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(54) **Title**: SAMPLING APPARATUS

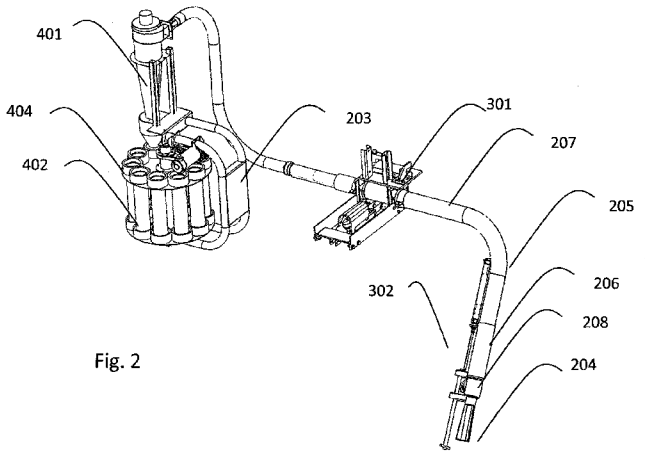

Fig. 2

(57) **Abstract**: Sampling apparatus for collecting geological samples from the subsurface, which sampling apparatus can be fixed to a drill apparatus (100), such as to a mining drill rig, which drill apparatus comprises a chassis (101), and a drill, said drill comprising a boring pipe (102) and a drill bit, which sampling apparatus can be fixed to the chassis (101) of the drill apparatus, which sampling apparatus comprises a sampling pipe arrangement (202) as well as a nozzle (201) to be fitted to the end of it, as well as a collecting apparatus (203) to be connected to the sampling pipe apparatus, in which collecting apparatus samples can be collected, which nozzle is a suction nozzle, in which suction is arranged, and which sampling pipe arrangement comprises an attitude adjustment apparatus (301, 302), with which the nozzle can be arranged into the proximity of the boring pipe in such a way that the nozzle is near the borehole and the mouth of it is directed towards the borehole in such a way that it is able to take samples directly from the mantle rock flying out from the borehole.

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SAMPLING APPARATUS

FIELD OF THE INVENTION

The object of the invention is an apparatus intended for collecting geological samples, which apparatus is suited e.g. for underground drilling use.

BACKGROUND OF THE INVENTION

The excavating of ore or other minerals is performed typically at mines by drilling and by loading a number of pluralities of deep holes in an advantageous grouping in terms of the blasting technique. Compressed air, or a compressed air-water mix, blown via the boring pipe is used in drilling the deep holes to transport the rock material that is detached by the drill bit out of the hole. Due to the action of the compressed air, rock material typically flies into a small heap around the borehole. The ore being sought is not evenly distributed in the bedrock of the mining area, but instead adjoining rock formations having a smaller or non-existent ore content are mixed up with the ore deposit. The excavation of encasing rock cannot be avoided, but it is worth minimizing the progression of the encasing rock into the crushing phases and ore cleaning phases. From the viewpoint of the ore cleaning process, it is advantageous to know in advance as accurately as possible the grade of the crushed ore material entering the process. The grade of the ore material in the ore intended to be excavated is first ascertained with trial boring and in the production drilling stage by collecting rock samples, into sample bags with a shovel, from the piles of rock material produced around the boreholes in the drilling. The sample collecting work is performed manually and requires an employee to move about the drilling field. Drilling field conditions are typically dusty and the nature of the flying dust detaching from the piles can be detrimental to the health of the employee collecting the samples. From the collected samples a sample is made by splitting a number of times, from which sample the content of the target minerals is determined. A weakness with pile samples is that it is no longer possible to ascertain from the rock material taken from a pile information about the depth of adjoining rock deposits or ore deposits from the drilling level. A sample taken from a pile represents a sort of hole average. It is also known in the art that some of the target mineral has possibly escaped along with the finer material carried by the wind, so remaining in the pile is a higher proportion of

adjoining rock in relation to the target mineral. Known solutions to the problem are to install on the boring pipe a collar, or suchlike system, covering the whole borehole to collect rock material coming out of the hole and to split the whole amount of material a number of times, automatically or manually, or to install on the collar a flow guide and turn part of the flow into a separate bag functioning as a sample collector.

Publication US 4650013 presents a subsurface sampling apparatus, by means of which subsurface samples can be taken from a hole drilled in the ground. It has a bag-like collection container, in which the subsurface samples are collected. The subsurface samples are fed into the collection container via a mouth piece that is in an inclined attitude on the edge of a vertical pipe. The area of the borehole is covered with an elastic cover.

