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

(11) **EP 3 744 902 A2**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
**02.12.2020 Bulletin 2020/49**

(21) Application number: **20171550.5**

(22) Date of filing: **27.04.2020**

(51) Int Cl.:
***E02D 31/10*** *(2006.01)* ***E02D 37/00*** *(2006.01)*
***C09K 17/10*** *(2006.01)* ***C09K 17/12*** *(2006.01)*
***E02D 3/12*** *(2006.01)* ***E02D 5/46*** *(2006.01)*
***E02D 5/66*** *(2006.01)*

(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**
Designated Extension States:
**BA ME**
Designated Validation States:
**KH MA MD TN**

(30) Priority: **27.05.2019 IT 201900007254**

(71) Applicant: **Clivio S.r.l.**
**43015 Noceto (Parma) (IT)**

(72) Inventors:
- **SANELLA, Antonio**
  **43015 NOCETO (PARMA) (IT)**
- **AVANZINI, Filippo**
  **43123 PARMA (IT)**

(74) Representative: **Dondi, Silvia**
**Bugnion S.p.A.**
**Largo Michele Novaro, 1/A**
**43121 Parma (IT)**

(54) **A METHOD FOR SOIL CONSOLIDATION**

(57) A placing system of a stopper plug (6) in a perforation in which a land consolidation material is present, said system (1) comprising:
-said plug (6);
-a conduit (2), said conduit (2) at least partly extending outside the perforation along an imaginary prolongation of said perforation;
-introduction means (3) for introducing the plug (6) into said conduit (2);
-a pusher member (4) of the plug (6); the pusher member (4) is movable along the conduit (2) so as to position the plug (6) in the perforation.

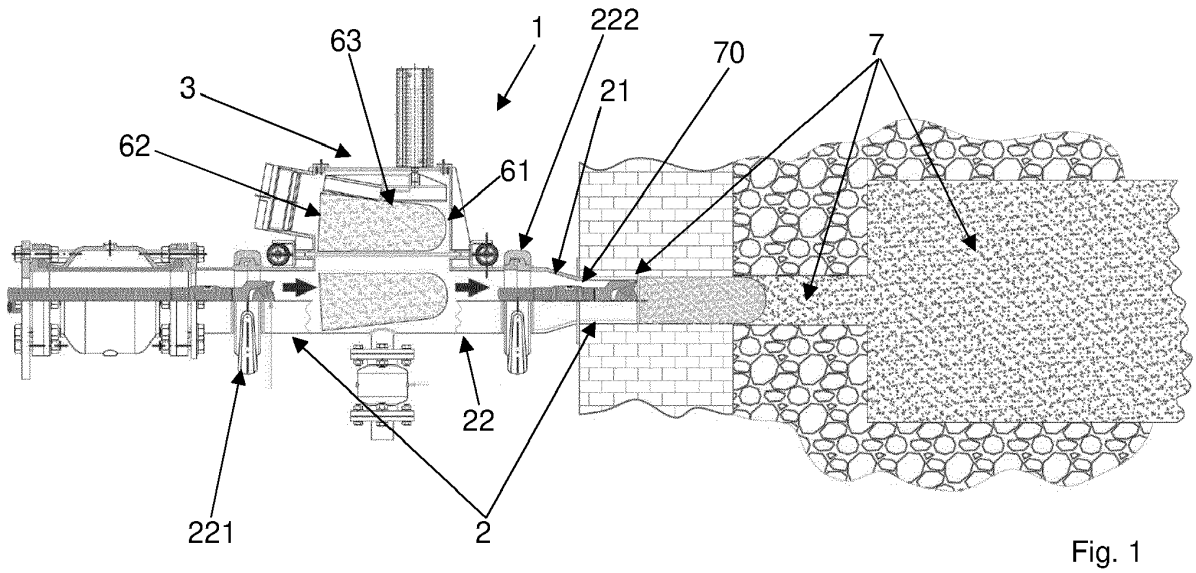


Fig. 1

EP 3 744 902 A2

## Description

**[0001]** The present invention relates to a placing system and method of a stopper plug in a land consolidation perforation.

