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(71) Applicant: **Prometec S.r.l.**
81025 Marcianise (CE) (IT)

(72) Inventor: **FICHERA, Alfredo**
I-81025 MARCIANISE (CE) (IT)

(74) Representative: **Carangelo, Pierluigi et al**
Jacobacci & Partners S.p.A.
Via Tomacelli 146
00186 Roma (IT)

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(54) **ANCHOR DEVICE FOR ANCHORING TIE RODS AND PROCESS FOR ANCHORING SAID TIE RODS**

(57) There is described an anchorage device (1; 1A; 1E) for anchorage tie rods suitable for being inserted into a perforating hole (H) made in a ground to allow anchoring an anchorage tie rod (5). The features of the anchorage device meet the need to increase the efficiency of transferring loads to the ground while almost completely eliminating the extraction problems of the tie rod. Indeed, the anchoring no longer occurs by relying on the friction resistance due to the mortar-ground adhesion, rather it is ensured by the mechanical resistance of penetrating and anchorage plates (40) which are first driven into the side wall (SW) of the perforating hole and then embedded with slurry. Therefore, with such a device, it will be more than sufficient to penetrate about 3 to 4 meters into the active stretch (thus drastically reducing the active length which generally may also reach 40 meters for conventional tie rods), open the penetrating and anchorage plates (40) by means of actuating a hydraulic cylinder, and once the penetration is complete, inject cement grout.

Once anchored, the system can no longer be removed because the penetrating and anchorage plates (40), which are now spread and penetrated in the side wall (SW) of the hole (H), have an open diameter which is much greater than the diameter of the perforation, thus achieving, as mentioned, a mechanical type anchoring and no longer a friction anchoring. A process for anchoring anchorage tie rods is also described.

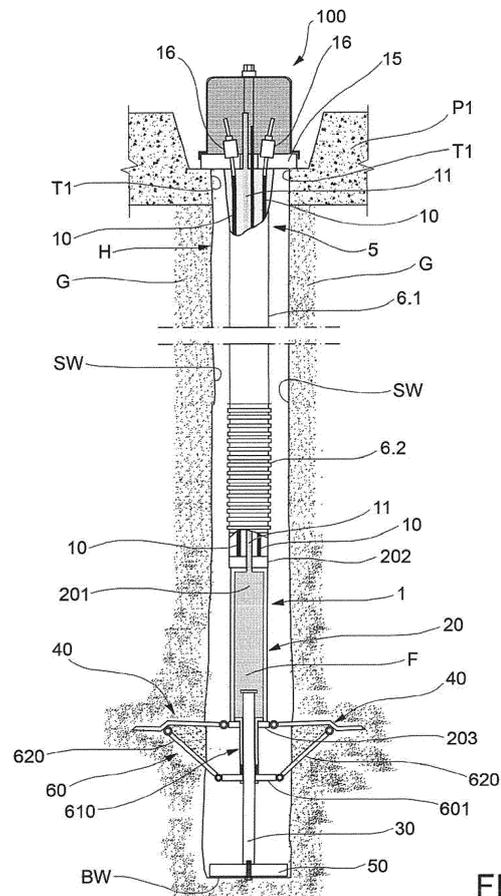


FIG.1

Description

[0001] The present invention relates to the field of anchorage systems for geotechnical use, and more specifically relates to an anchorage device for anchorage tie rods and to a process for anchoring such tie rods.

[0002] In the field of geotechnical engineering, it is known to use anchorage tie rods which are installed within a perforating hole to stabilize rocky walls, make bearing walls, partition walls, consolidate excavation walls, tunnels, etc. In particular, there are various types of tie rods, such as e.g. strand, bar, cable, tube tie rods, etc.

[0003] Anchorage tie rods of the known art broadly consist of three main elements: the anchorage head, the free length and the active length (the latter also referred to as a restrained length or foundation bulb).

[0004] The anchorage head typically consists of a steel plate having shape and sizes such as to allow the transfer of the stresses onto a contrast structure such as e.g. a reinforced cement wall, partition wall, bearing wall, etc. The free length, which is the stretch measured from the head of the tie rod up to exceeding the slide line of the ground, forms the part of the tie rod not restrained to the ground in which the reinforcement of the tie rod, which generally is protected with a sheath, may be freely extended.

[0005] The active length is the part of the tie rod in which the reinforcement of the tie rod is anchored to the ground by means of the injection of the final stretch of the perforating hole by means of cement mortar. Once the injection of the cement mortar is complete and it has hardened, the tie rod is tensioned with jacks and hydraulic power units and the reinforcement is fastened at the head with suitable locking clamps. Thereby, the active length transfers the load applied to the ground due to the friction resistance due to the mortar-ground adhesion.

