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(54) **Title**: A METHOD AND A DEVICE FOR REGISTERING AT LEAST ONE ROCK DRILL PARAMETER WHEN DRILLING IN ROCK

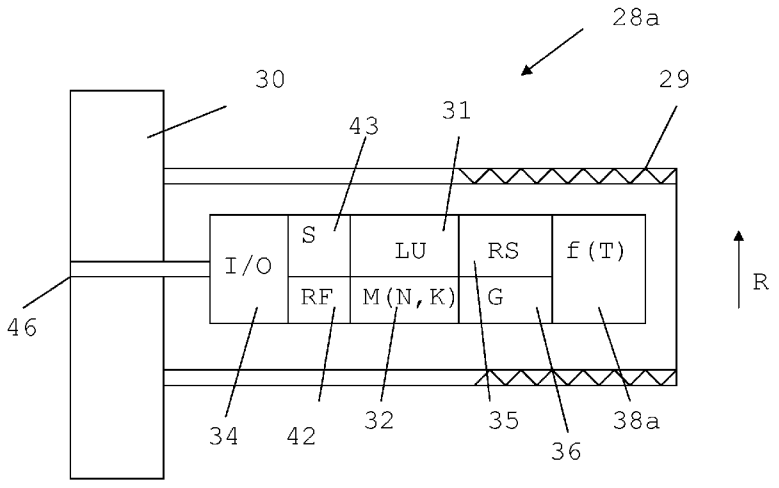

Fig.3A

(57) **Abstract**: A method and a device for registering at least one rock drill parameter when drilling in rock with an impulse generating device comprising an impact device arranged to induce shock waves in a tool acting against the rock. The impulse-generating device is arranged so that it can be moved in the direction of drilling relative to a support device. A predefined direction of vibration in the impulse-generating device is detected. The period of time for which the impulse-generating device vibrates in the above direction of vibration is registered.

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A method and a device for registering at least one rock drill parameter when drilling in rock

TECHNICAL AREA

The present invention concerns a method and a registration device for registering at least one rock drill parameter in connection with drilling in rock. The invention also concerns a computer program for carrying out the method in accordance with the invention. Furthermore, the invention concerns a rock drill that comprises such a registration device and a drilling rig comprising the rock drill.

THE PRIOR ART

The drilling rig includes a boom, one end of which is attached in articulated fashion to a carrier, such as a vehicle, via one or more articulation devices, and at the other end of which is arranged a feed beam that supports a percussion mechanism in accordance with the invention with a rock drill. The rock drill can be moved along the feed beam. In connection with percussion drilling, the rock drill usually also comprises a percussion mechanism with a hydraulically driven ram to generate a shock wave which spreads via a drill rod down to a drill bit with a tungsten carbide pin. When the shock wave strikes the drill bit, its tungsten carbide pin is pressed into the rock, generating a force sufficient to crush the rock.

Rock drilling rigs are often relatively stationary and remain at the rock drilling site and are not often transported from mine to mine. The drilling rigs automatically measure the operating time for the rigs' respective feed beams. An operating time counter for the drilling rigs of today also usually calculates the operating time for the rigs' respective booms. However, it is a problem to decide whether the rock drill itself has been active at the same time. The rock drill may, for

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example, have been replaced, and the operator also often has a few rock drills for the same drilling rig so that the rig can be in continuous operation without needing to depend on whether service is being carried out on one of the rock drills at the same time. The operating time of each rock drill is, therefore, usually estimated manually by the operator.

The problem is that the operating time of the rock drill is a decisive parameter for the assessment of various tests that are performed in connection with work during field testing and in connection with service work. The rock drill's operating time is also important to calculations for other rock drill parameters. Therefore, there is a desire in the industry to arrive at an improved method and device for registering when a rock drill is active.

DESCRIPTION OF THE INVENTION

A first purpose of the invention is to arrive at a registration device of the type specified in the introduction that solves the above problem.

The solution is a registration device that has the characteristics in claim 1.

Such a registration device designed to be arranged in connection with a rock drill is arranged to register at least one rock drill parameter in connection with drilling in rock, in which connection the registration device comprises an internal generator, which supplies power to the registration device when the rock drill is active, and a direction sensor, which direction sensor is arranged to detect that the rock drill is vibrating in its axial longitudinal direction, in which connection the registration device comprises means for registering, as a first rock drill parameter, a period of time during which

the rock drill vibrates in its axial longitudinal direction.

The rock drill's axial longitudinal direction means the ram's axial extension, i.e. its extension along the ram's symmetry axis parallel to the direction of percussion. In the same way, the rock drill's radial extension means the ram's radial extension, an extension along a radius proceeding from the ram's symmetry axis in a plane perpendicular to the ram's symmetry axis.

By supplying power to the registration device with an internal generator, it is possible to arrange the registration device in connection with the individual rock drill, in which connection it is possible to provide each rock drill with a unique sensor. By also detecting the vibrations that arise in the rock drill's axial longitudinal direction, it is possible to detect when the percussion mechanism is active, in which connection it is possible to register the actual period of time during which the individual rock drill has been in operation, i.e. vibrated in its axial longitudinal direction, which occurs when the percussion mechanism is active. The fact that the registration device is autonomous is an advantage in connection with operation as no batteries need to be replaced. Today the operating time for the drilling rig is measured instead, and the operating time of each individual rock drill is, therefore, estimated by the operator. As each rig may have a number of rock drills which are replaced and some of which may be being serviced, it is, therefore, difficult to estimate the operating time for the individual rock drills.

The invention, therefore, offers the advantage that service can be needs-based instead of being carried out after an estimated time. With this correct operating time as a calculation parameter, instead of using an assumed operating time, the operator can evaluate the results of

field tests more reliably and more easily. In addition, other parameters such as employment rate can be calculated more correctly. Therefore, for example, expected wear and the need to maintain the rock drill can be estimated more correctly. In another embodiment, the above registration of a period of time is used for operating time-based maintenance. This maintenance strategy is preferable to maintenance work based on calendar time. Operating time-based maintenance will enhance the productivity of the rock drills as the actual operating time is used instead of an operator estimating the operating time manually and thus also when service is required, which is assessed with a certain time safety margin and therefore reduces production time. This facilitates both calculations of other rock drill settings and the work in connection with field tests for service engineers as the operating time is decisive in the various tests carried out in connection with field tests.