Particular drawbacks in sampling apparatuses according to prior art are poor sampling accuracy and the complex structure of the apparatus.

SUMMARY OF THE INVENTION

The aim of the present invention is thus to eliminate, *inter alia*, the aforementioned drawbacks of prior-art solutions, and to achieve an apparatus with which a more truly representative sample than before with respect to sampling of the excavated ore can be produced. Further, the aim of this invention is to bring about the following advantages: to achieve a better level in sampling accuracy, to achieve savings in the labor costs in sampling, and to achieve a better work safety level and work hygiene level in sampling.

The invention is based on the concept that a geological sample is taken from the air that is discharging from a borehole and that contains rock material, from as close to the mouth of the borehole as possible without covering the hole with a collar or with a rubber protector. In addition, the size of a sample is limited, preferably already at the point of the mouth aperture of the borehole, to be small but to be highly representative of the bedrock by collecting the sample from the rock material flying out of the hole.

In the concept according to the invention an advantageously shaped suction nozzle connected to a pipe is taken to near the mouth of the borehole and

negative pressure is connected to it. A negative pressure point in the outflowing field of the borehole collects rock material that has flown out of the hole and struck its surface area. This material also contains a fraction of fine-grained rock material flying out along with the wind.

Only a part of the whole flow of rock material plus air coming from the hole flies into the sampling aperture on the frontal surface area. Selecting the size of the aperture advantageously achieves the benefit that less post-processing of a sample by splitting, or with another such method, is needed or is not needed at all. The representativeness of a sample is better than that of methods known in the art, because the sample contains also particles normally escaping as airborne dust.

Cyclones, filters, or combinations of cyclones and filters, or other such dust separation methods generally known in industry, can be used as methods for separating the rock material and air, however in such a way that the rock material in the separating system does not mix in the separating process with the rock material that came earlier from the borehole. This is important because the part of the material that is closest to the surface collects at the bottom of the sample bag and last of all comes the part of the rock material from the bottom of the borehole.

The apparatus according to the invention comprises a sampling pipe provided with a suction nozzle and a collecting apparatus, in which a number of samples of the borehole can be preserved for collection for further periodic analyses.

The apparatus according to the invention is further characterized in that the sampling apparatus comprises an adjustment apparatus, with which the nozzle can be fitted next to the drill bit in such a way that the nozzle is near the borehole and the mouth of it is directed towards the borehole in such a way that it is able to take samples directly from the mantle rock flying out from the borehole.

The suction nozzle is shaped in such a way that it protects the rest of the structure of the sampler from wear by rock material flying out of the hole by guiding the air coming out of the borehole to pass by the side of the support structures of the suction nozzle.

In the immediate proximity of the suction nozzle is a flow amplifier producing negative pressure and transferring a sample by means of positive pressure into the collecting apparatus.

The position of the suction nozzle can be shifted if inclined holes are drilled, so that the sampling location remains the same or almost the same.

The solution according to the invention is described in detail in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following, the invention will be described in detail by the aid of some embodiments with reference to the attached drawings, wherein:

Fig. 1 presents a front view of a drill rig in which is a sampling apparatus according to the invention,

Fig. 2 presents a sampling apparatus according to the invention,

Fig. 3 presents a sampling pipe and the adjustment apparatuses of it, and

Fig. 4 presents a sampling apparatus according to the invention in more detail disposed according to an inclined borehole.

DESCRIPTION OF PREFERRED EMBODIMENTS

Fig. 1 presents a simplified view of a mobile crawler-tracked drill rig 100 used in open-cast mines, said rig comprising a chassis 101, and a drill fitted into the rig, said drill comprising an extendable boring pipe 102 and a drill bit (not presented) on the end of it. The drill rig according to Fig. 1 comprises motor-driven crawler tracks 103, by the aid of which the drill rig can be moved in the mining area. In addition, the drill rig comprises a control unit (not presented) for controlling it.

Holes 105 are bored in the ground 104 with the drill, from which holes rock material 106 discharges out of the borehole onto the surface of the ground. The apparatus according to Fig. 1 is used in drilling deep boreholes, in which case compressed air, or a compressed air-water mix, is blown via the stem 102 of the drill bit to transport the rock material that is detached by the drill bit out of the hole.

