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(54) Title: SPARGER DEVICE FOR SPARGING A FLUID INTO A SLURRY TANK, FLOTATION APPARATUS AND SYSTEM HAVING SUCH SPARGER DEVICE, AND METHOD FOR SETTING CONTROL FLUID PRESSURE OF A SPARGER DEVICE

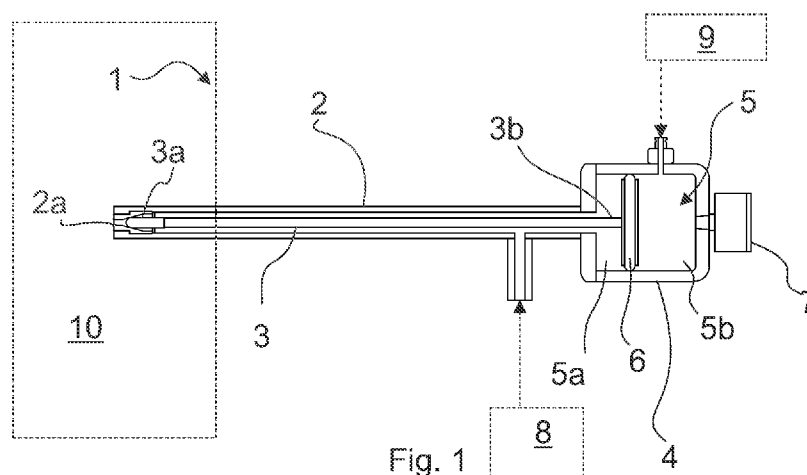


Fig. 1

(57) Abstract: A sparger device (1) for sparging fluid into a slurry tank (10), said sparger device (1) comprising a hollow elongated body (2) having a nozzle opening (2a) for sparging a sparging fluid flow to a slurry tank (10). The device further comprises a needle (3) for opening and closing the nozzle opening (2a), and a control device (4) being arranged to actuate the needle (3). The control device (4) comprises a control chamber (5) partitioned into a first portion (5a) and second portion (5b) such that a pressure differential between the first portion (5a) and the second portion (5b) closes or opens the nozzle opening (2a). The second portion (5b) may be provided with a control fluid pressure preventing slurry backflow from the slurry tank (10). A flotation apparatus comprising a sparger device and a flotation system comprising a flotation apparatus are also discussed.



**SPARGER DEVICE FOR SPARGING A FLUID INTO A SLURRY TANK, FLOTATION APPARATUS AND SYSTEM HAVING SUCH SPARGER DEVICE, AND METHOD FOR SETTING CONTROL FLUID PRESSURE OF A SPARGER DEVICE****FIELD OF THE DISCLOSURE**

5 The present disclosure relates to sparger devices, and more specifically sparger devices for sparging fluid into a slurry tank. The present disclosure further concerns a flotation apparatus having such a sparger device, and a flotation system in which a flotation apparatus having such a sparger device is used. In addition, the present disclosure concerns a method for setting a control fluid pressure of a sparging device.

**10 BACKGROUND OF THE DISCLOSURE**

Sparger devices are commonly used for introducing a fluid flow, such as an airflow, a mixture of air and another gas, a mixture of gas and a water flow, a mixture of air and a water flow or any combination thereof, into slurry in such a manner that bubbles and / or froth is generated.

15 For a sparger device to operate properly, it is important that no impurities are introduced into the sparger device, particularly a nozzle opening thereof, as any impurities could hinder the flow of the sparging fluid or otherwise result in reduced operational capabilities. This is particularly prominent in flotation applications, where the slurry to be sparger contains solids in the form of mineral particles.

20 During normal operation, the flow of the sparging fluid itself prevents slurry backflow via the nozzle opening of the sparger device. However, if the flow of the sparging fluid is interrupted the fluid pressure of the slurry, namely hydrostatic pressure within the slurry tank, induces a slurry backflow via the nozzle opening unless this is somehow prevented.