In accordance with one embodiment of a registration device in accordance with the invention, the direction sensor comprises a piezoelectric sensor. The piezoelectric sensor comprises a piezoelectric crystal arranged to detect vibrations or to vibrate the rock drill axially. The direction sensor is thus arranged to detect the direction of vibration of the rock drill. When a piezoelectric crystal is exposed to regular vibrations such as the above vibrations in one direction, it generates an electric voltage.

The fact that the registration device comprises an internal generator that supplies power to the registration device when the rock drill is active also solves the problem of avoiding an external power supply with an external power source for the electronic circuit in the registration device, which is an advantage as the rock drill is usually located in an environment that is difficult to access and dirty, in which the problem of

supplying power to the circuit is difficult to solve. Other operating time counters today are usually electronic. However, an electronic operating time counter needs some kind of power supply such as batteries or an external power supply. Our solution requires no galvanic connection to the rig or any other external equipment. If, instead, the circuit were provided with a battery, the battery would need to be replaced or checked occasionally, which we now avoid. In a preferred embodiment, the above generator comprises a piezoelectric generator that converts the vibrations into electric voltage. The piezoelectric generator comprises a piezoelectric crystal. By using a piezoelectric generator, it is possible to use the rock drill's vibrations as an energy source by the piezoelectric generator converting the vibration energy in the rock drill's axial longitudinal direction into electric energy so that electricity is generated that can be used to drive the registration device. Therefore, no external or replaceable energy source such as a battery is required. The piezoelectric sensor/generator can use the same crystal.

In accordance with one embodiment of a registration device in accordance with the invention, the registration device comprises a transponder arranged to temporarily supply power to the registration device with a radio signal sent from an external programming and reading unit. This makes it possible to read off the rock drill parameters without any external power supply from the drilling rig. In this case, it is possible both to activate and supply power to the registration device with the energy from the aerial signal from the external reading unit when the rock drill parameters are read off or programmed with the external unit. In accordance with a preferred embodiment, the registration device comprises an RFID (Radio Frequency Identification) unit for wireless communication, in which connection the RFID unit comprises the transponder.

In accordance with one embodiment of a registration device in accordance with the invention, the registration device is connected to a piezoelectric pressure sensor arranged in connection with the rock drill and adapted to detect the percussion pressure, in which connection the registration device is arranged to register the above hydraulic pressure as a second rock drill parameter. In accordance with another embodiment of a device in accordance with the invention, further rock drill parameters include: service interval, operating time, percussion pressure, customer identification, rig identification, rock drill identification.

In accordance with one embodiment of a registration device in accordance with the invention, the registration device is connected to a piezoelectric pressure sensor arranged in connection with the impulse-generating device and adapted to detect a percussion pressure, a hydraulic pressure that drives the percussion mechanism, in which connection the registration device is arranged to register the above hydraulic pressure as a second rock drill parameter.

In accordance with one embodiment of a registration device in accordance with the invention, the registration device is contained in a shell part of the impulse-generating device. In a preferred embodiment of a registration device in accordance with the invention, the registration device is contained in an enclosure such as a fixing device. The registration device is thus well-arranged to detect the rock drill's vibrations. With this location, the registration device is also easy to install and to use. The registration device is also robust and resistant to dirty environments as it is enclosed. This also makes it possible to use the registration device on drills that have already been produced.

A second purpose of the invention is to arrive at a method of the type specified in the introduction that solves the above problem. The method demonstrates equivalent advantages to those described above for the device.

The invention also comprises a computer program, which program comprises program code for controlling a method in accordance with claims 10-17. The invention also comprises a computer-readable medium with a computer program loaded onto it, which computer program is designed to make a logical unit carry out steps in accordance with any of claims 10-17.

The invention also comprises a drilling rig, comprising a registration device in accordance with any of claims 1-9.

The below description and claims contain advantageous further developments of the invention.

DESCRIPTION OF DRAWINGS

The invention will be explained in further detail via descriptions of embodiments with reference to the attached drawings, in which:

Figure 1 shows a drilling rig with a rock drill, comprising a registration device in accordance with the invention;
Figure 2 shows a perspective view of the rock drill, comprising a registration device shown in Figure 1;
Figure 3A shows an axial section of a registration device shown in Figure 2;
Figure 3B shows another registration device in accordance with an embodiment of the invention;
Figure 4A shows a registration device being read with a handheld unit in accordance with the invention;
Figure 4B shows the handheld unit in Figure 4A;

Figure 5A shows an outline of a method in accordance with the invention in the form of a flow chart; and
Figure 5B shows an outline of another method in accordance with the invention in the form of a flow chart.

DESCRIPTION OF EMBODIMENTS

The following description describes an underground rig. However, the invention can also be applied to a surface rig.

Figure 1 shows a rock drilling rig 10 for tunnelling, ore mining or installation of rock reinforcement bolts in connection with, for example, tunnelling or mining. The drilling rig 10 includes a boom 11, one end 11a of which is attached in articulated fashion to a carrier 12, such as a vehicle, via one or more articulation devices, and at the other end 11b of which is arranged a feed beam 13 that supports a percussion mechanism in accordance with the invention with an impulse-generating device in the form of a rock drill 14. The rock drill 14 can be moved along the feed beam 13. The rock drill itself may, for example, be fixed to a saddle which, in turn, runs along the feed beam. The rock drill comprises a percussion mechanism that generates shock waves that are transferred to the rock 17 via a drill pipe 15 and a drill bit 18. The percussion mechanism comprises an impact device, a ram that can move forwards and backwards and a shank adapter, not shown. The shank adapter is provided with means, for example threads, not shown, for connection to the drill pipe 15. The ram is arranged to act via percussion against the upper end of the shank adapter, in which connection a first part of the ram is adapted to strike the shank adapter and thus transfer the percussion energy to the drill pipe. By driving the saddle and thus the rock drill along the feed beam towards the rock, the drill bit is pressed against the rock. The hydraulic pressure that drives the hydraulic motor that drives the percussion mechanism is generally

called the percussion pressure and indicates the force with which the drill bit is pressed against the rock.