**[0002]** This system and method is used to prevent copious and undesired leakage of consolidation material, previously introduced into the perforation to form a columnar volume of consolidation. In particular, but not exclusively, it is used in applications where the perforation has a mouth that is located at a lower or identical height with respect to the bottom and therefore gravity facilitates this leakage. The system and method according to the present invention are in particular used in conjunction with the jet grouting technique, known per se.

**[0003]** In fact, a land consolidation technique known as jet grouting is known, which involves:

- carrying out a perforation by means of a perforation rod;
- dispensing a pressurised jet of a cementitious consolidation material by means of the perforation rod; this occurs during an extraction stroke of the rod from a bottom to a mouth of the perforation; the pressurised dispensed cementitious material digs the surrounding land and mixes therewith to form a columnar volume.

**[0004]** One drawback of this solution is that once the perforation rod has been extracted it is necessary to apply a plug that prevents a copious leakage of the cementitious consolidation material introduced into the perforation (due to the fact that the perforation is pressurised and possibly due to the slope). To date, for the application of the plug, an operator is lifted by means of a ladder or forklift basket to the mouth of the perforation and physically inserts the plug into the perforation. This operation is inconvenient since first, due to the pressure present in the perforation, there is an abundant leakage of material. Consequently, the plug is often applied when the pressure in the perforation has decreased, but this means that a significant part of the consolidation material introduced is dispensed externally, penalising the consolidation action.

**[0005]** In addition, when performing the plugging operation, the operator is covered with a considerable amount of cementitious material. This creates considerable problems due to the fact that the operator becomes dirty and must also be careful to cover himself with protective clothing, including his face and hands.

**[0006]** The defined technical task and the specified objects are substantially achieved by a placing system and method of a plug comprising the technical characteristics set forth in one or more of the appended claims.

**[0007]** Further characteristics and advantages of the present invention will become more apparent from the approximate and thus non-limiting description of a preferred, but not exclusive, embodiment of a placing system and method of a plug, as illustrated in the accompanying drawings, of which:

- figure 1 shows a section view of a placing system of a plug according to the present invention;
- figure 2 shows an enlarged detail of figure 1;
- figures 3 to 7 show in succession a series of steps of a portion of the method according to the present invention.

**[0008]** In the appended figures the reference numeral 1 refers to a placing system of a stopper plug 6 in a perforation 7 in which a land consolidation material is present. This system 1 is used in a jet grouting system.

**[0009]** The system 1 comprises a conduit 2. The conduit 2 extends at least in part outside the perforation 7. In particular, it extends along an imaginary prolongation of said perforation 7. The conduit 2 is typically straight. The conduit 2 also extends inside the perforation 7. The conduit 2 may comprise a connection flange 71 connecting to a front wall 72 from which the perforation 7 extends. Typically this wall extends between the top and the bottom.

**[0010]** The system 1 further comprises introduction means 3 for introducing the plug 6 into the conduit 2. The introduction means 3 may therefore define a loader of the plug 6.

**[0011]** The system 1 further comprises a pusher member 4 of the plug 6. The pusher member 4 is movable along the conduit 2 so as to position the plug 6 in the perforation 7. In fact, by advancing along the conduit 2, the pusher member 4 pushes the plug 6 towards an end of the conduit that opens into said perforation 7. The plug 6 is typically inserted into the perforation 7 by interference. Typically, the plug 6 is deformable; thanks to this deformability it can be compressed transversely to an insertion direction in the perforation 7 and perform a sealing action on the walls of the perforation 7. As non-limiting examples, it could be made of rubber or polyurethane resin.

