(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 834 420 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
05.10.2016 Bulletin 2016/40

(21) Application number: **12772982.0**

(22) Date of filing: **18.10.2012**

(51) Int Cl.:
E02D 3/08 *(2006.01)*

(86) International application number:
PCT/EP2012/070677

(87) International publication number:
WO 2013/135317 (19.09.2013 Gazette 2013/38)

(54) **METHOD OF PRODUCING GRAVEL COLUMNS**

VERFAHREN ZUR HERSTELLUNG VON KIESPFÄHLEN

PROCÉDÉ POUR PRODUIRE DES PIEUX EN GRAVIER

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority: **16.03.2012 PCT/EP2012/054702**

(43) Date of publication of application:
11.02.2015 Bulletin 2015/07

(73) Proprietor: **VSL International AG**
3098 Köniz (CH)

(72) Inventor: **HAYE, Olivier**
49400 Bagneux (FR)

(74) Representative: **BOVARD AG**
Optingenstrasse 16
3000 Bern 25 (CH)

(56) References cited:
EP-A1- 2 258 903 WO-A2-2006/127571

Description

TECHNICAL FIELD

[0001] The present invention relates to a soil improvement method as basically known from EP 2 258 903 A1. More specifically, the present invention relates to a method of producing gravel columns, such as stone columns, with the aim of improving the soil. The invention also relates to a corresponding system with which the method can be carried out.

BACKGROUND OF THE INVENTION

[0002] The main goal of most soil improvement techniques is to densify the soil and/or to improve its drainage capacity. There exist several techniques to achieve this, but this invention concerns building gravel columns in the soil. This can generally be achieved by a technique called vibroflotation combined with a gravel backfill which results in the formation of stone columns.

[0003] Vibroflotation involves the use of a vibrating probe that can penetrate the soil to be improved down to the required depth. The vibrating probe penetrates to the required depth by vibration and jetting action of air. The vibrations of the probe cause the soil structure to collapse or to be pushed aside, thereby densifying the soil surrounding the probe.

[0004] There are two basic methods to introduce the gravel in the column. The first one, usually named "top feed" method, consists of just pushing the gravel at ground level into the annulus around the probe previously lowered in the ground. However, with the top feed method, there is no control whether the gravel actually reaches the bottom of the probe.

[0005] Nowadays, the second method named "bottom feed" is the most commonly specified as it enables to ensure that the gravel has actually been placed and compacted at the bottom of the probe. When using the bottom feed technique, the gravel is added through a pipe, generally called a follow-up pipe, which runs alongside and all the way down the vibrating probe. The outlet of the gravel is therefore placed directly below the vibrating probe. The gravel column is then created by feeding of successive gravel batches below the probe, with each batch being compacted by the probe before the next batch is fed. The column diameter can vary depending on the initial stiffness or density of the soil. It is possible to allow more gravel to be placed in weaker soil regions. The obtained stone columns not only increase the amount of densification, but also provide a degree of reinforcement and a potentially effective means of drainage.

[0006] When using the bottom feed technique a feed tank for the gravel is usually located on top of the follow-up pipe. The gravel can then be fed into the follow-up pipe from this tank. A stockpile of gravel is usually located on the ground. From this stockpile the gravel has to be somehow transported to the feed tank on top of the follow-up pipe. The most commonly used method consists of using a skip which is filled with a backhoe or loader at ground level, then lifted up and emptied into the feed tank at the top of the follow-up pipe. However, this method is cumbersome and has the disadvantage of producing lots of dust which leads to increased pollution. Another method to do this is to transport the gravel from a reservoir (called blow-tank) at ground level to the feed tank by using pressurized air. However, gravel is not easily transported by air and blockages due to accumulation of gravel in the transfer pipes are frequent.

[0007] Another difficulty in the known methods of creating gravel columns relates to the actual feeding of the gravel into the soil. Especially in the case of soft clayey or silty soil, the end of the follow-up pipe becomes easily clogged by the soil material, which impairs the gravel feeding operation into the soil.

[0008] It is the object of the present invention to overcome at least some of the problems identified above related to building material columns.

SUMMARY OF THE INVENTION

[0009] According to a first aspect of the invention, there is provided a method of building a gravel column in soil for consolidating the soil by using a soil improvement system comprising a reservoir connected to a gravel transferring means leading to the soil, the method comprising: transferring the gravel through the gravel transferring means, by using liquid as a transfer medium, from the reservoir to the soil to build the gravel column.

[0010] The proposed method offers a solution allowing gravel columns to be created very efficiently. For instance as the feeding medium for feeding the gravel to the soil is not air, but liquid, pollution can be drastically reduced as the existence of dust particles can be essentially eliminated. The liquid transfer medium can be e.g. water. This has the further advantage that this kind of transfer medium is easily available and is inexpensive.

[0011] According to a second aspect of the invention, there is provided a system where the method according to the first aspect can be carried out.

[0012] Other aspects of the invention are recited in the dependent claims attached hereto.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Other features and advantages of the invention will become apparent from the following description of non-limiting exemplary embodiments, with reference to the appended drawings, in which:

- Figure 1 is a schematic side view of a gravel feeding system according to a first embodiment of the present invention;

- Figure 2 is a schematic perspective view showing the reservoir shown in Figure 1;

- Figure 3 is a schematic top view showing the reservoir of Figure 2.

- Figure 4a is a schematic cross-sectional side view illustrating the separation hopper (first tank) and the pressurisable or pressurising tank (second tank) shown in Figure 1, where a valve in the pressurisable tank is closed while another valve is open;

- Figure 4b is a schematic cross-sectional side view illustrating the separation hopper and the pressurisable tank shown in Figure 1, where the valve in the pressurisable tank is open while the other valve is closed;

- Figure 5 is a flow chart illustrating the method of building gravel columns according to the first embodiment of the present invention;

- Figure 6 is a schematic side view illustrating a twin assembly for building gravel columns according to a second embodiment of the present invention;

- Figure 7 is a schematic side view of a gravel feeding system according to a third embodiment of the present invention; and

- Figure 8 is a flow chart illustrating the method of building gravel columns according to the third embodiment of the present invention.

DETAILED DESCRIPTION OF AN EMBODIMENT OF THE INVENTION

[0014] Some embodiments of the present invention will be described in the following in more detail with reference to the attached figures. Identical functional and structural elements which appear in the different drawings are assigned the same reference numerals.

[0015] The purpose of the system or apparatus explained below is to transfer aggregate, such as gravel, from a source tank, hereinafter referred to as a reservoir, though a gravel transferring means to the soil using a liquid, such as water, as a transfer medium. The word gravel in the present description and in the claims is understood to cover other granular materials suitable for the intended application of the method. Examples of these materials are crushed rubble, concrete, broken glass, etc. The size of the gravel particles in a specific application may be dependent on the diameter of the column to be built. For instance, the larger the diameter of the column is, the larger the particles are that are used to build the column. However, often there is no link between column diameter and gravel size. The gravel size is often governed by the availability/price in the area of the project, and is limited by the size of the piping and follow-up pipes so as to avoid blockages.

[0016] In some applications the liquid transfer medium flows continuously while the gravel is fed in batches into the fluid medium in a controlled manner, using for instance a screw feed system which is started and stopped in cycle with the operation of the double valve system described later. Feeding the liquid transfer medium continuously has the advantage that there is no need to turn on/off the related pump. If the screw feed system is used, then the density of the "fluid+gravel" mix is controlled by adjusting the rotational speed of the screw relative to the fluid medium flow. The quantity of gravel sent in each batch is controlled by the number of screw rotations in each cycle.

[0017] Figure 1 illustrates a system for building gravel columns according to the first embodiment of the present invention. Only the elements relevant for understanding the present invention are shown. Thus, for instance a vibrator probe is omitted in that figure. A gravel supply, such as a storage tank 101, hereinafter referred to as a reservoir 101, is used for storing the gravel and the liquid transfer medium, such as water. The reservoir 101 is shown in more detail in Figures 2 and 3. Just outside the reservoir 101 there is shown a motor 103 for operating the screw that is used for feeding the gravel into a feed pipe 105. The feed pipe 105 is connected in the vicinity (in this example) of the reservoir 101 to a gravel and liquid feeding means, such as a pump 106 that is arranged to feed or pump the gravel and liquid into a receiving tank or separation tank, hereinafter called separation hopper 107 or directly to an outlet tube leading to the soil. In some implementations the pump 106 is submerged in water, and is below the water surface in the reservoir 101. The pump can be located, for example, below the surface level of a sea, a river, a lake or a pond, so that supply of liquid medium is such that it does not necessitate being recycled. It is possible to place the reservoir 101 on a barge, and to submerge the pump 106 in the sea, for instance, so that the pump is located below the reservoir 101. Thus, the pump can have one inlet for the gravel that comes from the reservoir and another inlet for the water,e.g. from the sea.

