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

(11) **EP 2 039 881 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
25.03.2009 Bulletin 2009/13

(51) Int Cl.:
E21D 9/00 *(2006.01)* ***E21D 9/06*** *(2006.01)*

(21) Application number: **07116683.9**

(22) Date of filing: **18.09.2007**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC MT NL PL PT RO SE SI SK TR
Designated Extension States:
AL BA HR MK RS

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(54) Process for determining additives used in tunnel boring machines and device

(57) The present invention relates to a method for determining the quantity and/or the composition of an additive and its recipe to the encountered soil and ground water condition of an "Earth Pressure Balanced Machines" (EPBM) characterized in that it comprises at least the following steps of :
- taking at least one sample of the encountered soil,
- mixing the sample with water and/ or with at least one additive to obtain a paste,
- measuring at least one rheological property of said paste, and
- comparing the measured value with predetermined reference values prestored in a database.

In another embodiment, the invention relates to a device for determining the quantity and/or the composition of an additive and its recipe to the encountered soil and ground water condition of an "Earth Pressure Balanced Machines" (EPBM) characterized in that it comprises at least one chamber called reactor including means to introduce a sample of encountered soil into said reactor, means to introduce water and/or at least one additive into reactor, means for mixing to obtain a paste, and means to measure at least one rheological property of said paste.

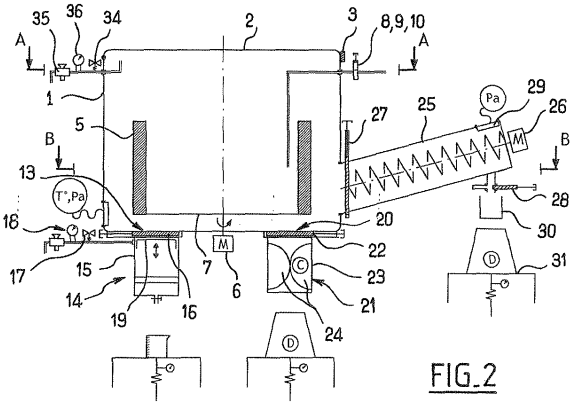

FIG_2

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Description

[0001] The subject matter described herein generally relates to earth pressure balanced shield driving machine, usually called EPBM according to the acronym "Earth Pressure Balanced Machines", and method and more particularly to the additives introduced in the muck of these EPBM.

[0002] In mechanised shield tunnelling in soft ground, the tunnel boring machine called TBM has as a primary function to cut the tunnel profile as it is driven forward and as secondary functions to stabilise the excavated area and to transport the muck away from the cutting head.

[0003] In soft ground, two different types of TBM are currently used STBM according to the acronym "Slurry Shield Machines" and EPBM. These machines differ principally in the method of stabilising the excavated area.

[0004] The STBM achieves the stabilisation of the excavated area by means of bentonite or polymer slurry which is injected at the tunnel.

[0005] With the EPBM, the pressurised excavated ground itself is the support medium for the tunnel face.

[0006] Comparatively to STBM, the EPBM makes the one-site muck handling easier with more traditional means and eliminates the need for a sophisticated separation plant.

[0007] An EPBM usually comprises a cutter head, a working chamber, a pressure wall, a screw conveyor, a thrust arm, a tail sealant, segments and an annulus grout.

[0008] Soil conditioning products, such as additives, are generally injected ahead of the cutter head and often also into the working chamber and screw conveyor.

[0009] By correctly choosing and adapting the additive and its recipe to the encountered soil and ground water condition, iit can:

- Reduce stickiness of plastic clays which can lead to blocakeage of muck conveying,
- Give a lower angle of internal friction and abrasiveness of the soil slurry in order to reduce power for soil extraction and conveyance and wear costs,
- Create plastic deformation behaviour,
- Adjust the soil consistency,
- Reduce the soil permeability to minimise water ingress, and
- Take into account environmental issues such as biodegrability and spoil treatment.

[0010] An example of additive is disclosed in the Japanese patent application JP 7082559. The additive is prepared by mixing water with 1-80 vol.% at least one water-soluble organic polymeric compound selected from among polysodium acrylate, polyacrylamide, carboxymethylcellulose, sodium carboxymethyl cellulose, sodium alginate, PVA, starch, etc... and 100 vol.% clay.

[0011] Nevertheless, this kind of additive is not adapted for every encountered soil and the quantity of the additives is generally determined by the operator in such a manner that it is not efficient for most of the encountered soil.

