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

(11) EP 2 520 724 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
07.11.2012 Bulletin 2012/45

(51) Int Cl.:
E02D 3/11 *(2006.01)*

(21) Application number: **11425126.7**

(22) Date of filing: **06.05.2011**

(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

(71) Applicant: **Novatek S.r.l.**
37021 Bosco Chiesanuova (Verona) (IT)

(72) Inventor: **Canteri, Renato**
37021 Bosco Chiesanuova (Verona) (IT)

(74) Representative: **Ponchiroli, Simone**
Ruffini Ponchiroli e Associati S.r.l.
Via Caprera, 6
37126 Verona (IT)

(54) **Method and plant for treating foundation soils by means of electro-osmosis**

(57) A method for treating foundation soils by means of electro-osmosis, in which a pulsating unidirectional voltage is applied between a plurality of first electrodes (1) and second electrodes (2) to bring about a passage of pulsating unidirectional current through the soil. Preferably, the first electrodes (1) and the second electrodes (2) are arranged alternately around the foundation soil to be treated. In one embodiment the method also comprises the use of one or more third electrodes (3) which are placed in a central position relative to the foundation soil to be treated, which are used as additional negative electrodes if the treatment is intended to draw water into the foundation soil, and as the only positive electrodes if the treatment is intended to remove water from the foundation soil. A plant for implementing said method is also claimed.

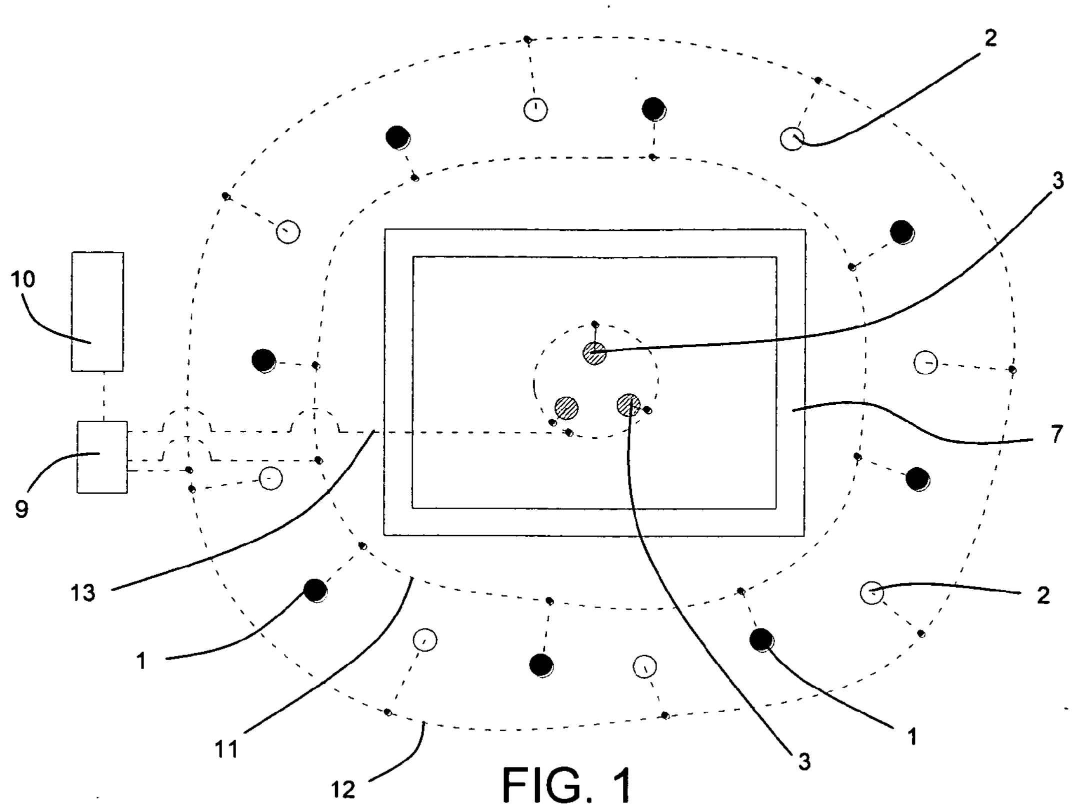

FIG. 1

EP 2 520 724 A1

Description

[0001] This invention relates to a method and a plant for treating foundation soils by means of electro-osmosis.

[0002] As is known, electro-osmosis is a method involving modification of the amount of water contained in a soil by means of application of a unidirectional voltage between two points of the soil and is advantageously applied in the case of clayey soils and the like. Indeed, in general, it is known that by applying a direct voltage between two points of the soil, the water contained in it tends to move from the positive electrode to the negative electrode. However, this being a method which in itself is known to experts in the field, it will not be described in further detail as regards its operating principles.

[0003] Until now, electro-osmosis has been used with two opposite aims: either to remove water from excessively wet soils, or to add water to excessively dry soils.

[0004] In particular, examples of this latter application are described in patent applications EP 1 108 817 and EP 2 231 934.

[0005] In all of the prior art applications the electro-osmosis process is carried out by applying a direct voltage between the electrodes driven into the soil so as to generate, in the soil, the circulation of a unidirectional direct current.

[0006] In the case of rehydration of the soil, the technique described in patent application EP 2 231 934 (more complete and detailed than the other patent application referred to) requires the overall length of treatment to be around six months, divided into a first step in which a direct voltage of between 10 V and 50 V is applied between the electrodes, and a second step (twice as long as the first step) in which an increased direct voltage, equal to at least 100 V and advantageously between 200 V and 400 V is applied between the electrodes.