**[0012]** Advantageously the plug 6 comprises a first and a second axial end 61, 62. The plug 6 also comprises a lateral surface 63 extending between the first and the second end 61, 62.

**[0013]** The lateral surface 63 narrows as it passes from the first to the second end 61, 62.

**[0014]** The first axial end 61 is destined to reach more deeply into said perforation 7 with respect to the second axial end 62. The plug 6 thus has a converging shape; for example, in the preferred solution the lateral surface 63 is truncoconical.

**[0015]** Advantageously the system 1 comprises a perforation rod 5 for carrying out said perforation 7. The rod 5 is movable along the conduit 2.

**[0016]** The conduit 2 is a guide conduit of the perforation rod 5. It is also a guide conduit of the plug 6. The pusher member 4 coincides with/is a part of the perforation rod 5. The pusher member 4 is therefore integrated

in the rod 5. There are no additional mechanical parts.

**[0017]** Advantageously, the introduction means 3 for introducing the plug 6 in the conduit 2 comprise a containing tank 31 of the plug 6. The tank 31 is located by a side of the conduit 2. The tank 31 may comprise an occludable opening 35 that allows loading the plug 6 in the tank 31 from outside the introduction means 3.

**[0018]** The introduction means 3 further comprise a thrust actuator 32 suitable to move said plug 6 from a first position in which it is located in the tank 31 to a second position in which it is located in the conduit 2. This thrust actuator 32 moves transversely (preferably orthogonally) to the conduit 2. Advantageously the actuator 32 is linear. It is typically fluid-dynamically driven.

**[0019]** The thrust actuator 32 further comprises a concavity 320 at one end destined to come into contact with and push the plug 6. This concavity 320 is destined to at least partially house the plug 6. In particular, the concavity 320 could be counter-shaped to a portion of the plug 6 with which it comes into contact. This allows to better transfer the thrust on the plug 6, minimising the risk that the plug 6 may slip or position itself in an undesired way.

**[0020]** The introduction means 3 comprise a dividing wall 33 that is movable between a first configuration (see figures 3 and 7) in which it separates said tank 31 from the conduit 2 and a second configuration (see figures 4, 5, 6) in which it allows communication between said tank 31 and said conduit 2. In the first configuration, the dividing wall 33 thus occludes a communication passage 330 between the conduit 2 and the tank 31. The dividing wall 33 is a guillotine. In the second configuration, the plug 6 is allowed to pass from the tank to the conduit 2 (through the above-mentioned communication passage 330).

**[0021]** Advantageously, the introduction means 3 comprise a moving device 34 suitable to move said dividing wall 33 between the first and the second configuration parallel to the conduit 2. The moving device 34 can advantageously be driven fluid-dynamically. The moving device 34 is a linear moving device. In the first configuration, the dividing wall 33 sealingly separates the tank 31 from the conduit 2. This allows preventing the consolidation material injected into the perforation 7 from dirtying the tank 31. This also prevents the consolidation material from dirtying the plug 6 before it is introduced into the conduit 2.

**[0022]** The conduit 2 comprises a stretch 22 in which the above-mentioned communication passage 330 is obtained. This stretch 22 of the conduit 2 is interposed between a first and a second junction 221, 222 connecting it to two further sections of the conduit 2 between which it is interposed.

**[0023]** The conduit 2 advantageously also comprises a converging section 21 interposed between the above-mentioned communication passage 330 and one end 23 of the conduit 2 destined to engage in the perforation 7. Advantageously, the placing system 1 may also comprise radial sealing means between the conduit 2 and the rod 5. The radial sealing means comprise, for example:

- a sealing element,
- pneumatic means that allow inflation; advantageously this makes it possible to come into contact with the conduit 2 and the rod 5 and exert the radial seal.

**[0024]** This passage 330 advantageously lies between the radial sealing means and an end of the conduit 2 opening into the perforation 7.