Figure 2 shows a perspective view of the rock drill 14 in Figure 1 in more detail. The rock drill 14 comprises a machine housing 22 with a ram that can move forwards and backwards. The machine housing 22 consists of several shell parts 22a - 22d. The machine housing is arranged essentially to seal the percussion mechanism hydraulically. Inside the machine housing, not shown, there is a piston bore arranged to accommodate the ram so that it can move. A registration device 28 is arranged in connection with the rock drill. The registration device 28 is arranged to detect when the rock drill is active and to register and store rock drill parameters. The registration device 28 is contained in an enclosure that is adapted to be installed in one of the rock drill's shell parts. In this case, the registration device is arranged inside a fixing device 30, a threaded screw device. When the registration device is installed, a hole is drilled in the shell part 22c in which the registration device is to be installed and the fixing device is screwed in place in the hole. The registration device is here embedded in an enclosure to resist a stressful environment, including, among other things, powerful vibrations and contaminants such as dust, drill cuttings and oil. The enclosure may also be something else such as another type of fixing device, for example a bolt. The size of and requirements for the enclosure of the registration device determine the physical size and design of the registration device itself. In this case, the aim is for it to be easy to install.

Figure 3A shows an axial section of an embodiment of the registration device in Figure 2. The registration device 28a is contained in a screw with threads 29 and a head 30. The registration device 28a comprises an electric circuit comprising a logical unit 31 such as a CPU (central

processing unit), FPGA (**field-programmable gate array**) unit or some other logical programmable unit, a memory device 32 comprising a non-volatile memory, for example a flash memory, and an I/O unit 34 (a write/read device) to store and access the information stored in the memory. The registration device 28a has at least one direction sensor 35 arranged in connection with the impulse-generating device to detect vibrations in the longitudinal direction R coincident with the rock drill's axial longitudinal direction in that it comprises a piezoelectric crystal.

The registration device 28 also comprises a piezoelectric generator 36 to supply power to the registration device 28. The piezoelectric generator 36 is arranged to generate power when it vibrates in a predetermined direction. In connection with drilling with or without rock contact, the rock drill vibrates as a result of the shock waves the rock drill induces. The vibrations are thus strongest in the direction of drilling, i.e. in the axial longitudinal direction of the rock drill. The vibrations that occur are converted by the piezoelectric crystal into electric energy that can be used to drive the electronic circuit in the piezoelectric generator 36. The piezoelectric generator is thus arranged physically so that it only generates power when the rock drill vibrates in the direction of drilling. The power from the piezoelectric generator 36 is thus used as the drive power for the registration device 28.

The registration device also comprises a time registration unit 38A that registers a period of time T as a rock drill parameter in the memory 32. The time registration unit 38A comprises a clock with an oscillator circuit, in which connection the time registration unit adds a new pulse to the memory each time the time registration unit counts a period in accordance with the relevant time base. For example, the time registration unit may use an oscillator circuit of 1 Hz. The time base is thus one (1) second and

a new pulse is added once a second. The clock in the registration device's electric circuit is thus arranged to add one pulse to the count for each second for which the vibration lasts. In this way the operating time can be registered in the memory 32. The number of pulses K is stored in the memory unit 32. The total number of periods is then the total time for which the registration device registered the time. A different time base may also be used, for example 0.5-10s. The time base is selected depending on the level of precision required for measurement of how long the rock drill has been in operation. A time base with a different purpose, such as the time between two service intervals, may also be used. As the power from the piezoelectric generator 36 is used as the drive power for the registration device 28 while the rock drill is active, the registration device is arranged only to register time when the piezoelectric generator is driving the registration device. When the drilling ceases and the vibrations therefore stop, the counter will stop on account of a lack of energy, i.e. the piezoelectric generator stops generating electric energy. As the memory is static, not volatile, the memory will retain the value last stored when the power disappears. In this way, the total operating time is stored as a rock drill parameter in the static memory.

In order to be able to read off information, such as rock drill parameters, from the registration device's memory 32, an RFID (Radio Frequency Identification) system is used in this case. An RFID system consists of three components, an RFID unit: a transponder, an aerial and a read unit. The aerial creates an electromagnetic field that oscillates at a specific frequency. The transponder is activated and driven by the field and transmits a unique code that the aerial receives. The read unit translates and interprets the signal and presents it, for example on a display on the read unit. A transponder

consists of a small aerial and a logical unit such as a microchip (IC circuit) in an enclosure.

In this connection, the registration device also comprises an RFID unit 42 comprising a transponder 43 and an aerial 46. In this case, a hole has been drilled in the bolt/enclosure and an aerial 46 installed in the hole. The aerial 46 is, for example, of copper wire or something with similar properties. To achieve a greater range for the RFID unit, the aerial is galvanically isolated from the rest of the enclosure in this case.

In this case, the RFID system also comprises a handheld unit, not shown. The handheld unit comprises an aerial, a logical unit, a read unit and a memory. The handheld unit works with RFID technology.

In connection with reading the registration device, for example reading a rock drill parameter such as the operating time T, the transponder 43 in the RFID unit 42 in the registration device will be activated by the aerial signal from the handheld unit. The handheld unit thus transmits both an information signal and a sufficient quantity of energy to activate the RFID unit 42 so that it can send information before it becomes dead again. This technology makes it possible to read and programme the memory in the registration device without it having its own simultaneous energy supply. Instead it is supplied with energy via the aerial signal from the external handheld unit. The rock drill parameters can thus be read even if the rock drill is not active, so that the piezoelectric crystal drives the registration device. The RFID unit 42 then retrieves information such as rock drill parameters, such as the operating time T, from the memory via the I/O unit (write/read unit) and the aerial 46 and transmits it to the handheld unit.

