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APPARATUS, ROCK BREAKING MACHINE AND METHOD OF MONITORING ROCK BREAKING MACHINE

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Abstract

A hydraulic rock breaking machine and an apparatus and method for monitoring operation of same. The apparatus comprises at least one pneumatic sensor (S) for monitoring an inner space of the machine (10) and at least one control unit (CU) configured to receive and process the pneumatic sensing data.

(Figure 5)

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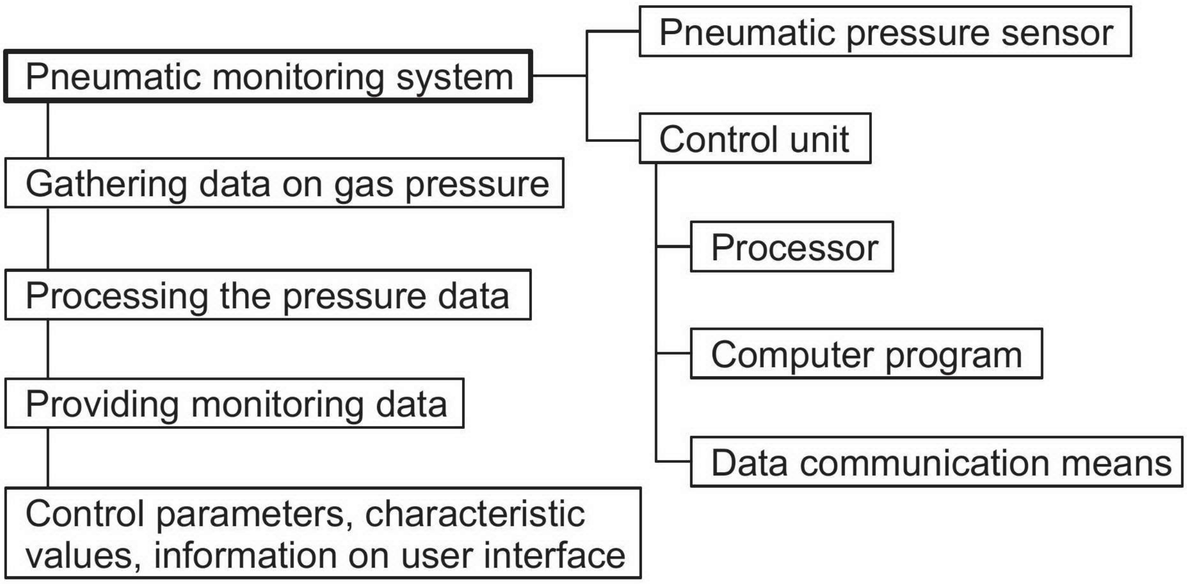

FIG. 5

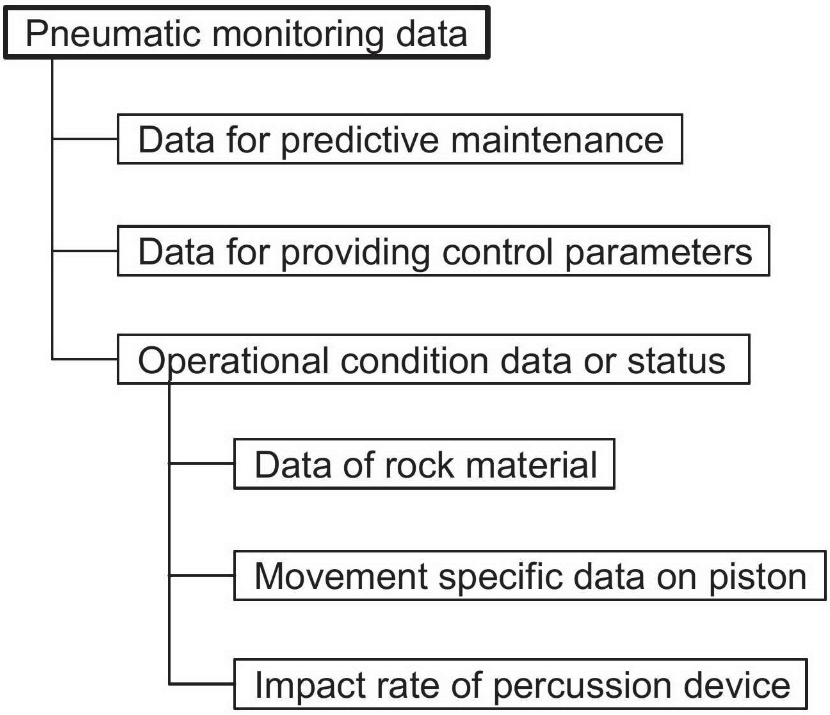

FIG. 6

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Apparatus, rock breaking machine and method of monitoring rock breaking machine

This application claims priority from European Patent Application No. 20166668.2 filed on 30 March 2020, the contents of which are incorporated by this reference.

Technical field

The invention relates to a hydraulic rock breaking machine and to a method for monitoring it.

Background of the invention

The discussion of the background to the invention that follows is intended to facilitate an understanding of the invention. However, it should be appreciated that the discussion is not an acknowledgement or admission that any aspect of the discussion was part of the common general knowledge as at the priority date of the application.

In mines and construction sites there exists a need to break rock material. The rock material to be broken may be stones or boulders whereby hydraulic breaking hammers are implemented. When breaking undetached rock material, hydraulic drilling machines are used for making drill holes prior to blasting the rock surface. These both types of hydraulic rock breaking machines are equipped with hydraulically operable percussion devices. Operation of the percussion device and the entire rock breaking machine needs to be monitored in order to control the machine properly. Therefore different measuring and monitoring systems are developed for this purpose. However, the known monitoring systems have shown to include disadvantages.

Brief description of the invention

It is desirable to provide a novel and improved rock breaking machine, more specifically a rock drilling machine, and method for monitoring operation of a rock breaking machine.

According to one form of the invention there is provided a hydraulic rock drilling machine, which is intended to be mounted to a work machine and comprises: a body; a percussion device mounted inside the body, the percussion device being hydraulically operating, whereby a reciprocating percussion piston of the percussion device is moved by means of pressurized hydraulic fluid, and configured to generate impact pulses by means of the reciprocating piston to a tool mountable to a front end of the body; and at least one apparatus for sensing prevailing fluid pressure inside the rock drilling machine wherein the apparatus comprises: at least one pressure sensing device for sensing pressure of fluid inside the rock drilling machine; at least one control unit configured to receive sensed pressure data from the at least one pressure sensing device; and wherein the control unit is configured to process the received sensing data and to provide monitoring data in accordance with a control strategy input to the control unit; wherein the rock drilling machine comprises an oil mist lubrication system for providing pressurized air-oil mist flow inside the body; and the rock drilling machine is provided with at least one sensor for sensing pneumatic pressure of the air-oil mist prevailing inside the body in order to monitor pneumatic pressure fluctuation caused by the hydraulically movable piston of the hydraulic percussion device.