**BRIEF DESCRIPTION OF THE DISCLOSURE**

25 An object of the present disclosure is to provide a sparger device for sparging fluid into a slurry tank, which sparger device may efficiently be used in different operating conditions, e.g. with slurries of different types, at different positions of a slurry tank, and / or with tanks of different height, while ensuring that slurry backflow is prevented if the flow of sparging fluid is interrupted.

30 This object is achieved by a sparger device characterized by what is stated in the Claim 1. It is a further object of the present disclosure to provide a flotation apparatus having such a sparger device, and a flotation system in which a flotation apparatus having such a sparger device is used, and a method for setting a control fluid pressure of such a sparging device.

These objects are achieved by a flotation apparatus, a flotation system, and method characterized by what is stated in Claims 6, 9 and 10, respectively.

The disclosure is based on the idea of providing sparger device with a control device having a control chamber partitioned into two portions such that the pressure differential between these portions closes or opens the nozzle opening. Moreover, the fluid pressure of the first portion is determined by the sparging fluid, and the fluid pressure of the second portion is determined by a control fluid. Hence, the control fluid pressure may be set such that the interruption of the sparging fluid flow causes the nozzle opening to close, thus preventing slurry backflow.

An advantage of solutions according to the disclosure is that the control fluid pressure may be easily set to correspond to different operation conditions. As a result, a single sparger device can be easily adapted for different types of slurries, different position at a slurry tank, and/or for different types of slurry tanks simply by changing the control fluid pressure.

In conventional sparger device a biasing spring has been used to bias a needle against a nozzle opening to prevent backflow. However, adapting such sparger device for different operating conditions has required a separate screw for pre-tensioning the spring or using a different spring altogether. Fatigue over time of such springs has also been an issue.

#### BRIEF DESCRIPTION OF THE DRAWINGS

In the following the disclosure will be described in greater detail by means of preferred embodiments with reference to the accompanying drawings, in which

Fig. 1 illustrates schematically a sparger device according to the disclosure in connection with a slurry tank, and

Fig. 2 illustrates schematically a portable detachable control fluid supply.

#### DETAILED DESCRIPTION OF THE DISCLOSURE

According to an embodiment of a first aspect of the disclosure, a sparger device 1 for sparging fluid into a slurry tank 10, is provided.

The sparger device 1 comprises a hollow elongated body 2 having a nozzle opening 2a at a distal end thereof for sparging a sparging fluid flow to a slurry tank 10 from an inside of the hollow elongated body 2. The inside of the elongated hollow body 2 is configurable for fluid communication with a sparging fluid supply 8, when in use. Suitably, the sparger device 1 comprises a connector connecting the inside of the hollow body 2 to a sparging fluid supply 8.

The sparger device 1 further comprises a needle 3 movably arranged along a longitudinal axis of the sparger device 1 within the hollow elongated body 2. The needle 3 has a first end 3a for opening and closing the nozzle opening 2a in order to allow, and respectively block, fluid flow via the nozzle opening 2a. Particularly, the first end 3a of the needle 3 may block sparging fluid flow from the inside of the hollow elongated body 2 to the slurry tank 10 via the nozzle opening 2a, and respectively, block slurry backflow from the slurry tank 10 to the inside of the hollow elongated body 2 via the nozzle opening 2a.

The sparger device 1 further comprises a control device 4 coupled with a second end 3b of the needle 3. The control device is arranged to actuate the needle 3 along the longitudinal axis so as to open or close nozzle opening 2a.

The control device 4 comprises a control chamber 5 partitioned by a piston member 6 into a first portion 5a and second portion 5b. Suitably, the piston member 6 partitions the control chamber 5 such that there is no fluid communication between the first portion 5a and the second portion 5b. The piston member 6 is coupled with the needle 3, and configured to be movable within the control chamber 5 along the longitudinal axis in response to a pressure differential between the first portion 5a and the second portion 5b.

Particularly, the piston member is configured such, that a lower fluid pressure in the first portion 5a with respect to that of the second portion 5b will move the needle 3 against the nozzle opening 2a, thereby closing it. Respectively, a higher fluid pressure in the first portion 5a with respect to that of the second portion 5b will move the needle away from nozzle opening 2a, thereby opening it.