[0007] Also according to the above-mentioned patent applications, the negative electrodes of the plant must be positioned at the pressure bulb below the foundations present in the soil, whilst the positive electrodes are positioned further away from the building. In other words, in most applications, if seen in plan view the electrodes are positioned according to two concentric circles, one at the foundations and one more external.

[0008] However, the prior art technology has several disadvantages.

[0009] First, as has been seen, with the prior art plants the times necessary to obtain the desired result are relatively lengthy.

[0010] Second, the prior art methods require the use of relatively high direct voltages which result in equally high consumption and consequent costs. Moreover, in some cases, the high voltages involved may even be dangerous for people who accidentally come into contact with them (especially at the end of treatment, hazardous step voltages could even be generated).

[0011] Furthermore, placing the electrodes according to the prior art methods is relatively complicated and invasive, since is requires insertion of the electrodes directly below the foundations, often necessitating drilling of the foundations.

[0012] A further disadvantage of the prior art is the inability to treat all of the layers of the foundation soil in a sufficiently uniform way. Even the solution proposed in patent application EP 2 231 934 which involves the use of two sets of electrodes at different depths is, in fact, unable to overcome this disadvantage.

[0013] Another significant disadvantage of all of the prior art methods and plants is their inability to allow the best level of the amount of water in the soil to be reached and maintained. In fact, depending on the applications, there is always the risk of bringing the amount of water above or below the preset level.

[0014] Finally, but by no means less importantly, the prior art plants have the significant disadvantage of not allowing definitive results to be achieved. Indeed, after months of treatment, only a relatively short time is needed before the soil, if left untreated, loses or accumulates water, sinking or rising according to the specific cases.

[0015] In this context, the technical purpose which forms the basis of this invention is to provide a method and a plant for treating foundations soils by means of electro-osmosis which overcome the above-mentioned disadvantages.

[0016] In particular, the technical purpose of this invention is to provide a method and a plant for treating foundation soils by means of electro-osmosis which allows a reduction in energy consumption and the related costs compared with the prior art methods.

[0017] It is also the technical purpose of this invention to provide a method and a plant for treating foundation soils by means of electro-osmosis which, at least in the most complete embodiments, guarantee a result which is constant as time passes.

[0018] A further technical purpose of this invention is to provide a method and a plant for treating foundation soils by means of electro-osmosis which, at least in some embodiments, allow precise control of the level of water contained in the soil.

[0019] Yet another technical purpose of this invention is to provide a method and a plant for treating foundation soils by means of electro-osmosis which, at least in some embodiments, allow easier installation of the electrodes in the soil and which guarantees more uniform treatment of the different layers of the soil.

[0020] The technical purpose specified and the aims indicated are substantially achieved by method and a plant for treating foundation soils by means of electro-osmosis as described in the appended claims.

[0021] Further features and the advantages of this invention are more apparent in the detailed description, with reference to the accompanying drawings which illustrate several preferred, non-limiting embodiments of a method and a plant for treating foundation soils by means of electro-osmosis, in which:

- Figure 1 is a schematic plan view of a first embodiment of the method and the plant according to this invention;
- Figure 2 is a view of a more complex embodiment of the method and the plant of Figure 1, with some parts cut away for clarity;
- Figure 3 is a view of a first way of applying the method according to this invention using the plant of Figure 1, for increasing the water content of the foundation soil;
- Figure 4 is a view of a second way of applying the method according to this invention using the plant of Figure 1, for reducing the water content of the foundation soil;
- Figure 5 is a schematic plan view with many parts cut away for clarity, of a second embodiment of the method according to this invention;
- Figure 6 is an axial section of a piece of a pipe and of an electrode;
- Figures 7 to 12 show six different waveforms which can be used for supplying voltage to the electrodes according to this invention, represented in graphs with the voltage value on the y-axis and the time on the x-axis. The method for treating foundation soils by means of electro-osmosis according to this invention comprises in general, and similarly to the prior art methods, at least the operating steps of inserting in a foundation soil a plurality of first electrodes 1 and a plurality of second electrodes 2 which are spaced out and designed to so that in practice one plurality forms the positive electrodes and the other the negative electrodes, and the step of applying, at least for a predetermined period of time, a unidirectional voltage between the first electrodes 1 and the second electrodes 2 to render them respectively positive and negative electrodes, or negative and positive electrodes. In this way it is possible to bring about a circulation of unidirectional current between the electrodes through the soil, and consequently to draw water into or to remove water from the foundation soil being treated.

[0022] However, in accordance with a first innovative aspect of this invention, unlike all of the prior art methods in which the voltage applied is a direct voltage, in accordance with this invention the voltage application step is performed by applying between the first electrodes and the second electrodes 2 a pulsating unidirectional voltage in such a way as to cause a passage of pulsating unidirectional current between the first electrodes and the second electrodes 2 and through the soil.

[0023] As is explained in more detail below, the choice of which electrodes to use as the positive electrodes and which to use as the negative electrodes depends both on the type of work to be carried out (drawing water in or removing it), and on their arrangement in the foundation soil. In fact, this first aspect of this invention may be implemented irrespective of the arrangement of the electrodes in the soil, which may therefore be of the conventional type (as described for example in patent applications EP 1 108 817 and EP 2 231 934) or of the innovative type described below.

[0024] Depending on requirements, the pulsating unidirectional voltage may be generated with any waveform. For example, Figure 11 shows the case of a unidirectional voltage obtained by means of half-wave rectification of a sinusoidal voltage, while Figure 12 shows the case of a pulsating voltage obtained by means of full-wave rectification of a sinusoidal voltage. In contrast, Figure 10 shows a case similar to that of Figure 11 in which only every other half wave is used.

