



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
11.09.2013 Bulletin 2013/37

(51) Int Cl.:
E02D 1/02 (2006.01)
E02D 5/56 (2006.01)
E02D 5/46 (2006.01)
E02D 7/22 (2006.01)

(21) Application number: **13158224.9**

(22) Date of filing: **07.03.2013**

(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: **Kappazeta S.p.A.**
43124 Parma (IT)

(72) Inventor: **Kauber, Rodolfo**
43124 Parma (IT)

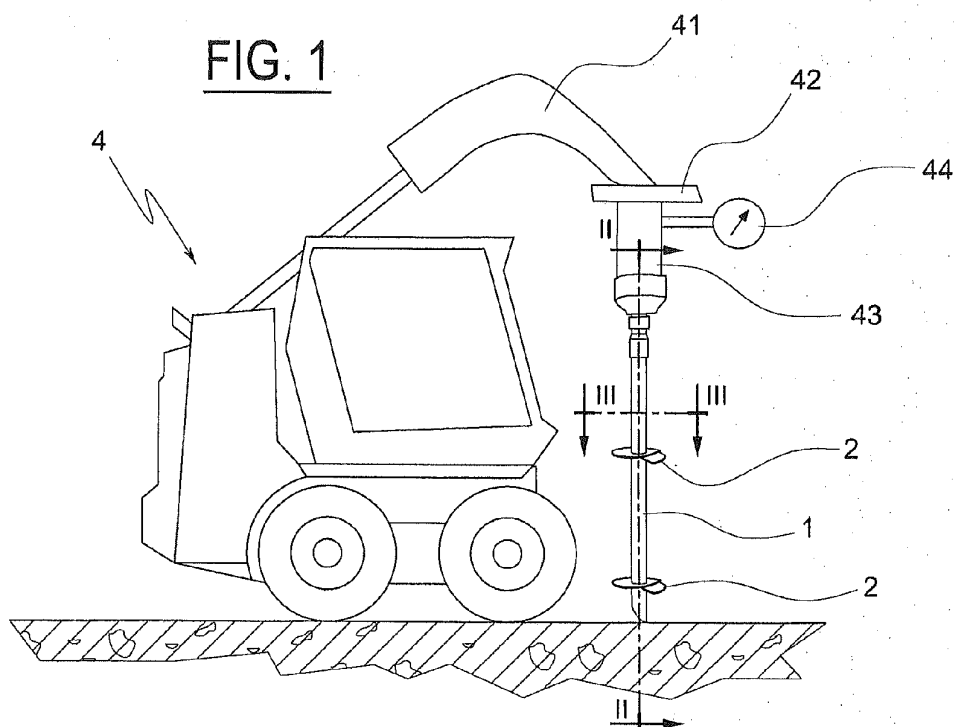
(74) Representative: **Paparo, Aldo**
Bugnion S.p.A.
Via Vellani Marchi, 20
41124 Modena (IT)

(30) Priority: **09.03.2012 IT RE20120016**

(54) **Method and device for ground consolidation.**

(57) The method for consolidating the foundation ground of a building comprises the activities of determining the relation between the torque for driving a pile into the ground and the bearing capacity thereof; driving the pile into the ground by fixing it into the ground; monitoring the driving torque of the pile up to obtaining the torque corresponding to the desired bearing capacity. The ground consolidation apparatus comprises: a consolida-

tion pile having at least one portion proximal to the end provided with a helical blade; means for rotating the pile around the axis thereof so as to drive it into the ground; means for monitoring the driving torque of the pile; where the pile comprises an axial conduit for the injection of a consolidating fluid/ which terminates along the trunk of the pile, both above and below the helical blade, as well as means for injecting a consolidating fluid into the axial conduit of the shaft.



Description

[0001] The present invention refers to a system for consolidating the ground by means of foundation piles. The expression consolidation system is used to indicate both the consolidation method and the apparatus for implementing the method.

[0002] In particular the patent refers to a system for consolidating the ground by means of suspended piles, i.e. which do not lie on a solid plane, such as a rocky or extremely resistant layer.

[0003] The expression bearing capacity is used both to indicate the resistance offered by the pile to the sinking of an overlying construction into the ground (compression pile) and the resistance offered by the pile to the hoisting of a construction which should be anchored to the ground (tension pile).