[0018] In the hopper 107 the gravel is separated from the liquid transfer medium, which is then returned to the reservoir 101, through one or more suitable return pipes 109. The separation process is explained in more detail later on. Instead of returning the liquid back to the reservoir, it could also be disposed of. This could be the case for instance if the reservoir 101 is submerged in water, for instance placed on the seabed or suspended from a barge. The purpose of the separation process is to simply evacuate the excess liquid from the separation hopper 107, since otherwise it could fill quickly. The liquid feed rate could be in the range of 4000 to 8000 litres per minute and the capacity of the separation hopper 107 could be 1 to 3 m^3, for example. However, it is not necessary to separate all the liquid from the gravel.

[0019] If the condition of the soil in which the gravel columns are to be built is too soft and necessitates preventing ingress of soil at the bottom tip of a gravel feed pipe, another tank 111, hereinafter named pressurisable tank, becomes necessary.

[0020] The granular material, possibly together with some liquid, is then transferred from the separation hopper 107 to the pressurisable tank 111 situated below the separation hopper 107 by gravity through a first valve 113 situated between the separation hopper 107 and the pressurisable tank 111. The capacity of the pressurisable tank 111 is bigger than, or at least the same as, the capacity of the separation hopper 107. The pressurisable tank 111 can be pressurised, as will be explained later in more detail.

[0021] From the pressurisable tank 111 the gravel, possibly together with some liquid, is fed by gravity into an outlet tube 115, hereinafter referred to as a gravel pipe 115, alongside a vibratory probe follow-up pipe 114, or directly into a vibratory probe follow-up pipe 114 through a second valve 401 situated at the bottom of the pressurisable tank 111 (see Figures 4a and 4b). The second valve could also be immediately below the pressurisable tank 111, for instance if a "gate" type valve is used, as the one shown for the first valve 113. In the illustrated example, the pipe 114 that has the vibratory probe at its distal end (the end remote from the pressurisable tank 111) is different from the gravel pipe 115 that is used for feeding the gravel into the soil. These two pipes run parallel next to each other leading to the soil. In other configurations, the gravel can fall directly down the vibratory probe follow-up pipe 114, then diverted alongside the vibratory probe, i.e. only at the distal (bottom) section of the assembly.

[0022] In Figure 1 there is also shown a compressor 117 for producing compressed air which can be led to the gravel pipe 115 through a pressure pipe 119. A pressurisable inlet is provided at the top of the gravel pipe 115, below the second valve 401. The pressurisable medium may be either compressed air or liquid, e.g. water. In the case of a liquid, and depending on the application, control of flow may be used in lieu of pressure.

[0023] If the condition of the soil in which the gravel columns are to be built is such that ingress of soil and clogging at the bottom tip of the gravel pipe are not a likely issue, the pressurisable tank 111 and the second valve 401 would not be required. In such a case, the gravel pipe 115 may be connected directly below the first valve 113, or if the first valve 113 is not used, then the gravel pipe 115 would be connected directly to the separation hopper 107.

[0024] Figures 2 and 3 illustrate the reservoir 101, Figure 2 being a perspective view, whereas Figure 3 is a top view. As can be seen from these figures, the reservoir 101 in this example comprises two compartments: a first compartment 201 for the gravel, and a second compartment 202 for the liquid. These compartments are separated by a wall 203. The purpose of the wall 203 is to keep the outlet 207 free of gravel and to enable free flow of liquid only when a screw feed system 205 is stopped. As the opening in the wall 203 for the screw feed system 205 does not prevent the liquid from entering the first compartment 201, the gravel in the first compartment 201 may be partially submerged. However, this is not an issue.

[0025] The motor 103 is arranged to drive a screw feed system 205 which is arranged to feed the gravel from the first compartment 201 through a first opening in the wall 203 into the second compartment 202, and more specifically to the outlet 207 (second opening 207) located at the bottom of the second compartment 202 as shown in Figure 3. The feed pipe 105 is in the state of operation connected to this second opening 207. Thus, the gravel together with the liquid as a transfer medium are arranged to leave the reservoir through the outlet 207 at the bottom of the reservoir 101.

[0026] It can be determined how much gravel is transferred to the feed pipe 105 by each rotation of the screw. Thus, by calculating the number of rotations of the screw, the quantity of gravel can be accurately determined. This point is actually a significant advantage of the present method from a quality control viewpoint, compared to prior art solutions, where the quantity of gravel is controlled by number of hopper or backhoe bucket fillings, which may not always be fully or equally filled. By adjusting the rotational speed of the screw with respect to the liquid flow through the bottom opening 207, the density of the "liquid and gravel" mix can be controlled.

[0027] One example of a method of building stone columns is now explained in more detail with reference to Figures 1 to 4a and 4b and to the flow chart of Figure 5. In step 501 the first valve 113 and the second valve 401 are closed. Once this is done, then in step 503 the gravel pipe 115 can be pressurised. If the second valve 401 is open, this also means that the pressurisable tank 111 is also pressurised. Now in step 505 the pump 106 is turned on to feed liquid, in this example water, into the separation hopper 107. In step 507 the motor 103 is turned on in order to turn the screw 205 and thereby to feed gravel into the separation hopper 107. In other words, the gravel is pumped together with water into the separation hopper 107. Now the separation hopper 107 fills with gravel.

[0028] In step 509 the gravel is separated from the water in the separation hopper 107. This separation may be done by using one or more filter screens, which can be simple meshes. In the example of Figures 4a and 4b, there are shown two inclined filter screens 403 inside the separation hopper 107. The gravel is arranged to travel on the surface of the screens while the water falls through the screens to be fed out of the separation hopper 107. The inclination of the filter screens 403 can be adjusted if necessary. As shown in Figures 4a and 4b there are further provided liquid guides 405, which can be simply plates for guiding the water into the return pipes 109 to be fed back to the reservoir 101 (step 511). The purpose of these plates 405 is also to prevent gravel from going upwards inside the separation hopper 107 due to a possible whirling motion of the gravel and water inside the separation hopper 107. It would also be possible to separate the gravel from the water by gravity sedimentation, in which case return outlets for the return pipes 109 would be situated in the upper part of the separation hopper 107. In step 511, instead of feeding the water back to the reservoir 101, it can be disposed of.

[0029] In step 513 it is determined whether the required amount of gravel has been sent from the reservoir 101 to the separation hopper 107. If the required amount has not been sent, then the process continues in step 509. On the other hand, if the required amount has been sent, then the motor 103 is turned off in step 515 to stop feeding gravel into the separation hopper 107. In step 517 it is determined whether all the gravel that was sent is received at the separation hopper 107. As the feed pipe 105 can be quite long, there can be some delay between the moment of time when the last batch was sent from the reservoir 101 and the moment of time when this batch is received by the separation hopper 107. If not all the gravel has been received, then this step is repeated until all the gravel has been received. Once all the gravel has been received at the separation hopper 107, then the process continues in step 519 by opening the first valve 113 to feed the gravel by gravity from the separation hopper 107 into the pressurisable tank 111.

[0030] In step 521 it is determined whether the pressurisable tank 111 is full. If the pressurisable tank 111 is not full, then this step is repeated. If, on the other hand, the pressurisable tank 111 is full, then the process continues in step 523 by closing the first valve 113. After this, in step 525, the second valve 401 is opened. The second valve 401 is shown in the open state in Figure 4b, where it is in the down position. Now the gravel can be fed by gravity from the pressurisable tank 111 into the gravel pipe 115 to be fed into the soil.

[0031] In step 527 it is determined whether the pressurisable tank 111 is empty. If the pressurisable tank is not empty then this step is repeated. If this tank is empty, then in step 529 the second valve 401 is closed. In Figure 4a the second valve 401 is shown in its closed state. At least one of the two valves is kept closed at all times. This makes it possible to keep the follow-up pipe 115 pressurised at all times. This has the effect of facilitating the gravel feed operation into the soil. In this example the second valve 401 is a conical valve that is arranged to move up and down. When it is in the up position as shown in Figure 4a, the valve is closed. From step 529 the process continues in step 519.

[0032] From step 523 the process continues also in step 531. In this step it is determined whether more gravel is needed to finish the gravel column. If more gravel is needed, then the process continues in step 507. If, on the other hand, in step 531, it is determined that no more gravel is needed, then in step 533 the pump 106 and the pressurisation of the gravel pipe 115 are turned off. After this step the method comes to an end. It is to be noted that step 531 runs in parallel with step 525.