[0006] Therefore, as may be understood, the operating principle of anchorage tie rods commonly used is based on the resistance to extraction obtained due to the friction between the injected bulb and the surrounding ground.

[0007] As clarified below, a drawback of the above-described anchorage tie rods of the known art is due to the fact that often during the useful life of a tie rod or even after a few hours from the placement thereof at the site, there are losses of adhesion such as to compromise the resistance of the anchorage, thus jeopardizing the stability and safety of the work itself.

[0008] Certain considerations have been provided below to better clarify the technical problems which often occur in anchorage tie rods currently used.

[0009] The injection of the active length of the tie rod is a very delicate and tricky operation for many types of grounds (grounds with alluvial features, unconsolidated stratifications) because more often than not, an adequate mortar-ground adhesion cannot be obtained, an adhesion such as to ensure the resistance to extraction. In many situations, the injections become necessary also after the tensioning of the tie rod precisely because often

there are losses of adhesion with the ground, while also implementing suitable additives for mitigating the phenomenon of the cement mortar shrinking.

[0010] It indeed is known that complications may occur such as to significantly impact the resistance to extraction during the placement and also during the useful life of the tie rods actually used.

[0011] It is therefore apparent that the greater the active length and perforating diameter for conventional anchorage tie rods, the greater the hold of the tie rod.

[0012] The active length of a classic anchorage tie rod therefore may vary from a minimum of 3 to 4 meters up to reaching a length of about 40 meters in certain types of grounds.

[0013] Therefore, the main parameter to be assessed during the design step is precisely the resistance that the anchoring should put up to the extraction from the ground. In the calculation, only one estimate may be obtained of such a parameter by means of analytical and semi-empirical methods, using the results from geological prospecting and laboratory tests for determining geotechnical parameters of the ground. In any case, legislation obligates the designer to perform load tests on the tie rods in order to arrive at an experimental measurement of the value of resistance to extraction. The calculation of the connected stretch becomes even more problematic in the presence of unconsolidated, sandy, fractured grounds, or even worse in the presence of subsurface water, because additional conditions arise which are difficult to schematize with analytical formulations and in many cases, not even the test tie rods reassure the designer on the hold of the work.

[0014] It is a general object of the present description to provide an anchorage device for anchorage tie rods which allows the above drawbacks with reference to the anchorage tie rods of the known art to be at least partly resolved and obviated.

[0015] These and other objects are achieved by means of an anchorage device for tie rods as defined in claim 1 in the most general embodiment thereof, and in the dependent claims in certain particular embodiments thereof.

[0016] An assembly of parts as defined in claim 5 is also the subject of the present invention.

[0017] Moreover, a process for anchoring anchorage tie rods as defined in claim 6, is the subject of the present invention.

[0018] Moreover, an anchorage device for anchoring anchorage tie rods as defined in claim 7, is the subject of the present invention.

[0019] Moreover, an assembly of parts as defined in claim 14 is the subject of the present invention.

[0020] Moreover, a process for anchoring anchorage tie rods as defined in claim 15, is the subject of the present invention.

[0021] The invention will be better understood from the following detailed description of embodiments thereof, given by way of non-limiting example with reference to

the accompanying drawings, in which:

- Fig. 1 is a diagrammatic cross-section plan view of an assembly of parts comprising an anchorage tie rod which is anchored within a perforating hole by means of an anchorage device for anchorage tie rods according to a currently preferred embodiment, such an anchorage device being depicted in an anchorage configuration;
- Fig. 2 is a diagrammatic top plan view of the anchorage device in Fig. 1, inserted in the hole in Fig. 1, in which the anchorage device is depicted in a first configuration;
- Fig. 3 is a diagrammatic front plan view in which the anchorage device in Fig. 1 is shown in cross section along the line A-A in Fig. 2 in the first configuration in Fig. 2, and inserted in the perforating hole in Fig. 1;
- Fig. 4 is a diagrammatic plan view similar to Fig. 3, in which the anchorage device is depicted in a different configuration with respect to Fig. 3;
- Fig. 5 is a diagrammatic plan view similar to Figures 3 and 4, in which the anchorage device is depicted in a different configuration with respect to such drawings;
- Fig. 6 is a diagrammatic plan view similar to Figures 3 to 5, in which the anchorage device is depicted in the configuration in Fig. 1;
- Fig. 7 is a view similar to Fig. 3, in which there is depicted a further embodiment of an anchorage device for anchorage tie rods according to the present description;
- Fig. 8 is a diagrammatic cross-section plan view of an assembly of parts comprising an anchorage tie rod which is anchored within a perforating hole by means of an anchorage device for anchorage tie rods according to a further embodiment, such an anchorage device being depicted in an anchorage configuration;
- Fig. 9 is a diagrammatic top plan view of the anchorage device in Fig. 8, inserted in the perforating hole in Fig. 8, in which the anchorage device is depicted in a rest configuration;
- Fig. 10 is a diagrammatic front plan view in which the anchorage device in Fig. 9 is shown in cross section along the line B-B in Fig. 9; and
- Fig. 11 is a diagrammatic plan view similar to Fig. 10, in which the anchorage device is depicted in a different configuration with respect to Fig. 10.