According to another form of the invention there is provided a method for monitoring operation of a hydraulic rock drilling machine, wherein the method comprises: providing the rock drilling machine with at least one sensing device for providing pressure data for the monitoring; and providing pressurized air-oil mist flow inside a body of the rock drilling machine to lubricate the rock drilling machine; sensing pneumatic pressure of the prevailing air-oil mist inside the body of the rock drilling machine by means of at least one sensing device; transmitting the sensed pneumatic pressure data to at least one control unit; and processing the sensed pneumatic pressure data in the control unit and generating monitoring data.

An idea of the disclosed solution is that an apparatus for monitoring a hydraulically operable rock breaking machine is disclosed. The apparatus comprises one or more pressure sensing devices, sensors or measuring elements configured to sense pneumatic pressure variations inside the hydraulic rock breaking machine. The machine comprises a percussion device provided with a piston moving in impact direction and return direction. The percussion piston of the hydraulic percussion device is moved by means of pressurized hydraulic fluid. The reciprocating movement of the percussion piston causes pressure fluctuation inside the machine and this can be sensed by means the sensing device or element. The apparatus further comprises one or more control devices configured to receive sensed pressure data from the sensing device. The control unit may process the received sensing data and may provide monitoring data.

An advantage of the disclosed solution is that reciprocating movement of a hydraulically movable percussion piston can be monitored conveniently by sensing gas pressure variations inside the machine. The gathered gas pressure data may be analyzed and implemented in a versatile manner. Use and mounting of the pneumatic sensing means is easy. Furthermore, the pneumatic pressure sensors are durable and inexpensive.

An additional advantage is that the disclosed pneumatic monitoring system may substitute other known monitoring systems based on complicated, vulnerable, unstable and expensive sensing means and arrangements.

According to an embodiment, the control unit is configured to detect pneumatic pressure variations in the sensing data and is configured to determine percussion rate of the percussion device in response to detected pneumatic pressure variations.

According to an embodiment, the control unit is configured to detect pneumatic pressure variations in the sensing data and is configured to determine length of travel of a piston of the percussion device in response to detected pneumatic pressure variations. For example, the pressure change is inversely proportional to volume change that is caused by the piston movement and this could be converted to travelling distance of the piston.

According to an embodiment, the control unit is configured to detect pneumatic pressure variations in the sensing data and is configured to determine striking moment of time of a piston of the percussion device in response to detected pneumatic pressure variations. The striking moments can be noted as peak values in the pressure sensing data. The peak values in function of time may be either highest or lowest values depending on whether the pneumatic pressure is detected at front of the piston or at its rear.

According to an embodiment, the control unit is configured to detect a so called striking point on the basis of the above mentioned data. This may be useful in order to detect whether feeding of the rock breaking machine is correct or not. The control unit may also determine suitable control values for feed force and rate. Thereby the rock breaking process can be controlled to be as effective as possible and without causing unnecessary loads to the structure.

According to an embodiment, the control unit is configured to detect pneumatic pressure variations in the sensing data and is configured to determine and analyze any other details regarding the movement of the piston. The control unit may also be provided with additional sensing signals from other type of sensor and measuring devices. Then the control unit may combine the gathered data and may calculate in a versatile manner different characterizing values for control and monitoring purposes.

According to an embodiment, the control unit is configured to detect pneumatic pressure variations in the sensing data and is configured to determine and analyze smoothness of movement of the piston. When abnormal movements, such as jerking and delays are noted, it may indicate of wearing or damage of a control valve, for example.

According to an embodiment, the control unit is configured to determine speed of the piston in both directions, i.e. in impact and return direction on the basis of the received sensing data. The determined speed of the piston provides valuable information on used impact energy and recoil. In other words, operation and contact between the rock and a tool may provide information on rock material being broken. The control unit may be provided with suitable algorithms and programs for analyzing and calculating the needed data on the basis of the pneumatic pressure data. The gathered rock data may be utilized for controlling the actual rock breaking and may also be utilized later for other purposes such as when considering reinforcing of the rock.

According to an embodiment, the control unit is configured to compare the sensed pneumatic pressures to input reference data and is configured indicate detected deviations. Detected abnormal pressure values may trigger the control unit to initiate execution of further analyzing and control measures. Further, the control unit may indicate an operator of the detected deviations.

According to an embodiment, the control unit is provided with at least one pressure limit value and the control unit is configured to compare the sensed pneumatic pressures to the input pressure limit value.

According to an embodiment, the control unit is configured to store data on sensed previous pneumatic pressures and is configured to compare newly sensed pneumatic pressures with the stored history data on sensed pneumatic pressures in order to notify deviations and trends in the operation of the hydraulic rock breaking machine.

According to an embodiment, the control unit is provided with several input scenarios based on which the control unit is configured to determine condition state of the hydraulic rock breaking machine itself, condition state of lubrication system of the hydraulic rock drilling machine or operational situation or condition of the rock drilling process.

According to an embodiment, the pressure sensing device is a pressure sensor or pressure sensing apparatus or element.

According to an embodiment, the pressure sensing device is a pneumatic pressure sensor.

According to an embodiment, the pressure sensing device is a hydraulic pressure sensor which is now configured to sense pneumatic pressures.

According to an embodiment, the pneumatic pressure sensing device is a low pressure sensor operable under pressures of 10 bar. An advantage of this embodiment is that low pressure sensors are inexpensive and well available. Furthermore, their structure and operation may be reliable.

According to an embodiment, the pneumatic pressure inside the rock breaking machine is sensed indirectly whereby this embodiment differs from the ones disclosed above in embodiments using pressure sensors. The sensing device may be configured to sense effects of the pneumatic pressure fluctuations by utilizing other sensing technologies. The sensing device may comprise force sensors, torque sensors, acceleration sensors or any other sensors of devices suitable for the purpose. Thus, the sensing device may be a strain gauge, for example.

According to an embodiment, the solution relates to

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a hydraulic rock breaking machine, which is intended to be mounted to a working machine and comprises a body and a percussion device, which is hydraulically operable and mounted inside the body. The percussion device generates impact pulses by means of a reciprocating piston to a tool mountable to a front end of the body. The machine further comprises one or more pneumatic sensors for sensing pneumatic pressure inside the body in order to monitor pneumatic pressure fluctuation caused by the piston of the hydraulic percussion device.

According to an embodiment, the rock breaking machine is a rock drilling machine. The rock drilling machine comprises a rotation device for turning a drilling tool around its longitudinal axis.

According to an embodiment, the rock breaking machine is a rock drilling machine provided with an oil mist lubrication system for providing pressurized air-oil mist flow inside the body. The rock drilling machine is provided with at least one pneumatic sensor for sensing pneumatic pressure of the air-oil mist prevailing inside the body. In other words, pressure fluctuation of the lubricating mist is sensed and the data on the fluctuation may be analyzed and used as it is disclosed in several embodiments in this document.