**[0025]** An object of the present invention is also a placing system of a stopper plug 6 in a perforation 7 in which a land consolidation material is present. This material is typically fluid. This method is advantageously carried out by means of a placing system 1 having one or more of the characteristics described above. The method comprises the step of extracting a perforation rod 5 from the perforation 7 while keeping the perforation rod 5 inside a conduit 2 that extends from said perforation 7. This conduit 2 is advantageously straight. In particular, the conduit 2 is coaxial with the perforation 7. Advantageously, this step can be accompanied by a leakage of land mixed with the consolidation material from the perforation 7 in the conduit 2. In fact, it is not yet fully consolidated and is therefore movable. The consolidation material is typically a mixture comprising water and cement that mixes with the land. Advantageously the conduit 2 also extends inside the perforation 7.

**[0026]** The method further comprises the step of introducing the plug 6 into the conduit 2, positioning the plug 6 between the perforation rod 5 and an inlet mouth 70 of the perforation 7. This occurs after extracting the rod 5 from the perforation 7. In particular, the step of introducing the plug 6 in the conduit 2 occurs after retracting the rod 5 so that a zone for introducing the plug 6 into the conduit 2 is interposed between the rod 5 and the perforation 7.

**[0027]** With particular reference to figures 3-7, the step of introducing the plug 6 in the conduit 2 comprises the sub-steps of (advantageously figure 3 shows an initial situation at rest):

- opening a dividing wall 33 that separates a tank 31 in which the plug 6 is placed from the conduit 2 (figure 4);
- pushing the plug into the conduit 2 by means of a thrust actuator 32 (figure 5).

**[0028]** These sub-steps are advantageously automated. In fact, they can be controlled sequentially by the operator with a single input.

**[0029]** The method comprises the step of pushing the plug 6 along the conduit 2 to fit the plug 6 into the inlet mouth 70 of the perforation 7.

**[0030]** The step of pushing the plug 6 along the conduit 2 to fit the plug 6 into the inlet mouth 70 of the perforation 7 is carried out by pushing the plug 6 using the perforation rod 5. To perform the pushing step, the rod 5 is then moved along the conduit 2 and in particular approached

and/or introduced into the inlet mouth 70 of the perforation 7.

**[0031]** After or during the step of pushing the plug, the method may comprise the steps of:

- recalling said thrust actuator 32 by extracting it from the conduit 2, advantageously positioning it in the tank 31 (figure 6);
- closing the dividing wall 33 (figure 7).

**[0032]** These steps are advantageously automated. In fact, they can be controlled sequentially by the operator with a single input.

**[0033]** An object of the present invention is also a method for land consolidation. This land consolidation method comprises the step of implementing a placing method of a plug 6 having one or more of the steps described above. Prior to the step of implementing said placing method of the plug 6, the land consolidation method comprises the step of carrying out a perforation 7; advantageously, the step of carrying out the perforation 7 is carried out using the perforation rod 5.

**[0034]** The method further comprises the step of dispensing consolidation material inside the perforation 7. The step of dispensing the consolidation material takes place using at least a dispenser 50 located along the perforation rod 5. In particular this occurs during at least a part of a stroke of the rod 5 which moves from a bottom of said perforation 7 towards the inlet mouth 70 of the perforation 7.

**[0035]** The dispensed consolidation material advantageously comprises a cementitious material (other components may then be present e.g. a grip accelerator). The step of dispensing the consolidation material comprises the step of dispensing a pressurised jet that breaks down the surrounding land. The consolidation material will then mix with the surrounding land to form a columnar volume that reinforces the land (especially if several columnar volumes are made connected to each other, each obtained by a corresponding perforation). Advantageously, during at least a part of the step of dispensing the consolidation material, the method comprises the step of rotating said rod 5 around an axis of longitudinal extension of said rod. Advantageously, the step of dispensing the consolidation material can be carried out simultaneously by means of a plurality of nozzles, typically orientated along different dispensing directions (possibly they could also be diametrically opposite).