[0033] The above process can be modified in several ways. For instance, in the separation hopper 107 there can be a sensor for measuring the quantity of gravel in that tank. This sensor can send a signal to the motor 103 in order to turn it off, once the separation hopper 107 contains the desired quantity of gravel. Also, the gravel feed from the reservoir 101 could be restarted immediately after closing the first valve 113, or in some implementations the gravel could be fed into the separation hopper 107 while opening the first valve 113.

[0034] As explained above, the purpose of the first and second valves 113, 401 is to make it possible to keep the gravel pipe 115 pressurised at all times whilst enabling passage of the gravel successively from the separation hopper 107 to the pressurisable tank 111 (the first valve 113 opens when the second valve 401 is closed), then from the pressurisable tank 111 to the gravel pipe 115 (the first valve 113 is closed, the second valve 401 opens). Thus, an overpressure with respect to the surrounding environment is always kept in the gravel pipe 115. To achieve this, the pressure inlet (where the pressure pipe 119 is connected to the gravel pipe 115) is located below the second valve 401. The process of successively opening and closing the valves is repeated in a cycle so that in the illustrated example the gravel is fed in batches. Also the operations of the valves 113, 401 and the operation of the screw feed system 205 at the reservoir 101 are synchronised. However, it is also possible to have a solution where the gravel is continuously fed from the reservoir 101 into the separation hopper 107. In this case, however, the gravel feed rate should be slow enough to avoid wasting the gravel by filling the separation hopper 107 too quickly.

[0035] In the description above, a system was described comprising one separation hopper 107 and one pressurisable tank 111. In Figure 6 relating to the second embodiment some parts of a twin assembly are shown, where the assembly comprises among other elements two separation hoppers 107 and two pressurisable tanks 111. In this figure there is also shown a suspending means 601, such as a pulley, for raising or lowering the assembly by use of a crane, for example. As shown, the suspending means 601 is located at the level of the separation hopper 107, but well below the upper surfaces 603 of the separation hoppers 107. This arrangement has the particular advantage that the overall height of the assembly becomes smaller compared to a situation where the suspending means 601 is located above the separation hopper 107. Thanks to the twin assembly, the arrangement remains balanced even after insertion of the suspending means 601 between the separation hoppers 107.

[0036] In the twin assembly both sides (one side comprising one separation hopper 107 and one pressurisable tank 111) are independent. The sides may or may not operate synchronously. For instance, while filling on one side the separation hopper 107, on the other side the pressurisable tank 111 can be emptied. However, in the twin assembly it is also possible that one of the sides is used only when there is a defect on the other side. The gravel pipes 115 from the pressurisable tank 111 can merge into a single pipe, or two separate pipes 115 can run parallel to the soil. Also there can be one individual feed pipe 105 for each side, or, alternatively, there could be only one common feed pipe 105 for both sides. In the latter case, the cycling of the both sides is synchronised or the feed pipe 105 is equipped with a valve to direct the flow to the relevant tank at the relevant time. In case of a common feed pipe 105, it could also be possible that the position of the feed pipe 105 can be switched from side to side to feed both sides, if necessary. In this case, the gravel flow from the reservoir 101 could actually be continuous.

[0037] As described above, the proposed method according to the first and second embodiments consists essentially of using a liquid, generally water, to transport the gravel from ground level up to the separation hopper 107, then of separating most of the liquid from the gravel and either disposing of the liquid or recycling it, depending on site conditions. The gravel retained in the separation hopper 107 may then be fed to an intermediate tank 111, which can be pressurised together with the gravel pipe 115 below in order to prevent ingress of soil material and clogging at the bottom tip of the gravel pipe 115. Depending on existing soil conditions, such pressurisation may not be necessary, in which case this intermediate pressurisable tank 111 may not be required.

[0038] Figure 7 is a schematic side view of a gravel feed system illustrating the third embodiment of the present invention. The system according to this embodiment is actually a simplified version of the first embodiment. Compared to the first embodiment, in this third embodiment the following elements can be omitted: the separation hopper 107, all the elements inside this hopper 107, the return pipe 109, the pressurisable tank 111, the first valve 113, the second valve 401, the compressor 117 and the pressure pipe 119. Accordingly the feed pipe 105 is connected directly to the gravel pipe 115. In other words, in the third embodiment the gravel feeding system is exempt from any tanks or hoppers between the reservoir 101 and the soil. The remaining elements are the same and they can be operated in the same manner as in the previous embodiments. In the third embodiment there is no specific step to separate water and gravel from each other. When feeding the gravel to the soil, the excess water will travel from the distal end of the gravel pipe 115 to the surface in the space between the soil on one hand and the two pipes 114 and 115 on the other hand.

[0039] An exemplary method according to the third embodiment is next briefly described with reference to Figure 7 and to the flow chart of Figure 8. In step 801 liquid is fed from the reservoir 101 through the feed pipe 105 into the gravel pipe 115. Once liquid, such as water, is running in the feed pipe, then in step 803 gravel is fed from the reservoir 101 through the feed pipe into the gravel pipe 115. Here again liquid is used as a transfer medium to transfer the gravel.

[0040] In step 805 it is determined whether required amount of gravel is sent for one particular gravel column. If the response is in the affirmative, then the process continues in step 807, where the motor 103 is turned off in order to stop feeding of the gravel. However, if it is determined that not enough gravel has been sent, then more gravel is fed in step 803. After step 807 the pump 106 is turned off in step 809 and the process comes to an end. More gravel columns can be built by moving the follow-up pipe 114 and the gravel pipe 115 to another location and starting the process again.

[0041] In the above illustrated example, the gravel transferring means consist of the feed pipe 105 and the gravel pipe 115, which in the illustrated example are two separate pipes. However, the gravel transferring means could also be a single pipe. In the first and second embodiments the gravel transferring means were explained to comprise, in addition to the feed pipe 105 and the gravel pipe 115, also other elements, such as the separation hopper 107 and possibly also the pressurisable tank 111, etc.

[0042] While the invention has been illustrated and described in detail in the drawings and foregoing description, such illustration and description are to be considered illustrative or exemplary and not restrictive, the invention being not limited to the disclosed embodiments. Other embodiments and variants are understood, and can be achieved by those skilled in the art when carrying out the claimed invention, based on a study of the drawings, the disclosure and the appended claims. For instance, instead of having the inclined filter screens in the separation hopper(s) 107, it is possible to eliminate these screens and to simply put a mesh in front of the liquid outlet to block any gravel from entering the return pipes 109. Also, triple (comprising three separation hoppers 107 and three pressurisable tanks 111), quadruple (comprising four separation hoppers 107 and four pressurisable tanks 111) and so forth assemblies are also possible. In this case the number of the screw feed systems in the reservoir 101 can be equal to the number of the sides in the assembly. It is also to be noted that the present invention is not limited to the use of the screw feed system, but other feed systems can also be used.

[0043] In the present invention the different pipes, such as the feed pipe 105, the return pipe 109, the gravel pipe 115, the follow-up pipe 114 and/or the pressure pipe 119 can be made of metal or plastic or some other material or composite material, such as reinforced rubber, providing desired properties. For instance, the feed pipe 105 and the gravel pipe 115 are made of a material that is strong enough and hard enough to sustain the transfer of gravel inside these pipes. The pipes can be arranged such that the position of the pipes can be changed and possibly also deformed to a certain extent. It is especially advantageous that the feed pipe 105, the return pipe 109 and the pressure pipe 119 are deformable and/or flexible over at least part of their length because the assembly comprising the separation hopper 107, the pressurisable tank 111, the related valves, the follow-up pipe 114 and the gravel pipe 115 (in the third embodiment not all these elements are needed) is arranged to be reasonably mobile in comparison to the reservoir 101, the motor 103, the pump 106 and the compressor 117. The diameter of the different pipes is preferably between 1 cm and 2 m. According to a non-limiting example, the diameter is between 6 cm and 25 cm for the feed pipe 105 and for the return pipe 109, between 10 cm and 120 cm for the follow-up pipe 114, between 6 cm and 30 cm for the gravel pipe 115, and at least 1 cm for the pressure pipe 119. In case where the diameter of the pipes is not circular, then these pipes preferably have a cross-sectional area that corresponds to the area that can be obtained by using the above numbers.