[0012] To overcome this drawback, the Japanese patent application JP 6173583 discloses an EPBM comprising a plurality of sensors for measuring muck resistance in front of a rotary cutter of an EPBM and additive injection holes at a plurality of point on a partition wall. The EPBM includes a plurality of resistance type sensors disposed at regular intervals on a cutter wing in front of a rotary cutter. The sensor comprises a resistor which is erected in such a manner as to be slidable a certain distance in the rotational direction of the cutter wing, a displacement gauge, etc... Measured data from each of the sensors are inputted into a central processing unit CPU, where resistance values of mud at a point where each sensor is located are computed based on predetermined calculation equations and processed to display distributing states of mud in front of a facing. Based on the distribution of properties of mud obtained, a required amount of additives is forced through the injection holes of the partition wall into the mud where the additives are in short supply to obtain specified mud properties.

[0013] This kind of device is expensive and does not present a sufficient efficiency, the composition of the additive being not adapted to the encountered soil.

[0014] There is a need for a method and a device which can determine the quantity and the composition of the additive according to the encountered soil for usual EPBM.

[0015] The above-mentioned need is addressed by the embodiments described herein in the following description.

[0016] In one embodiment, a method for determining the quantity and/or the composition of an additive and its recipe to the encountered soil and ground water condition of an "Earth Pressure Balanced Machines" (EPBM) is provided. The method includes the following steps of:

- taking at least one sample of the encountered soil,
- mixing the sample with water and/ or with at least one additive to obtain a paste,
- measuring at least one rheological property of said paste, and
- comparing the measured value with predetermined reference values prestored in a database.

[0017] The additive is a foam and/or a polymer.

[0018] Moreover, the paste can be heated.

[0019] The input power consumption needed to rotate the mixer paddle is measured and/or the stability of the paste is measured.

[0020] Said stability is measured by :

- pouring the paste into a perforated glass or plastic cylinder of an atmospheric filter press, and
- measuring the level of the material and the liquid

drained during a determined time.

[0021] Moreover, the plasticizing effect of the paste is measured and/or the permeability of the paste is determined by the constant head method and/or the plastic viscosity and yield stress of the paste are measured.

[0022] The plastic viscosity and yield stress of the paste are measured by filling a slump cone between an horizontal base plate and an horizontal top plate sliding along a vertical rod, the yield stress being expressed in terms of final slump and paste density while the plastic viscosity being a function of final slump time and paste density.

[0023] The density of the paste is measured. This measurement is achieved by pouring a determined volume of paste sample into a cup and by measuring the weight of the fill cup.

[0024] Moreover, the shear strength of the paste is measured and/or the fluid loss of the paste is measured by using baroïd bentonite fluid loss apparatus.

[0025] Advantageously, before measuring at least one rheological property of the paste, said paste is pressurized and maintained under a constant pressure. Said pressure is up to 0.4 MPa.

[0026] In another embodiment, a device for determining the quantity and/or the composition of an additive and its recipe to the encountered soil and ground water condition of an "Earth Pressure Balanced Machines" (EPBM) is provided. The device comprises at least one chamber called reactor including means to introduce a sample of encountered soil into said reactor, means to introduce water and/or at least one additive into reactor, means for mixing to obtain a paste, and means to measure at least one rheological property of said paste.

[0027] The reactor is a cylindrical box including a removable cover with locking means.

[0028] Moreover, the device comprises at least one gate valve to introduce into the reactor a foam and/ or polymer.

[0029] Said device comprises a blender including paddles extending into said reactor and a motor driving said paddles around the axle of the reactor. The motor extends into a column holding the reactor.

[0030] In another embodiment, the motor extends in a horizontal casing emerging into the lower part of a column holding the reactor, the axle of the motor driving the axle of the blender by way of an universal joint.

[0031] Moreover, said reactor comprises on its upper part a discharge valve and on its bottom a Baroïd fluid loss type apparatus.

[0032] Said reactor comprises on its bottom a rubber diaphragm and a diaphragm valve coupled to a modified slump system.

[0033] A screw conveyor emerges into the lower part of the reactor, said screw conveyor extending radially from said reactor.

[0034] The screw conveyor comprises at its free end an exit flow supplying a modified slump system.

[0035] Said screw conveyor comprises at its free end an internal pressure sensor.

[0036] Moreover, the reactor comprises at its lower part an internal temperature sensor and an internal pressure sensor.

[0037] Embodiments of varying scope are described herein. In addition to the aspects described in this summary, further aspects will become apparent by reference to the drawings and with reference to the detailed description that follows.

- Figure 1 is a diagram of the principal steps of the method according to the invention,
- Figure 2 is a schematic representation in elevation view of the device according to the invention,
- Figure 3 is a schematic representation in elevation view B-B of the device according to the invention represented at the figure 1,
- Figure 4 is a schematic representation in elevation view A-A of the device according to the invention represented at the figure 1,
- Figure 5 is a plan view of the device according to the invention,
- Figure 6 is an elevation view A-A of the device according to the invention represented at the figure 5,
- Figure 7 is an elevation view B-B of the device according to the invention represented at the figure 5,
- Figure 8 is an elevation view C-C of the device according to the invention represented at the figure 5,
- Figure 9 is an elevation view C-C of another embodiment of the device according to the invention represented at the figure 5.