Figure 3B shows an axial section of another embodiment of the registration device 28b. What distinguishes this embodiment from the above is that several time registration units are included in the same electric circuit. These can be used for various things, for example a time registration unit 38B that can be reset and a time registration unit 38C that cannot be reset.

The number of memory slots 32a-32c can also be increased in the memory unit. Moreover, the number of time registration units 38a-38c can be increased. A memory slot can, for example, be defined so that it cannot be reset when the operating time is stored. One or more memory slots 32a-32c are used to store rock drill parameters M1, M2, M3 as time between service, time for which a specific drill part has been used, etc. Moreover, memory slots 32a-32c can be used to store other rock drill parameters such as service interval, customer identification, rig - identification, rock drill identification, etc. The RFID unit can also be used to programme the memory unit with other information in addition to operating time, for example rock drill identity, customer, date, service interval and rig type.

The hydraulic percussion mechanism circuit can also be arranged with a pressure sensor 48 that is connected to the electronic circuit, such as a piezoelectric pressure sensor. So that the sensor can detect, for example, the percussion pressure in the percussion mechanism's hydraulic system, a hole is drilled connecting the hydraulic system to the sensor in a suitable location on the rock drill 14, not shown. The location of the sensor on the rock drill is important and is chosen preferably so that the drilling of the extra hole is a simple operation in the production of the rock drill. The pressure sensor detects the hydraulic oil pressure in the percussion mechanism circuit and this is stored as another rock drill parameter in the memory. In this connection, the pressure

sensor is connected to the internal logical unit 31 that is in the register unit 30. This makes it possible, from the detected measured values for time and pressure, to calculate and document the current frequency, percussion pressure, percussion energy, output power and operating time and store this information in the memory M3 because other known rock drill parameters are registered in the rig's control system. Using the sampling theorem and if the percussion pressure is registered with at least double percussion frequency, it is possible to register the current percussion frequency at any time.

By connecting several sensors suitably located on the rock drill to a registration device in accordance with the invention, it is also possible to register other rock drill parameters such as the current damping pressure and/or rotational frequency, in which connection a sensor is suitably located in connection with the hydraulic motor, for example to detect the rotational frequency. Another sensor can also be arranged to detect the air pressure in the lubricating oil circuit. Detecting and storing many different rock drill parameters makes it easier for the operator to follow up on field tests and perform operation-based maintenance.

Embodiments of combinations or parts of the above embodiments are also possible.

Figure 4A shows how an operator 60 reads a registration device 28c of the same type as the registration device described above, with a handheld unit 62 as mentioned above. The operator 60 stands very close to the drilling rig 10, not shown in its entirety. In this case, the operator reads, programmes or updates information stored in the memory in the registration device 28c, such as the rock drill parameters described above, with the handheld unit 62 via wireless communication with RFID technology. In this case, the read distance is limited to < 10 m. The

handheld unit 62 is also adapted to our purpose in that it is provided with a specific user program.

For Radio Frequency Identification, electronic marking is implemented in the RFID unit in the registration device in that a unique code is stored in its memory. The code can be read at close quarters with the handheld unit using an aerial 63 arranged in connection with the handheld unit. The registration device can be read with wireless communication, independently of the level of activity of the impulse-generating device, as the transponder receives energy from the radio signal.

Figure 4B shows the handheld unit 62 shown in Figure 4A. The handheld unit comprises a logical unit 64 for controlling the unit, a memory unit 65 for storing information that is to be transmitted or has been received, an aerial 63, an RFID circuit 70 and an I/O unit comprising a keyboard 72 and a display 74.

Figure 5A shows an outline of a method in accordance with the invention in the form of a flow chart.

Item 100 indicates the start of the sequence.

Item 110 activates the registration unit.

Item 120 registers that the percussion mechanism is active.

Item 130 indicates registration of a rock drill parameter.

Item 140 indicates storage of the rock drill parameter in the memory.

Item 150 indicates the end of the sequence.

Figure 5B shows an outline of a method in accordance with the invention in the form of a flow chart.

Item 200 indicates the start of the sequence.

Item 210 indicates activation of the register unit.

Item 220 indicates receipt of a request to read a rock drill parameter in the memory.

Item 230 indicates transmission of the storage of the rock drill parameter in the memory.

Item 240 indicates the end of the sequence.

CLAIMS

1. A registration device (28a-28c) designed to be arranged in connection with a rock drill (14), in which connection the registration device is arranged to register at least one rock drill parameter (T, M1-M3) in connection with drilling in rock (17), **characterised in that** the registration device comprises an internal generator, which supplies power to the registration device when the rock drill is active, and a direction sensor (35) arranged to detect that the rock drill is vibrating in its axial longitudinal direction (R), in which connection the registration device comprises means for registering, as a first rock drill parameter, a period of time (T) during which the rock drill vibrates in its axial longitudinal direction (R).

2. A registration device (28a-28c) in accordance with claim 1, **in which connection** the direction sensor (35) comprises a piezoelectric sensor.

3. A registration device (28a-28c) in accordance with claim 1 or 2, **in which connection** the generator specified comprises a piezoelectric generator (36).

4. A registration device (28a-28c) in accordance with claim 1, 2 or 3, **in which connection** the registration device comprises a transponder (43) arranged to temporarily supply the registration device with power via an external radio signal.

5. A registration device (28a-28c) in accordance with claim 1, 2, 3 or 4, **in which connection** the registration device is connected to a piezoelectric pressure sensor (48) arranged in connection with the rock drill and adapted to detect the percussion pressure, in which connection the registration device is arranged to register

the above hydraulic pressure as a second rock drill parameter (M1-M3).

6. A registration device (28a-28c) in accordance with claim 1, 2, 3, 4 or 5, **in which connection** the registration device is contained in a shell part (22c) of the rock drill (14).

