatly improved.

[0049] At last, it should be noted that: the above descriptions are only embodiments of the present application, and are not intended to limit the scope of the present application. Those skilled in the art should understand that they can still modify the technical solutions recorded in the embodiments, or make equivalent substitutions for some of the technical features. These modifications or substitutions do not make the essence of the correspond-

ing technical solutions deviates from the scope of the technical solutions of each embodiment of the present application.

Claims

1. A pulse drilling device, **characterized by** comprising:

a plurality of drill rods, a plurality of drill bits, a plurality of energy storage capacitors and a plurality of discharge switches, wherein each of the drill rods is correspondingly connected to the energy storage capacitor, the energy storage capacitor is configured to charge the drill rod connected to the energy storage capacitor, the drill bit is connected to the drill rod, the discharge switch is connected to the drill rod to control the drill rod to discharge to the drill bit to break rocks, and the plurality of the drill rods are configured to continuously and alternately charge and discharge.

2. The pulse drilling device according to claim 1, wherein the drill bit comprises an integrated drill bit, and each of the drill rods is connected to the integrated drill bit.

3. The pulse drilling device according to claim 1, wherein the drill bit comprises a plurality of split drill bits, and each of the drill rods is connected to one of the split drill bits.

4. The pulse drilling device according to claim 2 or 3, wherein the drill bit is detachably connected to the drill rod through a drill bit connector.

5. The pulse drilling device according to claim 1, wherein each of the drill rods is equipped with the discharge switch to control a working state of each of the drill rods.

6. The pulse drilling device according to claim 5, wherein the pulse drilling device further comprises a control unit electrically connected to each of the discharge switches to control a working state of each of the discharge switches to control a discharge time and a discharge sequence of each of the drill rods.

7. The pulse drilling device according to claim 4, wherein an insulating layer is provided between a low-voltage end and a high-voltage end at a connecting port of the drill rod and the drill bit connector.

8. The pulse drilling device according to claim 6, wherein each of the drill rods is connected to at least one of the energy storage capacitors, and each of the

energy storage capacitors is connected to a high-voltage power supply electrically connected to the control unit.

9. The pulse drilling device according to claim 8, further comprising a casing, wherein the plurality of the energy storage capacitors and the plurality of the drill rods are installed in the casing.

10. The pulse drilling device according to claim 9, wherein a slag discharge channel is provided in the casing, and the plurality of drill rods are provided in an annular array inside of the casing with a center point of the slag discharge channel as a center point of the annular array.