For sampling the drill rig comprises a sampling apparatus, according to the invention, that is provided with a control unit, which sampling apparatus is fixed below the chassis of the rig. The control unit can be separate or, on the other hand, it can be integrated into the control system of the drill rig. The sampling apparatus comprises sampling pipe 202 having the additional parts described later and provided with a nozzle 201, as well as a collecting apparatus 203, in which the samples are collected. The samples are taken from the borehole made with the drill rig.

With the sampling apparatus according to the invention a geological sample is taken from the air that is discharging from a borehole 105 and that contains rock material 106 from as close to the mouth of the borehole as possible without covering the hole with a collar or with a rubber protector.

The sampling apparatus is described in more detail in Figs. 2 and 3.

So that the sample can be taken from as close as possible to the borehole 105, the nozzle 201 is a suction nozzle, in which is suction, and it is shaped in such a way that it has a shape expanding like a horn towards the bottom end, i.e. towards the mouth 204, of the nozzle and it can be fixed, in a manner allowing adjustment, to the bottom end if the sampling pipe 202 near the borehole (Fig. 1). The surface area of the bottom end of the suction nozzle is relatively small compared to the borehole, in which case the size of a sample is limited already at the point of the mouth aperture of the borehole to be small but to be highly representative of the bedrock. In addition, the material of the suction nozzle is wear-resistant rubber, polyurethane or ceramic.

According to Figs 2 and 3, the sampling pipe 202 is disposed on a rigid bent metal pipe 205, said metal pipe comprising a first pipe part 206 in the direction of the drill bit or at a small angle, of less than 45, preferably of less than 30,

degrees to it, as well as a second pipe part 207 in the direction of the chassis of the drill rig. The suction nozzle 201 is fixed to the bottom end of the first pipe part 206 of the sampling pipe 202. Additionally, a flow amplifier 208 is in the bottom part of the first pipe part 206. With the flow amplifier 208 the suction of the suction nozzle 201 is brought about and also at the same time positive pressure for the parts of the sampling pipe after the flow amplifier, which boosts the passage of rock material in the sampling pipe 202.

The attitude of the sampling pipe and the length of the first pipe part can be adjusted, in which case the suction nozzle can be positioned near the borehole, and when the drill bit is inclined when drilling inclined holes also for disposing the first pipe part in an inclined attitude to correspond to the inclined attitude of the drill bit.

For this purpose the metal tube surrounding the sampling pipe can be turned with the turning apparatus 301 and the length can also be adjusted with a length adjustment apparatus 302 provided with a ground plane sensor.

The turning apparatus 301 turns the sampling pipe in such a way that the first straight pipe part 205 is turned by means of it to a suitable angle with respect to the drill bit. The turning apparatus comprises a casing (not presented) and a frame 303 and also brackets 304 for fixing it to the chassis frame 101. For turning the pipe there is a spindle motor 305, the spindle 306 of which is fixed to a flange-shaped part 307 attached to the second pipe part. Turning the second pipe part around its center axis turns at the same time the nozzle at the end of the first pipe part, and the nozzle can be fitted to be close to the borehole 105. In addition, the turning apparatus can comprise a control part, with which the angle of the first pipe part with respect to the drill bit can be detected.

For the length adjustment of the first pipe part the apparatus comprises a length adjustment apparatus 302, in which is a pneumatic or hydraulic cylinder 308, comprising a piston rod 309 and a sensor pin 310 connected to its end. In addition, the pressure line controlling the cylinder comprises a pressure sensor.

The adjustment apparatus functions as follows:

The control logic of the sampling apparatus receives data about the turning angle of the drilling rod and adjusts with the spindle motor the turning angle of the sampler to suit the location of the drill when the drilling cycle starts. The control logic controls the hydraulic cylinder 308 to push the piston outwards at a suitable speed. The piston rod 309 is fixed to the nozzle 201 and to the sensor pin 310. When the pin touches the ground, its travel is prevented or becomes more laborious and the increase in the power requirement can be detected e.g. with a pressure sensor connected to the pressure line. The control logic disconnects the pressure supply when the set pressure level is reached or the piston is in the end position.

The ground-level sensor pin comprises a cross pin 311 for the purpose that there is a high probability that the cross pin will encounter rock and prevents the pin from jamming in a gap in the rock or sinking into loose sand. The narrow cross pin does not, on the other hand cling strongly to the pile of drilling cuttings but instead with a pulling movement comes out of the pile when the hole is completed.