[0038] Referring to figure 1, the method for determining the quantity and/or the composition of an additive and its recipe to the encountered soil and ground water condition of an "Earth Pressure Balanced Machines" (EPBM) comprises a first step 100 of taking at least one sample of the encountered soil and a second step 200 of mixing the sample with water and/ or with at least one additive to obtain a paste. The additive is typically chosen among the following list, alone or in combination, well known by the man skilled in the art:

- a foam :maintenance of pressure effect, fluidizing effect for the soil, creation of an homogeneous soil paste, permeability reduction lowering of torque, dispersing of clay, reduction of abrasion.
- a foam inhibitor : elimination of foam effects for the soil.
- a dispersing agents : mainly for heavy clay soil
- anti-abrasion agents : to ad to very abrasive soils or rock formation, to reuce wear of the cutting head and it tools, extraction screw.
- bentonite or similar particles : addition of fine particles to soils with lack of fines, support for polymer and foam, to use for maintenance and repair works.

- other additives : structuring effect on non-cohesive soils, stabilizing of foam or soil, water retention, viscosity effects.

[0039] For example, the additive can be a polymer.

[0040] Then, the process has a step 300 of measuring at least one rheological property of the paste obtained by mixing the sample of soil and the additive.

Mixing Method

[0041] The first measure is a measure of the input power consumption needed to rotate a mixer paddle when different combinations of materials are mixed in the mixer bowl.

[0042] Note that the goal of adding a foam or any additive in the soil's sample is to reduce the wear in the moving parts of the EPBM as well as the reduction of the required torque.

Stability of foam

[0043] The second measure is a measure of the stability of a foam when mixed with a standard soil at various foam quantities. We measure the degeneration speed of a foam when said foam is mixed with a soil in comparison with the degeneration speed of the foam alone.

[0044] Adequate samples in one hand of soil and water and in second hand of soil and foam mixture is prepared. Then, each sample is poured into a perforated glass/plastic cylinder with an atmospheric filter press for example.

[0045] The level of the material and the liquid draines is checked during the first hour, and on a daily or half daily basis over 21 days for example.

Plasticising effect of the foam

[0046] A third measure is a measure of the plasticizing effect of a foam using a reference soil and various foam quantities.

[0047] Adequate samples in one hand of soil and water and in second hand of soil and foam mixture is prepared. Then, the changes in permeability of each sample is determined by a procedure similar to he constant head method.

[0048] This procedure consists in an usual procedure well known by the man skilled in the art.

Modified slump test

[0049] The solidified slump test is intended to measure both the plastic viscosity and yield stress of samples.

[0050] The apparatus for this modified slump test consists for example of a vertical rod that extends from a horizontal bas plate thought the center of a standard slump cone.

[0051] The slump cone is filled with sample and a sliding disk is placed on top located on the vertical rod. After, the disk comes to rest, the sample continues to subside to its final position. The final slump measurement is recorded about 60 seconds after the removal of the slump cone.

[0052] The rheological parameters of yield stress and plastic viscosity can be expressed in fundamental units equations based on the results of the test.

[0053] The yield stress is expressed in terms of final slump and sample density according to an equation well known by the man skilled in the art.

[0054] The plastic viscosity is a function of final slump time and sample density according to an equation well known by the man skilled in the art.

[0055] Note that the equation for plastic viscosity is based on a semi-empirical model developed by using the results of the slump test.

[0056] In another embodiment of this modified slump test, the vertical rod is substituted by a magnetorestrictive or capacitive type linear displacement sensor. The measuring head is leaved below the base and the magnetic or capacitive ring is attached to the sliding top plate. A data acquisition system read the measure of the sensor. In this way, a very accurate measurement is obtained and the operator error in determining the slump time is avoided.

Density

[0057] A determined volume of paste sample is poured into a cup and the weight of the fill cup is measured using a balance.

[0058] The measurement of the density is given by the weight of the fill cup divided by the volume of the paste sample.

Shear stress

[0059] The shear stress of paste sample is measured.

[0060] The standard measuring system well known by the man skilled in the art consists of a stationary paddle which is mounted concentrically in a rotting cylindrical sample container. As the sample flows around the paddle, the shear stress generates a torque which is continuously monitored electronically. The paddle is advantageously mounted on a measuring head which run up and down automatically to allow easy filling, emptying and cleaning of the sample container.