[0004] Among the known methods for suspended piling there have been known over the years the so-called helical piles, in which there are used piles having - in proximity of the tip and in at least one position along the pile - at least one helical turn of a blade welded outside the pile.

[0005] There are generally used piles comprising groups of several turns arranged at a mutual distance.

[0006] The greater support surface provided by the single helices, and in particular by the deepest helix, or by the shallowest helix depending on whether the load to be supported is directed downwards or upwards, contributes considerably to the bearing capacity.

[0007] The known art of helical piles provides for that each intervention may vary in terms number and sizes of the helices in relation to the characteristics of the subsoil present in the site.

[0008] The characteristics of the subsoil vary consistently forcing the designer of the helical piles to many variables and thus many possible combinations of length of the pile (as a function of the depth at which it is possible to reach the suitable litostrato) and the number/dimension of the helices to be extended over the unitary load fraction transmitted to the ground.

[0009] Currently, piling by means of helical piles occurs empirically, driving one or more sample piles into the area to be consolidated, and verifying the relative bearing capacity using the known systems.

[0010] The dimension and number of the helices, as well as the penetration of the pile into the ground varies depending on the results of the test.

[0011] After a suitable number of tests, the characteristics of the piles that have revealed a good result are adopted also for the rest of the piles subject of the consolidation works.

[0012] According to the prior art the diameter of the pile is comprised between 75 mm and 150 mm, the diameter of the helices is comprised between 180 mm and 360 mm, the pitch of the helices is comprised between 50 mm and 120 mm, the number of the helices is comprised between 1 and 3, and the distance between the

helices is comprised between 5 and 15 times the pitch.

[0013] In order to obtain the desired bearing capacity of the ground as a function of the loads designated by the construction, there can be required very high numbers and large dimensions of helices and/or the attainment of excessive depth in search of a ground with suitable performance.

[0014] This leads to the requirement of an extremely high variety of types of elements, with the ensuing high cost implications.

[0015] Regardless of this it is not always possible to obtain a sufficient degree of consolidation in financially and technically reasonable terms.

[0016] The present invention aims at overcoming the aforementioned drawbacks of the prior art in a simple and inexpensive manner.

[0017] It was observed that the bearing capacity of the helical pile at any time during the driving thereof is related to the energy required for the driving thereof, assuming that the bearing capacity depends on the penetration energy, which in turn depends on the torque required to drive the pile into the ground.

[0018] It was observed that such torque varies almost linearly as a function of the bearing capacity of the pile, and it is related to the diameter of the helices, while it is much less influenced by the number and pitch thereof.

[0019] According to the invention there can be created a dependency factor of the bearing capacity as a function of the torque, with the certainty that when the torque reaches a given value, the corresponding bearing capacity is ensured regardless of the type of ground of the site to be consolidated. The relation between the bearing capacity of the pile and driving torque is a constant marginally influenced by the type of the ground, and it can be obtained empirically providing reliable values for any type of intervention. It can also be obtained in a site far from the consolidation site.

[0020] This allowed constructing, for each diameter of the blades comprised in the range of the practically utilizable blades, a first curve which compares the relation between the capacity expressed in kilograms Kg and the torque expressed in kilogrameters Kg x m as a function of the diameter of the blade.

[0021] The curve has the development expressed in Fig 5.

[0022] Analogously, a curve comparing the torque with the bearing capacity of the pile was constructed for each blade diameter.

[0023] The curves were constructed using usual pile driving tools, conveniently monitored, and equally usual test tools.

[0024] The availability of the aforementioned curves allowed providing a consolidation system which attains all the objects of the invention, whose characteristics are mentioned in the independent claims.

[0025] The dependent claims outline further advantageous characteristics of the invention.

[0026] With the aim of attaining the objects of the in-

vention and optimizing - case by case - the most economical relation regarding the number and size of the helices to be used and/or the length of the pile, or for making the intervention feasible when the required dimensions of the helices or the depths of the method are not to be suitable, the invention provides for locally improving the quality of the ground adapting it to an ideal combination of the number and dimension of the helices and the depth of the pile.

[0027] According to the invention the improvement of the geo-mechanical characteristics of the ground, located around each helix, between one helix and the other and below the deepest helix (for compression piles) or above the helix closest to the surface (for tension piles), over an ideal extension occurs by injecting consolidating fluids through the pile in proximity of the helices or in intermediate points between the helices.

