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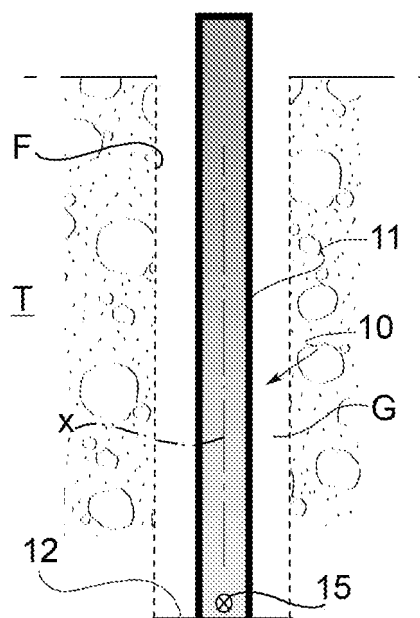
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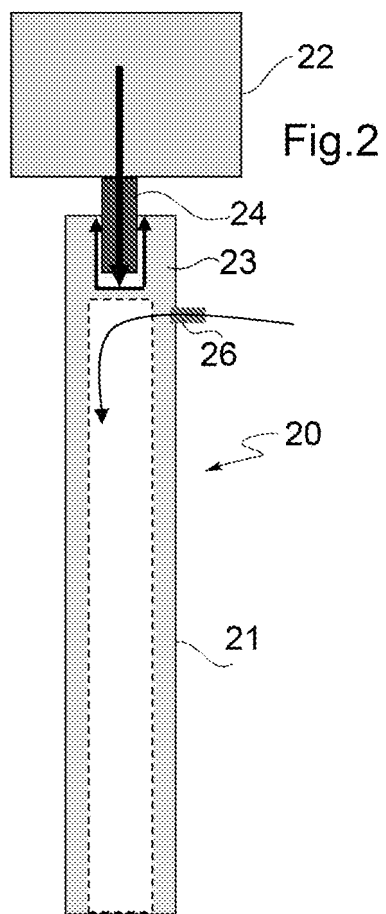
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(54) **A method for anchoring an elongate rectilinear element into the ground**

(57) An elongate rectilinear rigid member (10) is arranged, consisting of a rod (11) connected to or rested against an enlarged bottom member (12). A driving tube (21) is arranged around the rod (11), with a lower edge of the tube abutting against the enlarged bottom member (12). The assembly of elongate member (10) and driving tube (21) is controlled by a thrust, or percussion, or roto-percussion, or vibration movement, or a combination thereof, so as to drive the member (10) in the soil. A hole (F) is obtained, which is drilled around the rod (11). The driving tube (21) is removed from the hole, and a consolidating mixture is optionally injected in the hole drilled around the rod (11).

Fig.1





Description

[0001] The present invention relates to a method for anchoring in the soil an elongate rectilinear member, such as, for example, a stabilizing structural member, or a tubular member intended to perform drainage functions or to inject consolidating mixtures in the soil.

[0002] Systems which allow the installation of elongate rigid members by using disposable pile shoes and performing the driving through actuator devices which directly act on the top thereof (for example, top hammers) and by leaving *in situ* the member once the driving is completed are known. Systems known under the trade names *Odex*, *Tubex*, *KFC-FIT*, *Centrex* are also spread, which allow the installation of tubular members dragged by inner rods provided with disposable pile shoe or a top with retractile cam on which the driving devices operate. With both the above-mentioned systems, it is necessary to use suitably dimensioned members to support the driving stresses; furthermore, the formation of an outer coating capable of correctly and stably anchoring the member in the soil is not ensured.

[0003] The present invention aims at providing a rapidly performable method which can be used in any types of soil, allowing leaving installed and cementing functional members of any types in the soil in a quick, safe, and low cost manner. Furthermore, it is desired to implement a cementitious coating sheath that ensures an efficient anchoring around the member driven in the soil. Application examples are the driving and anchoring in the soil of metal tubes having the function of micropiles, riveting operations for unstable slopes, laying of tubes (fitted with valves or not) for injections, tubes in fibreglass-reinforced plastic, draining tubes, etc.