[0025] However, in the preferred embodiments, a square wave unidirectional voltage is used, such as that illustrated in Figures 7 to 9.

[0026] Depending on requirements, either the voltage may be applied in such a way that each pulse lasts for a time equal to the time separating two consecutive pulses (preferred solution illustrated in Figures 9 and 11), or the length of the pulse and of the time separating two consecutive pulses may be different (the length of the pulse being greater than the separating time in the case in Figures 7 and 12, less than it in the case in Figures 8 and 10).

[0027] As regards the value of the voltage applied and the frequency of the pulses, various solutions may be used. In particular they may be constant in time or vary according to various parameters.

[0028] In particular, in the preferred embodiment both the value and the frequency are reduced as the desired result is approached. In other words, the greater the difference between the water content of the soil and the desired water content to be reached, the greater both the voltage value applied and the frequency of the pulses are. Consequently, in general the voltage and frequency values will be greater at the start of treatment, then will be drastically reduced when treatment reaches the steady state.

[0029] However, in most embodiments, the variation range of the voltage applied is between 2 and 50 V, whilst that of the frequency of the pulses is between several Hertz (advantageously 5 - 10 Hz) and several thousand (advantageously around 2000 Hz). The lowest values are those applicable with treatment at the steady state.

[0030] Tests carried out by the Applicant showed that, even by using relatively low voltages which allow energy consumption to be kept low, powering the electrodes with a pulsating unidirectional voltage allows a faster migration of the water in the soil than the prior art plants.

[0031] A second innovative aspect of this invention, which could even be applied irrespective of what is described above (that is to say, by powering the electrodes in the conventional way with direct voltage), relates to the way in which the various electrodes are positioned in the foundation soil.

[0032] In fact, in its preferred embodiment, in the method according to this invention the steps of inserting the first electrodes 1 and the second electrodes 2 in the soil are carried out in such a way as to position the electrodes alternately around the foundation soil to be treated, as shown in Figures 1 and 2. In this way, the first electrodes 1 (represented by black dots in Figures 1 and 2) and the second electrodes 2 (represented by white dots) are substantially arranged along an annular path surrounding the foundation soil and are alternated. It should be noticed that, in the absence of further electrodes, the arrangement just described is suitable only for drawing water into the foundation soil. In contrast, it cannot be used for removing water from the foundation soil.

[0033] However, according to the preferred embodiment of this invention, the method and the plant are not designed exclusively to remove water from or draw water into the foundation soil, but to allow both such operations to be performed depending on requirements, in order to achieve true control of the soil water content. Consequently, if the foundation soil tends to dry out, the method comprises action to rehydrate it, whilst if it tends to accumulate excess water, the method comprises action to remove the excess.

[0034] This may be achieved with various arrangements of the electrodes. In particular, said result may be achieved with a conventional type arrangement of the electrodes such as that illustrated in Figure 5, simply using the first electrodes 1 and the second electrodes 2 respectively as the negative electrodes and as the positive electrodes for rehydration, and respectively as the positive electrodes and as the negative electrodes for removing excess water.

[0035] However, according to the preferred embodiment illustrated in Figure 1, where the first electrodes and the second electrodes 2 surround the foundation soil and are alternated, the method comprises a further operating step of inserting in the foundation soil one or more third electrodes 3 (three in Figure 1) at a central position relative to the foundation soil to be treated. The third electrodes 3 must be supplied with voltage independently of the other electrodes, so that they can be used as negative electrodes if the treatment is intended to draw water into the foundation soil, and as positive electrodes if the treatment is intended to remove water from the foundation soil (the ways of use are described in more detail below).

[0036] Also according to the preferred embodiment, the method then comprises an operating step of measuring the amount of water contained in the soil (for example with one or more suitable probes 4 inserted in the soil, or using the electrodes themselves), and an operating step of comparing the value measured and a reference value (which advantageously will correspond to the ideal water content for that soil) to determine if the soil can be considered too dry or too wet. Depending on the result of the comparison, the method comprises two different ways of proceeding. If the value measured is less than the reference value, the method comprises applying the voltage in such a way that the first electrodes 1 are the positive electrodes and the second electrodes and the third electrodes 3 are the negative electrodes. If the value measured is greater than the reference value, the method comprises applying the voltage in such a way that the first electrodes and second electrodes 2 are the negative electrodes and the third electrodes 3 are the positive electrodes. The two situations are represented visually respectively in Figures 3 and 4 which show only the foundations and the electrodes. The positive electrodes are shown as white dots and the negative electrodes are shown as black dots.

[0037] Advantageously, the method comprises systematically repeating the measurement and comparison steps, and of swapping the ways of applying the voltage just described if the value measured passes from a value which is less than or greater than the reference value, to a value which is respectively greater than or less than it.

[0038] Another particularly advantageous aspect of this invention (not necessarily linked to the others described above) is the fact that to guarantee that the result remains constant as time passes, the method comprises that the electro-osmotic process is implemented for a indefinite period, not just for a limited period of time as was traditionally the case. However, that is particularly advantageous in the case in which the method comprises true control of the water content as described above.

[0039] If, during the steady state, low voltages are used, maintaining the electro-osmotic process for an indefinite period also involves absolutely low operating costs.