**[0036]** Advantageously near the inlet mouth 70 of the perforation 7, the consolidation method involves stopping the step of dispensing the consolidation material. Thus, a first stretch of the perforation 7 has a reduced section, with respect to a second stretch of the perforation in which the land has been broken down by the step of dispensing the consolidation material. The first stretch also comprises the inlet mouth 70 of the perforation 7.

**[0037]** For example, the inlet mouth 70 of the perforation 7 is formed on an artificial wall. For example, the perforation 7 could extend from a wall 72 that extends between the top and bottom and defines the front of a tunnel under construction. This front is then coated with a layer of concrete or other material for safety.

**[0038]** In the preferred solution, the perforation 7 extends along a straight segment.

**[0039]** Advantageously, this straight segment has a horizontal component which is greater than the vertical one (meaning that the vertical component could also be zero). Preferably the inlet mouth 70 is located at a lower height or at the same height as the bottom of the perforation. The perforation 7 therefore extends horizontally or upwards (preferably slightly upwards). If necessary, the perforation could also extend downwards (if below a water head).

**[0040]** The present invention achieves important advantages.

**[0041]** First, it allows to plug a hole in a perforation 7 into which a consolidation material has been introduced by minimising the quantity of consolidation material that leaks due to the pressure present in the perforation 7. This is particularly important if the perforation 7 is carried out in a water-rich area, which increases the mobility of the consolidation material mixed with the land. Secondly, it allows the plugging to be carried out in conditions of maximum safety for the operator.

**[0042]** The invention as it is conceived is susceptible to numerous modifications and variations, all falling within the scope of the inventive concept characterising it. Furthermore, all the details can be replaced with other technically equivalent elements. In practice, all the materials used, as well as the dimensions, can be any according to requirements.

## Claims

**1.** A method for soil consolidation and/or impermeabilisation, comprising the steps of:

i) making a perforation (4) in the soil by means of a drilling rod (2);
ii) dispensing under pressure in the perforation (4), by means of said drilling rod (2):

- a fluid operating material (31) for consolidation and/or impermeabilisation which operates by disintegrating and mixing with the soil to form a columnar volume; and
- a fluid accelerating material (32) for accelerating the consolidation and/or impermeabilisation;

iii) performing an extraction of the rod (2) from said perforation (4); the step of dispensing in the perforation (4) by means of said drilling rod (2) the fluid operating material (31) and the fluid accelerating material (32) occurring during the

step of performing said extraction and generating a soil consolidation and/or impermeabilisation;

**characterised in that** said step of dispensing in the perforation (4) a fluid operating material (31) and a fluid accelerating material (32) comprises the step of feeding a first and a second dispenser (21, 22) formed on said rod (2) respectively with the fluid operating material (31) and the fluid accelerating material (32); the step of feeding the first and the second dispenser (21, 22) occurring while keeping the fluid operating material (31) and the fluid accelerating material (32) separate.

**2.** The method according to claim 1, **characterised in that** said fluid accelerating material (32) comprises a mixture comprising a diluent and an active accelerant ingredient; the step of dispensing the fluid operating material (31) and the fluid accelerating material (32) in the perforation (4) by means of said rod (2) comprises the sub-step of dispensing within a unit of time a quantity of said active accelerant ingredient that at least in a first position of the rod (2) is less than at least a second position of the drilling rod (2);
in said second position the drilling rod (2) being more extracted from said perforation (4) than in the first position.

**3.** The method according to claim 2, **characterised in that** the step of dispensing the fluid operating material (31) and the fluid accelerating material (32) occurs during an extraction stroke of the rod (2) from the perforation (4); the rod (2) assuming the first position at the beginning of said step of dispensing the fluid operating material (31) and the fluid accelerating material (32); the rod (2) assuming the second position at the end of the step of dispensing the fluid operating material (31) and the fluid accelerating material (32); the amount of said active ingredient dispensed within a unit of time in the second position is more than double the amount of said active ingredient dispensed in the unit of time in the first position.