[0022] In general, equal or similar elements are indicated by the same numerals in the accompanying drawings. However, for increased clarity of the present description, certain equal or similar elements related to different embodiments of the present invention may be indicated also by different numerals.

[0023] Moreover, it is worth noting that in the following description, the term "radial" or other similar terms used to define a part of an anchorage device according to the

present description refer to the translation direction of the body of the hydraulic cylinder, or of the rod of the hydraulic cylinder, of the anchorage device.

[0024] First, with reference to Fig. 1, such a drawing shows an assembly of parts which is indicated as whole with numeral 100. The assembly of parts 100 comprises an anchorage tie rod 5 preferably including at least one strand 10, and more preferably a plurality of strands 10, for example two strands 10 as shown in Fig. 1. According to a preferred embodiment, the part of the tie rod 5 corresponding to the free length of the tie rod 5 is protected by a smooth sheath 6.1 of the type in itself known, while the part of the tie rod 5 corresponding to the active length of the tie rod 5 is protected by a corrugated sheath 6.2 of the type in itself known. Moreover, assembly 100 comprises an anchorage device 1 for anchorage tie rods according to a currently preferred embodiment, and a head plate 15, or anchorage head 15, for anchoring the aforesaid tie rod. The head plate 15, preferably made of metal material, is arranged at an input opening T1 of a perforating hole H made in a ground G. Hole H has a side wall SW of hole H and a bottom BW of hole. In the example shown in the accompanying drawings, hole H is made both through a contrast structure P1, such as e.g. a reinforced cement wall, a partition wall, a bearing wall, etc., and through ground G. In particular, the head plate 15 is arranged at the input opening T1 to allow the transfer of the stresses onto the contrast structure P1.

[0025] The anchorage device 1 is suitable for being inserted into the perforating hole H to allow anchoring the aforesaid anchorage tie rod. It is worth noting, as indicated above, that the anchorage tie rod 5 in the example embodiment is a tie rod with strands, i.e. a tie rod comprising, or consisting of, one or more strands 10. However, the teachings of the present description may be applied in general to all types of anchorage tie rods, such as for example and not limited to, bar tie rods, cable tie rods, tube tie rods, etc.

[0026] The anchorage tie rod 5, the anchorage device 1 and the head plate 15 in Fig. 1 are depicted in the respective final anchoring configuration. As may be noted in Fig. 1, the tie rod 5 has each a respective end fixed to the anchorage device 1 and an opposite end fixed to plate 15, preferably by means of a locking clamp 16. In other words, in the example, each of the strands 10 has a respective end fixed to the anchorage device 1 and an opposite end fixed to plate 15, preferably by means of a respective locking clamp 16.

[0027] With reference to Figures 2 to 3, the anchorage device 1 comprises a hydraulic cylinder 20, 30, which in turn comprises a cylinder body 20 and a cylinder rod 30. Rod 30 is slidably mounted to body 20. The cylinder body 20 comprises a cylinder chamber 201, or expansion chamber 201, which is suitable for receiving a pressurized hydraulic fluid F, preferably pressurized oil F. According to a preferred embodiment, fluid F is input into chamber 201 by means of at least one input tube 11 (Fig. 1) communicating with chamber 201. Rod 30 comprises