Water loss

[0061] The water loss under 0.4 MPa is measured using an usual baroid bentonite fluid loss apparatus.

[0062] The measure is performed in a 3 inch vertical cylinder, approximately 2.5 inches in height. A porous mesh is placed at the base of the cylinder, with a thin filter paper placed over it. A predetermined ratio of paste is poured into the cylinder. The cylinder is then pressu-

rized to 0.4 MPa. As the filtrated water drains from the bottom of the cylinder, it is collected in abreaker and the mass of water is measured and recorded during the time up to air bubbles appear.

Conveyor adhesion

[0063] The adhesion of conditioned soil to a rubber conveyor is characterized.

[0064] A conveyor rubber piece is placed horizontally and attached to a supporting steel frame, one side of the steel frame being articulated to the floor. A determined amount of conditioned soil is poured on the rubber base to obtain a homogenous layer of about 100 mm thickness. Then, the support frame is raised vertically increasing the slope angle up to the conditioned soil is flowed out from the rubber base.

[0065] Then, the angle of the support frame is measured. The sample temperature should comprise between 20 and 25 °C.

[0066] All these measurement are performed under atmospheric pressure and are intended to characterize the behavior of the soil mixed with at least one additive in the chamber of an EPBM.

[0067] Nevertheless, the pressure at the front face in an EPBM chamber modifies the characteristics of liquid-solid interfaces.

[0068] Advantageously, the measurement of the input power consumption, of the plasticizing effect of a foam and more particularly of the plastic viscosity and the yield stress and of stability of a foam are performed under confining pressure up to 0.4MPa.

[0069] Then, in a last step 400, the measured values are compared with predetermined reference values prestored in a database, for example, for. determining the quantity and/or the composition of an additive and its recipe to the encountered soil and ground water condition of an "Earth Pressure Balanced Machines" (EPBM).

[0070] Referring to figure 2 to 4, the device according to the invention comprises a cylindrical box 1 called reactor including a removable cover 2 with locking means 3, said reactor receiving a sample of encountered soil. The locking means 3 can be any convenient locking means such as mechanical or magnetic locking means, well known by the man skilled in the art.

[0071] Moreover, the device comprises a blender 4 including paddles 5 extending into said reactor 1 and a motor 6 driving said paddles 5 around the axle X-X' of the reactor 1 in such a manner that the soil does not stick on the bottom of the reactor 1. The motor 6 is placed under the reactor 1 and the driving axis of said motor 6 is equipped with a torque sensor, not represented in figures, so as to define, for every kind of soil, the necessary power for a given rheology. The torque is measured by means of the torque sensor and also with a wattmeter. The motor 6 has a sufficient power and has a variable speed drive from 0 to about 120 rpm. Said motor 6 can turn in a regular way in very weak speed, about 1 or 2 rpm, corresponding to the average speed of rotation of the EPBM's cutter head.

[0072] The mobile paddles 5 are parallel to the axis X-X' of the reactor, each paddle 5 being fixed at the free end of an arm 7 rotated by the driving axle of the motor 6. These paddles 5 are interchangeable and can be substituted by another paddles adapted for a different type of soil.

[0073] Incidentally, the device comprises fixed paddles, not shown in the figures, consisting of tubes which allow shearing the soil inside the reactor and an additional cylinder extending from the bottom of the reactor 1, coaxially, to keep the soil in the mixed zone of said reactor 1.

[0074] To introduce into the reactor 1 water and/or a foam and/ or polymer and/or any additive, said device comprises at least one gate valve 8, 9 and 10. In this embodiment, the device comprises three gate valve uniformly réparti around the reactor 1 (figure 4), a first gate valve 8 for the foam (compressed air + foaming solution + additive), a second gate valve 9 for polymer and a third gate valve 10 for spare.

[0075] Referring, to figure 4, the device comprises also a gate valve 11 equipped with a manometer 12 to maintain a constant pressure up to 0.4 MPa into the reactor 1.

[0076] Referring to figures 2 and 3, the reactor 1 comprises a first exhaust 13 on its bottom to evacuate the paste toward a baroïd fluid loss type apparatus 14 including a bowl 15. The exhaust 13 includes a gate valve 16, a discharge valve 17 and a compressed air regulation system 18. The discharge valve 17 is opened in the bowl 15 to return the internal pressure at the level of atmospheric pressure. The fraction of soil which is at the contact of the gate valve 16 and which could be badly mixed can be evacuated by a piston 19. The gate valve 16 is opened and the piston 19 is placed in such a manner that it fill up the exhaust 13. Then, the piston 19 is pushed down and the inhomogeneous mixture is evacuated through the discharge valve 17 As described in the foregoing, the test consists in measuring the quantity of water which gets through a filter when the soil is still under pressure, the quantity of water as well as the time necessary for total drainage of the paste sample being measured,