In addition, the apparatus comprises a collecting apparatus 203, which can comprise a cyclone 401 separating the rock material and the air, and a rotating sampling magazine 402 as well as the sample bags 403 arranged on its rim. The feed-in into the sample pipes occurs by rotating the magazine 402 with a rotating machine filling a sample bag 403 at the point of the top feeder hopper 404, from which the rock material is fed into a sample bag.

It is advantageous to select plastic film as the material of the sample bags, which enables rapid analysis of samples with the XRF method and with portable devices before more time-consuming conventional analysis. It is also advantageous to select the shape of a sample bag to be elongated so that the material that has come from different points of the borehole can be analyzed visually or with the aforementioned method utilizing X-ray fluorescence.

In underground drilling it is also possible to drill holes that are inclined, and not at a right angle, with respect to the ground surface. This property is made to bores for reasons of blasting technique. From the viewpoint of sampling technology, therefore, it is essential that the sampler is able to follow an inclined

drilling rod and to take a sample always from the same point in relation to the borehole.

According to the invention the sampling pipe can be inclined at the pipe sections 205, 206 and the length can be adjusted so that the sampling location stays in the immediate proximity of the borehole according to Figs. 1 and 4.

A preferred method of producing the negative pressure needed by the sampling is to bring about negative pressure as close as possible to the suction point. If the negative pressurized pipe is long, various flow resistances such as pipe bends and constrictions, as well as leaks, significantly weaken the amount of negative pressure at the suction point. Flow amplifiers are generally used in the pneumatic conveying of powdery substances to convey a mix of solids and air long distances using positive pressure. It is typical of a flow amplifier that it forms negative pressure on the suction side and the flow after the amplifier is positive pressurized. It is advantageous in the sampling to use a flow amplifier near the suction aperture. The section with negative pressure remains short and solid matter does not collect in the conveying pipe when the flow speed is maintained with a flow amplifier.

It is obvious to the person skilled in the art that the different embodiments of the invention are not limited solely to the examples described above, but that they may be varied within the scope of the claims presented below. The sampling apparatus presented above functions in a turning angle-radius coordinate system. An alternative method of implementing it is straight-line movement according to an x and y coordinate system. The first pipe part can, instead of being straight in shape, also be slightly curved, however in such a way that the end of it nearest the borehole is in the direction of the boring pipe or at an angle of less than 45 degrees inclination with respect to the boring pipe.

CLAIMS

1. Sampling apparatus for collecting geological samples from the subsurface, which sampling apparatus can be fixed to a drill apparatus (100), such as to a mining drill rig, which drill apparatus comprises a chassis (101), and a drill, said drill comprising a boring pipe (102) and a drill bit,

   which sampling apparatus can be fixed to the chassis (101) of the drill apparatus,

   which sampling apparatus comprises a sampling pipe arrangement (202) as well as a nozzle (201) to be fitted to the end of it, as well as a collecting apparatus (203) to be connected to the sampling pipe apparatus, in which collecting apparatus samples can be collected,

   characterized in that

   the nozzle is a suction nozzle, in which suction is arranged,

   the sampling pipe arrangement comprises an attitude adjustment apparatus (301, 302), with which the nozzle can be arranged into the proximity of the boring pipe in such a way that the nozzle is near the borehole and the mouth of it is directed towards the borehole in such a way that it is able to take samples directly from the mantle rock flying out from the borehole.

2. Sampling apparatus according to claim 1, **characterized** in that the sampling apparatus comprises means arranged in the sampling piping for bringing about suction in the suction nozzle.

3. Sampling apparatus according to claim 1 or 2, **characterized** in that the sampling piping comprises near the mouth piece a flow amplifier (208), with which negative pressure bringing about suction can be formed in the suction nozzle and positive pressure in the sampling piping after the flow amplifier for boosting the flow.

4. Sampling apparatus according to any of the preceding claims, **characterized** in that the adjustment apparatus comprises indication means and turning apparatus or transfer apparatus (301) for adjusting the first pipe part according to the inclination or attitude of the boring pipe.

5. Sampling apparatus according to claim 4, **characterized** in that the sampling pipe in the sampling pipe arrangement is at least partly fitted inside a protective pipe, which sampling pipe or protective pipe comprises at least near the boring pipe a first pipe part (206), in connection with the end nearest the borehole of which first pipe part a nozzle is fixed,
the adjustment apparatus in which sampling pipe arrangement is configured to turn or to transfer the nozzle near the first pipe part.