**4.** The method according to claim 1, **characterised in that** said fluid accelerating material (32) comprises a mixture comprising a diluent and an active accelerant ingredient; the step of dispensing a fluid operating material (31) and a fluid accelerating material (32) in the perforation (4) through said drilling rod (2) comprises the step of progressively increasing the amount of active accelerant ingredient dispensed within the unit of time by the rod (2) during at least a predetermined portion of the extraction of the rod (2).

**5.** The method according to claim 2 or 3 or 4, **characterised in that** said active accelerant ingredient is sodium silicate and said fluid operating material (31) is a cementitious material.

**6.** The method according to any one of the preceding claims, **characterised in that** it comprises a step of:

- collecting said fluid operating material (31) from a first tank (25) and conveying it internally to said drilling rod (2) through a first line (23) which feeds the first dispenser (21);
- collecting said fluid accelerating material (32) from a second tank (26) and conveying it internally to said drilling rod (2) through a second line (24) which feeds the second dispenser (22).

**7.** The method according to claim 6 when directly or indirectly dependent on claim 2 or 3 or 4 or 5, **characterised in that** it comprises, during at least a part of the extraction of the rod (2), the step of adding to the accelerating material (32) already present in the second tank (26) a further active accelerant ingredient.

**8.** The method according to claim 6 or 7, **characterised in that** during the step of performing an extraction of the rod (2) from the perforation (4), the first line (23) is traversed exclusively by the fluid operating material (31) and the second line (24) is traversed exclusively by the fluid accelerating material (32); the fluid operating material (31) and the fluid accelerating material (32) coming into mutual communication only downstream of the rod (2) or in output from the rod (2), mixing with the soil surrounding the rod (2).

**9.** The method according to any one of the preceding claims, **characterised in that** the step of dispensing the fluid operating material (31) in the perforation (4) occurs by spraying said fluid operating material (31) at more than 350 bar; the step of dispensing the fluid accelerating material (32) in the perforation (4) occurring by spraying said fluid accelerating material (32) at a pressure comprised between 20 and 200 bar.

**10.** A system for soil consolidation and/or impermeabilisation **characterised in that** it comprises:

- a drilling rod (2) comprising a first dispenser (21) and a second dispenser (22);
- a first tank (25) containing a fluid operating material (31) for soil consolidation and/or impermeabilisation; said first tank (25) being connected to said first dispenser (21) through a first line (23);
- a dosing system of a fluid accelerating material (32) for accelerating soil consolidation/imper-

meabilisation; said dosing system being connected to the second dispenser (22) through a second line (24).