a first end portion 301 of rod received in chamber 201 and a second end portion 302 of rod opposite to the first end portion 301. Portion 301 comprises a thrust wall 301A suitable for receiving the thrust of fluid F. To this end, it is worth noting that the actual thrust surface of wall 301A corresponds to an area equal to the area of a section orthogonal to rod 30 which is intermediate between the end portions 301, 302. In other words, with reference to the example shown in Figures 1 to 6, the radially projecting portion of wall 301A does not contribute to the thrust on rod 30. Body 20 comprises a first end portion 202 of cylinder for connecting the hydraulic cylinder 20, 30 to the aforesaid anchorage tie rod 5, an opposite second end portion 203 of cylinder suitable for being operatively crossed by rod 30 and a cylinder side wall 204, or cylinder jacket 204, interposed between said first and second end portions 202, 203. According to a preferred embodiment, the second end portion 203 comprises a connection plate 203 which is fixed, and more preferably is welded, to the side wall 204. The anchorage device 1, comprises at least two penetrating and anchorage plates 40, preferably made of metal material, e.g. steel, which are hinged to body 20, and more preferably to the connection plate 203. In particular, as may be noted in Fig. 3, the anchorage device 1 comprises at least one pair of plates 40 opposed with respect to body 20, i.e. arranged on two opposite sides of body 20. With reference to Fig. 2, according to a preferred embodiment, the anchorage device 1 comprises four penetrating and anchorage plates 40 which are opposed two-by-two with respect to body 20. Each penetrating and anchorage plate 40 has a free end portion 401 of penetration. According to a convenient embodiment, the free ends 401 are sharp ends.

[0028] With reference to Fig. 3, the anchorage device 1 comprises a contrast base 50. Preferably, base 50 is a plate-shaped base. Base 50 is associated with the second end portion 302 of rod 30 to allow the anchorage device 1 to be rested on the bottom BW of hole H. According to one embodiment, base 50 is fixed to the end portion 302 of rod 30 preferably by means of at least one fastening screw 501.

[0029] Again with reference to Fig. 3, the anchorage device 1 comprises a movement mechanism 60 to allow the movement of the penetrating and anchorage plates 40. The movement mechanism 60 comprises a mechanism portion 601 which is operatively connected to the penetrating and anchorage plates 40 and is suitable for being operatively crossed by the cylinder rod 30 so as to allow a relative sliding between such a mechanism portion 601 and rod 30. Portion 601 in particular is arranged between the contrast base 50 and the second end portion 203 of cylinder. According to a preferred embodiment, portion 601 comprises a mechanism plate 601 comprising a plate hole 603 crossed by rod 30.

[0030] The anchorage device 1 is suitable for taking on a relatively compact rest configuration (Fig. 3), in which the penetrating and anchorage plates 40 take on a first angular position in which they are facing the side

wall 204 of body 20. Moreover, the anchorage device 1 is suitable for taking on an anchorage configuration (Fig. 1 and Fig. 6) which is relatively unfolded with respect to the rest configuration, in which the penetrating and anchorage plates 40 take on a second angular position, different from the first angular position.

[0031] The anchorage device 1 comprises an abutment portion 205 which preferably comprises an abutment wall 205 of plate 203. The abutment wall 205 is located within body 20. The movement mechanism 60 comprises a stroke end element 602 which is integral with the portion 601 of mechanism 60. The stroke end element 602 preferably comprises a stroke end wall 602 and is suitable for abutting against the abutment portion 205 to stop the penetrating and anchorage plates 40 in the aforesaid anchorage configuration (Fig. 6).

[0032] Again with reference to Fig. 3, the movement mechanism 60 comprises at least one distancing element 610, 70 operatively connected to portion 601 and arranged so as to allow such a mechanism portion 601 to move away from the second end portion 203 of cylinder when the hydraulic fluid F is input into chamber 201.

[0033] Again with reference to Fig. 3, according to a convenient embodiment, the aforesaid at least one distancing element 610, 70 comprises a sleeve member 610. According to a convenient embodiment, the sleeve member 610 is partly extended within body 20 and comprises a portion 611 of sleeve member which defines a movable wall 611 of chamber 201. This advantageously allows a more compact anchorage device to be made which requires less pressure of fluid F to actuate the anchorage device and to allow the penetration of the penetrating and anchorage plates 40 through the side wall SW of hole H with respect to the second embodiment of the anchorage device (Fig. 7), which will be described below in the present description.

[0034] According to a convenient embodiment, portion 611 has a thrust surface which is equal to about three times the above-mentioned actual thrust surface of the thrust wall 301A. The sleeve member 610 is integral with portion 601 and comprises the stroke end element 602. According to a preferred embodiment, the sleeve member 610 has a radially projecting end flange which comprises the stroke end wall 602 and the movable wall 611. The sleeve member 610 is coaxial to rod 30 and is slidably mounted to the second end portion 203 of the cylinder. Rod 30 is suitable for sliding through the sleeve member 610. According to a preferred embodiment, seal elements (not depicted) are provided between the sleeve member 610 and the side wall 204 of body 20.