7. A registration device (28a-28c) in accordance with claim 6, **in which connection** the registration device is contained in a fixing device (28).

8. A method for registering at least one rock drill parameter when drilling in rock with a registration device (28a-28c) arranged in connection with the rock drill, **characterised in that**
- the registration device (28a-28c) is supplied with power by an internal generator when the rock drill (14) is active;
- it detects when the rock drill (14) is vibrating in its axial longitudinal direction (R);
- it registers, as a first rock drill parameter, a period of time (T) for which the rock drill (14) vibrates in its axial longitudinal direction (R).

9. A method in accordance with claim 8, **in which connection** the method also involves registering the above vibrations with a piezoelectric sensor (35).

10. A method in accordance with claim 8 or 9, **in which connection** the registration device (28a-28c) is arranged with a piezoelectric generator (36) that converts the above vibrations into electrical voltage.

11. A method in accordance with claim 8, 9 or 10, **in which connection** a transponder (43) contained in the registration device (28a-28c) is arranged to temporarily

supply the registration device with power via an external radio signal.

12. A method in accordance with claim 8, 9, 10 or 11, **in which connection** the registration device (28a-28c) is connected to a piezoelectric pressure sensor (48) arranged in connection with the rock drill (14) and adapted to detect the percussion pressure, in which connection the registration device (28a-28c) is arranged to register the above hydraulic pressure as a second rock drill parameter.

13. A method in accordance with claim 8, 9, 10, 11 or 12, **in which connection** the above time period (T) or hydraulic pressure registered is read by wireless communication.

14. A computer program, which program comprises program code for controlling a method in accordance with claims 8-12.

15. A computer-readable medium with a computer program loaded onto it, which computer program is designed to make a logical unit carry out steps in accordance with any of claims 8-12.