[0044] The gravel feed system accordance with the present invention is arranged to feed under normal circumstances between 200 kg and 4000 kg per minute according to the first (single assembly) and third embodiments (twice that much for a twin assembly, second embodiment). In other words, this much gravel is arranged to be fed through the gravel transferring means or through the feed pipe 105 and/or the gravel pipe 115 per minute. The amount of gravel feed per minute depends on the sizing of the pump 106, screw size, pitch and rpm, and/or piping size which is designed to be consistent with the required flow of gravel and the gravel size range.

[0045] In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality. The mere fact that different features are recited in mutually different dependent claims does not indicate that a combination of these features cannot be advantageously used. Any reference signs in the claims should not be construed as limiting the scope of the invention.

Claims

1. A method of building a gravel column in soil for consolidating the soil by using a soil improvement system comprising a reservoir (101) connected to a gravel transferring means (105, 107) leading to the soil, the method comprising: transferring (507, 519, 525, 803) the gravel through the gravel transferring means (105, 107) to the soil, wherein

- in one step (505) liquid is fed into the gravel transferring means (105, 107), and
- in another step (507) gravel is fed into the gravel transferring means (105, 107),

wherein liquid is used as a transfer medium, from the reservoir (101) to the soil to build the gravel column.

2. A method of claim 1, wherein the gravel transferring means (105, 107) comprises a first pipe (105) connected to a second pipe (115) leading to the soil.

3. A method according to claim 2, wherein in the soil improvement system the first pipe (105) is connected to the second pipe through a separation hopper (107), wherein the method further comprising separating (509) at least some liquid from the gravel in the separation hopper (107).

4. A method according to claim 3, wherein the separation hopper (107) is connected by a first valve (113) to a pressurisable tank (111), which is connected by a second valve (401) to the second pipe (115) leading to the soil, the second pipe (115) being pressurisable, wherein the gravel is led from the separation hopper (107) through the pressurisable tank (111) and through the pressurisable second pipe (115) to the soil, and wherein at least one of the valves (113, 401) is closed at any time instant.

5. A method according to claim 4, wherein the method further comprises:

• closing (501) the first valve (113) and the second valve (401);
• opening (519) the first valve (113) to allow the gravel to be moved from the separation hopper (107) into the pressurisable tank (111);
• closing (523) the first valve (113); and
• opening (525) the second valve (401) to allow the gravel to be moved from the pressurisable tank (111) into the pressurisable second pipe (115) leading to the soil.

6. A method according to claim 4 or 5, further comprising pressurising (503) the pressurisable second pipe (115) after the first valve (113) and/or the second valve (401) has/have been closed.

7. A method according to claim 6, wherein the pressurisation is done by means of compressed air at a controlled pressure or by a controlled flow of liquid.

8. A method according to any one of claims 3 to 7, further comprising feeding (511) the liquid transfer medium back to the reservoir (101) from the separation hopper (107).

9. A method according to any one of the preceding claims, wherein the liquid transfer medium is fed continuously from the reservoir (101) to the gravel transferring means (105, 115), while the gravel is fed from the reservoir (101) into the gravel transferring means (105, 115) in batches by stopping (515) the gravel transfer and restarting it again.

10. A method according to any one of the preceding claims, wherein the liquid transfer medium is water.

11. A system for building a gravel column in soil for consolidating the soil, the system comprising:

• a reservoir (101);
• a means for transferring (105, 107; 115) gravel from the reservoir to the soil;
• a gravel feeding means (103) for transferring gravel to the gravel transferring means (105, 107; 115); and
• a gravel and liquid feeding means (106) connected to the gravel transferring means for transferring gravel and liquid to the soil,

wherein the gravel is arranged to be transferred from the reservoir (101) to the soil by using liquid as a transfer medium.

12. A system according to claim 11, wherein the reservoir (101) comprises a first compartment (201) which contains at least the gravel, and a second compartment (202) which contains the liquid transfer medium, and wherein the second compartment (202) has an opening (207) for the gravel and liquid to be fed to the gravel transferring means.

13. A system according to any one of claims 11 or 12, wherein the reservoir (101) comprises a screw feed system (205) to feed gravel from the reservoir (101) to the gravel transferring means (105, 107; 115).

14. A system according to any one of claims 11 to 13, wherein the gravel transferring means (105, 107; 115) comprises at least two separation hoppers (107), and at least two pressurisable tanks (111), wherein the system further comprises a suspending means (601), wherein the suspending means (601) is arranged in a balanced manner below the top surface (603) of the separation hoppers (107) and between them.

Patentansprüche

1. Verfahren zur Herstellung eines Kiespfahls im Boden zur Verbesserung des Bodens unter Verwendung eines Boden-Verbesserungssystems, umfassend ein Reservoir (101), verbunden mit Kiesübertragungsmitteln (105, 107), welche in den Boden führen, das Verfahren umfasst: Übertragen (507, 519, 525, 803) von Kies durch die Kiesübertragungsmittel (105, 107) in den Boden, wobei

- In einem Schritt (505) Flüssigkeit in die Kiesübertragungsmittel (105, 107) geleitet wird, und
- In einem anderen Schritt (507) Kies in die Kiesübertragungsmittel (105, 107) geleitet wird,

wobei Flüssigkeit als ein Transfermedium von dem Reservoir (101) zu dem Boden eingesetzt wird, um einen Kiespfahl herzustellen.

2. Verfahren nach Anspruch 1, wobei die Kiesübertragungsmittel (105, 107) eine erste Leitung (105) umfasst, die mit einer zweiten Leitung (115) verbunden ist, welche in den Boden führt.

3. Verfahren nach Anspruch 2, wobei in dem Boden-Verbesserungssystem eine erste Leitung (105) mit einer zweiten Leitung über einen Trennbehälter (107) verbunden ist, wobei das Verfahren weiter umfasst Abtrennen (509) zumindest teilweise von Flüssigkeit von dem Kies in dem Trennbehälter (107).

4. Verfahren nach Anspruch 3, wobei der Trennbehälter (107) mittels eines ersten Ventils (113) mit einem druckbeaufschlagbaren Behälter (111) verbunden ist, welcher mittels eines zweiten Ventils (401) mit der zweiten Leitung (115) verbunden ist, die in den Boden führt, wobei die zweite Leitung (115) druckbeaufschlagbar ist, wobei der Kies von dem Trennbehälter (107) über den druckbeaufschlagbaren Behälter (111) und durch die druckbeaufschlagbare zweite Leitung (115) in den Boden geleitet wird, und wobei zumindest eines der Ventile (113, 401) zu jedem Zeitpunkt geschlossen ist.

5. Verfahren nach Anspruch 4, wobei das Verfahren weiter umfasst:

- Schliessen (501) des ersten Ventils (113) und des zweiten Ventils (401);
- Öffnen (519) des ersten Ventils (113), damit sich der Kies von dem Trennbehälter (107) in den druckbeaufschlagbaren Behälter (111) bewegt;
- Schliessen (523) des ersten Ventils (113); und
- Öffnen (525) des zweiten Ventils (401), damit sich der Kies von dem druckbeaufschlagbaren Tank (111) in die druckbeaufschlagbare zweite Leitung (115) bewegt, welche in den Boden führt.

6. Verfahren nach Anspruch 4 oder 5, weiter umfassend eine Druckbeaufschlagung (503) der druckbeaufschlagbaren zweiten Leitung (115) nachdem das erste Ventil (113) und/oder das zweite Ventil (401) geschlossen wird/wurden.

7. Verfahren nach Anspruch 6, wobei die Druckbeaufschlagung mittels Druckluft bei einem gesteuerten Druck oder bei einer gesteuerten Flüssigkeitsströmung erfolgt.

8. Verfahren nach einem der Ansprüche 3 bis 7, weiter umfassend Leiten (511) des Flüssigkeitstransfermediums von dem Trennbehälter (107) zurück in das Reservoir (101).

9. Verfahren nach einem der vorhergehenden Ansprüche, wobei das Flüssigkeitstransfermedium kontinuierlich von dem Reservoir (101) in die Kiesübertragungsmittel (105, 115) geleitet wird, während der Kies aus dem Reservoir (101) in die Kiesübertragungsmittel (105, 115) batchweise durch Stoppen (515) des Kiestransfers und Wiederstarten desselben geleitet wird.

10. Verfahren nach einem der vorhergehenden Ansprüche, wobei das Flüssigkeitstransfermedium Wasser ist.

11. Anordnung zur Herstellung eines Kiespfahls im Boden zur Verbesserung des Bodens, wobei die Anordnung umfasst:

- Ein Reservoir (101);
- Ein Mittel (105, 107, 115) zum Übertragen von Kies aus dem Reservoir in den Boden;
- Ein Kieseinführmittel (103) zum Übertragen von Kies in die Mittel (105, 107, 115) zum Übertragen von Kies; und
- Mittel zum Führen von Kies und Flüssigkeit (106), verbunden mit den Kiesübertragungsmitteln, um Kies und Flüssigkeit in den Boden zu transferieren,

wobei der Kies angeordnet ist, um von dem Reservoir (101) in den Boden unter Einsatz von Flüssigkeit als Transfermedium übertragen zu werden.