According to an embodiment, the rock breaking machine is a rock drilling machine and comprises an oil mist lubrication system for providing pressurized air-oil mist flow inside the body. The rock drilling machine comprises a shank at a front end of the body for connecting a drilling tool. The shank is rotated by means of a rotating device via a gearing surrounding the shank. The oil mist lubricating system lubricates a front space surrounding a rear end portion of the shank and the gearing. One or more pneumatic sensors are in pneumatic connection with the front space and are arranged to sense pneumatic pressure of the air-oil mist prevailing inside the front space.

According to an embodiment, the rock breaking machine is a rock drilling machine and comprises a rear space at a rear end portion of the body. The rear space is limited by a rear cover mounted releasably to the body. Further, the rear space is in pneumatic communication with a rear end of a reciprocating piston of the percussion device. The at least one pneumatic sensor is in pneumatic connection with the rear space and is arranged to sense pneumatic pressure prevailing inside the rear space.

According to an embodiment, the mentioned rear space is in fluid communication via a venting channel to an air-oil lubrication system. Then the pneumatic pressure of the rear space may be sensed either directly or by sensing pressure of the air-oil lubrication system.

According to an embodiment, the rock breaking machine is a rock drilling machine and comprises a feed port for feeding the pressurized air-oil mist, and lubricating ducts for conveying the air-oil mist to at least one lubricating target inside the body. One or more pneumatic sensors are arranged to sense pneumatic pressure prevailing inside the feed port or the lubricating ducts.

According to an embodiment, the rock breaking machine comprises a lubrication system wherein lubrication oil and pressurized air are fed inside the body. Then the pressurized air or gas is configured to serve as a carrier medium for the lubrication oil. Thus, the machine may be provided with an oil circulating lubrication system. Further, the rock breaking machine is provided with one or more sensors for sensing pneumatic pressure of the carrier medium prevailing inside the body. In other words, there is pneumatic pressure inside the body and the piston causes pressure fluctuations which may be monitored and the gathered data may be utilized as it is disclosed in this document.

According to an embodiment, the disclosed pneumatic sensor is mounted in direct connection with the inner space of the monitored inner space of the rock breaking machine. Then the pneumatic sensor is mounted close to the monitored inner space. The pneumatic sensor may then have direct exposure to the inner space and no pressure losses and damping phenomena exists.

According to an embodiment, the disclosed pneumatic sensor is mounted directly to a body, a basic structure component or cover limiting the inner space. When the sensor is directly mounted, the monitoring may be sensitive and accurate measuring results can be gathered. Further, the mounting may be rigid and simple. For example, the basic structure of the machine may have an opening provided with inner threads and the pneumatic sensor provided with outer threads may simply be screw mounted.

According to an embodiment, the disclosed pneumatic sensor is connected by means of a pneumatic channel to the monitored inner space. The pneumatic channel may be a tube, hose or a drilling made to the basic structure. Then the pneumatic sensor may be located at a short distance from the monitored inner space. The distance between the monitored inner space and the pneumatic sensor is preferably as short as possible in order to ensure accurate sensing. An advantage of this embodiment is that it provides several alternative possibilities for the mounting of the sensors and when the location of the sensors may be selected more freely, thanks to the connecting pneumatic channel, the sensors may be placed to positions where they are well protected and where is free space for them.

According to an embodiment, the rock breaking machine may be provided with quick connect couplings for mounting the disclosed pneumatic sensors in a removable manner to the monitored machine. Then the sensors are easy to mount by anyone and may be changed if needed. Further, the machine may be provided with the quick couplings at the factory and may be equipped with the sensors later on. The sensor may be coupled also for duration of a special monitoring period and may be thereafter easily removed, if so desired.

According to an embodiment, the rock breaking machine is provided with a dedicated monitoring space which is pressurized with gas and inside which a rear end of the piston of the percussion device is configured to move. One or more pneumatic sensors are in pneumatic connection with the dedicated monitoring space and are configured to detect fluctuating pneumatic pressure caused by the reciprocating rear end of the piston.

According to an embodiment, the above mentioned dedicated monitoring space is formed only for the monitoring purpose. In this embodiment, the space is not for lubrication purposes.

According to an embodiment, constant gas pressure is fed to the mentioned dedicated monitoring space.

According to an embodiment, the mentioned dedicated monitoring space is prefilled with gas. The space is only provided with a gas feed port. No gas flow exists through the space.

According to an embodiment, inside the inner space of the monitored machine may be compressed air, air-lubricant mist or any inert gas, such as nitrogen. The pressurized gas may be arrange inside the inner space solely for the monitoring purposes or it may simultaneously serve as flushing gas, lubricating gas or cooling gas.

According to an embodiment, the disclosed solution relates to a method. The method relates to monitoring operation of a hydraulic rock breaking machine. The method comprises providing the rock breaking machine with at least one pressure sensor for providing pressure data for the monitoring. In the method prevailing pressure inside a body of the rock breaking machine is sensed by means of at least one pneumatic pressure sensing device. The sensed pneumatic pressure data is transmitted to at least one control unit wherein the sensed pneumatic pressure data is processed under for generating monitoring data.

According to an embodiment, the method comprises determining operational condition of the rock breaking machine by examining the monitoring data.

According to an embodiment, the mentioned operational condition data may comprise data on rock material being processed since by analyzing the pneumatic pressure data it is possible to detect whether the tool is penetrating into a hard or soft rock and whether there are cavities or fractures in the rock. Thereby, characterized features of the rock may be determined and the gathered data may be stored and taken into account in the control of the machine and also in following other measures executed at the work site.

According to an embodiment, the mentioned operational condition data may comprise data on recoil of the piston in the return direction. The detected recoil and movement speed in the return direction may be analyzed in more detailed and utilized for generating control parameters or performance factors. By means of analyzing the recoil i.e. amount of energy transmitted back to the percussion device from the rock being broken it is possible to determine properties of the rock, to determine whether operator of the machine uses the machine in a right manner and to determine whether proper settings and control parameters are implemented.

According to an embodiment, the mentioned operational condition data may comprise data on physical contact of the tool with the rock material being processed.

According to an embodiment, the mentioned operational condition data may comprise data on speed of the piston in the return direction. Further, the system may monitor the movement of the piston and detect if any abnormal movement or speed exists. These issues may indicate that one or more components of the machine is failed and needs to be replaced before they cause damage to other components.

According to an embodiment, the mentioned operational condition data may comprise data on moment of generated impact and moment when the piston is in its rear dead point.

According to an embodiment, the method further comprises utilizing the monitoring data for providing predictive maintenance for the rock breaking machine. The monitoring may show that one or more components of the percussion device are not working properly and that abnormal behavior can therefore be notified. For example, it is possible to detect if a control valve controlling working cycle of the piston is failed. Movement of the control valve in opposite directions may be nonlinear and this can be noted by the disclosed monitoring. The control valve can be substituted with a new one early enough before the entire percussion device will be damaged. The disclosed monitoring provides usage based triggers for the service measures and ensure that the percussion device operates effectively and that no unpredictable interruptions occur in the operation of the rock breaking machine.