16. A rock drill (14), comprising a registration device (28a-28c) in accordance with claims 1-7.

17. A drilling rig (10), comprising a rock drill (14) in accordance with claim 16.

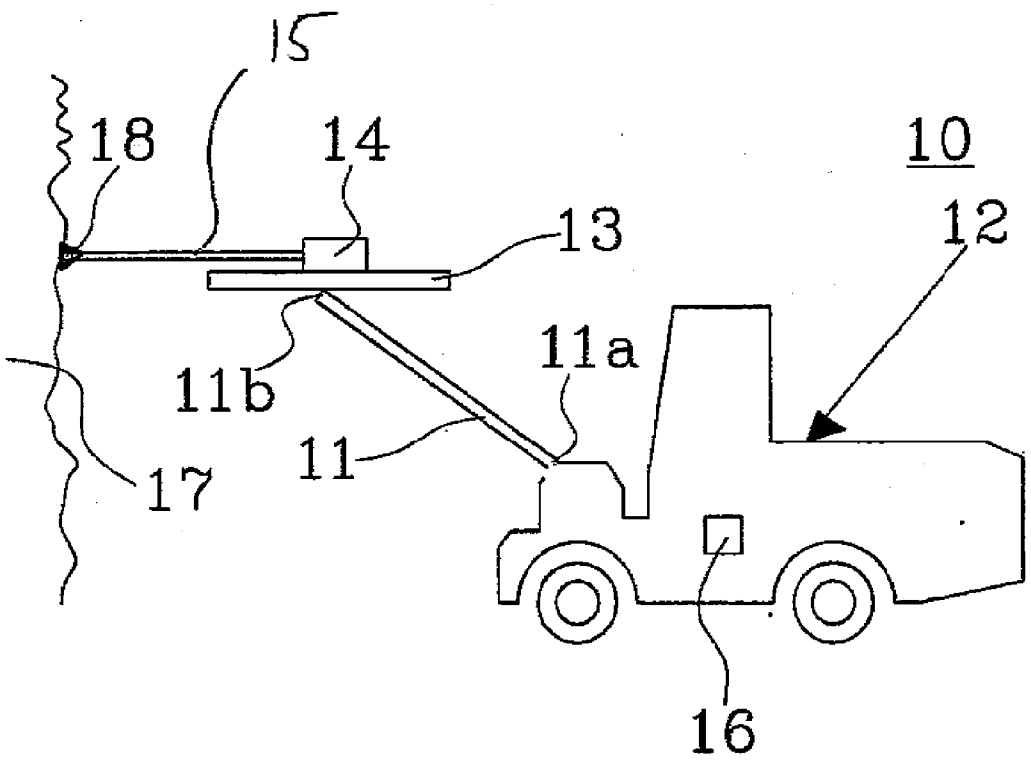

Fig.1

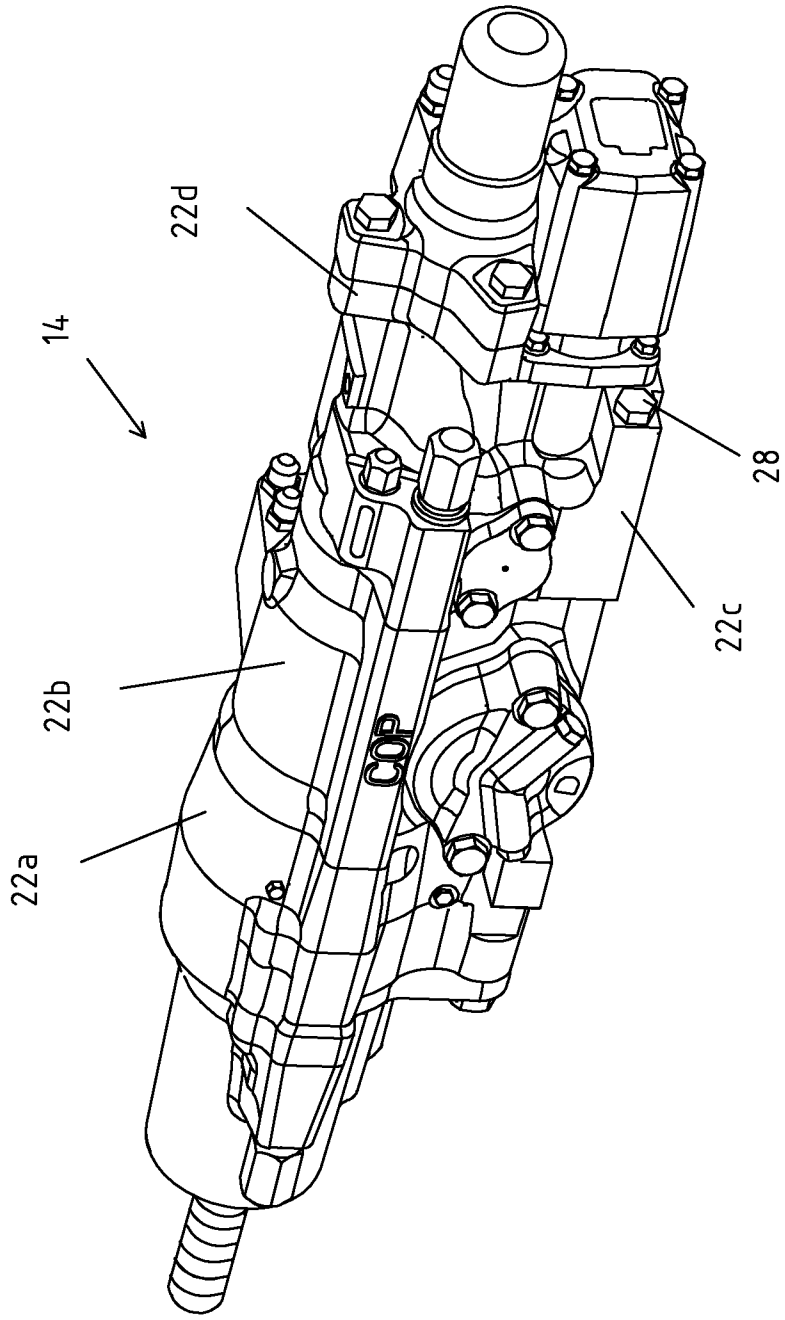