12. Anordnung nach Anspruch 11, wobei das Reservoir (101) eine erste Kammer (201) umfasst, welche zumindest den Kies enthält und eine zweite Kammer (202), welche das Flüssigkeitstransfermedium enthält, und wobei die zweite Kammer (202) eine Öffnung (207) aufweist, damit der Kies und Flüssigkeit zu den Kiesübertragungsmitteln geleitet wird.

13. Anordnung nach einem der Ansprüche 11 und 12, wobei das Reservoir (101) eine Schneckenfördereinrichtung (205) umfasst, um Kies aus dem Reservoir (101) in die Kiesübertragungsmittel (105, 107, 115) zu leiten.

14. Anordnung nach einem der Ansprüche 11 bis 13, wobei die Kiesübertragungsmittel (105, 107, 115) zumindest zwei Trennbehälter (107) umfassen, und zumindest zwei druckbeaufschlagbare Behälter (111), wobei die Anordnung weiter ein Absperrmittel (601) umfasst, wobei das Absperrmittel (601) symmetrisch unterhalb der oberen Oberfläche (603) der Trennbehälter (107) und zwischen denselben angeordnet ist.

Revendications

1. Méthode pour construire une colonne ballastée dans le sol pour consolider le sol en utilisant un système d'amélioration du sol comprenant un réservoir (101) connecté à des moyens de transfert de gravier (105, 107) menant au sol, la méthode comprenant: le transfert (507, 519, 525, 803) du gravier à travers les moyens de transfert de gravier (105, 107) au sol, dans laquelle:

- dans une étape (505), les moyens de transfert de gravier (105, 107) sont alimentés en liquide, et
- dans une autre étape (507), les moyens de transfert de gravier (105, 107) sont alimentés en gravier,

le liquide étant utilisé comme un moyen de transfert depuis le réservoir (101) vers le sol pour construire la colonne ballastée.

2. Méthode selon la revendication 1, dans laquelle les moyens de transfert de gravier (105, 107) comprennent un premier tuyau (105) connecté au deuxième tuyau (115) menant au sol.

3. Méthode selon la revendication 2, dans laquelle dans le système d'amélioration du sol le premier tuyau (105) est connecté au deuxième tuyau par un silo de séparation (107), dans lequel la méthode comprenant en outre la séparation (509) d'au moins le liquide du gravier dans le silo de séparation (107).

4. Méthode selon la revendication 3, dans laquelle le silo de séparation (107) est connecté par une première valve (113) à un réservoir pouvant être mis sous pression (111), qui est connecté par une deuxième valve (401) au deuxième tuyau (115) menant au sol, le deuxième tuyau (115) pouvant être mis sous pression, le gravier étant conduit depuis le silo de séparation (107) par le réservoir sous pression (111) et par le deuxième tuyau sous pression (115) au sol, et au moins une des valves (113, 401) étant fermée à n'importe quel moment.

5. Méthode selon la revendication 4, dans laquelle la méthode comprend en outre:

- la fermeture (501) de la première valve (113) et de la deuxième valve (401) ;
- l'ouverture (519) de la première valve (113) pour permettre au gravier d'être déplacé du silo de séparation (107) dans le réservoir pouvant

être mis sous pression (111);
- la fermeture (523) de la première valve (113); et
- l'ouverture (525) de la deuxième valve (401) pour permettre au gravier d'être déplacé depuis le réservoir sous pression (111) jusque dans le deuxième tuyau sous pression (115) menant au sol.

6. Méthode selon la revendication 4 ou 5, comprenant en outre la pressurisation (503) du deuxième tuyau pouvant être mis sous pression (115) après que la première valve (113) et/ou la deuxième valve (401) a/ont été fermée(s).

7. Méthode selon la revendication 6, dans laquelle la pressurisation est effectuée au moyen d'air comprimé à une pression contrôlée ou par un flux contrôlé de liquide.

8. Méthode selon l'une quelconque des revendications 3 à 7, comprenant en outre la réalimentation (511) du moyen de transfert du liquide vers le réservoir (101) depuis le silo de séparation (107).

9. Méthode selon l'une quelconque des revendications précédentes, dans laquelle le moyen de transfert de liquide est alimenté en continu depuis le réservoir (101) vers le moyen de transfert de gravier (105, 115) par fournées, en arrêtant (515) le transfert de gravier et en le redémarrant.

10. Méthode selon l'une quelconque des revendications précédentes, dans laquelle le moyen de transfert de liquide est de l'eau.

11. Système pour construire une colonne ballastée dans le sol pour consolider le sol, le système comprenant:

- un réservoir (101);
- un moyen pour le transfert (105, 107, 115) du gravier depuis le réservoir vers le sol;
- un moyen d'alimentation en gravier (103) pour transférer le gravier vers les moyens de transfert de gravier (105, 107, 115); et
- un moyen d'alimentation en gravier et en liquide (106) relié au moyen de transfert de gravier pour transférer le gravier et le liquide vers le sol,

dans lequel le gravier est agencé pour être transféré depuis le réservoir (101) vers le sol en utilisant du liquide comme moyen de transfert.

12. Système selon la revendication 11, dans lequel le réservoir (101) comprend un premier compartiment (201) qui contient au moins le gravier, et un deuxième compartiment (202) qui contient le moyen de transfert de liquide, et dans lequel le deuxième compartiment (202) a une ouverture (207) pour le gravier et le liquide pour alimenter les moyens de transfert de gravier.

13. Système selon l'une quelconque des revendications 11 ou 12, dans lequel le réservoir (101) comprend un système d'alimentation à vis (205) pour alimenter le gravier depuis le réservoir (101) vers les moyens de transfert de gravier (105, 107, 115).

14. Système selon l'une quelconque des revendications 11 à 13, dans lequel les moyens de transfert de gravier (105, 107, 115) comprennent au moins deux silos de séparation (107), et au moins deux réservoirs pouvant être mis sous pression (111), dans lequel le système comprend en outre un moyen de suspension (601), dans lequel le moyen de suspension (601) est agencé de manière équilibrée sous la surface supérieure (603) des silos de séparation (107) et entre eux.