According to an embodiment, the method further comprises controlling operating parameters of the rock breaking machine on the basis of the monitoring data. Then the monitoring data is utilized for detecting different drilling situations and phenomenon and suitable amendments to control parameters are made for controlling the operation. The control parameters may adjust operation of the percussion device. It is possible to adjust generated percussion rate and impact energy by adjusting feeding of hydraulic fluid to the percussion device. In addition to, it is also possible to adjust other operational parameters of the rock breaking device and its assisting actuators. It is possible to adjust feed force of the breaking device towards the rock surface, for example. This way contact between the rock and the tool may be affected. When the breaking hammer is a rock drilling machine, rotation of the tool may be adjusted as well as flushing.

According to an embodiment, the disclosed pneumatic pressure sensing system may also be retrofitted to an existing hydraulic rock drilling machine or hydraulic rock breaking hammer. This way the machines may be updated with this new kind of monitoring system whenever desired.

According to an embodiment, the control unit of the disclosed monitoring system may be located on a carrier of a rock drilling rig or excavator. The sensing data gathered by means of the pneumatic pressure sensing devices may be transmitted to the control unit by means of wired or wireless data communication path. Alternatively, or in addition to, the sensing data may be transmitted to one or more external control units, which may be personal computers, servers, cloud services or electrical terminal devices. In some cases it may be possible to provide rock breaking machine with a control unit and then provide it with a data communication connection with one or more other control devices or actuators.

According to an embodiment, the solution may relate to a rock drilling rig, comprising: a movable carrier; at least one drilling boom connected movably to the carrier and equipped with a rock drilling unit; and wherein the rock drilling unit comprises a feed beam and a hydraulic rock drilling machine supported movably on the feed beam; and wherein the drilling machine is in accordance with the features disclosed in this document and includes the disclosed pneumatic pressure sensing system.

The above disclosed embodiments may be combined in order to form suitable solutions having those of the above features that are needed.

Where any or all of the terms "comprise", "comprises", "comprised" or "comprising" are used in this specification (including the claims) they are to be interpreted as specifying the presence of the stated features, integers, steps or components, but not precluding the presence of one or more other features, integers, steps or components.

Brief description of the figures

Some embodiments are described in more detail in the accompanying drawings, in which

Figure 1 is a schematic side view of a rock drilling rig wherein a hydraulic rock drilling machine is provided with a pneumatic monitoring system,

Figure 2 is a schematic view of a work machine wherein a hydraulic rock breaking hammer is provided with a pneumatic monitoring system,

Figure 3 is a schematic view of a hydraulic rock drilling machine and pneumatic sensors arranged at possible measuring points,

Figure 4 is a diagram showing some pressure curves in function of time,

Figure 5 is a diagram showing some basic features relating to a pneumatic monitoring system,

Figure 6 is a diagram showing possible use cases for the generated monitoring data,

Figure 7 is a schematic view of a hydraulic rock drilling machine provided with a circulation lubrication system and comprising several pneumatic sensors arranged at possible measuring points, and

Figure 8 a schematic view of a rear space of the breaking machine comprising an inner space with a pneumatic space and pneumatic sensing arrangement.

For the sake of clarity, the figures show some embodiments of the disclosed solution in a simplified manner. In the figures, like reference numerals identify like elements.

Detailed description of some embodiments

Figure 1 shows a rock drilling rig 1 intended for drilling drill holes 2 to a rock surface 3. In this case the rock drilling rig 1 is intended for surface drilling, but the same principles disclosed in this document apply also for underground drilling machines. The rock drilling rig 1 comprises a movable carrier 4 and one or more drilling booms 5 connected to the carrier 4. At a distal end portion of the drilling boom 5 is a rock drilling unit 6 provided with a feed beam 7 and a rock drilling machine 8 supported on it. A drilling tool 9 is connectable to the rock drilling machine 8. The rock drilling machine 8 is a hydraulic rock breaking machine 10 which is connected to a hydraulic system powered by a hydraulic unit 11. The rock drilling machine 8 comprises a percussion device for generating impact pulses to the tool 9 in impact direction A. The rock drilling machine 8 also comprises a rotating device for turning R the tool 9 around its longitudinal axis. The rock drilling machine 8 is further provided with one or more pneumatic sensors S, whereby the rock drilling machine 8 is instrumented. In other words, the hydraulically operated machine is examined by means of pneumatic sensing means.

The rock drilling rig 1 may comprise one or more control units CU, which receive measuring signals from the sensors S and process the input sensing data. The control unit CU may be a dedicated device intended for the pneumatic monitoring system, or alternatively, a basic control unit of the rig 1 may serve also a processor for the pneumatic monitoring system. Alternatively, or in addition to, the system may comprise one or more external control units CU. Data communication between the sensors S and the on-board control unit CU may be wired or wireless. Further, the system may comprise at least one user interface UI or display unit through which the system may provide an operator with the monitoring data and by means of which the

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operator may input data, parameters, computer programs and make selections.

Figure 2 discloses an excavator 12 which is provided with a boom 5 and a hydraulic breaking hammer 13 at a distal end of the boom 5. The breaking hammer 13 is a hydraulic breaking machine 10 connected to a hydraulic system of the excavator 12 and is powered by means of a hydraulic unit 11. The breaking hammer 13 comprises a percussion device 14 which is intended to provide a tool 9 with impact pulses for breaking rock material 15. The breaking hammer 13 is provided with one or more pneumatic sensors S which monitor operation of the machine 10. Sensing data is transmitted to an on-board control unit CU or to an external control unit. The sensors S may detect pressure fluctuation inside the breaking hammer, which fluctuation is caused by a reciprocating percussion piston of the percussion device 14.

Figure 3 is a highly simplified presentation of a hydraulic rock drilling machine 8. The drilling machine 8 comprises a main body 16 inside which is a percussion device 14, comprising a percussion piston 17. The piston 17 moves in a reciprocating manner towards impact direct A and return direction B. A front end of the piston 17 strikes rear end of a tool 9. The tool 9 transmits impact pulses to a rock surface processed. The piston 17 is controlled by means of control valve 18, which may be located around the piston 17. The tool 9 is rotated around its longitudinal axis by means of a rotating device 19, which may be arranged to transmit the generated rotation via a gear 20 and rotation bushing 21 to a chuck 22 which receives the tool 9 or shank adapter. A front cover 23 may form a gear housing 24 surrounding the rotation means. At an opposite rear end of body 16 is a rear cover 25 which comprises an inner rear space 26 which is in communication with a rear end 17a of the piston 17. The machine 10 may be provided with an air-oil lubrication system, whereby air-oil mist is fed through

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a feed port 27 inside the rear cover 25. The gaseous lubrication medium is conveyed through lubrication channel 28 to the front part of the machine 10 in order to lubricate the rotation gearing, the shank adapter and their bearings. Thus, inside the gearing housing 24 is an inner space wherein pressurized gaseous lubrication medium prevails. As it is shown, there may be one or more pneumatic sensors S mounted at the front part of the machine 10 for detecting gas pressures therein. Further, the air-oil lubrication system may be in fluid connection with the inner rear space 26. There may be a narrow venting channel 29 for allowing the lubrication system to be vented to the inner rear space 26 whereby gas pressure prevails also therein. The rear cover 25 is provided with a pneumatic sensor S for sensing pressure in the space 26. When the rear end portion 17a of the piston 17 moves forwards and backwards, it causes pressure fluctuation inside the space 26 and this can be sensed by means of the sensor S. The movement of the piston 17 causes pneumatic pressure variations also in the front part of the machine 10 and they can also be detected by means of the sensors located at the front end portion.