[0040] Similarly to the prior art methods, the method according to this invention may comprise, if water has to be drawn into the foundation soil, a step of feeding additional water to the soil. The water can advantageously be fed by feeding it close to the positive electrodes using a plurality of pipes 5 inserted in the soil (a solution which in itself is known). However, while according to the known methods the positive electrodes are inserted in the water feed pipes 5, according to this invention, the positive electrodes are positioned in the soil outside the pipes 5, advantageously at their outer surface (Figure 6). Since in the preferred embodiments there are no exclusively positive electrodes (the polarity depends on how they are to be used), the pipes 5 will be positioned only at those electrodes intended to be used as positive electrodes if water has to be drawn into the foundation soil.

[0041] In accordance with the preferred embodiment, the pipes 5 are at least partly piezometric, that is to say, provided with a plurality of openings 6 distributed along their length (slits in the case illustrated in Figure 6). Preferably, however, said openings 6 are provided only from a depth lower than that of the foundations 7 present in the soil, in such a way as to limit the risks of water absorption by the foundations 7.

[0042] Also according to the preferred embodiment, the electrodes are not points as in the prior art, but are elongate elements 8 inserted deep in the soil and which act as electrodes at least along most of their length, for treating the entire thickness of the soil in which they are inserted.

[0043] Advantageously, at least the electrodes designed to be used as positive electrodes are made of a passivated metal (for example titanium) in order to prevent corrosion. In contrast, the others may be made of stainless steel.

[0044] To facilitate their fixing in the ground, the electrodes may be made of a plurality of modular components which are connected end-on and whose lower portion may comprise an expanded penetrating head (solution not illustrated).

[0045] Moreover, in the preferred embodiment, the electrodes (and, if present, the pipes 5) extend vertically in the soil at least covering a depth equal to the width of the short side of the foundations 7 (the vertical side in the accompanying drawings 1 to 4). Obviously, in the case of complex foundations 7 the "short side" must be interpreted on each occasion also with reference to individual parts of the foundations 7.

[0046] As regards the plant according to this invention (illustrated in Figures 1 and 2), in order to be able to implement the first innovative aspect described above, it comprises a plurality of first electrodes 1 which can be inserted in the foundation soil, a plurality of second electrodes 2 which can be inserted in the foundation soil, and means 9 for application of a voltage between the first electrodes and the second electrodes 2, structured in such a way as to supply a pulsating unidirectional voltage of the type described above.

[0047] At least in the case in which the plant is designed for the dual purpose of increasing or reducing the water content depending on requirements, it also comprises at least one probe 4 for measuring the amount of water (moisture) contained in the foundation soil (four in Figure 2), and an electronic control unit 10 operatively connected to the probe 4 for receiving the value measured from it and, and also connected to the voltage application means 9 to control their activation. In the case of the plant of Figure 5 (where the control unit 10, probe 4 and electrical connections are not illustrated, since they are similar to those of Figure 1), the control unit 10 is programmed to swap the polarity of the first electrodes 1 and the second electrodes 2 as indicated above. As an alternative to using suitable probes 4 for measuring the amount of water (moisture), it is also possible to use as probes 4 the electrodes themselves and the control unit 10. By using the control unit 10 to apply a voltage between two electrodes and measuring the current circulating it is possible to ascertain the resistance (or resistivity) of the soil between the electrodes. Then, a specific calibration is all that is needed in order to be able to monitor the trend of the soil water content. Therefore, hereinafter, any references to probes 4 refer to all possible embodiments of them.

[0048] In contrast, in the case of the preferred embodiment in Figure 1, the plant also comprise even one or more third electrodes 3 which can be inserted in the foundation soil and can be powered by the voltage application means 9, and the electronic control unit 10 is programmed to compare the value measured by the probe 4 with the reference value and, if the value measured is less than the reference value, to have the voltage applied in such a way that the first electrodes 1 are the positive electrodes and the second electrodes and the third electrodes 3 are the negative electrodes, whilst, if the value measured is greater than the reference value, it has the voltage applied in such a way that the first electrodes and the second electrodes 2 are the negative electrodes and the third electrodes 3 are the positive electrodes. In Figure 1 the dashed lines represent a first electric line 11, a second electric line 12 and a third electric line 13 which connect the voltage application means 9 respectively to the first electrodes 1, to the second electrodes 2 and to the third electrodes 3.

[0049] In the case in which the plant also allows the possibility of feeding the soil with additional water, it also comprises means 14 for feeding the external water at the positive electrodes, and the control unit 10 is connected to said feed means 14 to control their activation depending on the value measured by the probe 4. Advantageously, the feed means 14 comprise a plurality of pipes 5 inserted in the soil as described above and a hydraulic feed circuit 15 intercepted upstream by at least one solenoid valve 16 controlled by the control unit 10. Although in the embodiment illustrated in Figure 2 (where all of the parts relating to the electric power supply to the electrodes have been cut away for clarity) there is a single solenoid valve 16 which controls the feeding of water to all of the pipes 5, in other, more complex embodiments not illustrated, the hydraulic circuit 15 may be divided into a plurality of branches, each equipped with a solenoid valve and designed to feed only a limited number of pipes 5. Combining that embodiment with the use of several probes 4 distributed in the foundation soil (as illustrated in Figure 1) it is possible to feed the water selectively only in the zones which require it.

[0050] This invention brings important advantages.

[0051] First, the use of a unidirectional power supply voltage that is pulsating rather than direct allows a reduction in the times needed to achieve the desired result compared with the conventional methods, more so in the case of variation of the peak voltage value applied and the frequency of the pulses according to what is indicated above.