The first portion 5a of the control chamber 5 is in fluid communication with the inside of the elongated hollow body 2, thereby defining the fluid pressure within the first portion 5a to equal with that of the sparging fluid supply 8, when in use.

The second portion 5b of the control chamber 5 is configurable for being in fluid communication with a control fluid, thereby defining the fluid pressure within the second portion 5b to equal with that of a control fluid, when in use.

Thus, backflow of slurry from the slurry tank 10 to the sparger device 1 via the nozzle opening 2a may be prevented by providing a control fluid pressure exerting, on the piston member 6, a force greater than that exerted on the first end 3a of the needle 3 by the fluid pressure of the slurry tank 10 at a level of the sparger device 1.

When no sparging fluid is sparged i.e. injected via the nozzle opening 2a, the hydrostatic pressure within the slurry tank 10 at the level of the sparger device 1 strives to induce a slurry backflow from the tank to the inside of the hollow elongated body 2. Sparging fluid

flow may be stopped, e.g. when the sparging process is halted or when there is a malfunction in the sparging fluid supply. Moreover, as slurry has a high solids particle content, any slurry contamination within the sparger device 1 is undesirable, as it may prevent the sparger device 1 from operating in desired manner, or even brake it.

5 Backflow of the slurry from the slurry tank 10 to the sparger device 1 may be prevented by providing a control device 4, which closes the nozzle opening 2a when sparging fluid flow is stopped.

10 A sparger device 1 may be used with different types of slurry, having different density properties, with different types of slurry tanks, or at different positions of slurry tank, corresponding to different hydrostatic pressures of the slurry. Hence, there is a need to adjust the force exerted on the needle for closing the nozzle opening for different operating conditions. Particularly, the force exerted on the needle for closing the nozzle opening 2a has to be greater than the force exerted on the needle 3 by the hydrostatic pressure of the slurry. On the other hand, the pressure used for feeding the sparging fluid has to overcome  
15 the force exerted on the needle 3 for closing it. Hence, it is not desirable to use an unnecessarily great force for closing needle, as this means that an unnecessarily high pressure has to be used for sparging the sparging fluid, which results in weaker overall efficiency of the sparging process and hinders the accurate control of the sparging fluid flow

20 According to another embodiment of the first aspect of the disclosure, the control device 4 comprising a pressure sensor 7 for providing information indicative of the fluid pressure within the second portion 5b of the control chamber 5. This enables verification of the actual pressure level of the control fluid within second portion 5b. This, in turn, ensures, that the control fluid within the second portion 5b of the control chamber 5 may be kept at  
25 desired pressure level at all times.

Preferably, but not necessarily, the pressure sensor 7 is arranged on a continuation of the longitudinal axis of the sparger device 1. Such an arrangement ensures that, if the sparger device is installed horizontally, the pressure sensor 7 will never be located in a lowermost position of the second portion 5b of the control chamber 5, regardless of the rotational  
30 orientation of the sparger device about its longitudinal axis. It is not desirable to locate the pressure sensor 7 in a lowermost position of the second portion 5b, as any contamination, impurities, or possible water condensation will accumulate to said lowermost position under gravity. This may result in malfunction of the pressure sensor, which may result in an incorrect fluid pressure at the second portion 5b. Furthermore, incorrect control fluid

pressure may lead to the sparger device 1 being damaged if the nozzle opening 2a is not correctly closed, and backflow of the slurry occurs.

According to a further embodiment of the first aspect of the present disclosure, the second portion 5b of the control chamber 5 is configurable for being in fluid communication with a control fluid supply 9. Suitably, this is done by providing the sparger device 1 with a connector connecting the second portion 5b of the control device 5 to a control fluid supply 9.