An alternative to the solution shown in Figure 3 is that there is no venting channel 29 to the lubrication system, but instead there is a gas feed port for providing the inner space 26 with any other gaseous medium. Also the pressure variations can be measured by means of one or more pneumatic sensors S.

Figure 4 shows two pressure curves of pneumatic sensors mounted to a rear portion of a percussion device (a curve with greater amplitude) and mounted to a front portion (smaller amplitude). Movement of a piston of the percussion device may be analyzed based on the pressure data and the curves. When the piston moves in impact direction, then pressure decreases at the rear portion and correspondingly when the piston moves in return direction, pressure increases. More detailed analyzing programs allow use of the pressure data in a versatile manner. It has been noticed, that the most interesting curves are gathered from the sensors inside a rear cover of the machine and in volume spaces where the piston is striking. Thus, in practical solutions, the rear cover appears to be the best place to measure. Rear cover area is usually well accessible and, in many cases, a threaded hole that could be used for a sensor already exists therein or can be easily made.

Figure 5 shows a simplified diagram showing basic components of the disclosed pneumatic monitoring system and basic process steps executed in the monitoring. The presented issues have already been disclosed above in this document.

Figure 6 discloses some possible applications for the monitoring data produced by the disclosed pneumatic monitoring system. The figure is self-explanatory, and further, the presented issues have already been disclosed above in this document.

Figure 7 discloses a rock drilling machine provided with an oil circulation system wherein pressurized air is fed through a channel 30 and lubrication oil is fed through a channel 31. The pressurized air makes the oil to circulate inside the body. Otherwise the solution of Figure 7 may correspond to that shown in Figure 3.

Figure 8 discloses an end cover 25 of a breaking machine. An inner space 26 is provided with a breathing channel 32 which may be provided with a throttle device, which may have fixed adjustment or it may be adjustable. In this case the inner space is not connected to the lubrication system as it is in solutions disclosed in Figures 3 and 7. A sensor S may detect pressure fluctuations inside the space 26 and caused by the reciprocating movement of the hydraulically moved piston 17.

The drawings and the related description are only intended to illustrate the idea of the invention. In its details, the invention may vary within the scope of the claims.

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The claims defining the invention are as follows:

1. A hydraulic rock drilling machine, which is intended to be mounted to a work machine and comprises:

a body;

a percussion device mounted inside the body, the percussion device being hydraulically operating, whereby a reciprocating percussion piston of the percussion device is moved by means of pressurized hydraulic fluid, and configured to generate impact pulses by means of the reciprocating piston to a tool mountable to a front end of the body; and

at least one apparatus for sensing prevailing fluid pressure inside the rock drilling machine wherein the apparatus comprises:

at least one pressure sensing device for sensing pressure of fluid inside the rock drilling machine;

at least one control unit configured to receive sensed pressure data from the at least one pressure sensing device;

and wherein the control unit is configured to process the received sensing data and to provide monitoring data in accordance with a control strategy input to the control unit;

wherein

the rock drilling machine comprises an oil mist lubrication system for providing pressurized air-oil mist flow inside the body; and

the rock drilling machine is provided with at least one sensor for sensing pneumatic pressure of the air-oil mist prevailing inside the body in order to monitor pneumatic pressure fluctuation caused by the hydraulically movable piston of the hydraulic percussion device.

2. The rock drilling machine as claimed in claim 1, wherein

the rock drilling machine comprises an oil mist lubrication system for providing pressurized air-oil mist flow inside the body;

the rock drilling machine further comprises the drilling tool at a front end of the body, or a shank adapter for connecting the drilling tool;

the shank adapter or the drilling tool is rotated by means of a rotating device via a gearing surrounding the shank adapter or the drilling tool;

the oil mist lubricating system is configured to lubricate a front space surrounding a rear end portion of the shank adapter or the drilling tool and the gearing; and

the at least one sensor is a pneumatic sensor which is in pneumatic connection with the front space and is arranged to sense pneumatic pressure of the air-oil mist prevailing inside the front space.

3. The rock drilling machine as claimed in claim 1 or 2, wherein

the rock drilling machine comprises a rear space at a rear end portion of the body;

the rear space is limited by a rear cover mounted releasably to the body;

the rear space is in pneumatic communication with a rear end of a reciprocating piston of the percussion device; and

the at least one sensor is a pneumatic sensor which is in pneumatic connection with the rear space and is arranged to sense pneumatic pressure prevailing inside the rear space.

4. The rock drilling machine as claimed in any one of the preceding claims 1 to 3, wherein

the rock drilling machine comprises a feed port for feeding the pressurized air-oil mist, and lubricating ducts for conveying the air-oil mist to at least one lubricating target inside the body; and

at least one pneumatic sensor is arranged to sense pneumatic pressure prevailing inside the feed port or the lubricating ducts.

5. The rock drilling machine as claimed in any one of the preceding claims 1 to 4, wherein

the sensor is mounted in direct connection with the inner space of the monitored inner space of the rock drilling machine, whereby the sensor is mounted close to the monitored inner space.

6. The rock drilling machine as claimed in any one of the preceding claims 1 to 5, wherein

the rock drilling machine is provided with a dedicated monitoring space which is pressurized with gas and inside which a rear end of the piston of the percussion device is configured to move;

and wherein at least one sensor is in pneumatic connection with the dedicated monitoring space and is configured to detect fluctuating pneumatic pressure caused by the reciprocating rear end of the piston.

7. The rock drilling machine as claimed claim 1, wherein

the rock drilling machine comprises a lubrication system wherein lubrication oil and pressurized air are fed inside the body, and wherein the pressurized air is configured to serve as a carrier medium for the lubrication oil; and

the rock drilling machine is provided with at least one sensor for sensing pneumatic pressure of the carrier medium prevailing inside the body.

8. A method for monitoring operation of a hydraulic rock drilling machine, wherein the method comprises:

providing the rock drilling machine with at least one sensing device for providing pressure data for the monitoring; and

providing pressurized air-oil mist flow inside a body of the rock drilling machine to lubricate the rock drilling machine;

sensing pneumatic pressure of the prevailing air-oil mist inside the body of the rock drilling machine by means of at least one sensing device;

transmitting the sensed pneumatic pressure data to at least one control unit; and

processing the sensed pneumatic pressure data in the control unit and generating monitoring data.