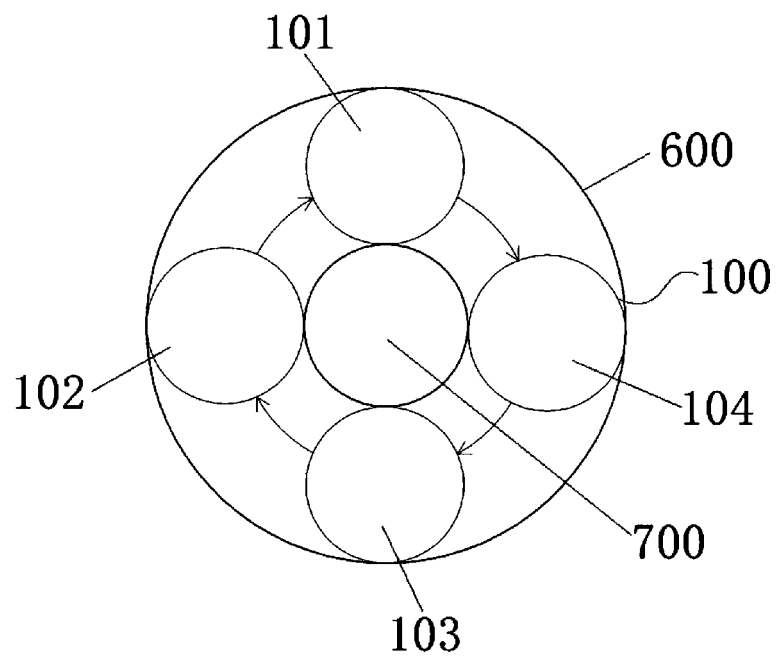


FIG. 1

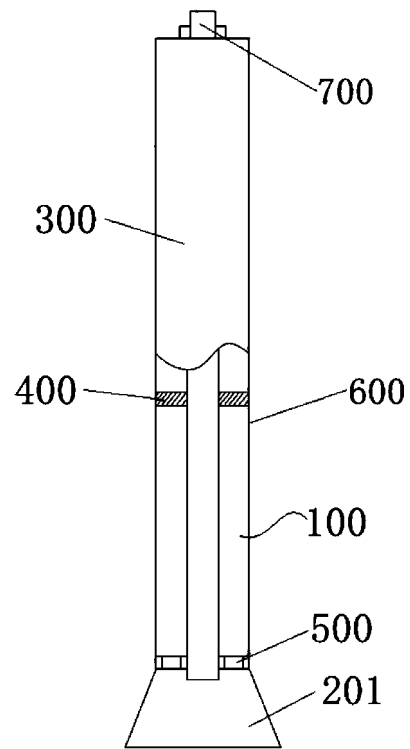


FIG. 2

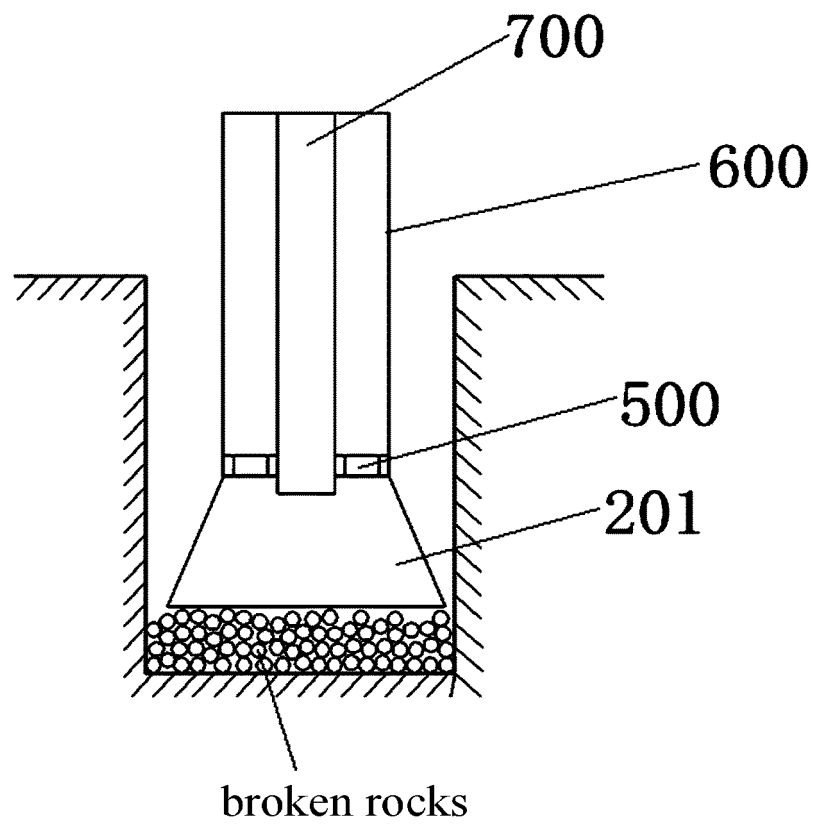


FIG. 3

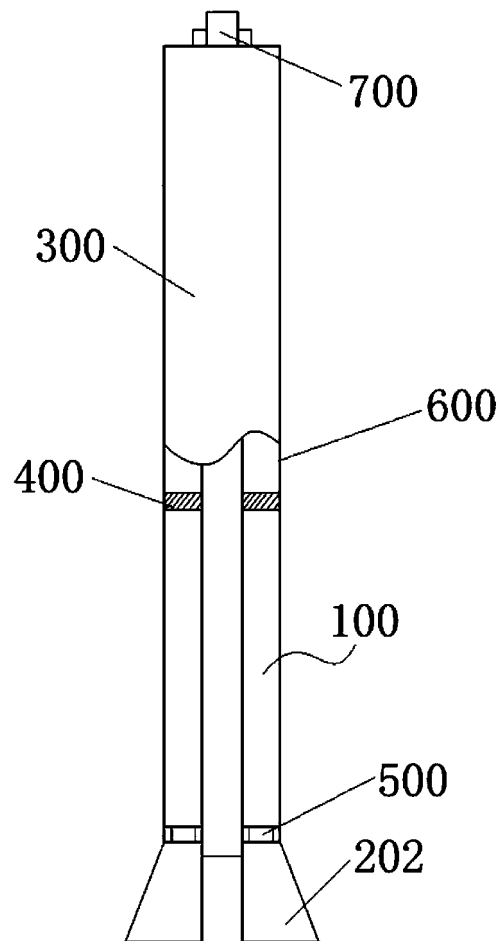


FIG. 4

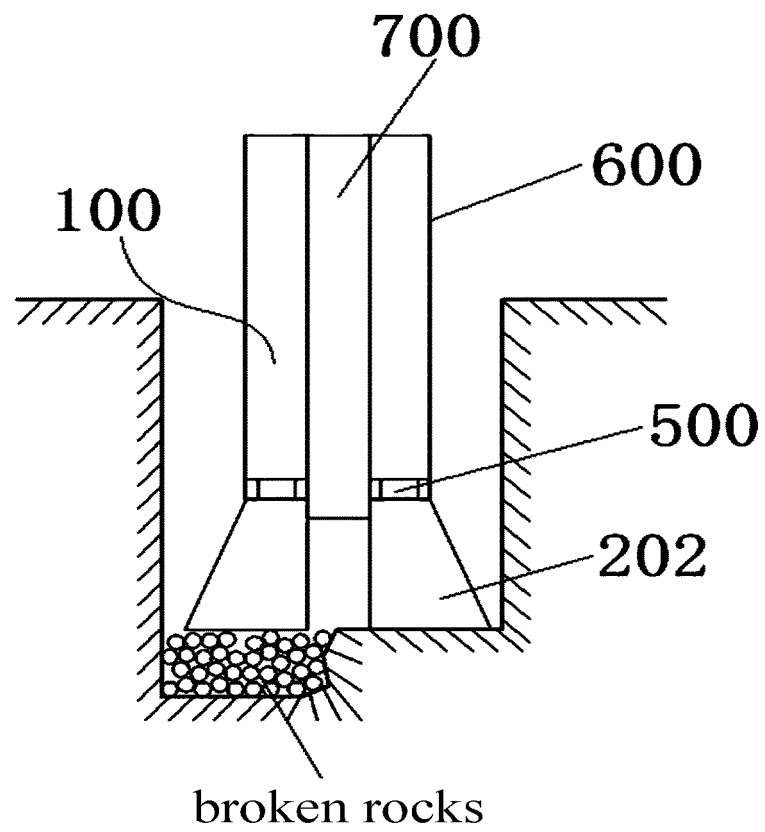


FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2022/073480

A. CLASSIFICATION OF SUBJECT MATTER E21C 37/18(2006.01)i; E21F 17/00(2006.01)i According to International Patent Classification (IPC) or to both national classification and IPC																					
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C. DOCUMENTS CONSIDERED TO BE RELEVANT																					
<table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>PX</td> <td>CN 113323661 A (BEIJING SANY INTELLIGENT TECHNOLOGY CO., LTD.) 31 August 2021 (2021-08-31) claims 1-10</td> <td>1-10</td> </tr> <tr> <td>Y</td> <td>CN 112922575 A (CHINA UNIVERSITY OF MINING AND TECHNOLOGY) 08 June 2021 (2021-06-08) description, paragraph 16, and figures 1-2</td> <td>1-10</td> </tr> <tr> <td>Y</td> <td>CN 103266853 A (710TH RESEARCH INSTITUTE OF CHINA SHIPBUILDING INDUSTRY CORP.) 28 August 2013 (2013-08-28) description, paragraphs 31-56, and figures 1-3</td> <td>1-10</td> </tr> <tr> <td>Y</td> <td>CN 111894445 A (CHINA RAILWAY CONSTRUCTION HEAVY INDUSTRY CORP. LTD.) 06 November 2020 (2020-11-06) description, paragraphs 33-36, and figures 1-9</td> <td>1-10</td> </tr> <tr> <td>Y</td> <td>CN 112227954 A (BEIJING SANY INTELLIGENT TECHNOLOGY CO., LTD.) 15 January 2021 (2021-01-15) description, paragraphs 