Alternatively, or additionally, the sparger device 1 may comprise a charging valve for charging the second portion 5b of the control chamber 5 with a desired control fluid pressure. That is, the second portion 5b may hold the desired control fluid pressure by itself. Alternatively, the second portion 5b may be arranged in fluid communication with, a control fluid accumulator. Moreover, in such an arrangement, the second portion 5b does not need to be in constant fluid communication with a separate control fluid supply 9, thus eliminating the need for a separate flow route between the control fluid supply 9 and the second portion 5b. In turn, the fluid pressure in the second portion can be adjusted via the charging valve as necessary. Particularly pneumatic or hydraulic quick coupling connectors or valves commonly used with pneumatic tires may be used as the charging valve.

According to a second aspect of the present disclosure, a flotation apparatus comprising a slurry tank is provided. In such a flotation apparatus, solids are separated from the slurry by sparging a fluid, most commonly compressed air, into the slurry tank 10 containing a slurry. Typically, the slurry is a mixture of a liquid portion and a solids portion, most often comprising solid particles of minerals. As the sparging fluid forms bubbles and/or froth, the solids particles adhere thereto. Moreover, the bubbles and/or froth rise up to the surface of the slurry within the slurry tank together with the adhered solids particles. From thereon, the solids particles can be recovered from the surface of the slurry.

Particularly, the flotation apparatus further comprises at least one sparger device 1 according to any embodiment of the first aspect of the present disclosure, as discussed above. Moreover, the sparger device 1 is arranged such that at least the nozzle opening 2a is within the slurry tank 10. Most suitably, the sparger device 1 is positioned such that the nozzle opening 2a is within the slurry tank 10 below an envisaged level of the slurry, when in use. The nozzle opening 2a may, however, be located at a desired position within the slurry tank 10, although it is generally desirable to locate the nozzle opening 2a near the bottom of the tank, thus enabling the bubbles and / or froth generated by the sparging to travel through the whole height of the slurry within the slurry tank 10.

Moreover, the sparger device 1 may be arranged such that the elongated hollow body 2 extends horizontally within the slurry tank 10. This ensures, that the nozzle opening 2a may be positioned at a distance from a wall of the slurry tank 10. This is desirable so that the bubbles / froth generated by sparging do not travel against the wall of the tank 10, but amongst the slurry, adhering solids particles more efficiently. Suitably, the sparger device 1 is positioned horizontally, i.e. the elongated hollow body 2 runs level with the horizontal. This is particularly beneficial when a sparger device having a pressure sensor 7 located on a continuation of the longitudinal axis of the sparger device 1 is used. Such an arrangement ensures that the sparger device 1 can not be installed in an incorrect orientation causing the pressure sensor 7 to malfunction, as discussed above in connection with the respective embodiment of the first aspect of the present disclosure.

In the flotation apparatus, the sparger device 1 is preferably configured such that the second portion 5b of the control chamber 5 comprises control fluid. More specifically, the control fluid in the second portion 5b is arranged at a control fluid pressure exerting, on the piston member 6, a force greater than that exerted on the first end 3a of the needle 3 by a fluid pressure prevailing in the slurry tank 10 at a level of the sparger device 1. The force exerted on the piston member by the control fluid can be determined simply by considering the area of the piston member and the fluid pressure of the control fluid. The force exerted on the first end 3a of the needle, in turn, can be determined by considering the area of the first end 3a and the pressure prevailing within the slurry tank at the level of the sparger device 1, specifically the nozzle opening 2a thereof. Moreover, the fluid pressure prevailing within the slurry tank 10 at the level of the sparger device 1 can be determined by considering the local atmospheric pressure within the tank, in addition to the density of the slurry and the height of the slurry column, i.e. hydrostatic pressure.

It should be understood that more than one sparging device 1 may be used in connection with a flotation apparatus according to any embodiment of the second aspect of the present disclosure, as described above.

According to a third aspect of the present disclosure, a flotation system is provided. The flotation system comprises at least one flotation apparatus according to any of the embodiments of the second aspect of the present disclosure, as discussed above.

The flotation system further comprises a sparging fluid supply 8 arranged to be in fluid communication with the inside of the hollow elongated body 2 of the sparger device 1 in order to sparge said sparging fluid into the flotation tank. For example, a compressed air supply, such as a blower or compressor may be used as a sparging fluid supply 8.