[0052] Second, using very low steady state voltages (two orders of magnitude less than the conventional methods) it is possible to keep the plant operating endlessly with consumption, and consequent costs, which are practically negligible. Consequently, it is also possible to obtain a definitive result. Moreover, the use of low voltages also minimises the risks for people.

[0053] By adopting the preferred arrangement of the electrodes described above, their installation is easy and non-invasive.

[0054] The use of elongate electrodes allows all of the layers of the foundation soil to be treated in a uniform way.

[0055] In addition, by adopting the more complete embodiment which allows an inversion of the electro-osmosis operation, it is possible to achieve and maintain the best level of the amount of water in the soil.

[0056] Finally, it should be noticed that this invention is relatively easy to produce and that even the cost linked to implementing the invention is not very high. The invention described above may be modified and adapted in several ways without thereby departing from the scope of the inventive concept. Moreover, all details of the invention may be substituted with other technically equivalent elements and the materials used, as well as the shapes and dimensions of the various components, may vary according to requirements.

Claims

1. A method for treating foundation soils by means of electro-osmosis, comprising the operating steps of:

inserting in a foundation soil a plurality of first electrodes (1) and a plurality of second electrodes (2) which are spaced out; and

applying, at least for a predetermined period of time, a unidirectional voltage between the first electrodes (1) and the second electrodes (2) to render them respectively positive and negative electrodes, or negative and positive electrodes and thus bring about a circulation of unidirectional current between the electrodes through the soil, consequently drawing water into or removing water from the foundation soil;

characterised in that the step of applying the voltage is performed by applying to the electrodes a pulsating unidirectional voltage in such a way as to cause a passage of pulsating unidirectional current between the first electrodes and the second electrodes (2) and through the soil.

2. The method according to claim 1, **characterised in that** the steps of inserting the first electrodes (1) and the second electrodes (2) in the soil are carried out in such a way as to position the electrodes alternately around the foundation soil to be treated.

3. The method according to claim 2, **characterised in that** it also comprises the operating step of inserting one or more third electrodes (3) in the soil in a central position relative to the foundation soil to be treated, and also being **characterised in that** the third electrodes (3) are used as negative electrodes if the treatment is intended to draw water into the foundation soil, and as positive electrodes if the treatment is intended to remove water from the foundation soil.

4. The method according to claim 3, **characterised in that** it also comprises the operating steps of:

measuring the amount of water contained in the soil;

comparing the value measured with a reference value;

if the value measured is less than the reference value, applying the voltage in such a way that the first electrodes (1) are the positive electrodes and the second electrodes and third electrodes (3) are the negative electrodes; and

if the value measured is greater than the reference value, applying the voltage in such a way that the first electrodes and the second electrodes (2) are the negative electrodes and the third electrodes (3) are the positive electrodes.

5. The method according to claim 4, **characterised in that** the measurement and comparison steps are systematically repeated, and also **characterised in that** the ways of applying the voltage are swapped if the value measured passes from a value which is less than or greater than the reference value, to a value which is respectively greater than or less than it.

6. The method according to any of the foregoing claims, **characterised in that** it is implemented for an indefinite period of time.

7. The method according to any of the foregoing claims, **characterised in that**, if water has to be drawn into the foundation soil, it comprises a step of feeding water to the soil.

8. The method according to claim 7, **characterised in that** the step of feeding water is carried out by feeding the water close to the positive electrodes using a plurality of pipes (5) which are inserted in the soil.

9. The method according to claim 8, **characterised in that** the electrodes are positioned in the soil outside the pipes (5), and also being **characterised in that** the pipes (5) are at least partly piezometric.

10. The method according to any of the foregoing claims, **characterised in that** the voltage is applied with a square wave profile and/or **characterised in that** the voltage is applied in such a way that each pulse lasts for a time equal to or different to the time separating two consecutive pulses.

11. The method according to any of the foregoing claims, **characterised in that** the voltage is applied with a value and/or a frequency which may vary as time passes.

12. The method according to any of the foregoing claims, **characterised in that** the electrodes are placed in contact with the soil at least along most of their length, for treating the entire thickness of the soil in which they are inserted.

13. A plant for electro-osmotic treatment of foundation soils, comprising:

a plurality of first electrodes (1) which can be inserted in the foundation soil;
a plurality of second electrodes (2) which can be inserted in the foundation soil;
means (9) for applying a voltage between the first electrodes and the second electrodes (2);
characterised in that the voltage application means (9) supply a pulsating unidirectional voltage.

14. The plant according to claim 13, **characterised in that** it also comprises one or more third electrodes (3) which can be inserted in the foundation soil and can be powered by the voltage application means (9), at least one probe (4) for measuring the amount of water contained in the foundation soil, and an electronic control unit (10) operatively connected to the probe (4) for receiving the value measured from it, and also connected to the voltage application means (9) for controlling their activation, and also being **characterised in that** the electronic control unit (10) is programmed to compare the value measured with a reference value and, if the value measured is less than the reference value, to have the voltage applied in such a way that the first electrodes (1) are positive electrodes and the second electrodes and the third electrodes (3) are negative electrodes, whilst, if the value measured is greater than the reference value, it has the voltage applied in such a way that the first electrodes and the second electrodes (2) are negative electrodes and the third electrodes (3) are positive electrodes.

15. The plant according to claim 14, **characterised in that** it also comprises means (14) for feeding the external water at the positive electrodes, the control unit (10) being connected to said feed means (14) for controlling their activation depending on the value measured.