[0077] The reactor 1 comprises also a second exhaust 20 on its bottom to evacuate the paste sample toward a diaphragm system 21. The exhaust 20 includes a valve 22 and the diaphragm system consists in a tube 23 containing a diaphragm 24 with a variable opening controlled by pressure of water for example. The faculty of the soil to pass through a defined section is measured. The diameter of the opening, for each type of soil, is defined during measurement at the atmospheric pressure prior to the measurement under pressure. The test is obtained by opening the valve 22 in such a manner that the paste sample penetrates into the tube 23 and passes through the diaphragm 24. The necessary time to fill the known volume of the bowl placed under the diaphragm system 21 with atmospheric pressure is measured. This test allows measuring the apparent density of the paste sample

at the exit of the reactor 1. The test can be performed with preservation of the pressure in the reactor 1 or without preservation of the pressure in the reactor 1, the pressure being cut in the reactor 1 prior to the opening of the valve 22 to extract soil.

[0078] Moreover, the device comprises a screw conveyor 25 drived by a motor 26 and emerging into the lower part of the reactor 1, said screw conveyor 25 extending radially from the base of the reactor 1 with a vertical inclination. A first valve 27 controls the opening of the screw conveyor 25 and a second valve 28 controls the exit of said screw conveyor 25, said screw conveyor comprising at its free end an internal pressure sensor 29. When the first valve 27 is opened, the tube of the screw conveyor 25, at atmospheric pressure, is filled with the paste sample. The opening of the exit valve 28 allows verifying that the screw conveyor 25 is full when the paste sample begins to go out. The measure consists in measuring the time put by the soil to fill a known volume of a bowl 30 placed under the exit of the screw conveyor 25. This volume of paste sample can be used to realize a test with a modified slump test system 31 as described in the foregoing. Another extraction can be performed at the exit of the screw conveyor to do a conveyor adhesion test as previously described.

[0079] To control parameters of the reactor 1 such as the temperature and the pressure, said reactor 1 comprises in one hand an internal temperature sensor 32 and an internal pressure sensor 33 at its lower part and in another hand a discharge valve 34, a safety valve 35 and a manometer 36.

[0080] Referring to figures 5 to 8, a preferred embodiment of the invention comprises a horizontal platform 37 holding a vertical column 38 receiving the motor 6 driving the blender 4, the reactor 1 being placed at the top of the column.

[0081] Incidentally, a transmission shaft 39 between the motor 6 and the blender 4 extends in the column 38, said transmission shaft 39 comprising one or a plurality of gear reducer 40.

[0082] In another embodiment of the invention, referring to figure 9, the motor 6 extends in a horizontal casing 41 emerging into the lower part of the column 38 holding the reactor 1, the axle of the motor 6 driving the axle of the blender 4 by way of a transmission shaft 39 including an universal joint 42.

[0083] This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to make and use the invention. The scope of the subject matter described herein is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal languages of the claims.

Claims

1. - Method for determining the quantity and/or the composition of an additive and its recipe to the encountered soil and ground water condition of an "Earth Pressure Balanced Machines" (EPBM) **characterized in that** it comprises at least the following steps of :

- taking at least one sample of the encountered soil,
- mixing the sample with water and/ or with at least one additive to obtain a paste,
- measuring at least one rheological property of said paste, and
- comparing the measured value with predetermined reference values prestored in a database.

2. - Method according to claim 1 **characterized in that** the additive is a foam.

3. - Method according to any claim 1 or 2 **characterized in that** the additive is a polymer.

4. - Method according to any claim 1 to 3 **characterized in that** the paste is heated.

5. - Method according to any claim 1 to 4 **characterized in that** the input power consumption needed to rotate the mixer paddle is measured.

6. - Method according to any claim 1 to 5 **characterized in that** the stability of the paste is measured.

7. - Method according to claim 6 **characterized in that** the stability is measured by:

- pouring the paste into a perforated glass or plastic cylinder of an atmospheric filter press, and
- measuring the level of the material and the liquid drained during a determined time.

8. - Method according to any claim 1 to 7 **characterized in that** the plasticizing effect of the paste is measured.

9. - Method according to claim 8 **characterized in that** the permeability of the paste is determined by the constant head method.

10. - Method according to any claim 1 to 9 **characterized in that** the plastic viscosity and yield stress of the paste are measured.

11. - Method according to claim 10 **characterized in that** the plastic viscosity and yield stress of the paste are measured by filling a slump cone between an

horizontal base plate and an horizontal top plate sliding along a vertical rod, the yield stress being expressed in terms of final slump and paste density while the plastic viscosity being a function of final slump time and paste density.