Fig. 2

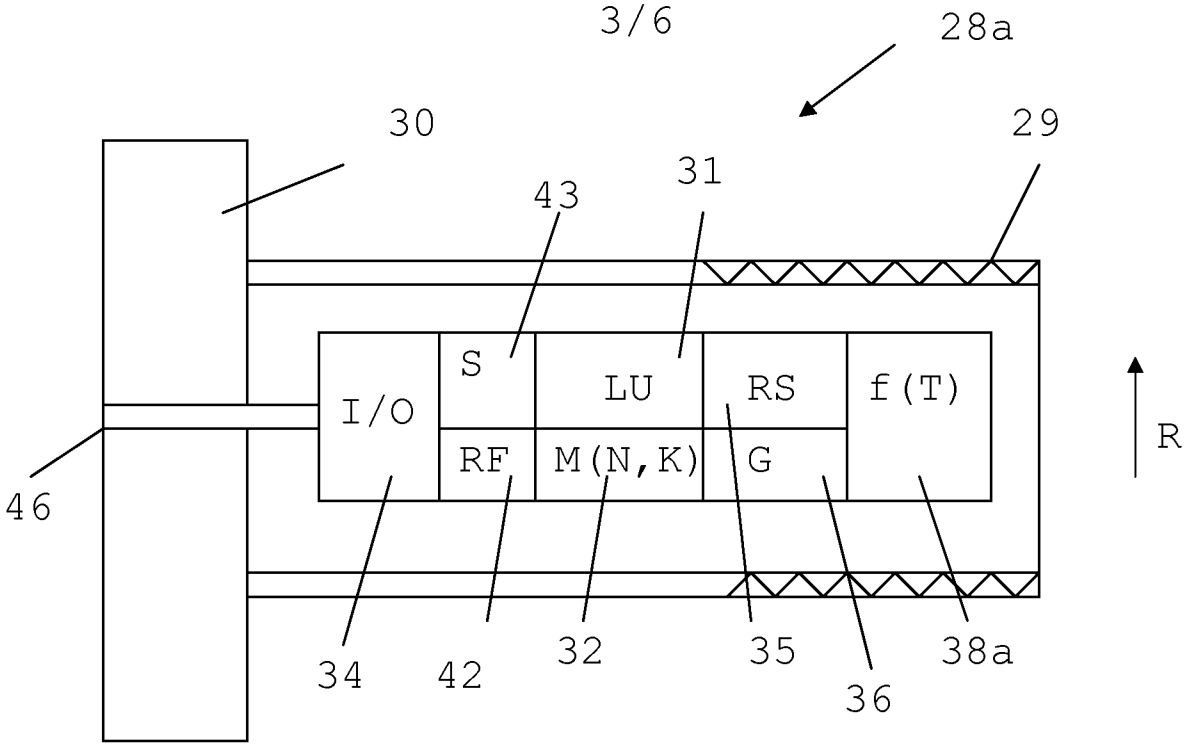
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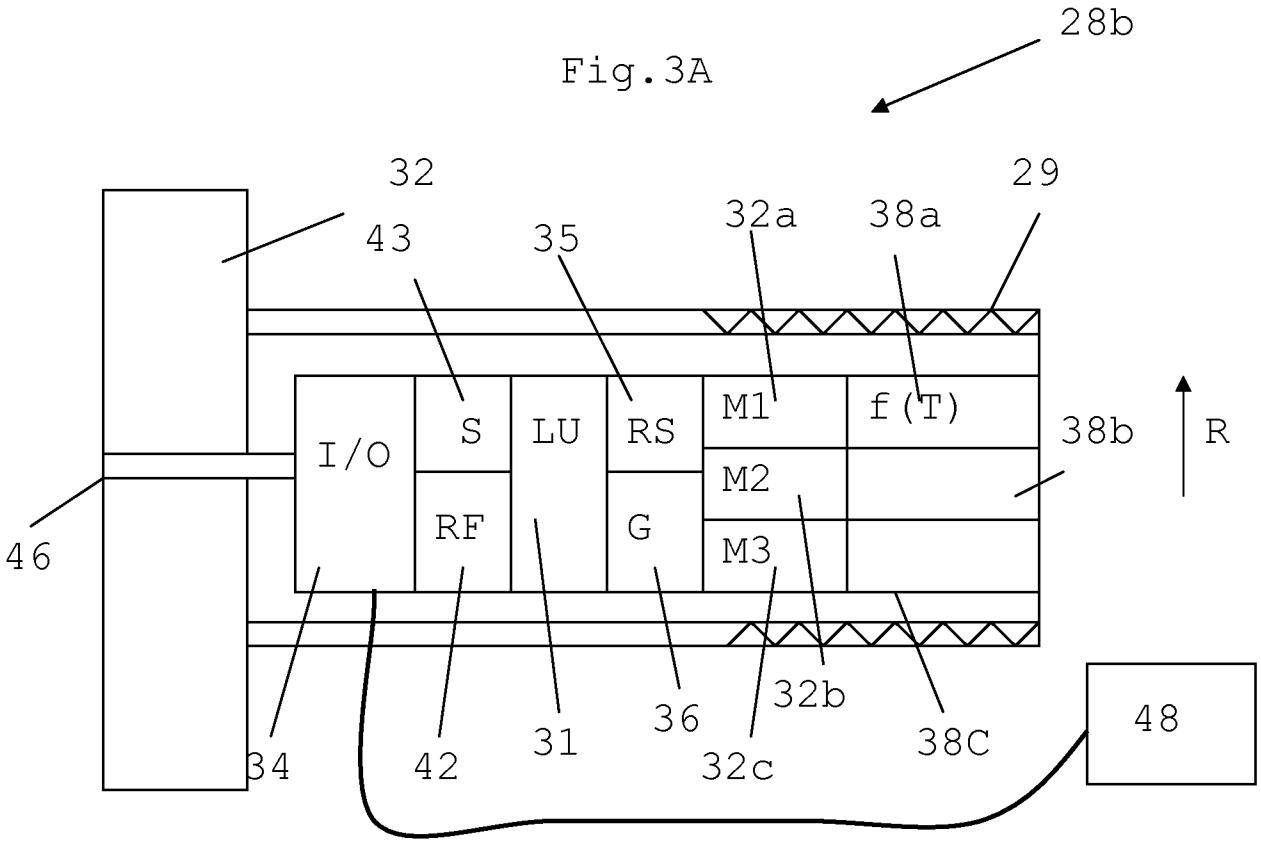
Fig.3A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I/O
S
LU
RS
M1
f(T)
38b
R
RF
G
M2
M3
46
34
42
31
36
32b
32c
38C
48