The flotation system further comprises a control fluid supply 9 arranged to be in fluid communication with the second portion 5b of the control chamber 5 for providing a control fluid pressure within the second portion 5b of the control chamber 5. For example, a compressed air supply, such as a blower or compressor may be used as a control fluid supply 9.

Particularly, the sparging fluid supply 8 and the control fluid supply 9 are suitably associated with respective separate devices. For example, separate compressed air supplies, such as blowers or compressors may be used as the respective separate devices. Such an arrangement ensures, that a control fluid supply 9 will continue to provide control fluid 9 if the sparging fluid supply 8 malfunctions. As a consequence, slurry backflow will not occur due to sparging fluid supply 8 malfunction.

Alternatively, a single physical device may be used for providing both the sparging fluid and the control fluid. In such an arrangement a combination of valves are suitably provided for achieving a desired fluid pressure differential between the first portion 5a and the second portion 5b of the control chamber, and for ensuring that that the control fluid pressure is maintained if the sparging fluid flow is interrupted even in the case of a malfunction of the single physical device providing both the sparging fluid and the control fluid. For example, a pressure regulator may be provided between the second portion 5a of the control chamber 5 and the single device providing both the sparging fluid and the control fluid in order to achieve a desired control fluid pressure. Moreover, check-valve may be provided between the second portion 5a of the control chamber 5 and the single device providing both the sparging fluid and the control fluid for ensuring that the control fluid will not flow out of the second portion 5b and the desired control fluid pressure is maintained if the single physical device providing both the sparging fluid and the control fluid malfunctions.

According to a fourth aspect of the present disclosure, a method of setting a control fluid pressure of a sparger device 1 is provided.

Firstly, a sparger device 1 having a charging valve for charging the second portion 5b of the control chamber 5 with a desired control fluid pressure, as discussed in connection with the respective embodiment of the first aspect of the present disclosure, is provided.

Secondly, a detachable control pressure supply 11 is provided. Any fluid supply that can provide suitable fluid and can be detached from the sparger device 1 may be used. For example, a compressed air system having a detachable quick coupling connector corresponding to the charging valve may be used. In addition to conventional quick

coupling connectors providing firm connections, inflation connectors of more temporary nature, such as inflation connectors commonly used for inflating pneumatic tires, may be used as a detachable quick coupling connector in the context of this disclosure. Suitably, a portable detachable control fluid supply 11 is provided. Such a portable control fluid supply 11 facilitates setting the control fluid pressure when several sparger devices 1 are used, as such a portable detachable control fluid supply 11 can easily be attached, removed and moved to the next sparger device.

The method further comprises determining a desired control fluid pressure. The control fluid pressure suitably exerts, on the piston member 6, a force greater than that exerted on the first end 3a of the needle 3 by a fluid pressure prevailing in the slurry tank 10 at a level of the sparger device 1. The force exerted on the piston member by the control fluid can be determined simply by considering the area of the piston member and the fluid pressure of the control fluid. The force exerted on the first end 3a of the needle, in turn, can be determined by considering the area of the first end 3a and the pressure prevailing within the slurry tank at the level of the sparger device 1, specifically the nozzle opening 2a thereof. Moreover, the fluid pressure prevailing within the slurry tank 10 at the level of the sparger device 1 can be determined by considering the local atmospheric pressure within the tank, in addition to the density of the slurry and the height of the slurry column, i.e. hydrostatic pressure.

The method further comprises connecting the detachable control pressure supply 11 to the charging valve for establishing fluid communication between the second portion 5b of the control chamber 5 and the detachable control fluid supply. It is not necessary to attach the detachable control pressure supply to the charging valve in a rigid manner, but it is sufficient that a fluid communication therebetween is established. Moreover, the second portion 5b of the control chamber 5 is charged with a desired control fluid pressure.

In Fig. 2, an example of a detachable portable control fluid supply 11 is illustrated. The detachable portable control fluid supply comprises a control fluid tank 12, and arranged in fluid connection therewith, a fill valve 13, a pressure gauge 14, and a pressure regulator 15. From the pressure regulator 15, fluid communication is provided to a quick coupling connector 17 with a hose 16.