12. - Method according to any claim 1 to 11 **characterized in that** the density of the paste is measured.

13. - Method according to claim 12 **characterized in that** a determined volume of paste sample is poured into a cup and the weight of the fill cup is measured.

14. - Method according to any claim 1 to 13 **characterized in that** the shear strength of the paste is measured.

15. - Method according to any claim 1 to 14 **characterized in that** the fluid loss of the paste is measured by using baroïd bentonite fluid loss apparatus.

16. - Method according to any claim 1 to 15 **characterized in that** before measuring at least one rheological property of the paste, said paste is pressurized.

17. - Method according to claim 16 **characterized in that** the paste is maintained under a constant pressure.

18. - Method according to claim 17 **characterized in that** the pressure is up to 0.4 MPa.

19. - Device for determining the quantity and/or the composition of an additive and its recipe to the encountered soil and ground water condition of an "Earth Pressure Balanced Machines" (EPBM) **characterized in that** it comprises at least one chamber called reactor (1) including means to introduce a sample of encountered soil into said reactor (1), means to introduce water and/or at least one additive into reactor (1), means for mixing to obtain a paste, and means to measure at least one rheological property of said paste.

20. - Device according to claim 19 **characterized in that** the reactor (1) is a cylindrical box including a removable cover (2) with locking means (3).

21. - Device according to claim 20 **characterized in that** it comprises at least one gate valve (8, 9, 10) to introduce into the reactor (1) a foam and/ or polymer.

22. - Device according to any claim 20 or 21 **characterized in that** it comprises a blender (4) including paddles (5) extending into said reactor (1) and a motor (6) driving said paddles (5) around the axle of the reactor (1).

23. - Device according to claim 22 **characterized in that** the motor (6) extends into a column (38) holding the reactor (1).

24. - Device according to claim 22 **characterized in that** the motor (6) extends in a horizontal casing (41) emerging into the lower part of a column (38) holding the reactor (1), the axle of the motor (6) driving the axle of the blender (4) by way of an universal joint (42).

25. - Device according to any claim 20 to 24 **characterized in that** said reactor (1) comprises on its upper part a discharge valve (34).

26. - Device according to any claim 20 to 25 **characterized in that** said reactor (1) comprises on its bottom a Baroïd fluid loss type apparatus (14).

27. - Device according to any claim 20 to 26 **characterized in that** said reactor (1) comprises on its bottom a diaphragm system (21).

28. - Device according to any claim 20 to 27 **characterized in that** it comprises a screw conveyor (25) emerging into the lower part of the reactor (1), said screw conveyor (25) extending radially from said reactor (1).

29. - Device according to claim 28 **characterized in that** the screw conveyor (25) comprises at its free end an exit flow supplying a modified slump system (31).

30. - Device according to any claim 28 or 29 **characterized in that** said screw conveyor (25) comprises at its free end an internal pressure sensor (29).

31. - Device according to any claim 19 to 30 **characterized in that** the reactor (1) comprises at its lower part an internal temperature sensor (32).

32. - Device according to any claim 19 to 31 **characterized in that** the reactor comprises at its lower part an internal pressure sensor (33).

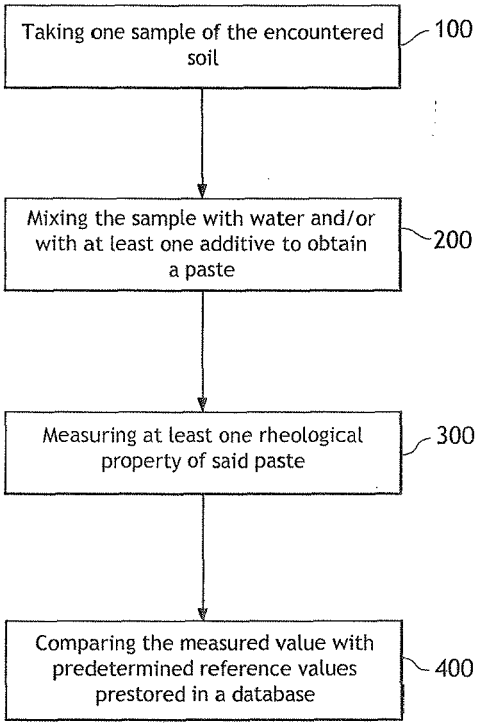
Taking one sample of the encountered soil
100
Mixing the sample with water and/or with at least one additive to obtain a paste
200
Measuring at least one rheological property of said paste
300
Comparing the measured value with predetermined reference values prestored in a database
400