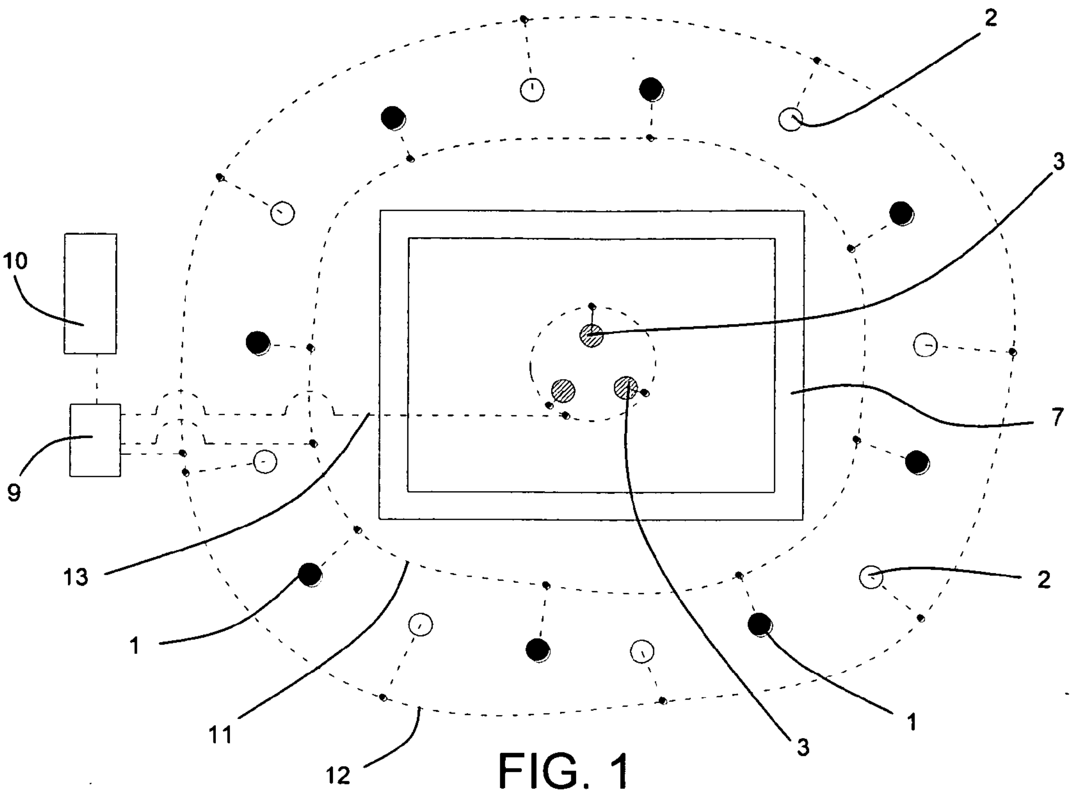

FIG. 1

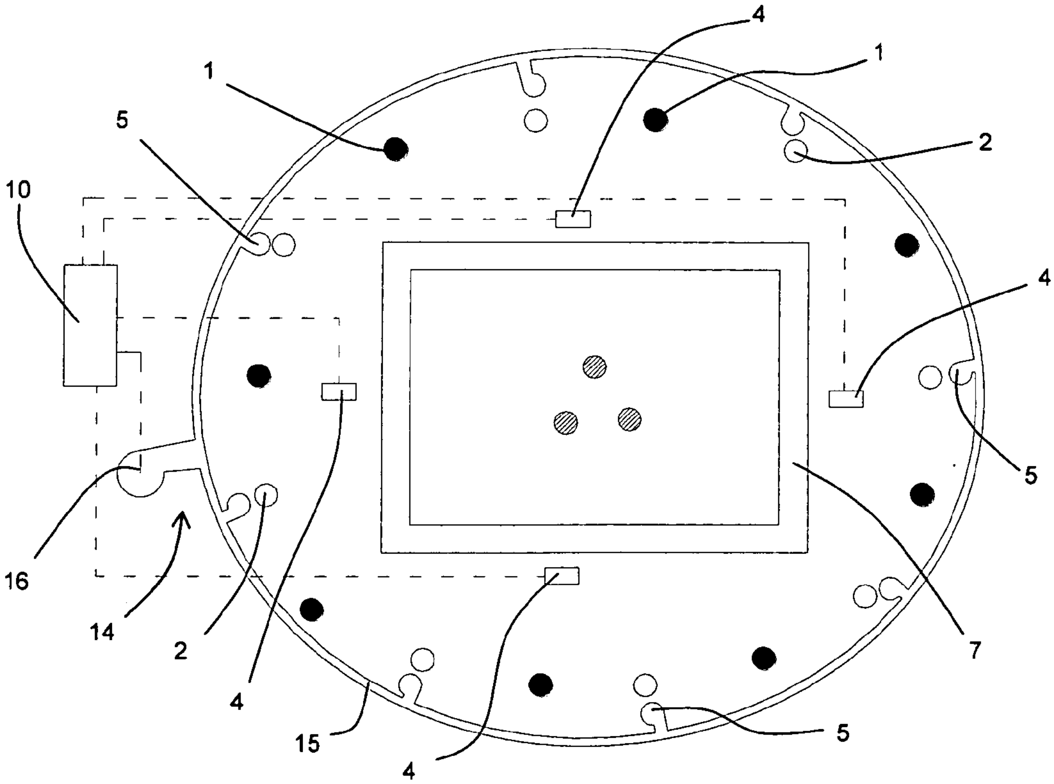

FIG. 2

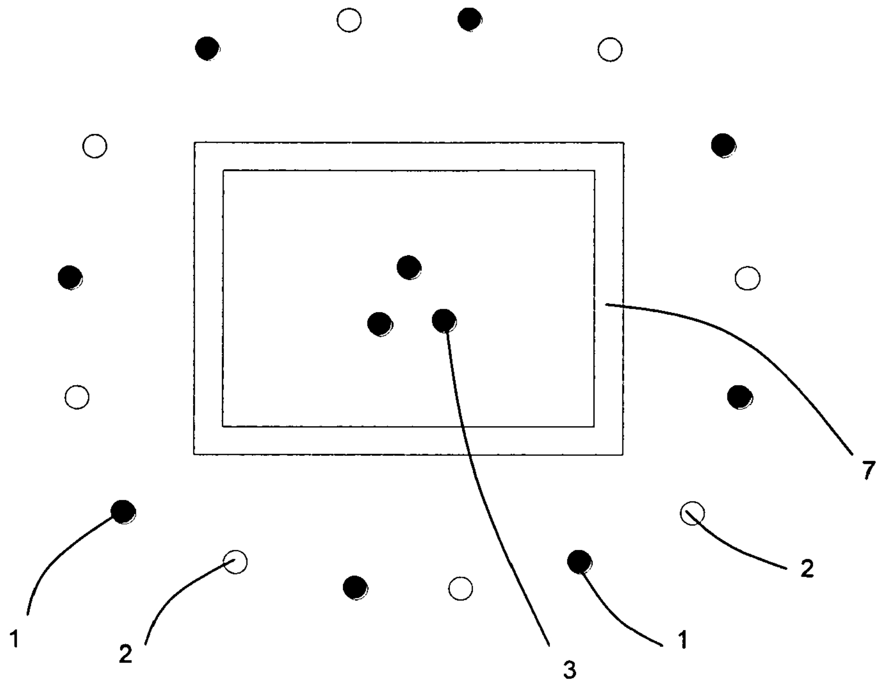

FIG. 3

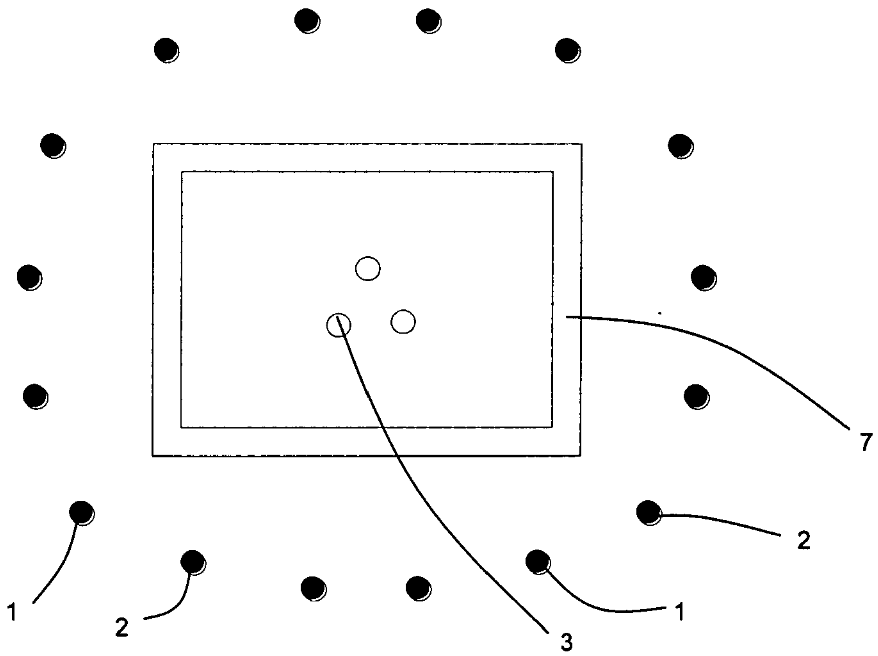

FIG. 4

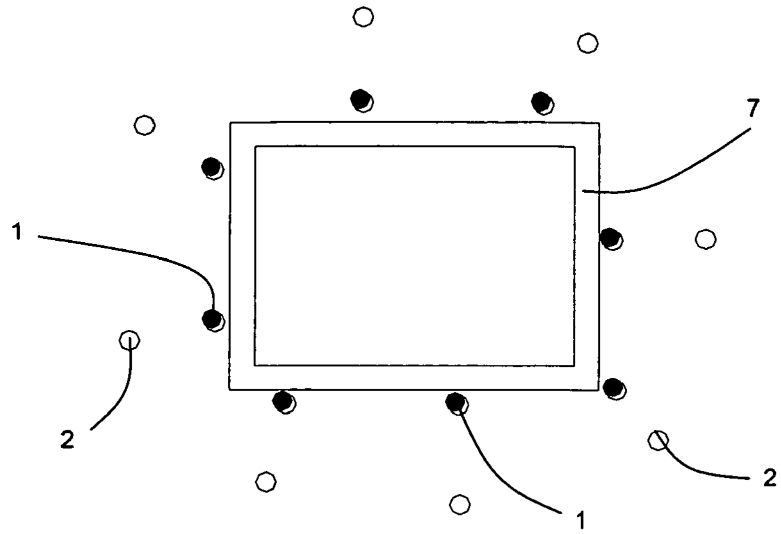

FIG. 5

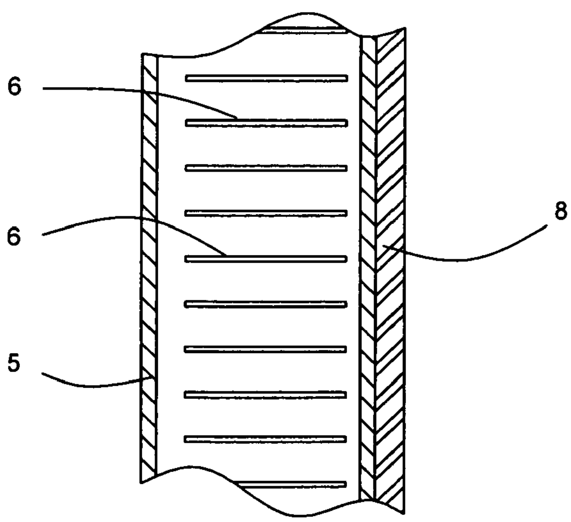

FIG. 6

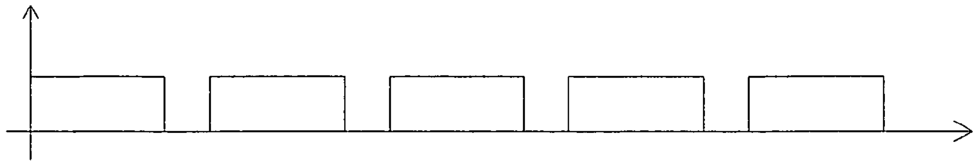

FIG. 7

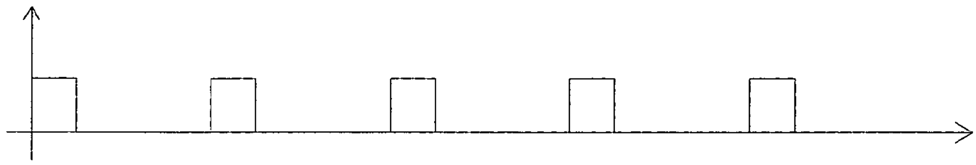

FIG. 8

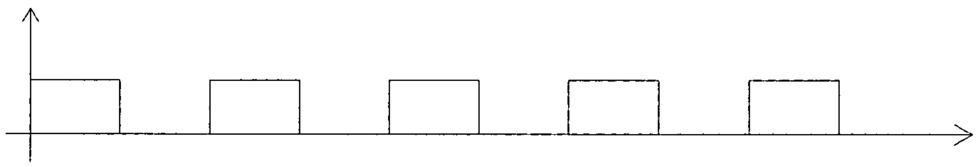

FIG. 9

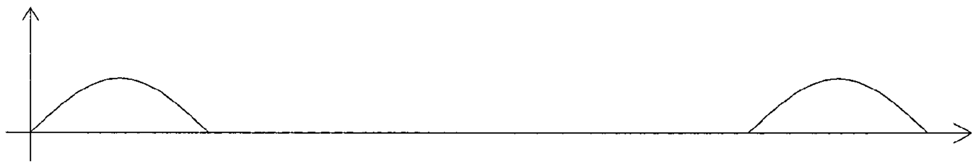

FIG. 10

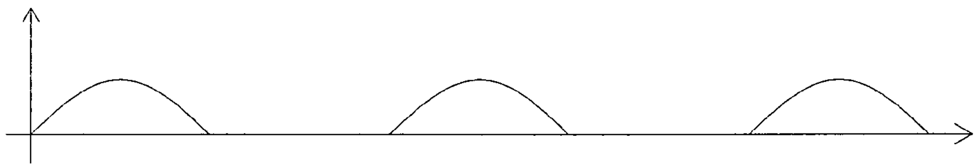

FIG. 11

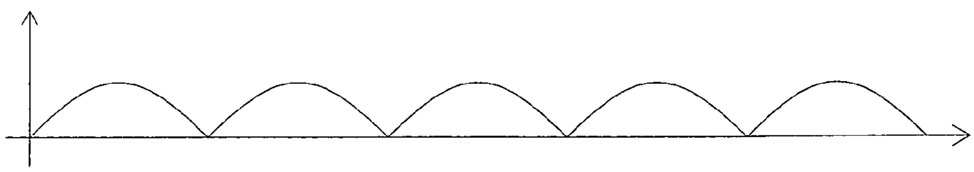

FIG. 12

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 11 42 5126