[0028] The consolidating fluids, according to the invention, are fluids based on cement, or inorganic or organic resins, possibly expanding resins well known in the field, possibly mixed with inert material and/or additives).

[0029] The consolidating mixture is injected through the pile, which may be conveniently modular, starting from the upper end thereof, and it reaches - from within the pile - the holes previously made along the trunk of the pile or at the helices and spreads around the holes.

[0030] This allows creating around the pile up to outside the helices a mass of consolidated ground which considerably improves the bearing capacity of the pile both of the compression and tension type.

[0031] As consolidating fluids there can be used one or more of the following:

- portland cement and water
- cement added with RHEOBUILD 200 PF a super fluidifying agent produced by BASF
- RHEOBUILD microfine cement produced by BASF
- MEICO MP 325 or MP 320 colloidal silica produced by BASF
- CARBOPURS polyurethane resin produced by MI-NOVA
- LD, MD and HD polyurethane resins in the various versions produced by GEORESINE
- other equivalent known products

[0032] The advantages as well as the constructive and functional characteristics of the invention will be clear from the detailed description that follows, illustrating with reference to the attached drawings thereof a particular embodiment provided by way of a non-limiting example.

[0033] Fig. 1 schematically shows a helical pile subjected to a tip load, and provided with means for the rotation thereof.

[0034] Fig. 2 shows the section II-II of Fig 1.

[0035] Fig. 3 shows the section III-III of Fig 1.

[0036] Fig. 4 shows the pile driven into the ground.

[0037] Fig. 5 is the curve comparing the relation between the capacity expressed in kilograms Kg and the

torque expressed in kilogrammeters Kg x m as a function of the diameter of the blade.

[0038] The figures show the consolidation pile 1 provided with two helices 2.

[0039] The pile, in the illustrated example, has an outer diameter of 100 mm, while the diameter of the helices is equivalent to 240 mm, while the pitch of each helix is equivalent to 65 mm.

[0040] Each helix, in the illustrated example, is wound for more than one turn.

[0041] The pile comprises injection holes 3 in proximity of the helices.

[0042] The pile is driven into the ground using self-propelling means 4 comprising a hoisting arm 41 provided - at the end - with means 42 for supporting the pile 1.

[0043] The means for supporting the pile include a hydraulic Motor 43 adapted to rotate the pile 1 around the axis thereof.

[0044] The hydraulic motor 43 comprises a manometer 44 adapted to indicate the motor actuation pressure, which is proportional to the driving torque transmitted to the pile.

[0045] The self-propelling means comprise means adapted to pump a consolidating liquid through the pile; these means are known and thus shall not be described in detail.

[0046] The invention operates as follows, and reflects the sequence of the method.

[0047] After selecting the area to be consolidated, and once the bearing value of the ground is determined as a function of the characteristics of the construction intended to rest on the ground, the driving torque required to provide the desired bearing capacity of the pile is identified by means of the diagram of Fig 5.

[0048] The pile is then driven into the ground monitoring the driving torque.

[0049] When the driving torque reaches the preset value, the pile portion projecting from the ground is cut, and the projecting end of the pile is ensured to the connection means on the overlying construction.

[0050] If the driving torque is not attained by driving a reasonable pile length, the consolidating substances are injected, and the measuring of the torque is repeated until the desired value is reached.