The tank 12 of the portable detachable control fluid supply 11 may be filled with via the fill valve 13 from a main control fluid supply, such as a compressed air system. In order to maximize capacity, the tank 12 may be filled up to a pressure substantially higher than the desired control fluid pressure. The pressure gauge 14 is provided for indicating when the tank 12 needs to be refilled and to prevent overfilling. The pressure regulator 15, in turn,

may be set to provide a desired pressure. Hence, when in use, the pressure regulator 15 is set to correspond to the determined desired control fluid pressure. The pressure regulator is connected to the quick coupling connector 17 via the hose 16 for easy coupling with the charging valve of a sparging device.

## CLAIMS

1. A sparger device (1) for sparging fluid into a slurry tank (10), said sparger device (1) comprising

5 ... a hollow elongated body (2) having a nozzle opening (2a) at a distal end thereof for sparging a sparging fluid flow to a slurry tank (10) from an inside of the hollow elongated body (2), the inside of the elongated hollow body (2) being configurable for fluid communication with a sparging fluid supply (8), when in use;

10 ... a needle (3), movably arranged along a longitudinal axis of the sparger device (1) within the hollow elongated body (2), the needle (3) having a first end (3a) for opening and closing the nozzle opening (2) in order to allow, and respectively block fluid flow via the nozzle opening (2a), and

... a control device (4) coupled with a second end (3b) of the needle (3), the control device (4) being arranged to actuate the needle (3) along the longitudinal axis so as to open or close nozzle opening (2a),

15 **characterized** in that the control device (4) comprises a control chamber (5) partitioned by a piston member (6) into a first portion (5a) and second portion (5b), the piston member (6) being coupled with the needle (3), and configured to be movable within the control chamber (5) along the longitudinal axis in response to a pressure differential between the first portion (5a) and the second portion (5b), such that:

20 ... a lower fluid pressure in the first portion (5a) with respect to that of the second portion (5b) will move the needle (3) against the nozzle opening (2a), thereby closing it, and respectively,

25 ... a higher fluid pressure in the first portion (5a) with respect to that of the second portion (5b) will move the needle away from nozzle opening (2a), thereby opening it,

wherein the first portion (5a) of the control chamber (5) being in fluid communication with the inside of the elongated hollow body (2), thereby defining the fluid pressure within the first portion (5a) to equal with that of the sparging fluid supply (8), when in use, and

30 the second portion (5b) of the control chamber being configurable for being in fluid communication with a control fluid, thereby defining the fluid pressure within the second portion (5b) to equal with that of a control fluid, when in use,

whereby backflow of slurry from the slurry tank (10) to the sparger device (1) via the nozzle opening (2a) may be prevented by providing a control fluid pressure exerting,

on the piston member (6), a force greater than that exerted on the first end (3a) of the needle (3) by the fluid pressure of the slurry tank (10) at a level of the sparger device (1).

- 5        2. The sparger device (1) according to Claim 1, **characterized** by the control device (4) comprising a pressure sensor (7) for providing information indicative of the fluid pressure within the second portion (5b) of the control chamber (5).
3. The sparger (1) device according to Claim 2, **characterized** in that the pressure sensor (7) is arranged on a continuation of the longitudinal axis of the sparger device (1).
- 10      4. The sparger device (1) according to any of the preceding Claims, **characterized** in that the second portion (5b) of the control chamber (5) is configurable for being in fluid communication with a control fluid supply (9).
5. The sparger device (1) according to any of the preceding Claims, **characterized** in that the sparger device (1) comprises a charging valve for charging the second portion  
15        (5b) of the control chamber (5) with a desired control fluid pressure.
6. A flotation apparatus comprising a slurry tank (10), **characterized** by further comprising at least one sparger device (1) according to any of the preceding Claims, the at least one sparger device (1) being arranged such that at least the nozzle opening (2a) is within the tank (10).
- 20      7. The flotation apparatus according to Claim 6 **characterized** by the sparger device (1) being arranged such that the elongated hollow body (2) extends horizontally within the tank (10).
8. The flotation apparatus according to Claim 6 or 7 **characterized** by the second portion  
25        (5b) of the control chamber (5) comprising control fluid arranged at a control fluid pressure exerting, on the piston member (6), a force greater than that exerted on the first end (3a) of the needle (3) by a fluid pressure prevailing in the slurry tank (10) at a level of the sparger device (1).
9. A flotation system comprising the flotation apparatus according to any of Claims 6 - 8, **characterized** in that the flotation system further comprises