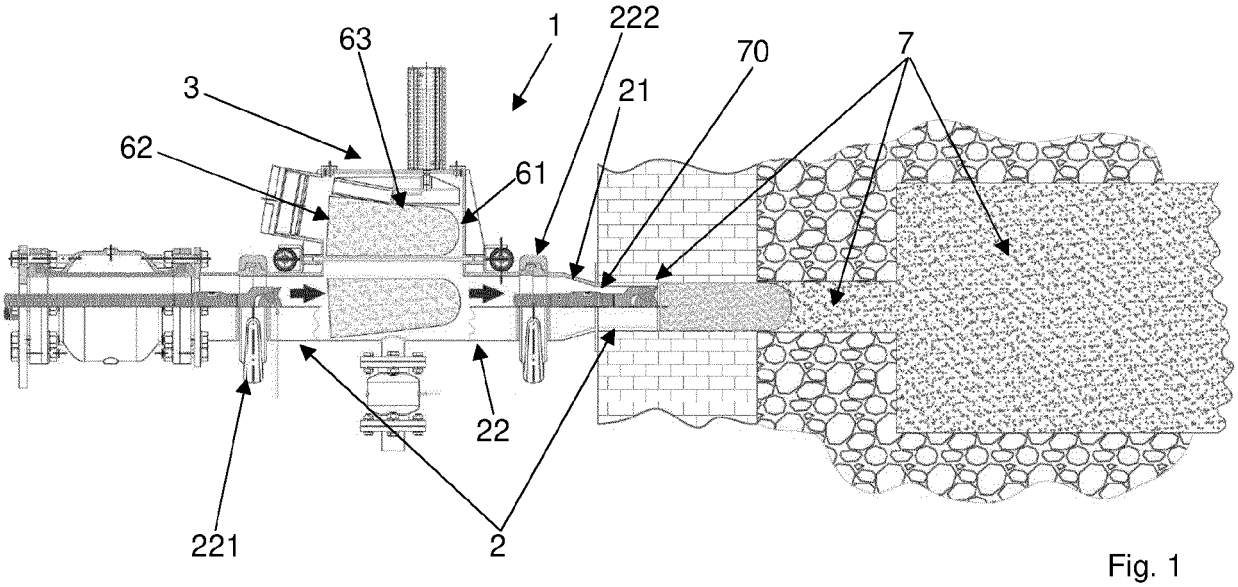


Fig. 1

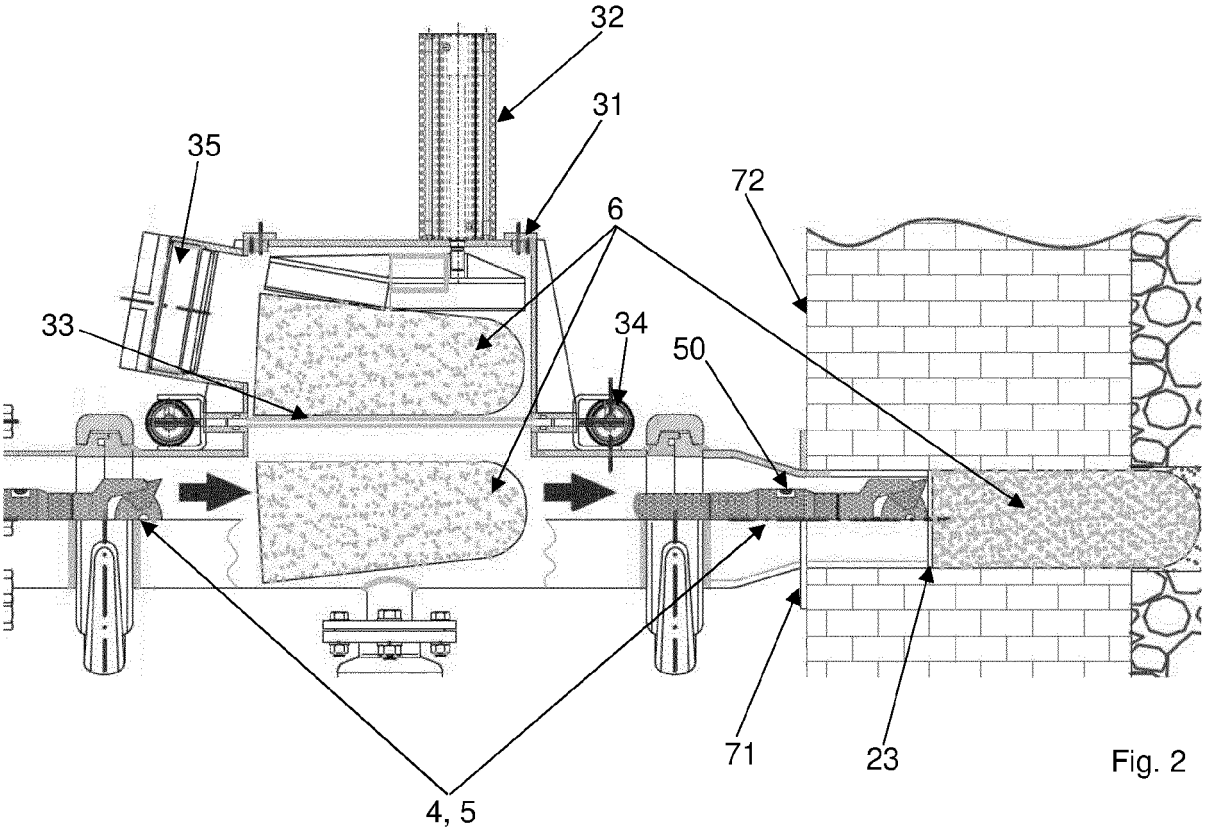


Fig. 2

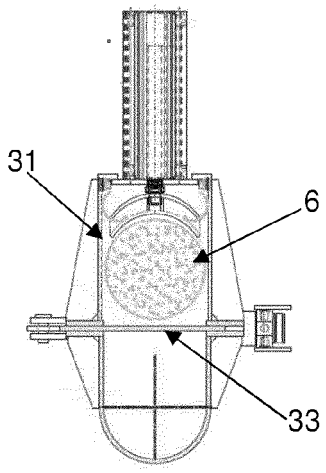


Fig. 3

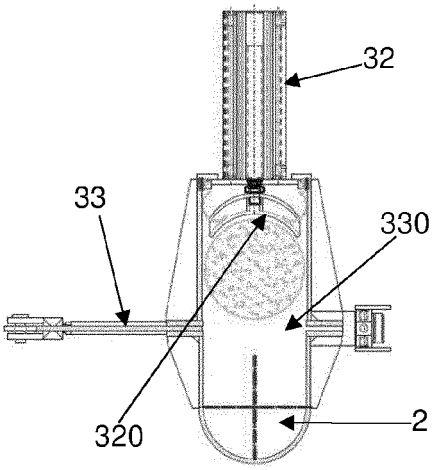