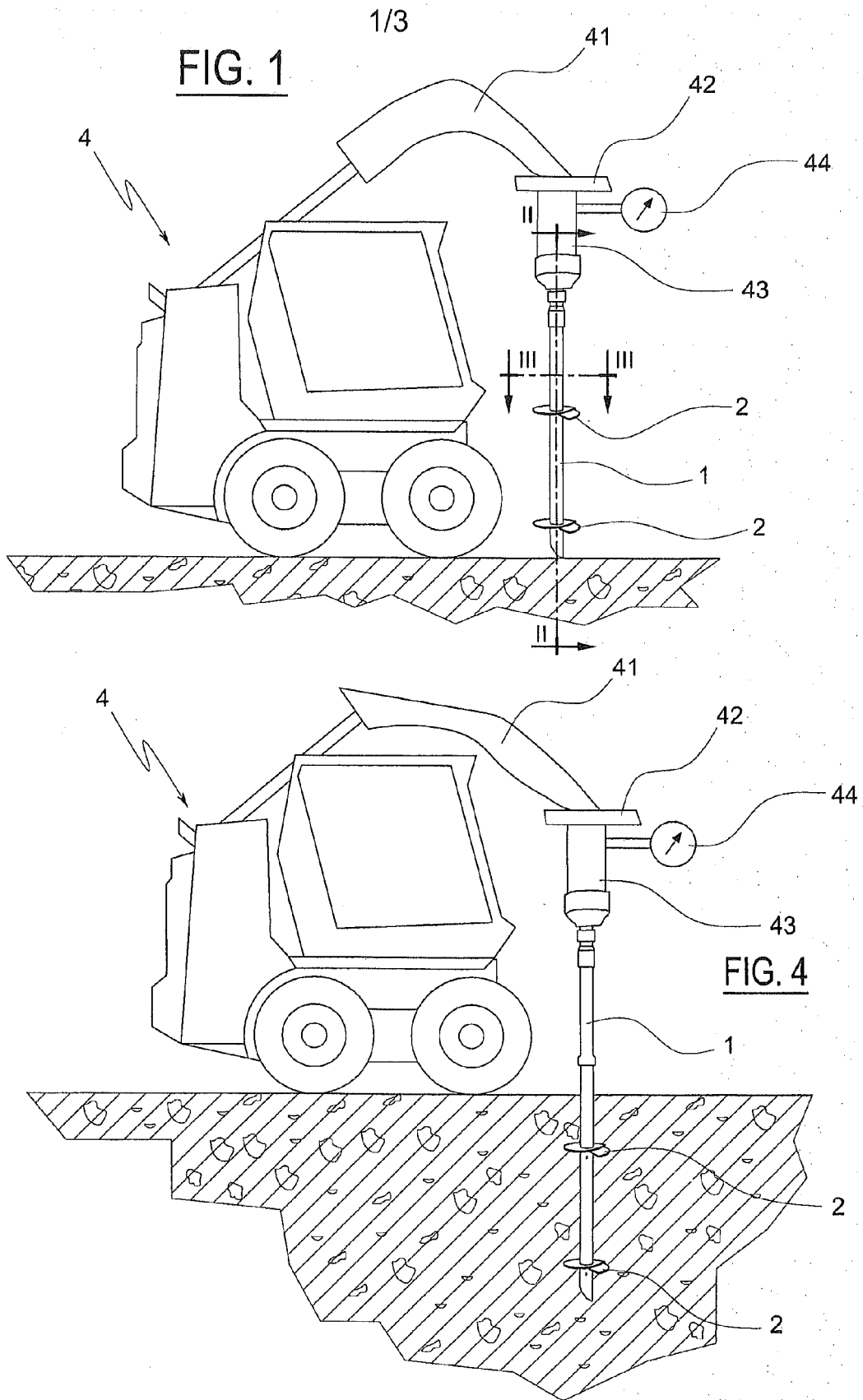
[0051] It shall be deemed that the invention shall not be limited to the example described above, and that the invention may be subjected to variants and modifications without departing from the scope of protection of the claims that follow.

Claims

1. Method for consolidating the foundation ground of a building comprising the following activities:

- a. driving a helical pile into the ground by fixing it into the ground;

- monitoring the driving torque of the pile required to rotate the pile up to obtaining the desired bearing capacity of the pile;
 c. suspending the driving of the pile into the ground: where the relation between the bearing capacity of the pile and the driving torque of the pile is a function depending on the diameter of the helices of the pile. 5
2. Method according to claim 1 **characterised in that** it comprises the injection of a consolidating liquid through the axial cavity of the pile and through holes obtained at the helices and/or along the trunk of the pile. 10
3. Method according to claim 2 **characterised in that** the consolidating fluid is selected from among one or more of the following: portland cement and water; cement added with RHEOBUILD 200 PF a super fluidifying agent produced by BASF; RHEOBUILD microfine cement produced by BASF; MEICO MP 325 or MP 320 colloidal silica produced by BASF; CARBOPURS polyurethane resin produced by MI-NOVA; LD, MD and HD polyurethane resins in the various versions produced by GEORESINE; other equivalent known products. 15 20 25
4. Apparatus for consolidating grounds comprising:
 - a consolidation pile having at least one portion proximal to the end provided with a helical blade;
 - means for rotating the pile around the axis thereof so as to drive it into the ground;
 - means for monitoring the driving torque of the pile; 30 35
 where the pile comprises an axial conduit for the injection of a consolidating fluid, which terminates along the trunk of the pile, both above and below the blade, as well as means for injecting a consolidating fluid into the axial conduit of the shaft. 40
5. Apparatus according to claim 4 **characterised in that** the at least one portion of helical blade has a diameter comprised between 180 mm and 360 mm, and a pitch comprised between 50 mm and 120 mm. 45
6. Apparatus according to claim 4 **characterised in that** the at least one portion of helical blade comprises at least one turn. 50
7. Apparatus according to claim 4 **characterised in that** the shaft is a modular construction.
8. Apparatus according to claim 4 **characterised in that** it comprises at least two helical blade portions arranged at a mutual distance greater than the pitch. 55
9. Apparatus according to claim 8 **characterised in that** the mutual distance is a multiple of the pitch.