... a sparging fluid supply (8) arranged to be in fluid communication with the inside of the hollow elongated body (2) of the sparger device (1) for sparging said sparging fluid into the flotation tank;

5       ... a control fluid supply (9) arranged to be in fluid communication with the second portion (5b) of the control chamber (5) for providing a control fluid pressure within the second portion (5b) of the control chamber (5),

wherein the sparging fluid supply (8) and the control fluid supply (9) are associated with respective separate devices.

10. A method of setting a control fluid pressure of a sparger device, comprising:

10       providing a sparger device according to Claim 5;

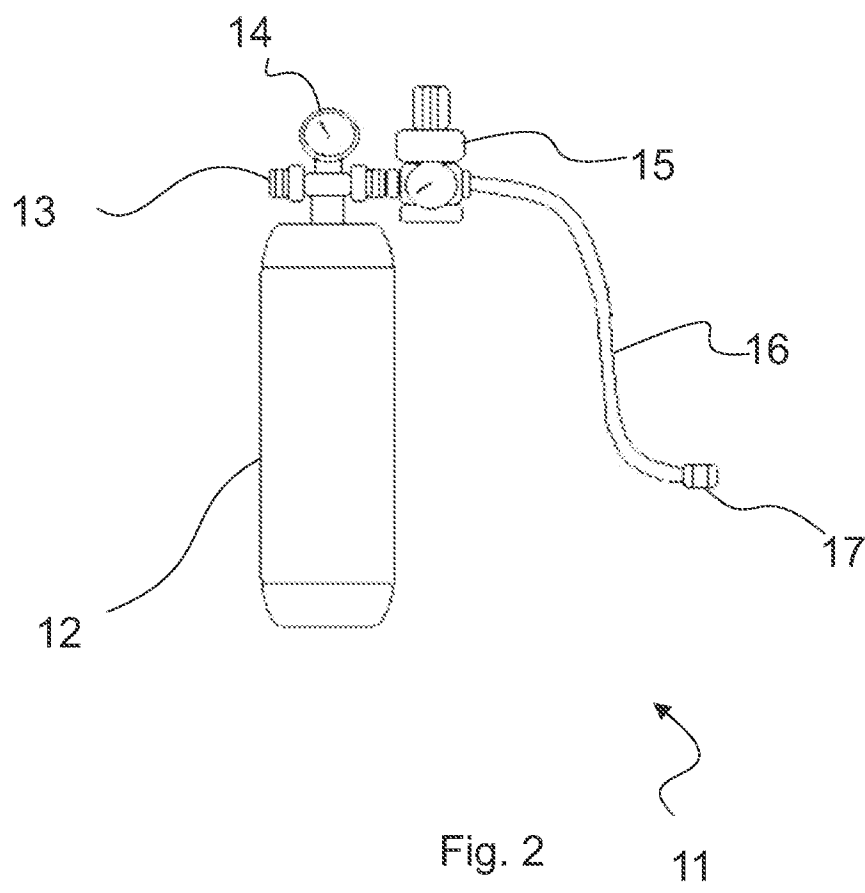
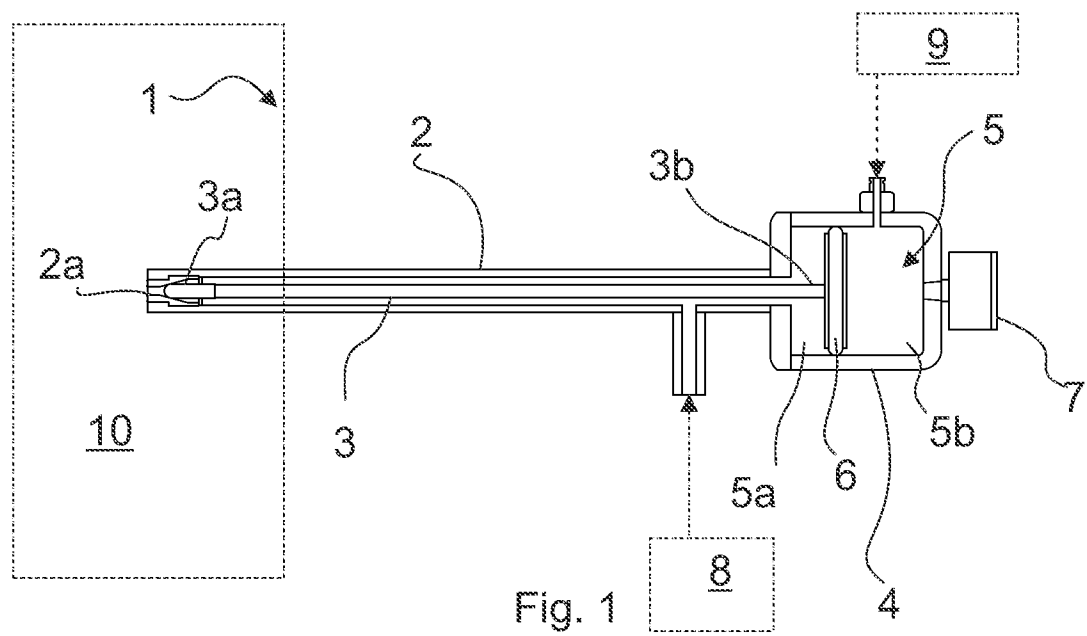
providing a detachable control pressure supply (11)