6. Sampling apparatus according to any of the preceding claims, **characterized** in that the turning apparatus comprises indication means for determining the inclination of the boring pipe as well as a controllable actuator to turn the rigid pipe part according to the inclination of the boring pipe defined with the indication means.

7. Sampling apparatus according to any of the preceding claims, **characterized** in that the part of the sampling pipe arrangement near the boring pipe comprises a pipe part, or at least the bottom end of it, that is parallel with the boring pipe or at an angle of less than 45° to it, onto which pipe part means are fitted for adjusting its length for fitting the nozzle (201) close to the borehole.

8. Sampling apparatus according to any of the preceding claims, **characterized** in that for the length adjustment the apparatus comprises a sensing means to indicate the distance of the nozzle piece from the ground as well as control means to adjust the length of the first pipe part.

9. Sampling apparatus according to any of the preceding claims, **characterized** in that for the length adjustment the apparatus comprises a cylinder arrangement, which is configured to function in such a way that the control unit of the sampling apparatus controls the cylinder to

move the piston rod, which piston rod is fixed to a nozzle and to a sensing means.

10. Sampling apparatus according to claim 9, **characterized** in that the control unit of the sampling apparatus is configured to function in such a way that it controls the cylinder to move the piston rod outwards, and when the sensing means touches the surface of the ground, its passage is at least partly prevented, the increase in the required power is detected with a detector, and the control unit disconnects the pressure supply and the movement of the piston stops when the set pressure level is reached or the piston is in the end position.