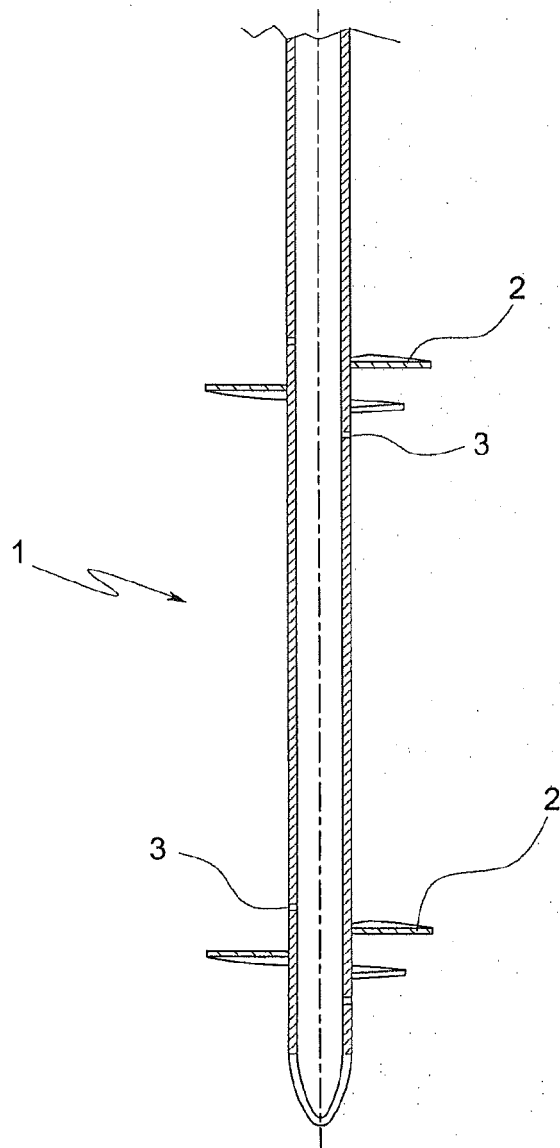


FIG. 2

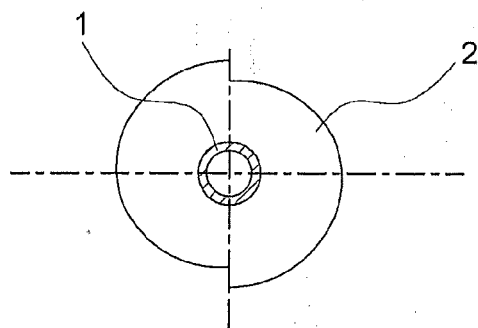


FIG. 3

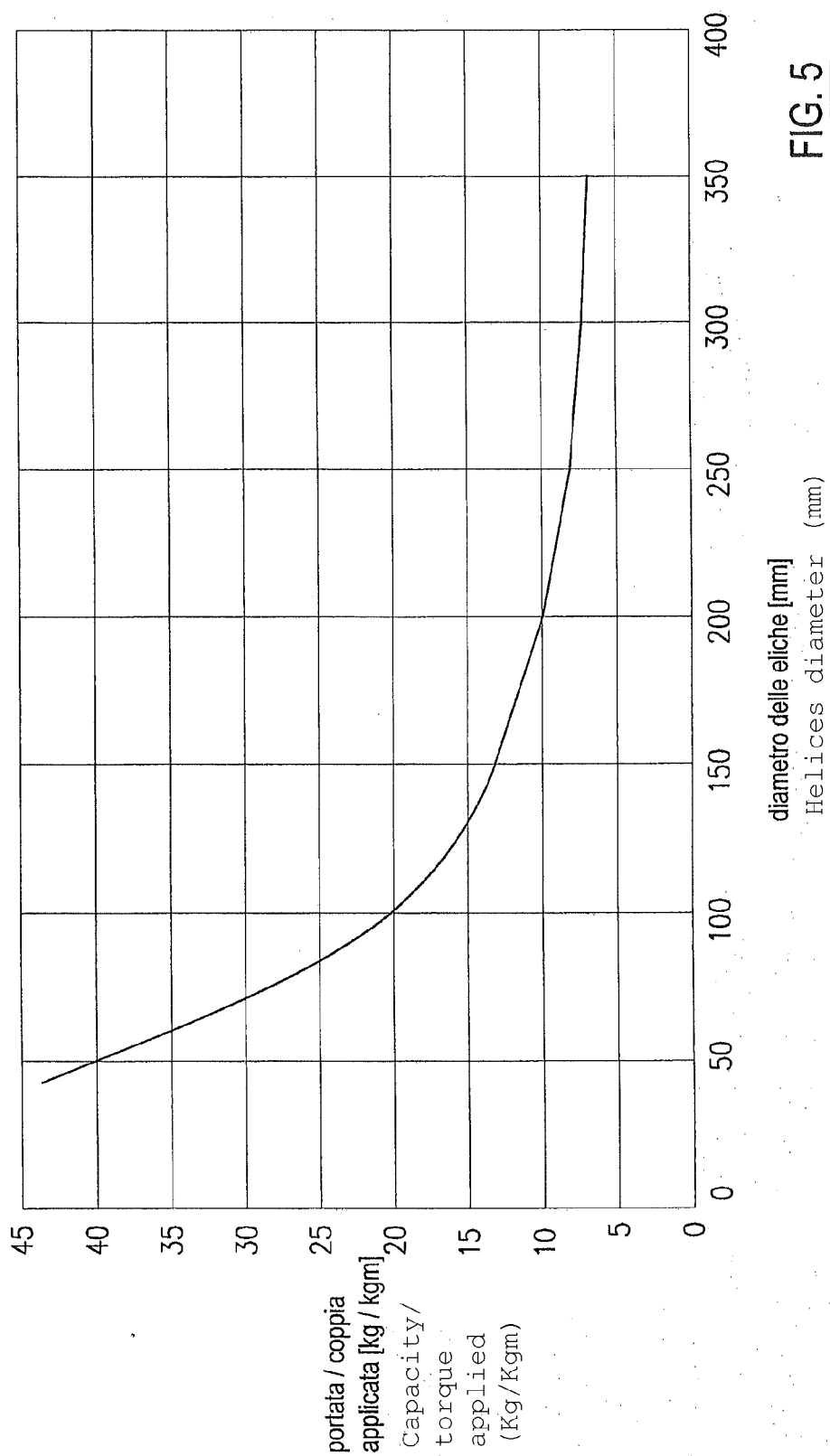


FIG. 5



EUROPEAN SEARCH REPORT

Application Number
EP 13 15 8224

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2008/031695 A1 (NASR MAMDOUH A [CA]) 7 February 2008 (2008-02-07)	4-9	INV.
A	* the whole document *	1-3	E02D1/02
	-----		E02D5/46
A	DE 10 2008 022478 B3 (KRINNER INNOVATION GMBH [DE]) 1 October 2009 (2009-10-01)	1-9	E02D5/56
	* the whole document *		E02D7/22

			TECHNICAL FIELDS SEARCHED (IPC)
			E02D
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 6 May 2013	Examiner Geiger, Harald
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			

2

EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 13 15 8224

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.

06-05-2013

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2008031695 A1	07-02-2008	NONE	
DE 102008022478 B3	01-10-2009	AU 2009245815 A1	12-11-2009
		CA 2723482 A1	12-11-2009
		CN 102016181 A	13-04-2011
		DE 102008022478 B3	01-10-2009
		EP 2281090 A1	09-02-2011
		JP 2011520048 A	14-07-2011
		RU 2010150118 A	20-06-2012
		US 2011091285 A1	21-04-2011
		WO 2009135884 A1	12-11-2009