FIG.1

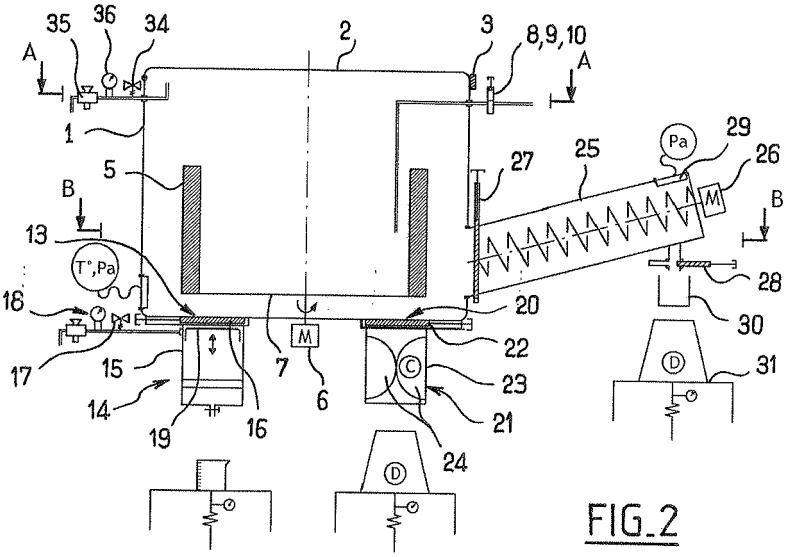

FIG_2

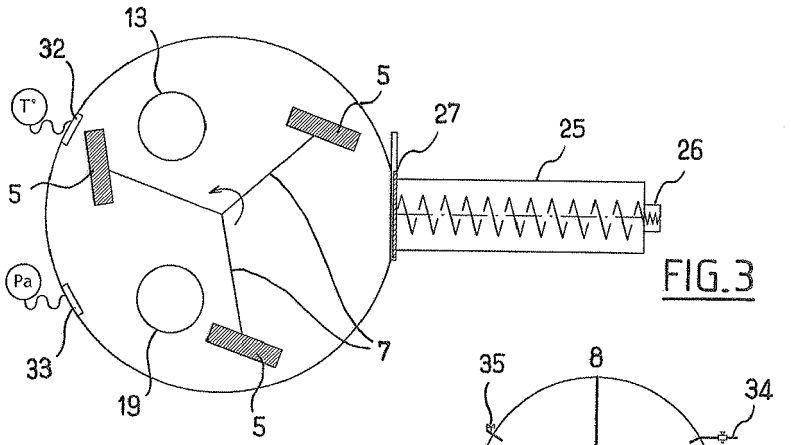

FIG_3

FIG_4

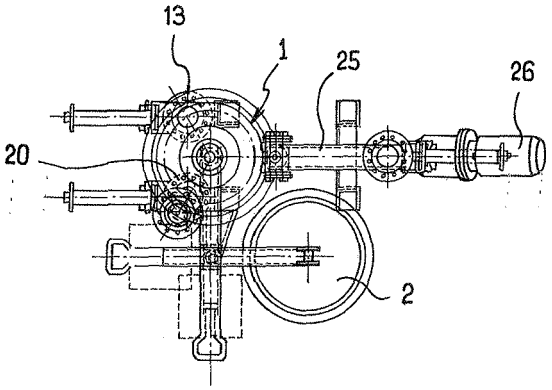

FIG_5

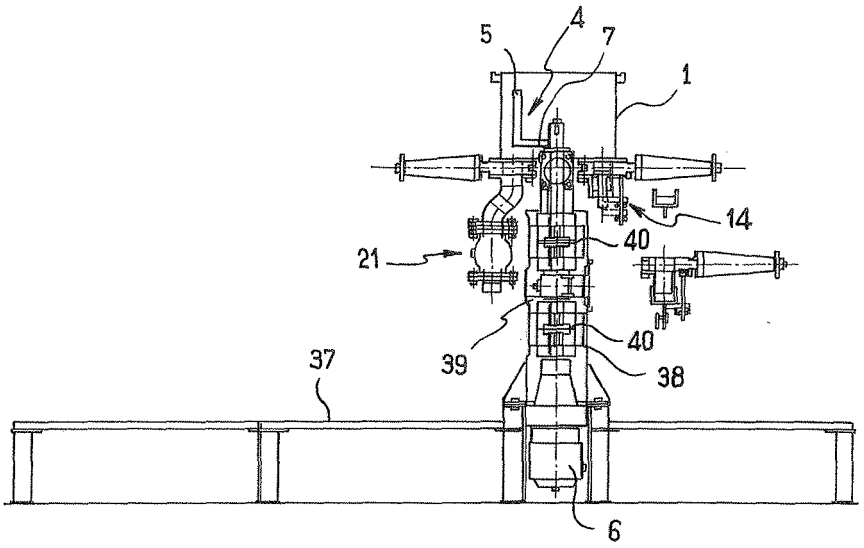

FIG_6

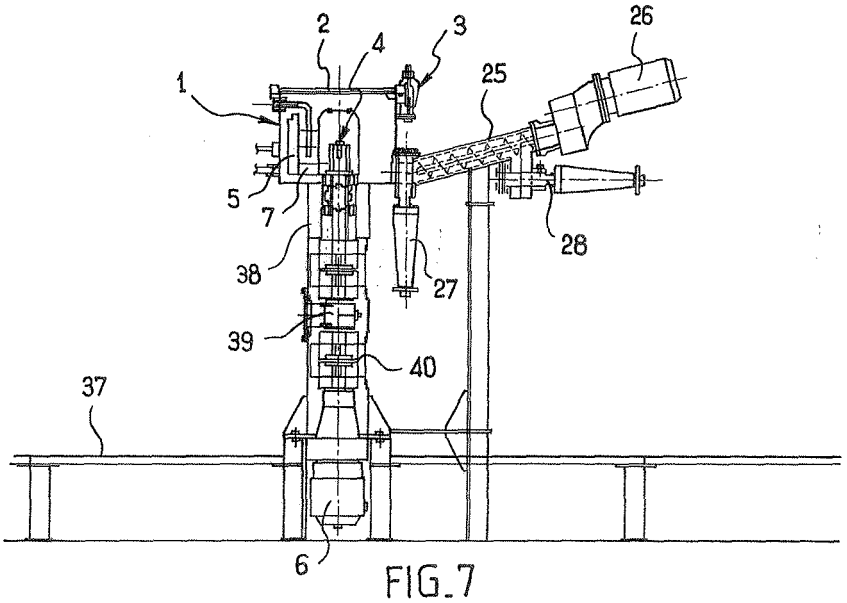