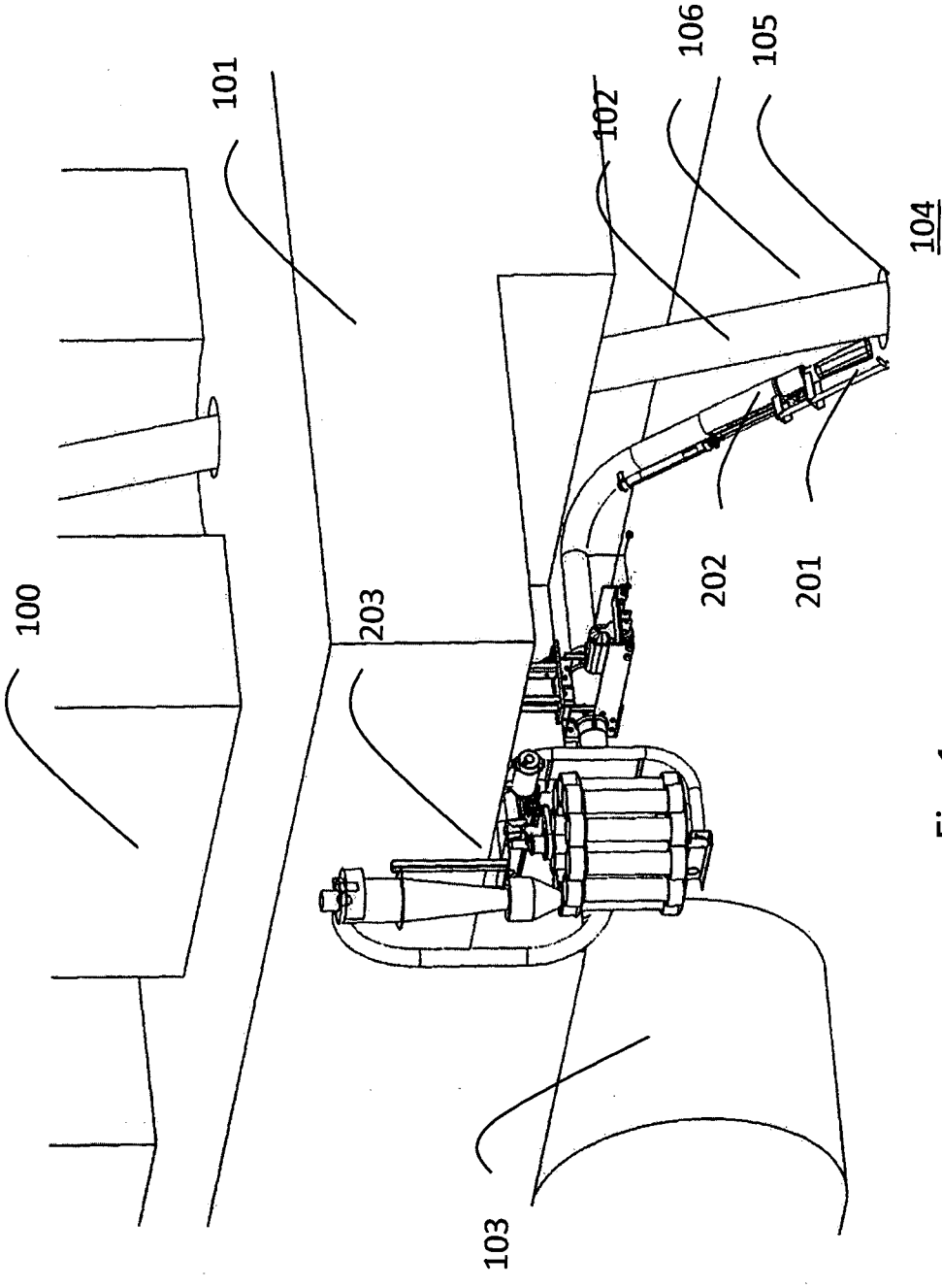

Fig. 1

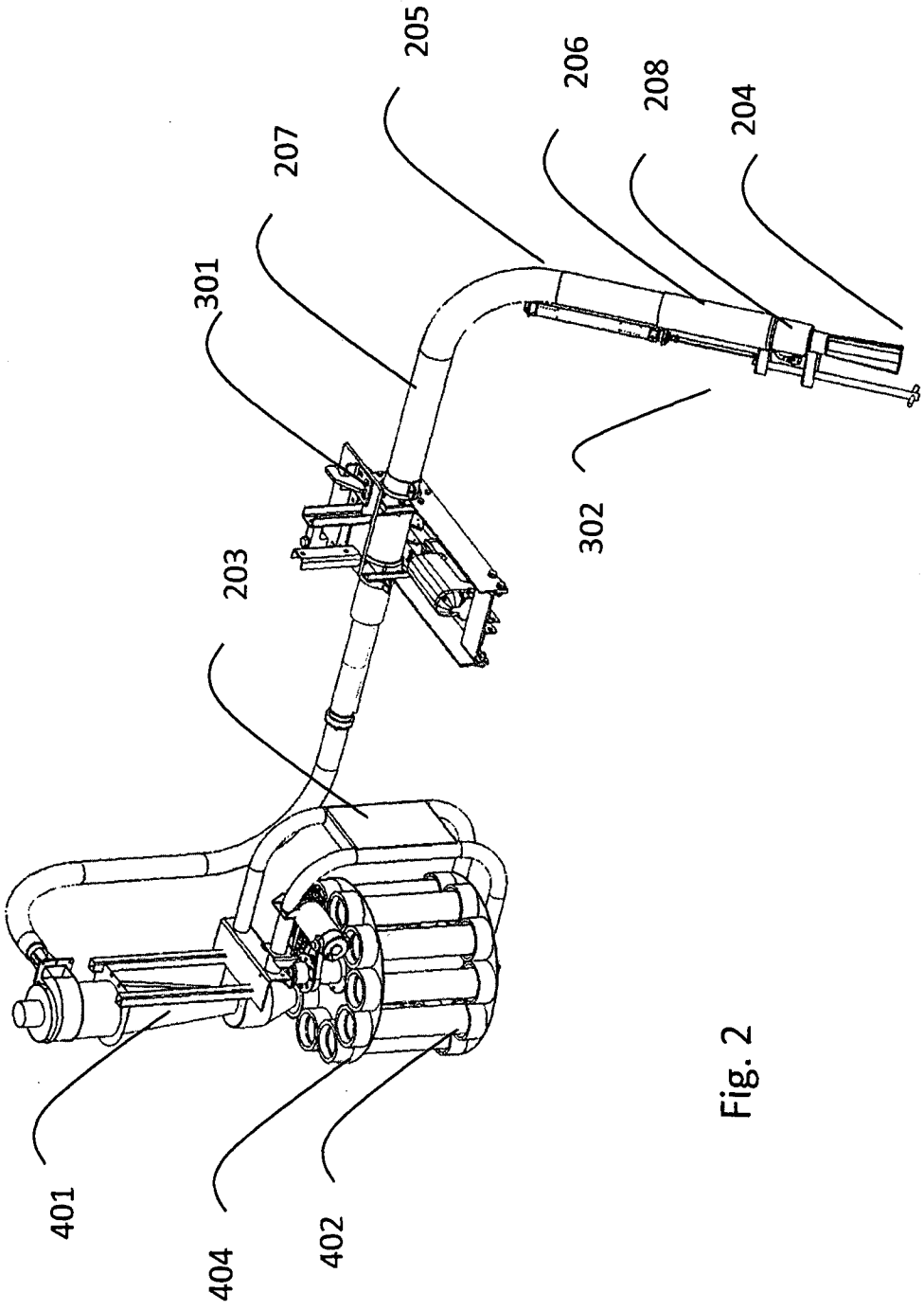

Fig. 2

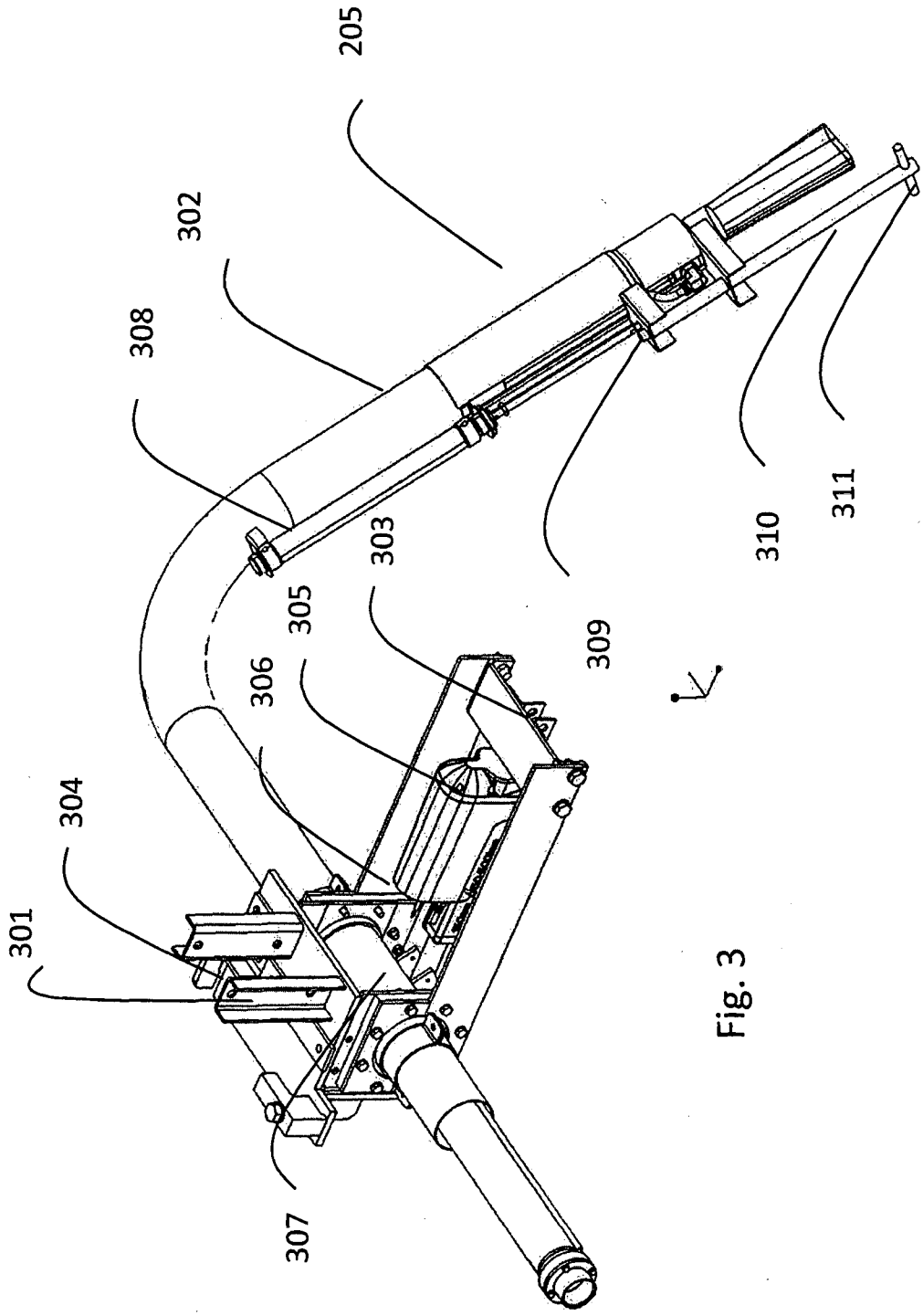

Fig. 3

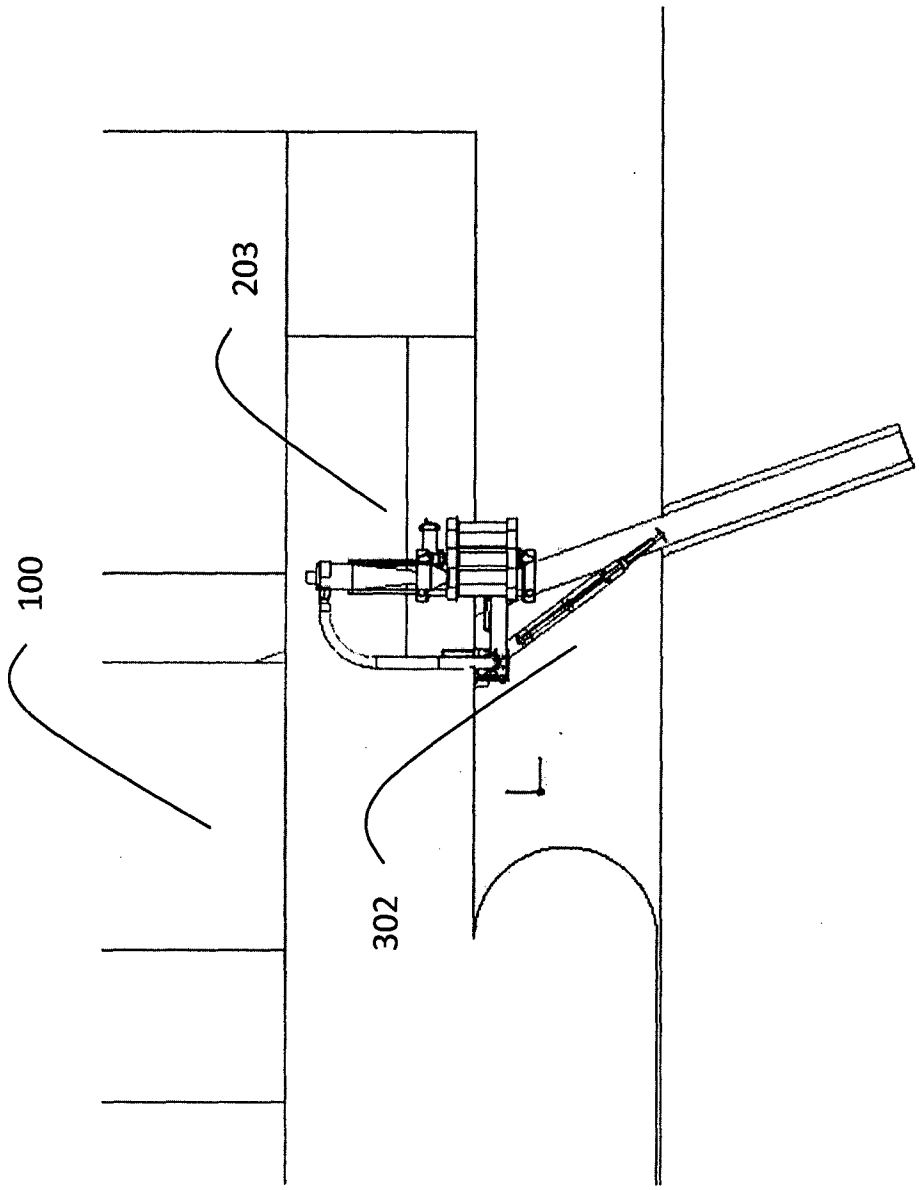

Fig. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI2013/050872

A. CLASSIFICATION OF SUBJECT MATTER

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, E02D, G01N

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

FI, SE, NO, DK

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

EPO-Internal, WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2010000040 A1 (ROESNER PTY LTD [AU]) 07 January 2010 (07.01.2010) abstract; page 4, line 28 – page 5, line 33; page 15, line 3 – page 17, line 19; claim 20; figures 1-3	1, 3-9
X	US 6332308 B1 (MILLER RODNEY [US]) 25 December 2001 (25.12.2001) column 4, line 9 – column 5, line 43; figures 1-5	1, 2
X	US 4332301 A (JONELL PER-OLOF) 01 June 1982 (01.06.1982) column 4, line 9 – column 5, line 43; figure 1	1, 2

☐ 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

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"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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 December 2013 (11.12.2013)	16 December 2013 (16.12.2013)

Name and mailing address of the ISA/FI
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INTERNATIONAL SEARCH REPORT
Information on patent family members

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Patent document cited in search report	Publication date	Patent family members(s)	Publication date
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