[0004] The above-mentioned and other objects and advantages are achieved, according to the invention, by a method as defined in claim 1. Other important characteristics of the method according to the invention are defined in the dependant claims.

[0005] Some preferred, but non-limiting, embodiments of the invention will be now described. Reference is made to the annexed drawings, in which:

- Fig. 1 is a schematic view of an embodiment of a rectilinear elongate member driven in the soil;
- Fig. 2 is a sectional schematic view of a device for the driving of the member of Fig. 1;
- Fig. 3 is a side view of a drilling machine for the implementation of the method by vertical drilling;
- Fig. 4 is a perspective view, in enlarged scale, of the lower part of a member and a tube for the driving thereof in a soil;
- Fig. 5 is a vertical sectional view of an elongate member while it is driven in the soil by driving means which are different from those of Figs. 2 and 3; and
- Fig. 6 illustrates the member of Fig. 5 once the driving has been carried out.

[0006] With reference first to Figs. 1 and 2, a first embodiment of an elongate rectilinear rigid member to which the present invention is applicable is indicated with 10, a stabilizing structural member in this example. The member 10 comprises a rod 11, preferably a tubular rod, at the lower end of which an enlarged bottom portion 12 is firmly secured which, in the example of Fig. 1, is a transversal disc-shaped plate 12. The member 10 is intended to be permanently driven in a soil and optionally connected to a surface structure (not shown) to be stabilized. Alternatively, the elongate member 10 will be able to be a tubular member adapted to perform functions of a non-structural type, for example, a tubular member to carry out soil-consolidation injections, or a draining tubular member. According to the functions, the elongate member 10 can be made in plastic material, for example, PVC. If it has to perform structural functions, the member 10 is preferably in steel or fibreglass-reinforced plastic. For some applications, the rod 11 will be able to be simply rested against the enlarged bottom portion 12.

[0007] Throughout the present description and in the following claims, the terms and phrases denoting positions and orientations are meant to refer to the rod 11 longitudinal central axis x, in a condition thereof as installed in the soil. Such terms as "upper" and "lower" are to be meant relative to the driving depth in the soil, considering that the member 10 in many cases will be driven according to different orientations relative to the vertical one. Thus, the term "lower end" denotes the part intended to be located more deeply from the soil surface.

[0008] A driving device for the member 10 is generally indicated with 20 in Fig. 2, and includes an driving tube 21 which is open inferiorly and associated to an actuator device schematically indicated with 22. The latter, by means of percussion, or vibration, or rotation, or static thrust, or a combination of these actions, acts on the tube 21 upper end 23 through a coupler 24.

[0009] As indicated in Fig. 3, the actuator device 22 is slidably driven along a tower or guide antenna of a self-propelled drilling machine 30. The implementation and operative characteristics of the machine 30 (which will be able to be of any known types, for example, a revolving tower) are not *per se* relevant for the purposes of understanding the invention; therefore, they will not be described herein in detail. It will be sufficient to point out herein that the machine 30 will be able to drive only the transverse handling of the driving device 20, or to transmit a combined roto-translation movement to the latter in order to transmit a roto-percussion, or vibration, or static driving movement to the member 10 to be driven. Furthermore, the machine 30 may include a pump (not shown) for the injection of a cementitious mixture.

[0010] The driving tube 21 lower end engages with the bottom portion 12 upper face. According to the operative modes (simple percussion, or roto-percussion, or vibration, or static thrust), the engagement type and the shape of the contacting surfaces will be able to vary. In the example of the Figs. 1 and 2, for the operation by simple

percussion, the tube 21 lower edge abuts against the peripheral part of the bottom portion 12 upper face to transmit the percussion blows to the latter. In an alternative embodiment, illustrated in Fig. 4, for the operation by roto-percussion, both the bottom portion 12 and the lower end of the tube 21 have an interface with radial or transversal relieves 13 and corresponding recesses 25 to impart a rotative motion component to the member 10 around the translation axis.