determining a desired control pressure

connecting the detachable control pressure supply (11) to the charging valve for establishing fluid communication between the second portion (5b) of the control

15       chamber (5) and the detachable control fluid supply (11), and

charging the second portion (5b) of the control chamber (5) with a desired control fluid pressure.



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI2016/050860

**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: B01F, B01J, B03D, C02F, F16K

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)

EPODOC, EPO-Internal full-text databases, Full-text translation databases from Asian languages, WPIAP

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                                                                                                                                                                                             | Relevant to claim No. |
|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| Y         | US 5139663 A (MAPLES WILLIAM A [US]) 18 August 1992 (18.08.1992)<br>the whole document, especially column 1, line 53 – column 2, line 2;<br>column 3, line 49 – column 4, line 14; column 4, lines 39–65; column 5,<br>lines 41–52; figures 1–3<br>& abstracts [online] EPOQUENET EPODOC & WPI | 1-10                  |
| Y         | US 3410518 A (CARSTEN PAUL W) 12 November 1968 (12.11.1968)<br>the whole document, especially column 4, line 66 – column 5, line 28;<br>figures 1 and 3                                                                                                                                        | 1                     |
| Y         | CN 201231183 Y (BEIJING GEN RES INST MINING [CN])<br>06 May 2009 (06.05.2009)<br>especially figure 1<br>& abstracts [online] EPOQUENET EPODOC & WPI<br>& the whole machine translation into English by the EPO [online]<br>EPOQUENET TXPCNEY                                                   | 1-10                  |

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

|                                                                                                                                                                         |                                                                                                                                                                                                                                                  |
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Date of the actual completion of the international search

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**INTERNATIONAL SEARCH REPORT**

International application No.

PCT/FI2016/050860

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                                            | Relevant to claim No. |
|-----------|-----------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
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**INTERNATIONAL SEARCH REPORT**  
**Information on Patent Family Members**

International application No.  
PCT/FI2016/050860

| Patent document<br>cited in search report | Publication<br>date | Patent family members(s)                                                          | Publication<br>date                                                |
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CLASSIFICATION OF SUBJECT MATTER

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