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y,D A	WO 2009/083811 A1 (FALUGI CARLO [IT]) 9 July 2009 (2009-07-09) * page 6, line 3 - page 16, line 12; figures 1,2 * -----	1,2,13 3-12,14, 15	INV. E02D3/11
Y A	DE 898 723 C (TNO) 3 December 1953 (1953-12-03) * page 1, line 57 - page 1, line 69; figure 1 * -----	1,2,13 3-12,14, 15	
A	US 6 308 135 B1 (HOCKING GRANT [US]) 23 October 2001 (2001-10-23) * column 5, line 31 - column 7, line 20; figure 1 * -----	1-15	
A,D	EP 1 108 817 A2 (F P PARTNERS S R L [IT]) 20 June 2001 (2001-06-20) * abstract; claims 1-12 * -----	1,13	

TECHNICAL FIELDS SEARCHED (IPC)

E02D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	25 November 2011	Friedrich, Albert

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

1
EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 11 42 5126

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

25-11-2011

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2009083811 A1	09-07-2009	EP 2231934 A1 WO 2009083811 A1	29-09-2010 09-07-2009
DE 898723 C	03-12-1953	NONE	
US 6308135 B1	23-10-2001	NONE	
EP 1108817 A2	20-06-2001	EP 1108817 A2 IT PR990093 A1	20-06-2001 18-06-2001

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- EP 1108817 A **[0004] [0023]**
- EP 2231934 A **[0004] [0006] [0012] [0023]**