[0011] The lower surface of the member 10 bottom portion 12 can take a flat shape, as illustrated in Fig. 1, suitable for the operation by simple percussion. For the operation by roto-percussion (Fig. 4), the bottom surface preferably has a circular shape (plane view), and it is suitably provided with lower projections 14 in the shape of chisel blades or other shapes which are typical of the disaggregating means of the drilling bits.

[0012] The driving tube 21 has an outer cylindrical surface with a diameter substantially equal to or slightly lower than the bottom portion 12 diameter or maximum transversal dimension.

[0013] The rod 11, if it is a hollow tubular one, has the end thereof upwardly open, and it has one or more lower outlet holes 15 at the bottom to inject a cementitious consolidating mixture through the member 10.

[0014] Alternatively, the mixture can be injected through the driving tube 21, which to this aim has an upper inlet 26 (Fig. 2) for the inlet of the mixture.

[0015] An embodiment of the method according to the invention is carried out in the following ways. First, the driving tube 21 is inserted on the member 10, with the tubular members 11 and 21 coaxially arranged, and the driving tube 21 lower edge engaged against the enlarged bottom portion 12. Next, the driving device 20 is actuated, by making it to slide downwardly along the drilling machine tower, thus creating a borehole F in the foundation soil T. The downward movement of the driving device is stopped once the desired depth is reached. Then, the injection of a consolidating cementitious mixture is started, which saturates the gap G between the tubular rod 11 and the borehole, and the tube 21 is withdrawn from the soil, which tube is reclaimed and reused. Once it has hardened, the mixture injected in the gap G concurs to firmly anchor the member 10 in the soil, so that the latter is able to perform efficiently. In the case where the member 10 is a stabilizing member, it will have to be able to efficiently exchange forces, mainly traction ones, with the structure to be stabilized.

[0016] The injection of the consolidating mixture around the member 10 can occur according to different modes. According to a first embodiment, the pressurized cementitious mixture is injected through the driving tube 21 from the inlet 26, preliminarily or simultaneously to the withdrawal step of the tube 21 from the borehole. Alternatively, the mixture can be injected through a packer tube (not shown) inserted through the tubular rod 11, so as it exits from the outlet nozzles 15 at the base of the member 10 or through other holes prearranged therein

at different levels, according to the needs. This second mode is to be performed following the withdrawal of the driving tube, and it can be repeated in successive steps, as needed.

[0017] However, it is preferred that the filling of the gap G between the borehole F drilled in the soil and the rod 11 outer surface occurs from the bottom, since the rise of the mixture drags the debris upwardly, and avoids the build-up thereof at the bottom of the hole. In this way, it is possible to carry out successive injection steps after the first injection is set, thus forming a pressurized injection bulb. According to a less preferred embodiment, the mixture can be poured around the rod 11 from above after the withdrawal of the driving tube 21, according to modes which are similar to those followed for the implementation of conventional micropiles or anchoring tension rods.

[0018] Experimental tests carried out by the Applicant proved that, in the presence of sandy and gravelly soils, as well as in the case of road embankments, the stabilizing members can be driven in a rapid manner, with excellent results in terms of structural reliability, beside cost effectiveness. It shall be appreciated that the tubular rod 11, which is left *in situ*, and which does not need to support significant dynamic stresses during the driving step, can be suitably thin. Only the driving tube 21 which, however, is reused, needs to be thick to support the percussion or roto-percussion.

[0019] According to an alternative embodiment illustrated in Fig. 5 of the method according to the invention, the thrust movement caused by driving of the assembly composed of the elongate member 10 and the driving tube 21 in the soil is of the static, and not percussion, type. According to this variation, the thrust is imparted by an oleodynamic device 22, preferably consisting of one or more hydraulic pistons connected through brackets 32 to contrast means 33 anchored to an external structure 34 or to the soil. The same device can be used, at the end of the driving step, to lift the tube 21, thus withdrawing it from the hole. The final step of the driving operation is represented in Fig. 6.