9. The method as claimed in claim 8, comprising

determining operational condition of the rock drilling machine by examining the monitoring data.

10. The method as claimed in claim 8 or 9, comprising

utilizing the monitoring data for providing predictive maintenance for the rock drilling machine.

11. The method as claimed in any one of the preceding claims 8 to 10, comprising

controlling operating parameters of the rock drilling machine on the basis of the monitoring data, whereby the monitoring data is utilized for detecting different rock breaking situations and for controlling them.

12. The method as claimed in any one of the preceding claims 8 to 11, comprising

determining speed of a piston of a percussion device in impact direction and return direction in response to the detected pneumatic pressure variations.

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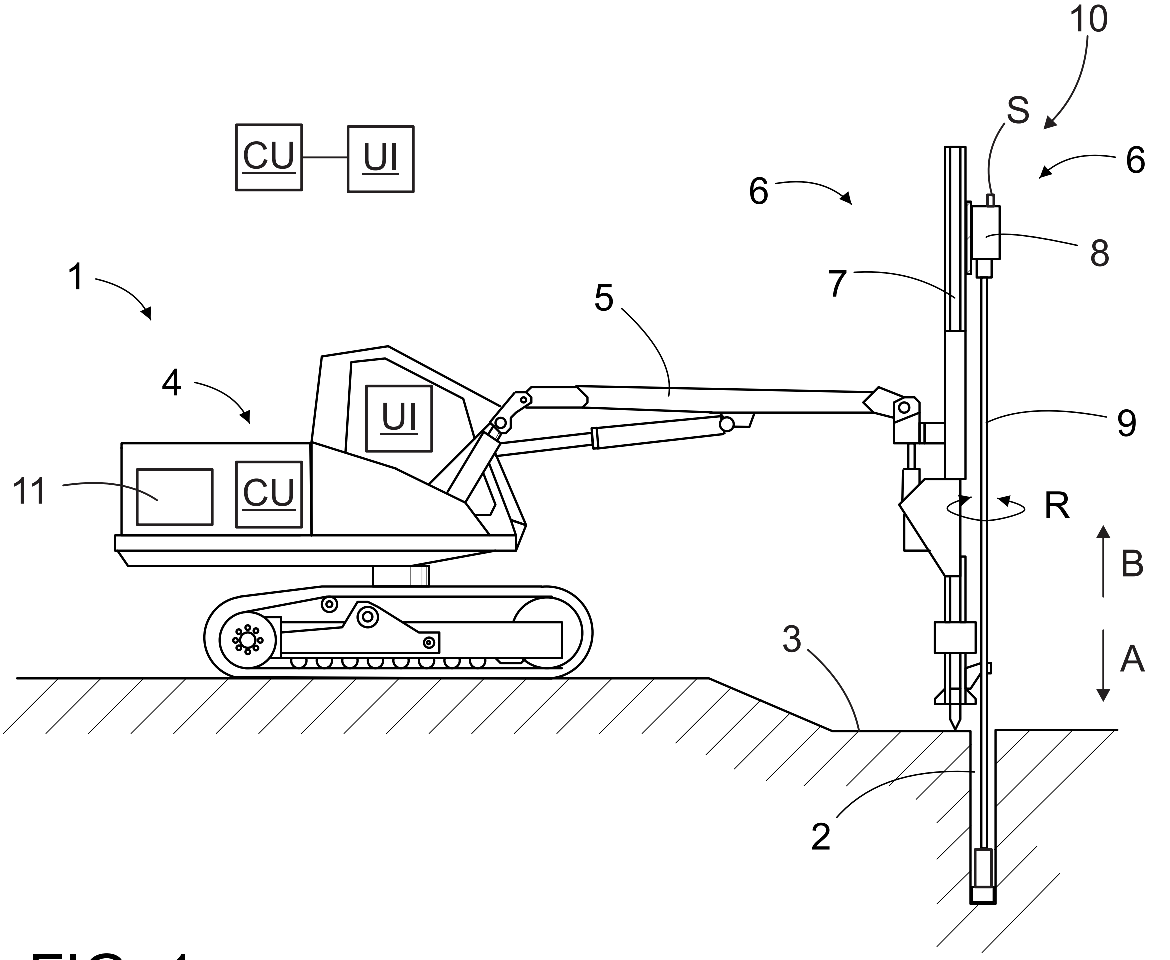