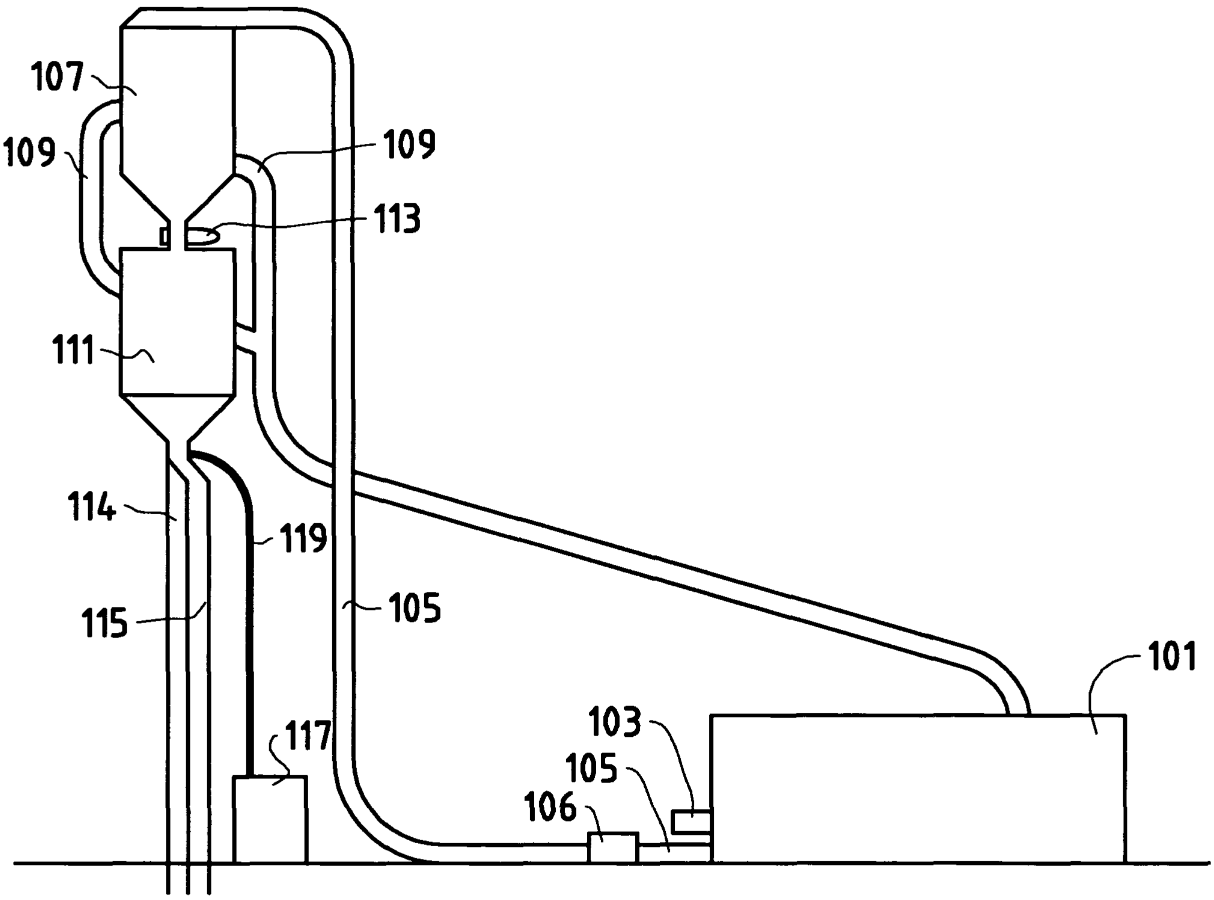

FIG. 1

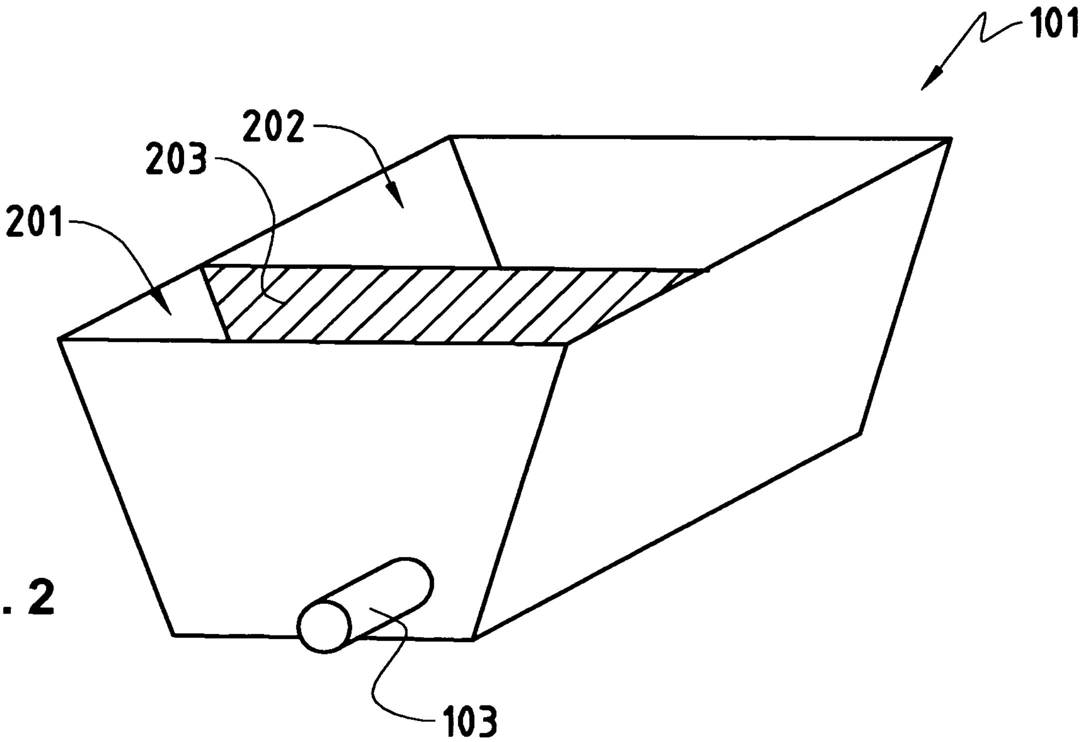

FIG. 2

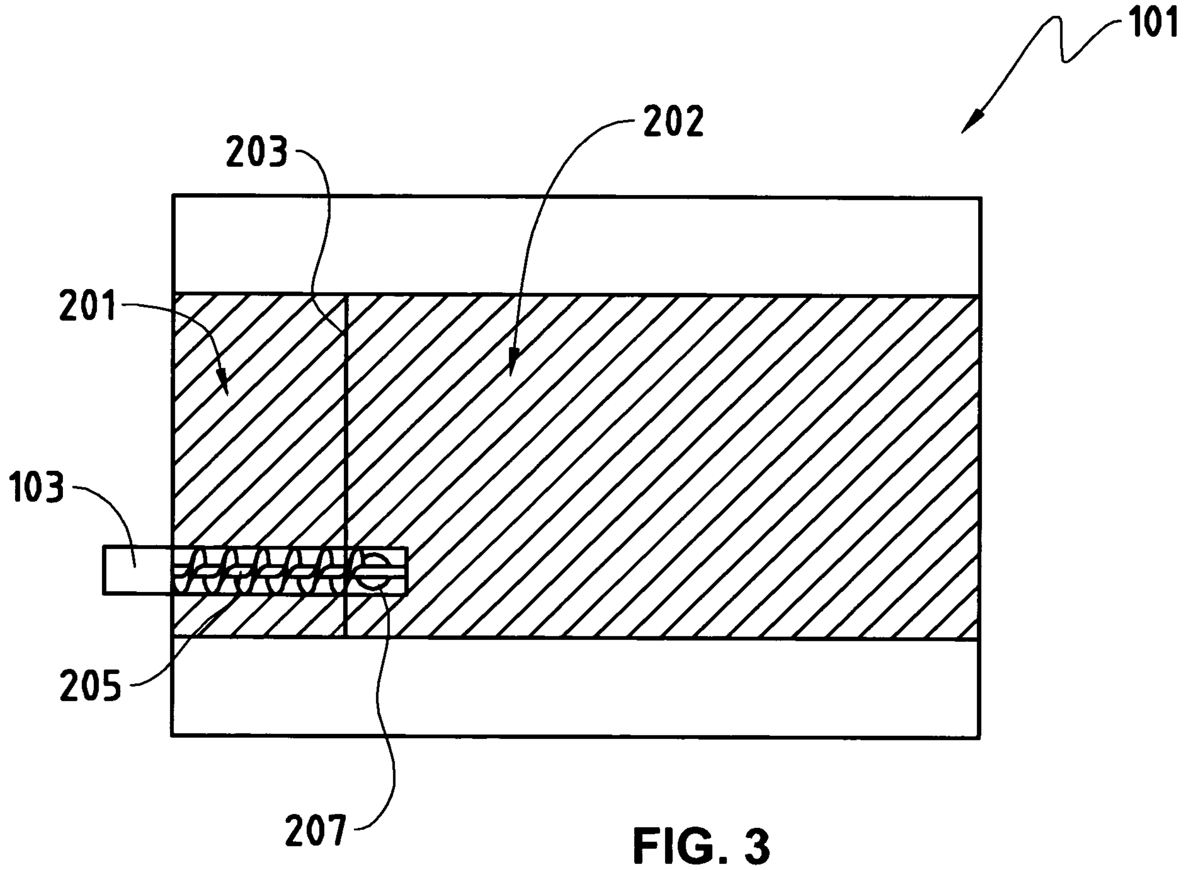

FIG. 3

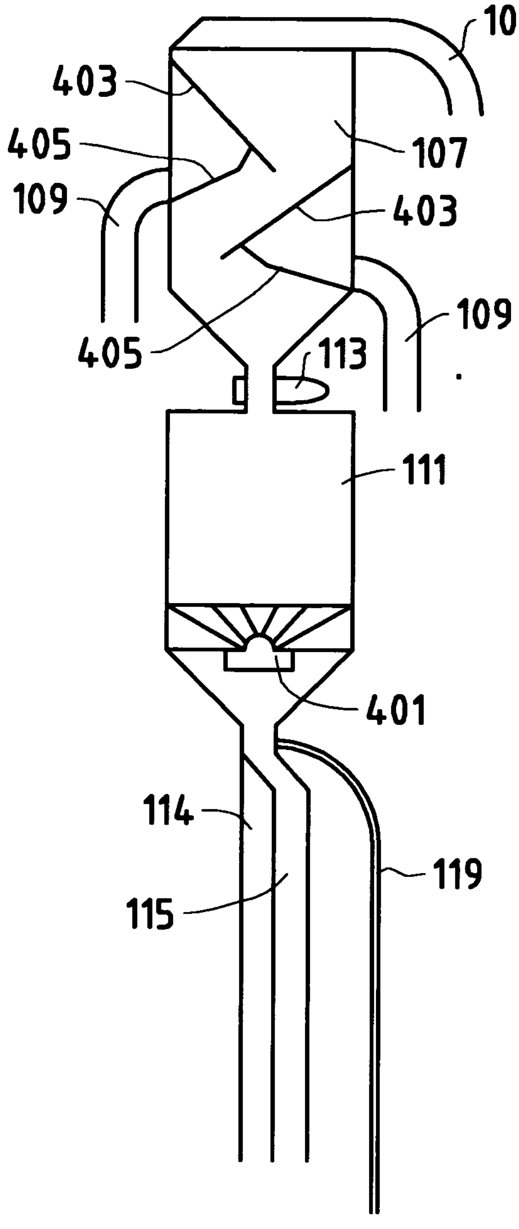
105
403
405
107
109
403
109
405
113
111
401
114
119
115