Fig. 4

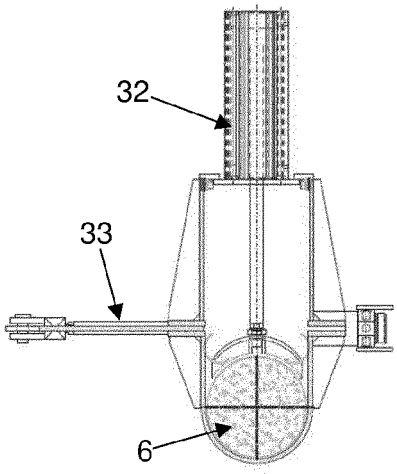


Fig. 5

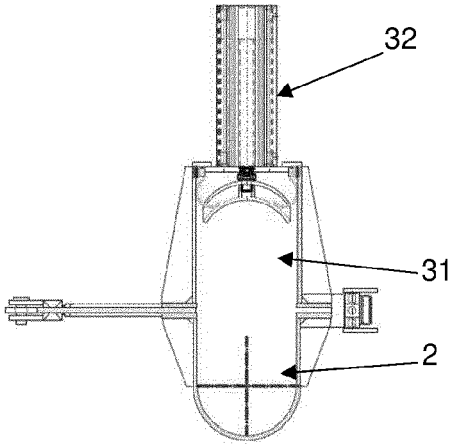


Fig. 6

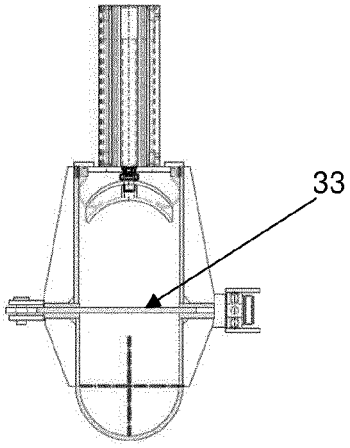


Fig. 7