FIG. 1

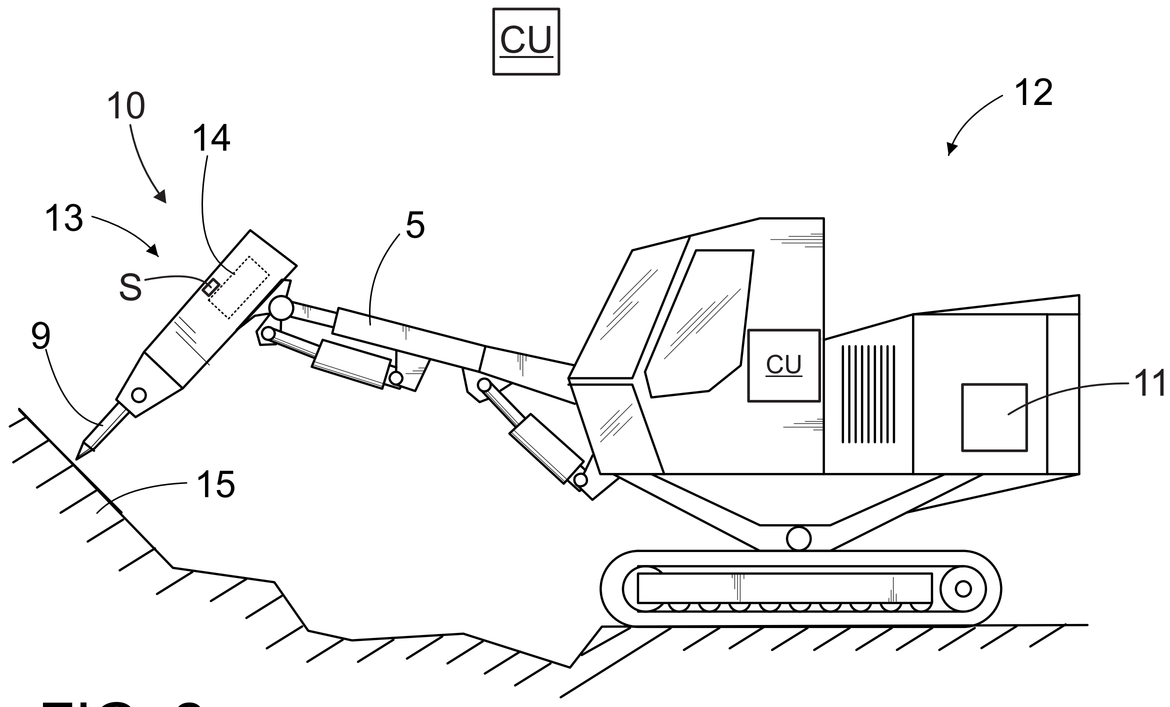

FIG. 2

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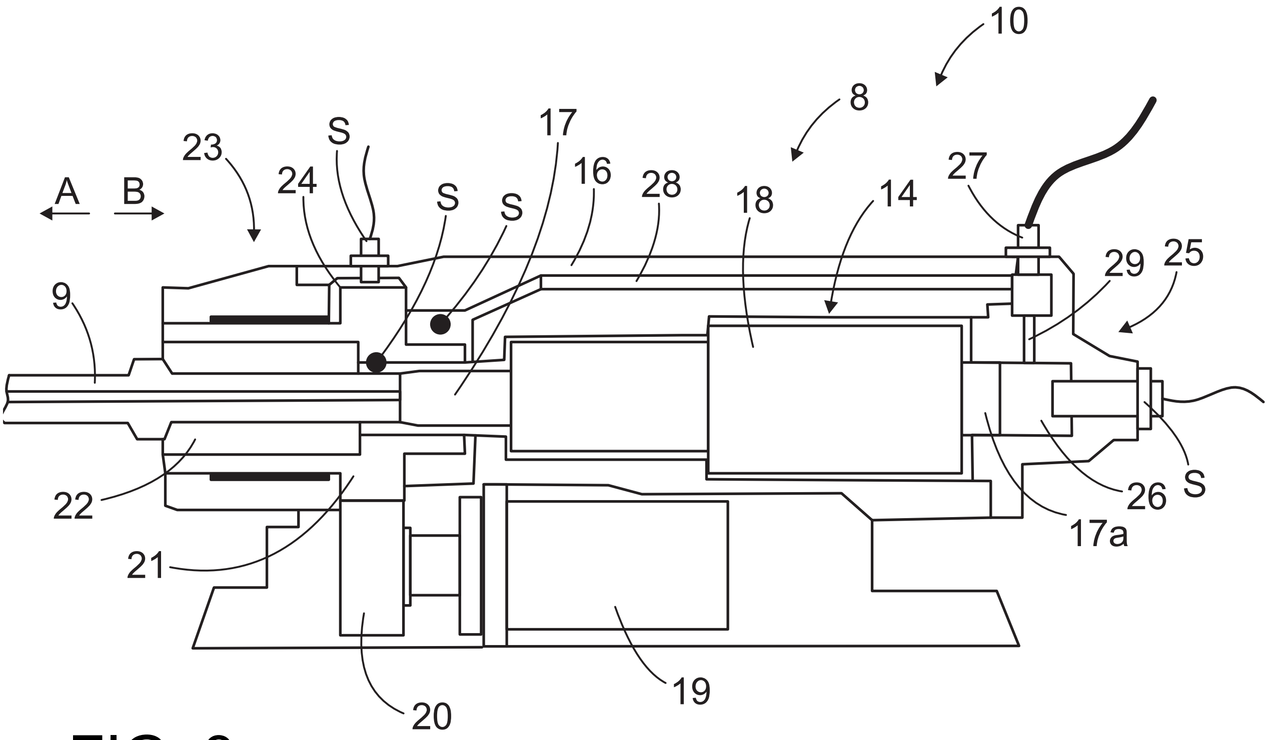

FIG. 3

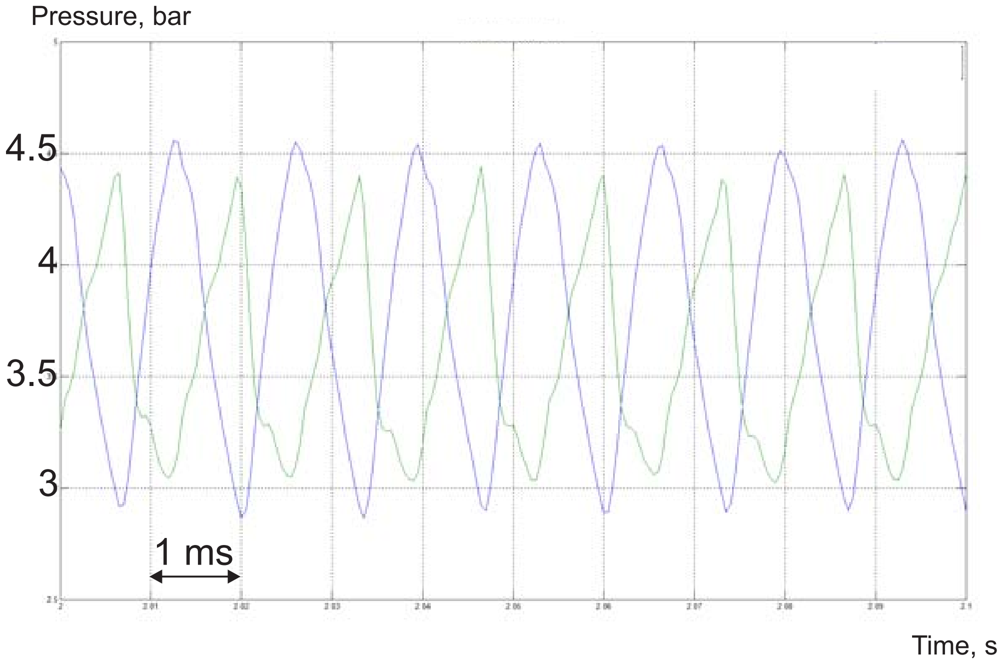

FIG. 4

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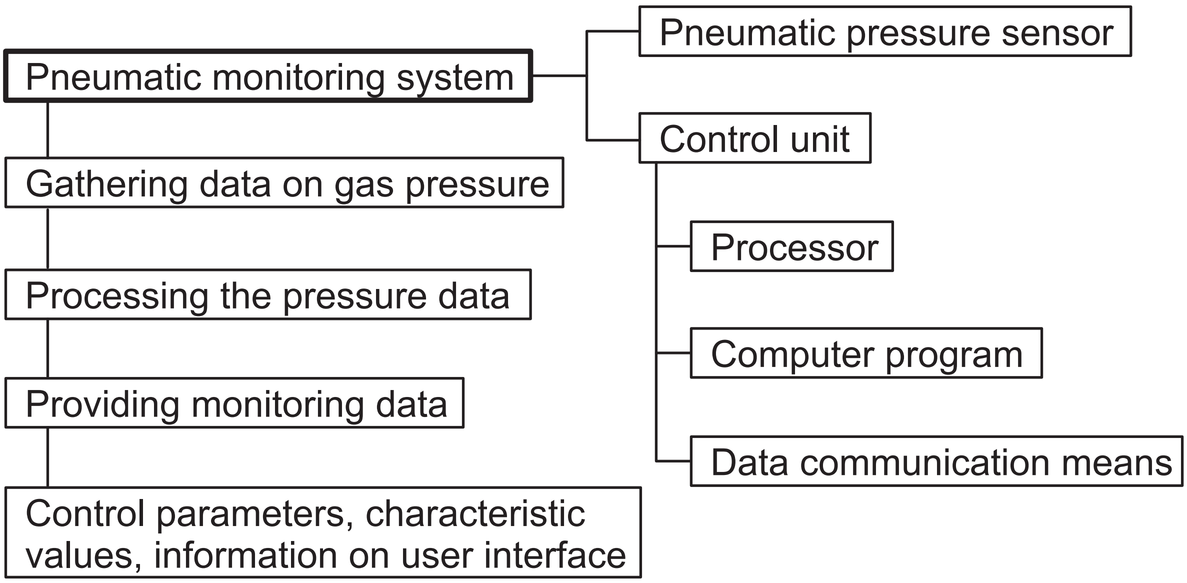