[0020] It is understood that the invention is not limited to the embodiments described and/or illustrated herein, which are to be meant as examples. Instead, the invention is susceptible to modifications regarding shapes, dimensions, materials employed, structural and functional details. By way of example only, in the case of the driving of stabilizing structural members, the length of the tubular bodies 11 and 21, preferably of steel, will be able to reach some metres in length, with an outer diameter of the order of 60-200 mm. The tubular rod 11, which is left *in situ* as a reinforcement, can have a reduced thickness, for example, of 4 mm, while the driving tube 21 will have a significantly larger thickness, of the order of 10-20 mm. The outer diameters of the tubular bodies will be able to vary from some centimetres to 10 cm and above. If the method does not provide for the injection of the consolidating mixture through the rod 11, the latter can be solid,

instead of being tubular and hollow.

Claims

1. A method for anchoring an elongate member in the soil, **characterized in that** it comprises the steps of:

a) providing an elongate member (10) comprising an enlarged bottom member (12), and a rod (11);
 b) coaxially arranging a driving tube (21) around the rod (11) with a lower edge of the tube (21) abutting against an upper surface of the enlarged portion (12);
 c) driving the assembly of rectilinear member (10) and driving tube (21) by a thrust movement along a preset excavation direction (x), so as to drive the elongate member (10) in the soil and to obtain a hole (F) excavated around and spaced apart from the rod (11); and
 d) removing the driving tube (21) from the hole (F).

2. The method according to claim 1, **characterized in that** the step d) is followed by the step of

e) injecting a consolidating mixture in the hole (F) excavated around the rod (11).

3. The method according to claim 2, **characterized in that** the injection step e) of the consolidating mixture in the borehole (F) occurs preliminarily or simultaneously to the removal step d) of the driving tube (21) from the hole (F).

4. The method according to claim 2 or 3, **characterized in that** in the step e), the consolidating mixture is injected through the driving tube (21).

5. The method according to any one of the claims 2 to 4, **characterized in that** the rod (11) is tubular, and that in the step e) the consolidating mixture is injected through the tubular rod (11).

6. The method according to any one of the preceding claims, **characterized in that** mutual engagement means (13, 25) are provided for, at the interface between the enlarged bottom member (12) and the driving tube (21) lower end, to impart a rotational movement around an axis (x) which is parallel to the excavation direction to the elongate member (10).

7. The method according to any one of the preceding claims, **characterized in that** the driving tube (21) has a transversal dimension which is substantially equal or slightly lower than the maximum transversal dimension of the enlarged bottom member (12) of