Fig.3B

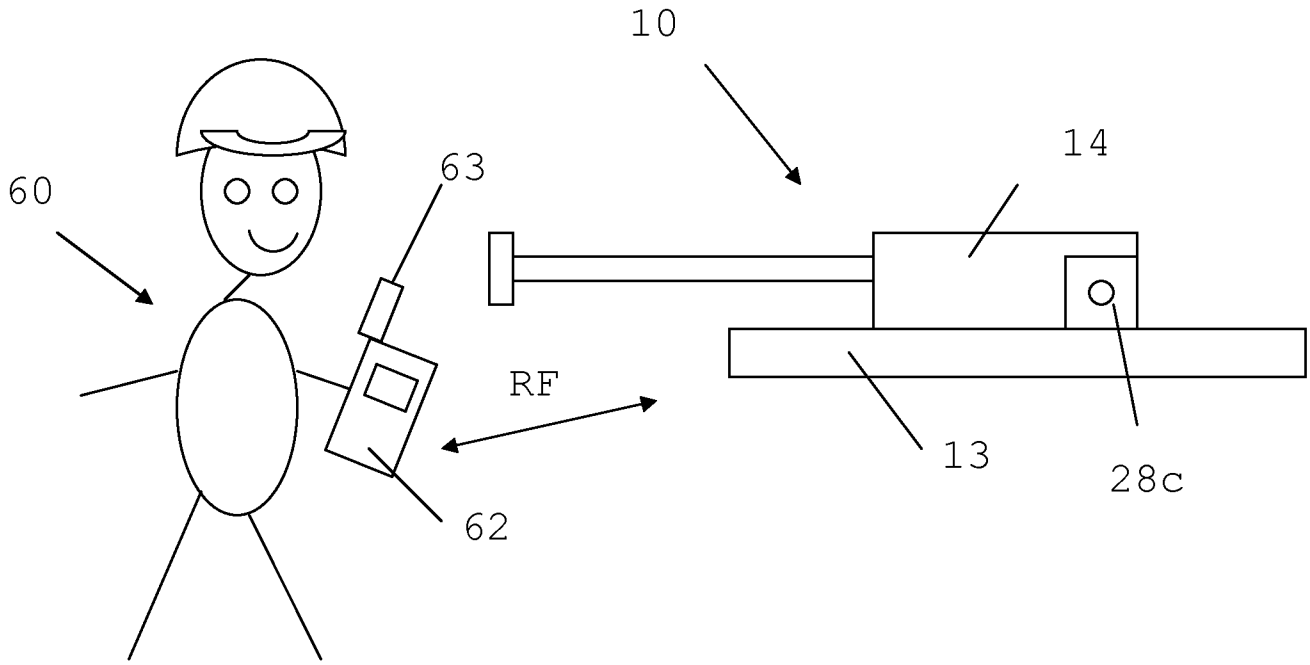

Fig. 4A

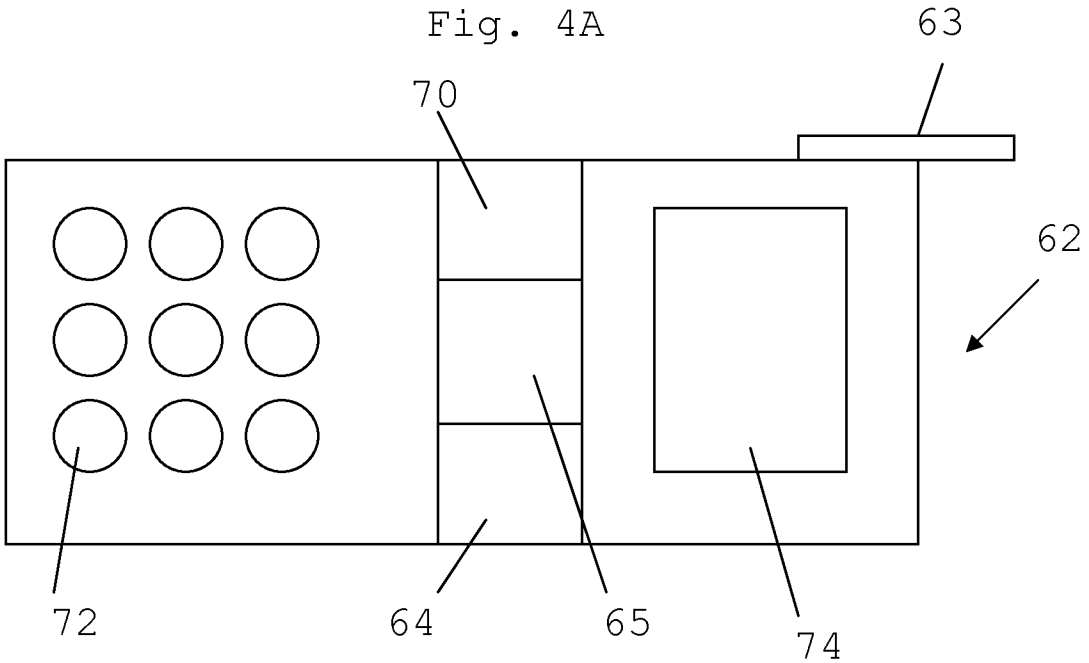

Fig. 4B

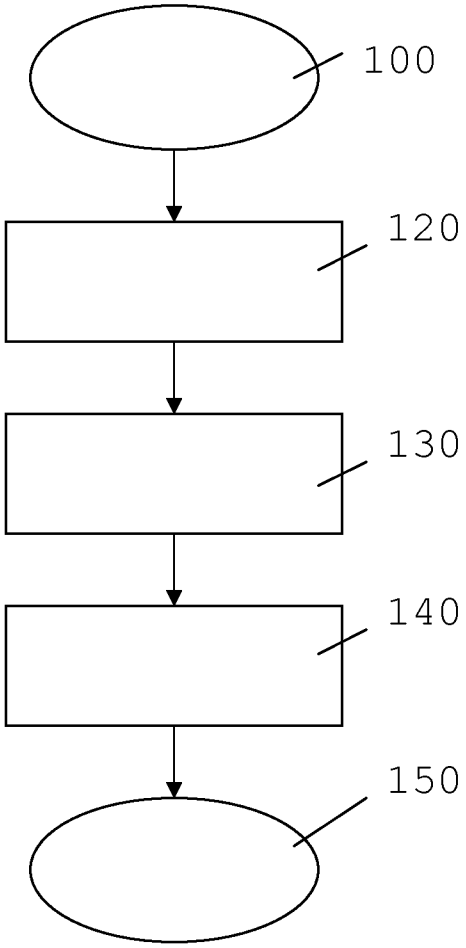

Fig. 5A

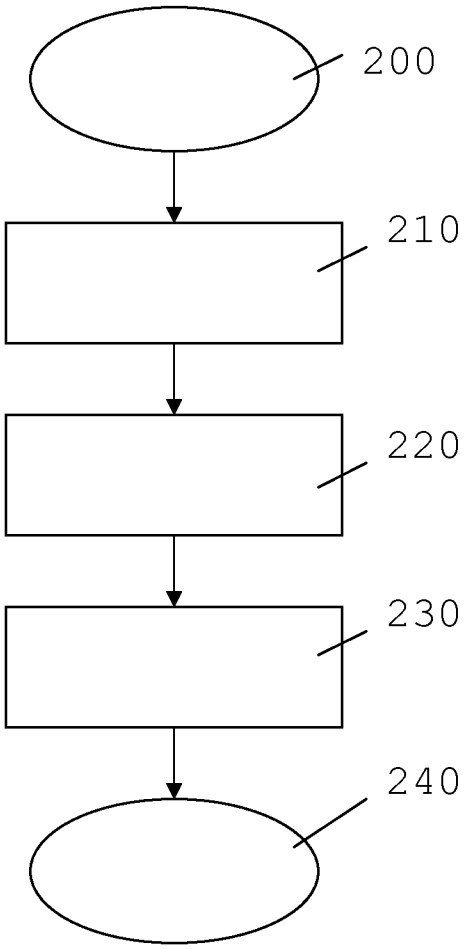

Fig. 5B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2010/050391

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: E21B, G07C

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

SE,DK,FI,NO classes as above

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

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 20050228557 A1 (M.D. SWAN), 13 October 2005 (13.10.2005), whole document ---	1-17
A	FR 2635894 A1 (MARIAULLE, D.), 2 March 1990 (02.03.1990), figures 1-5, claims 1-9 ---	1-17
A	US 20090038848 A1 (F. GARCIA-OSUNA), 12 February 2009 (12.02.2009), claims 1-23 ---	1-17
A	US 20060027400 A1 (J.A. GARCIA ET AL), 9 February 2006 (09.02.2006), whole document --- --------	1-1713-14

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Date of the actual completion of the international search	Date of mailing of the international search report
5 July 2010	12 -07- 2010
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Christer Bäcknert / JA A Telephone No. +46 8 782 25 00

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International patent classification (IPC)

E21B 45/00 (2006.01)
G07C 3/02 (2006.01)
E21B 41/00 (2006.01)

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US	20050228557	A1	13/10/2005	NONE
FR	2635894	A1	02/03/1990	NONE
US	20090038848	A1	12/02/2009	NONE
US	20060027400	A1	09/02/2006	NONE