FIG_7

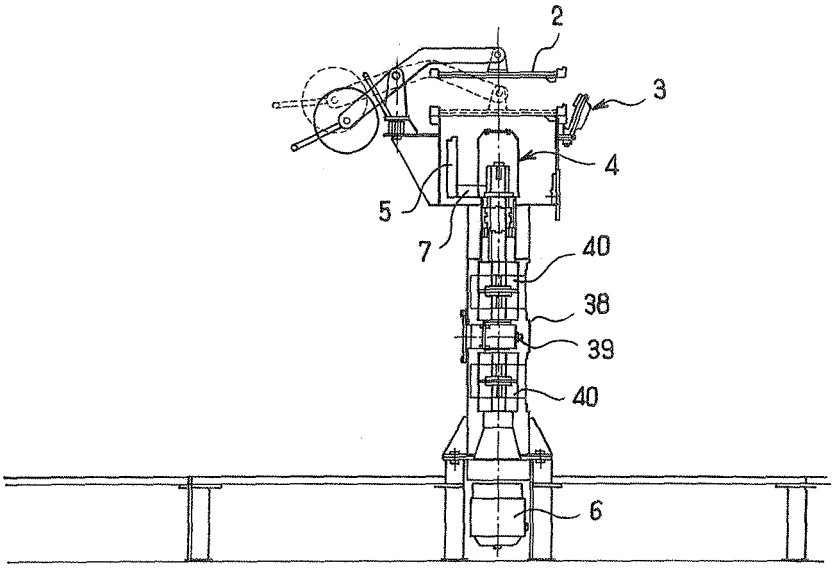

FIG_8

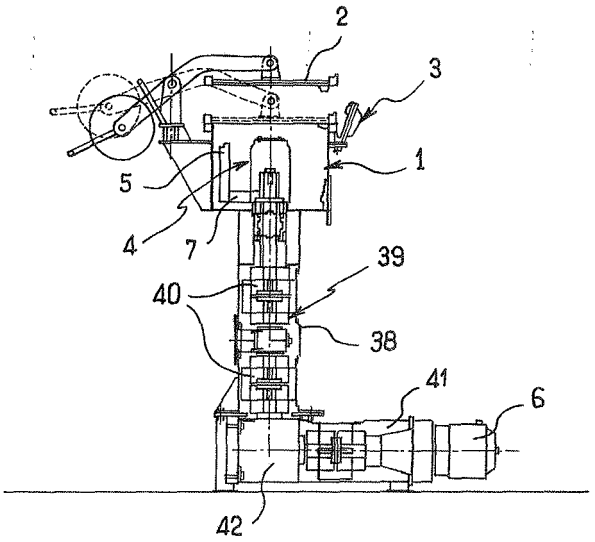

FIG_9

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	18 December 2007	Morrish, Susan

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