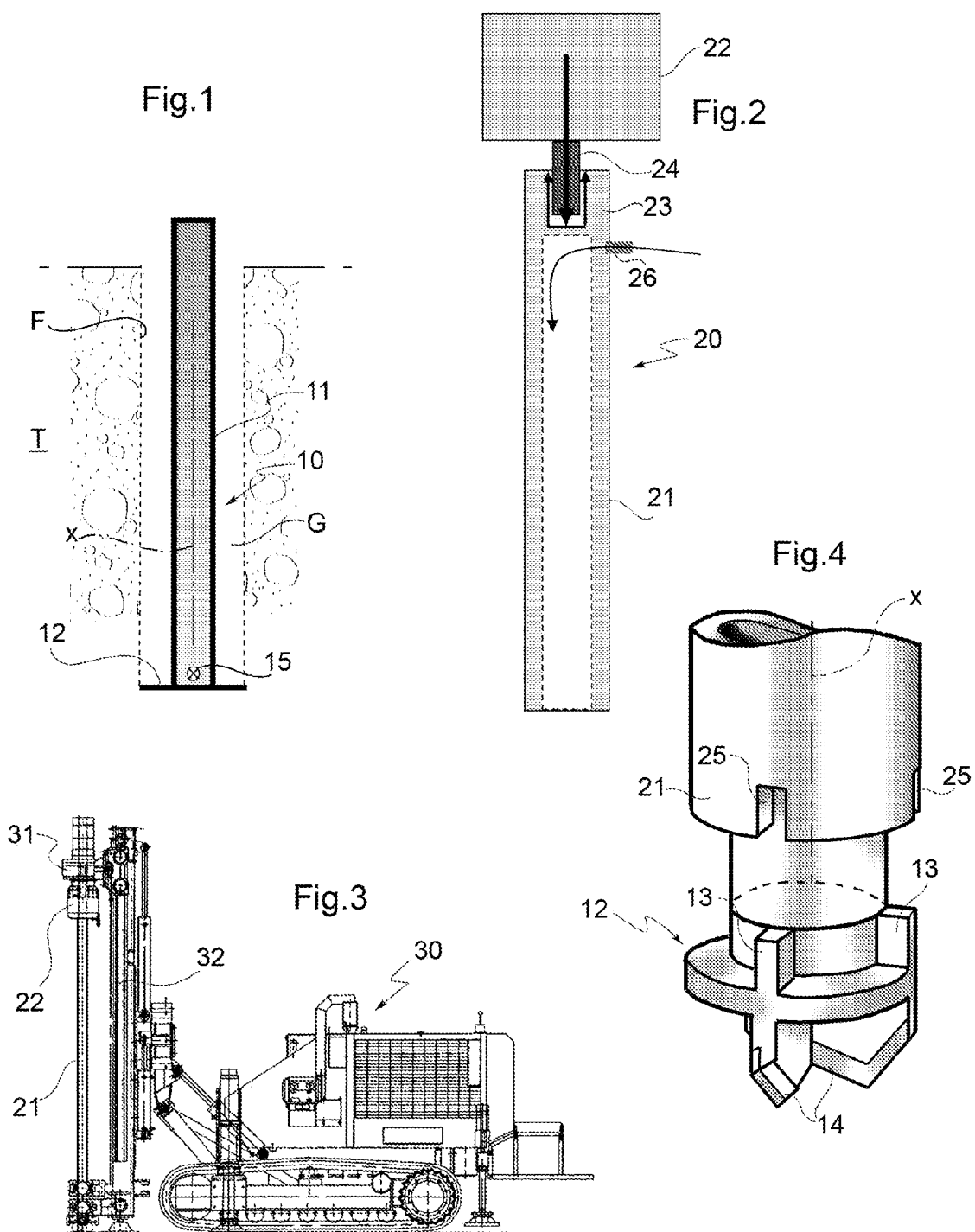
the elongate member (10).

8. The method according to any one of the preceding claims, **characterized in that** the thrust movement imparted to the elongate member (10) and the driving tube (21) in the step c) is a percussion, or roto-percussion, or vibration, or static thrust movement, or a combination thereof.

9. The method according to claim 8, **characterized in that** the percussion, or roto-percussion, or vibration movement is imparted to the elongate member (10) through a pneumatic or hydraulic hammer (22), or a vibrator (22), acting on the driving tube (21).

10. The method according to any one of the claims 1 to 7, **characterized in that** the thrust movement imparted to the stabilizing member (10) and the driving tube (21) in the step c) is imparted by hydraulic actuator means (22) connected to contrast means (32, 33) anchored to external structures (34) or to the soil.

11. The method according to any one of the preceding claims, **characterized in that** soil-disaggregation means (14) project inferiorly from the enlarged bottom portion (12).