FIG. 5

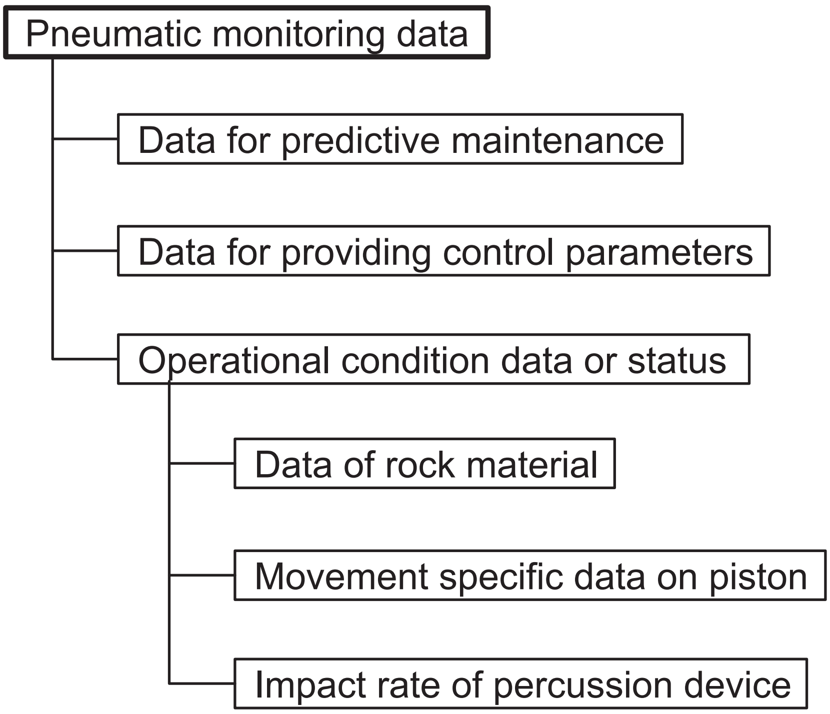

FIG. 6

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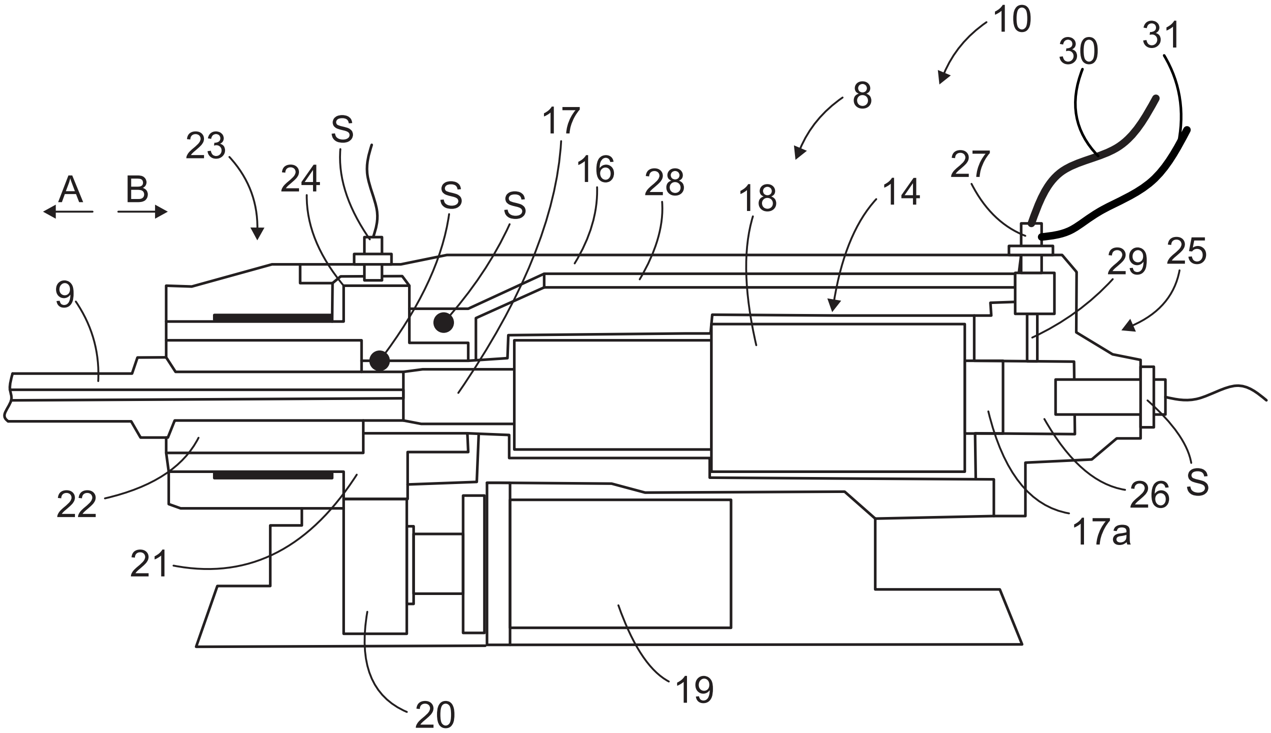

FIG. 7

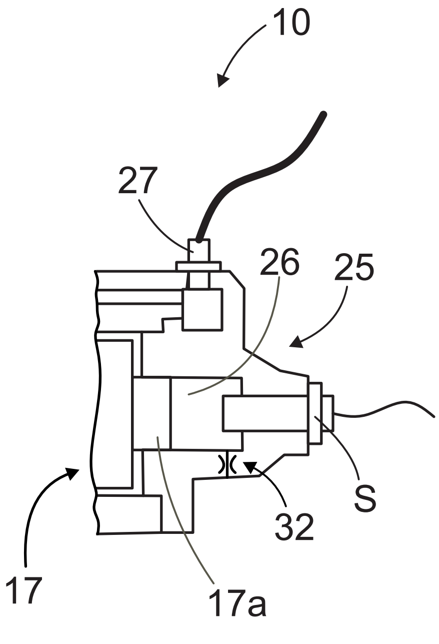

FIG. 8