FIG. 4a

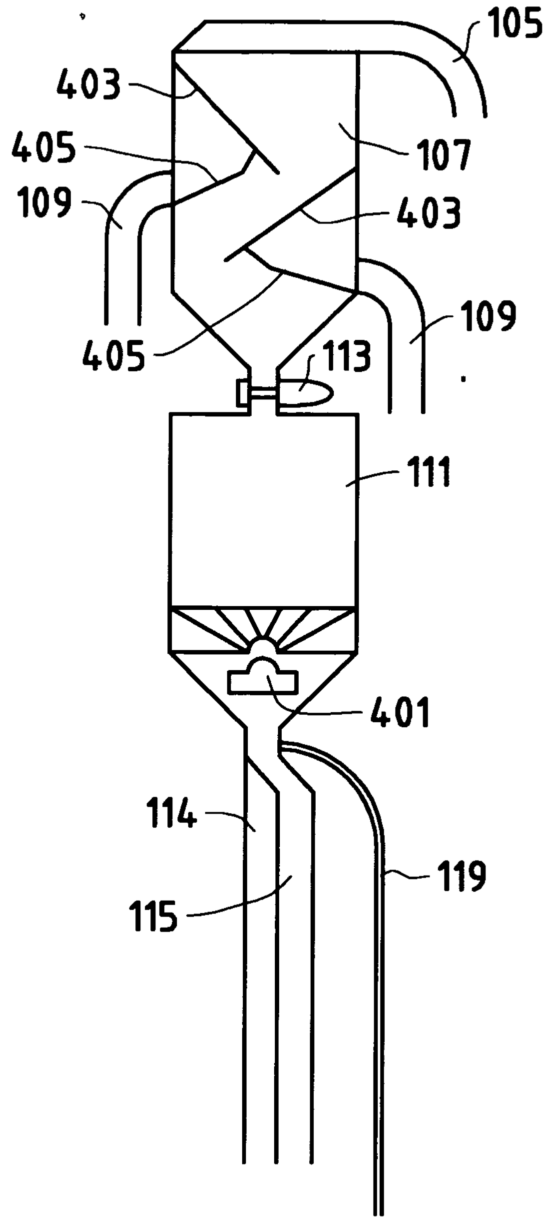
105
403
405
107
109
403
109
405
113
111
401
114
119
115

FIG. 4b

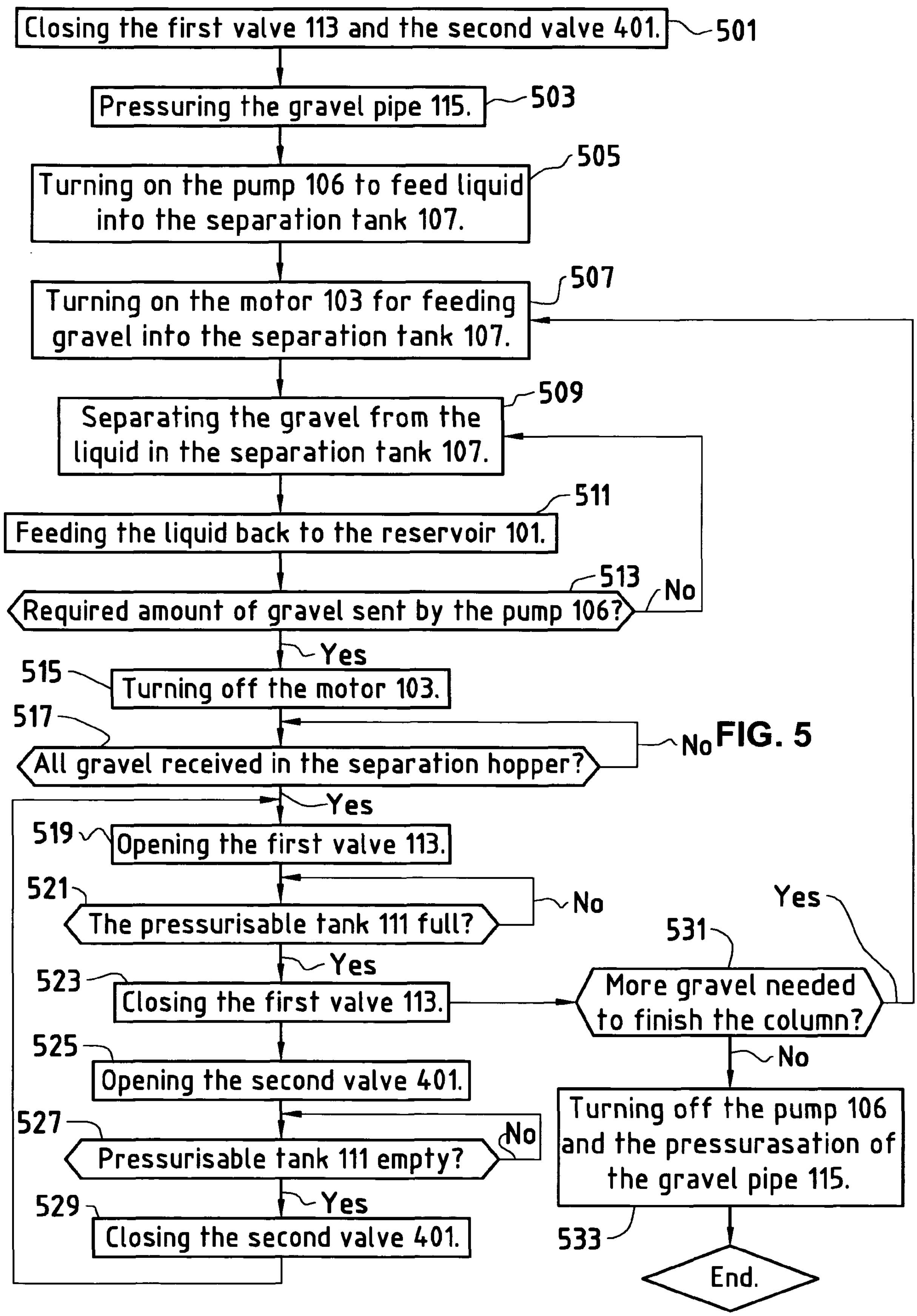
Closing the first valve 113 and the second valve 401.
501
Pressuring the gravel pipe 115.
503
Turning on the pump 106 to feed liquid into the separation tank 107.
505
Turning on the motor 103 for feeding gravel into the separation tank 107.
507
Separating the gravel from the liquid in the separation tank 107.
509
Feeding the liquid back to the reservoir 101.
511
Required amount of gravel sent by the pump 106?
513
No
Yes
515
Turning off the motor 103.
517
All gravel received in the separation hopper?
No
Yes
519
Opening the first valve 113.
521
The pressurisable tank 111 full?
No
Yes
523
Closing the first valve 113.
525
Opening the second valve 401.
527
Pressurisable tank 111 empty?
No
Yes
529
Closing the second valve 401.
531
More gravel needed to finish the column?
Yes
No
Turning off the pump 106 and the pressurasation of the gravel pipe 115.
533
End.