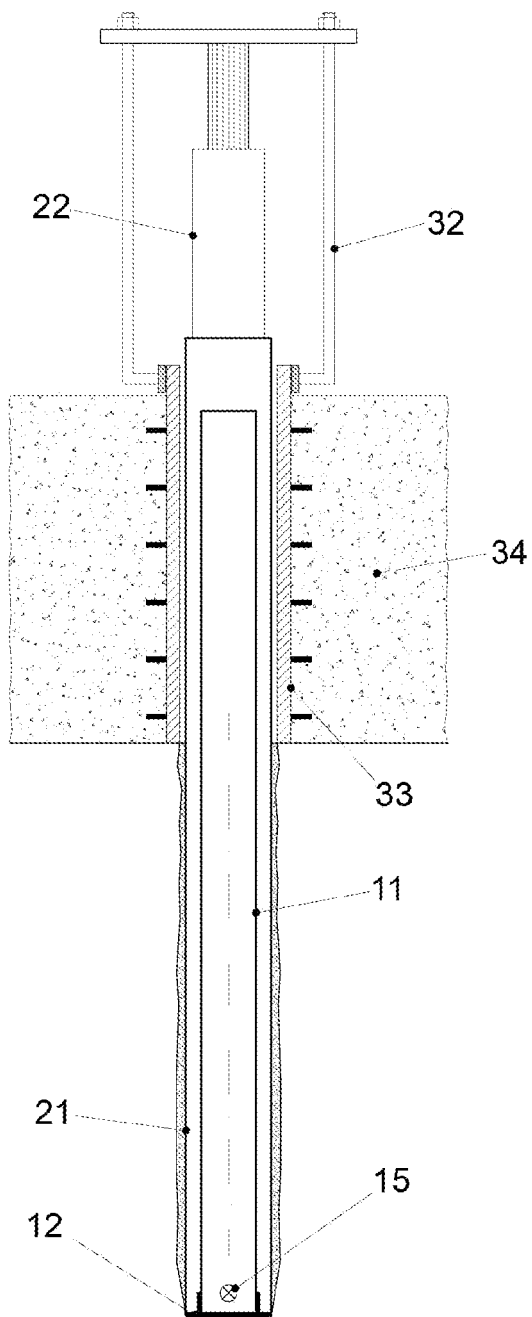


FIG.5

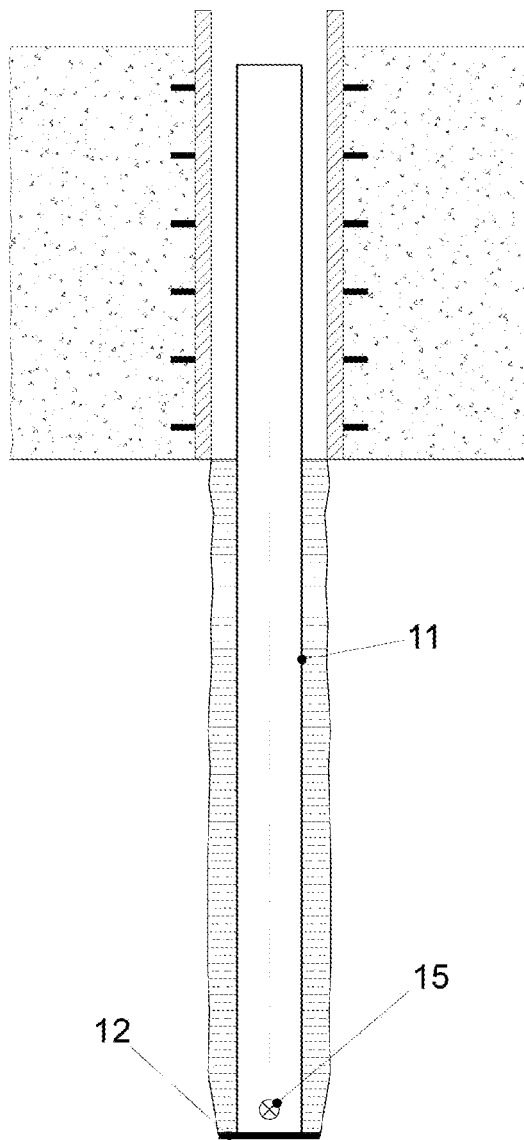


FIG.6



EUROPEAN SEARCH REPORT

Application Number
EP 09 15 6748

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 30 June 2009	Examiner Gallego, Adoración
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			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 09 15 6748

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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