35-52, and figures 1-4</td> <td>9-10</td> </tr> <tr> <td>A</td> <td>CN 106703682 A (JILIN UNIVERSITY) 24 May 2017 (2017-05-24) entire document</td> <td>1-10</td> </tr> </tbody> </table>	Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	PX	CN 113323661 A (BEIJING SANY INTELLIGENT TECHNOLOGY CO., LTD.) 31 August 2021 (2021-08-31) claims 1-10	1-10	Y	CN 112922575 A (CHINA UNIVERSITY OF MINING AND TECHNOLOGY) 08 June 2021 (2021-06-08) description, paragraph 16, and figures 1-2	1-10	Y	CN 103266853 A (710TH RESEARCH INSTITUTE OF CHINA SHIPBUILDING INDUSTRY CORP.) 28 August 2013 (2013-08-28) description, paragraphs 31-56, and figures 1-3	1-10	Y	CN 111894445 A (CHINA RAILWAY CONSTRUCTION HEAVY INDUSTRY CORP. LTD.) 06 November 2020 (2020-11-06) description, paragraphs 33-36, and figures 1-9	1-10	Y	CN 112227954 A (BEIJING SANY INTELLIGENT TECHNOLOGY CO., LTD.) 15 January 2021 (2021-01-15) description, paragraphs 35-52, and figures 1-4	9-10	A	CN 106703682 A (JILIN UNIVERSITY) 24 May 2017 (2017-05-24) entire document	1-10
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☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex. * Special categories of cited documents: “A” document defining the general state of the art which is not considered to be of particular relevance “E” earlier application or patent but published on or after the international filing date “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) “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 “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 “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 “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 “&” document member of the same patent family																					
Date of the actual completion of the international search 24 February 2022	Date of mailing of the international search report 16 March 2022																				
Name and mailing address of the ISA/CN China National Intellectual Property Administration (ISA/CN) No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088, China Facsimile No. (86-10)62019451	Authorized officer Telephone No.																				

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2022/073480**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 102493768 A (NORTHEAST PETROLEUM UNIVERSITY) 13 June 2012 (2012-06-13) entire document	1-10
A	CA 851047 A (BYRON JACKSON INC.) 08 September 1970 (1970-09-08) entire document	1-10

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2022/073480

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Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
CN 113323661 A	31 August 2021	None	
CN 112922575 A	08 June 2021	None	
CN 103266853 A	28 August 2013	CN 103266853 B	27 May 2015
CN 111894445 A	06 November 2020	None	
CN 112227954 A	15 January 2021	None	
CN 106703682 A	24 May 2017	None	
CN 102493768 A	13 June 2012	CN 102493768 B	28 May 2014
CA 851047 A	08 September 1970	None	

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- CN 202110653591 [0001]