FIG. 5

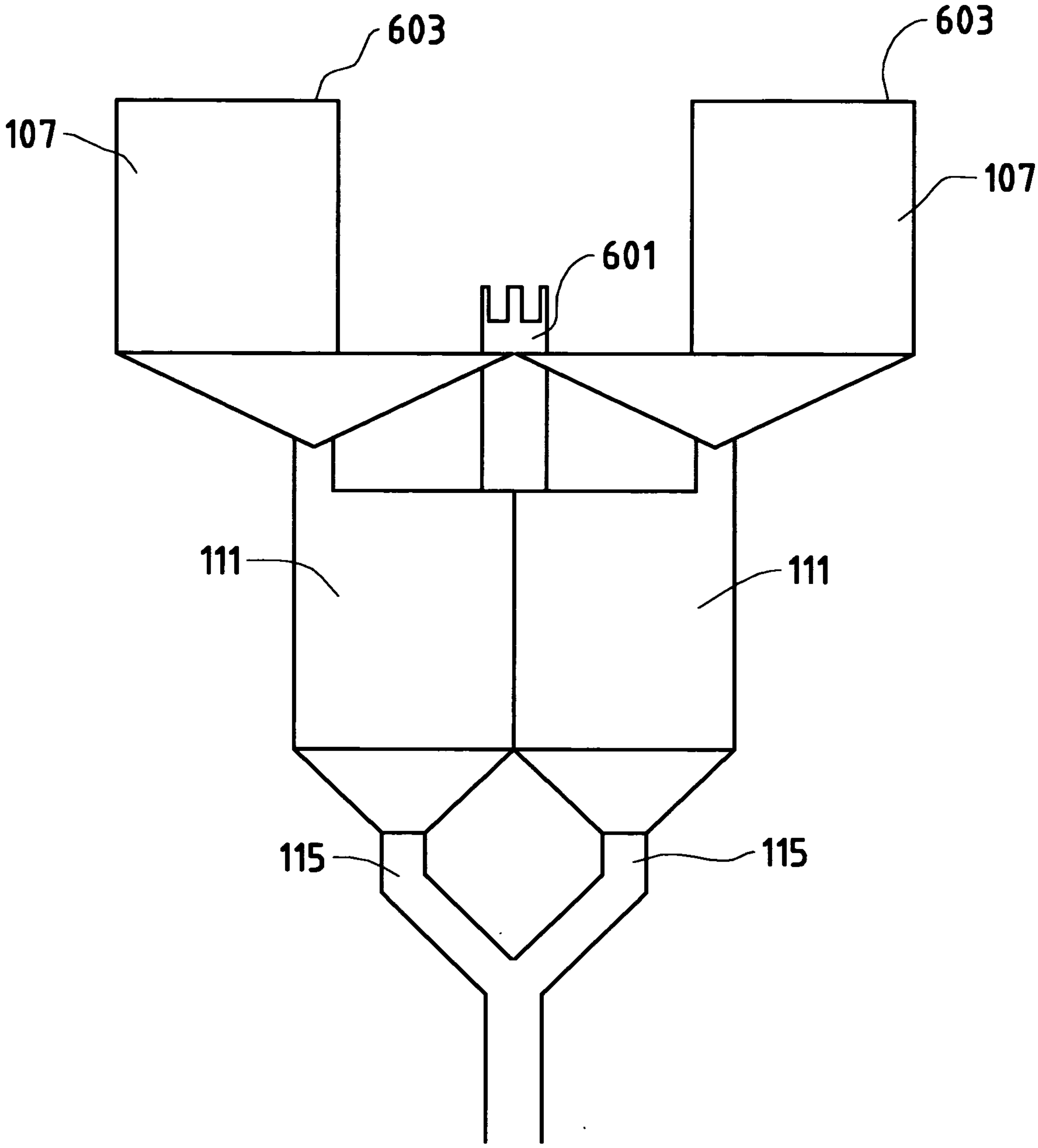

FIG. 6

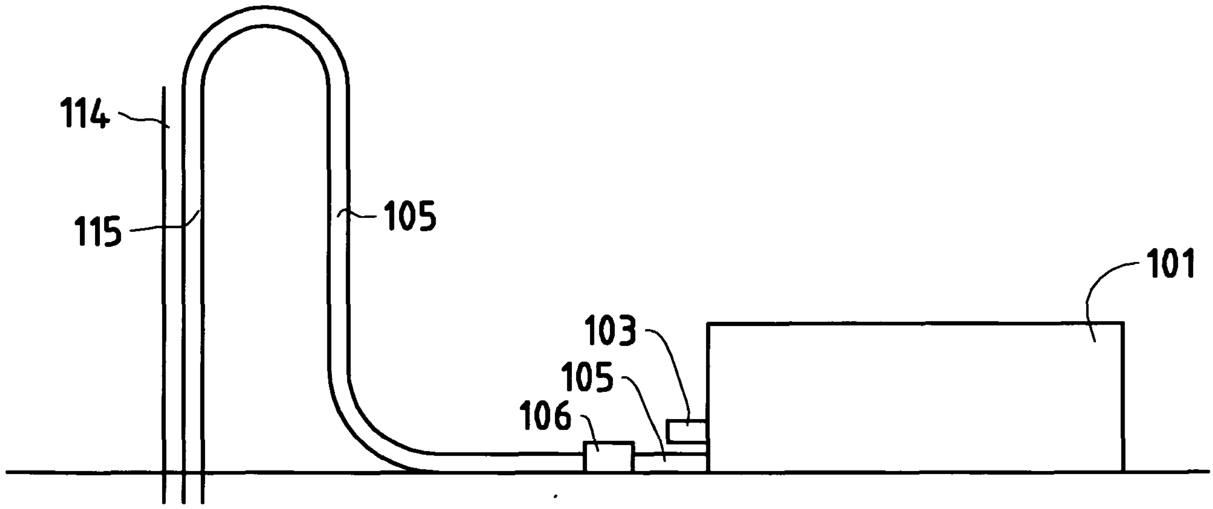
114
115
105
101
103
105
106

FIG. 7

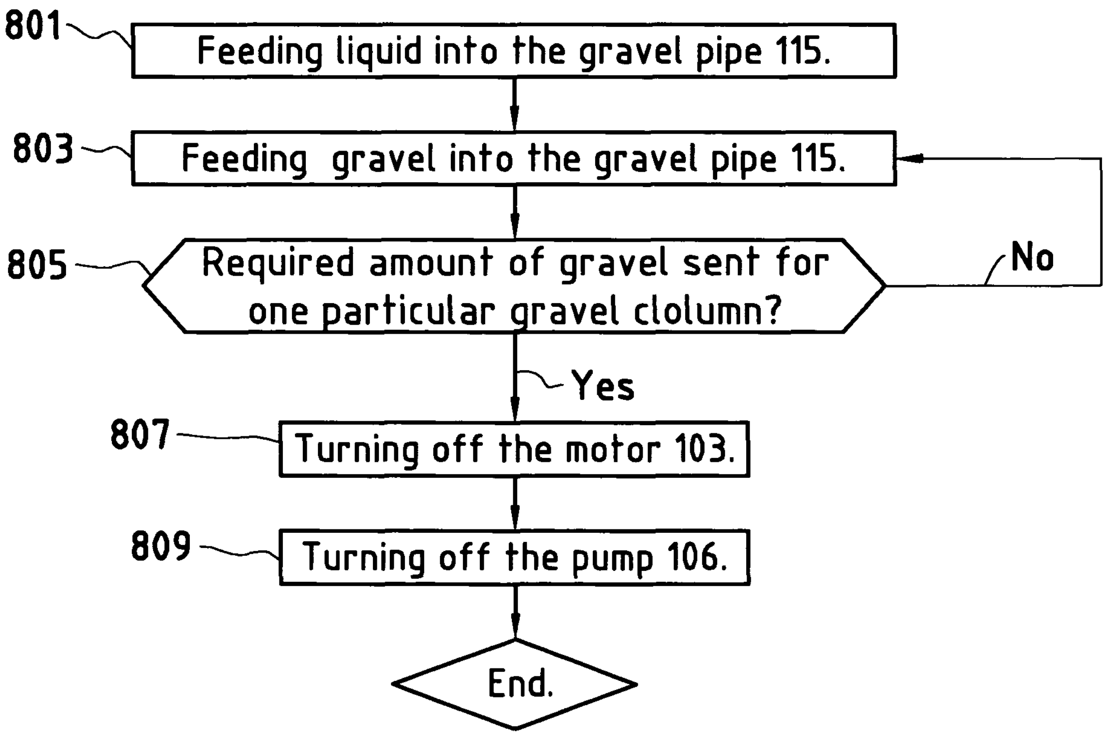
801
Feeding liquid into the gravel pipe 115.
803
Feeding gravel into the gravel pipe 115.
805
Required amount of gravel sent for one particular gravel clolumn?
No
Yes
807
Turning off the motor 103.
809
Turning off the pump 106.
End.

FIG. 8

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- EP 2258903 A1 **[0001]**