[0035] According to a preferred embodiment, the aforesaid at least one distancing element 610, 70 may comprise a resistance 70 to the sliding of portion 601, or brake 70, which is integral with portion 601 or the sleeve member 610 and is suitable for engaging or operatively contacting rod 30. For example, brake 70 may comprise a pair of jaws rigidly connected to portion 601 and suitable for tightening rod 30 so as to contrast the relative sliding

between rod 30 and portion 601. In the example shown, brake 70 is arranged between portion 601 and portion 203. However, according to an alternative embodiment, brake 70 may be arranged between portion 601 and base 50.

[0036] Again with reference to Fig. 3, according to a preferred embodiment, the movement mechanism 60 comprises a plurality of connection linkages 620 which are interposed between the mechanism portion 601 and the penetrating and anchorage plates 40. According to a preferred embodiment, such connection linkages 620 comprise a plurality of connection plates 620, for example one connection plate 620 for each penetrating and anchorage plate 40. Mechanism 60 further comprises a first and a second connection hinge 621, 622 arranged to connect each connection linkage 620 to portion 601 and to one of the penetrating and anchorage plates 40, respectively. According to a convenient embodiment, each penetrating and anchorage plate 40 comprises a seat 402 suitable for at least partly receiving one of the aforesaid second connection hinges 622 so as to reduce or eliminate the radial projection of such a second connection hinge 622 beyond the respective penetrating and anchorage plate 40 in the aforesaid rest configuration of device 1. According to a preferred embodiment, seat 402 is made by shaping the penetrating and anchorage plates 40 so that such plates have a bayonet profile, as shown for example in Fig. 3. It is worth noting that the fact of reducing the radial projection of the hinges 622 in the rest configuration conveniently allows increasing the penetration efficiency of the plates 40 because it avoids the hinges 622 from coming into contact with the side wall SW of hole H before the free ends 401 of penetration of the plates 40.

[0037] The structure of the anchorage device 1 and assembly 100 being described, now there is described a method of using device 1 with reference to the embodiment shown in the accompanying Figures 1 to 6.

[0038] First, the anchorage device 1, connected to the tie rod 5, is inserted into the perforating hole H by resting the contrast base 50 on bottom BW of such a hole. Once rested on bottom BW, device 1 takes on the rest configuration in Fig. 3. Device 1 is then actuated by inputting the pressurized fluid F into chamber 201 by means of the input tube 11. The pressure of fluid F on portion 611 of the sleeve member 610 has the effect of the sleeve member 610, and accordingly of plate 601 which is integral with the sleeve member 610, sliding towards the bottom BW of hole H. The distancing of the plate 601 of mechanism 60 from the connection plate 203 results in the initial opening of the penetrating and anchorage plates 40 which take on a third angular position (shown in Fig. 4), which is intermediate between the aforesaid first angular position (Fig. 3) and second angular position (Fig. 1 or Fig. 6). It is worth noting that according to a preferred embodiment, in the passage from the first angular position to the third angular position of the plates 40, the distancing between plate 601 and the connection plate 203

is very limited, for example equal to about 10 mm. It is also worth noting that although the penetrating and anchorage plates 40 in Fig. 4 are depicted with the respective free ends 401 of penetration resting on the side wall SW of hole H, the free ends 401 of the plates 40 preferably press against the side wall SW and more preferably partly penetrate through the side wall SW in the third angular position.

[0039] Continuing to input the pressurized fluid F into chamber 201 from the aforesaid third angular position of the plates 40, since rod 30 cannot translate towards the bottom of hole H because the contrast base 50 contrasts with the bottom BW of hole H, a translation occurs of the cylinder body 20 in the distancing direction X1 from the bottom BW of hole H, while rod 30 remains stopped. Accordingly, there is a translation in direction X1 also of the plate 601 of mechanism 60 and of the penetrating and anchorage plates 40. To this end, it is worth noting that during the translation of body 20 in direction X1, due to the effect of the thrust of fluid F on portion 611 of the sleeve member 610, such a sleeve 610 continues to be thrust in direction opposite to direction X1, i.e. towards the bottom BW of hole H. Accordingly, the translation in direction X1 of the plate 601 of mechanism 60 is slowed down or braked with respect to the translation in direction X1 of body 20, and more specifically with respect to the translation of the connection plate 203. Thereby, during the translation of body 20 in direction X1, plate 601 progressively moves away from the connection plate 203, thus allowing a further spreading or umbrella opening of the plates 40 and accordingly, the penetration of such plates 40 through the side wall SW of hole H. To this end, it is worth noting that the penetration of the plates 40 through the side wall SW occurs at least partly diagonally due to the effect of the translation of body 20 in direction X1, in the sense that the plates 40 penetrate through the side wall SW both in lateral direction, i.e. in direction orthogonal to direction X1, and in direction X1. It is worth noting that when present, brake 70 allows the mutual distancing of plate 203 and of portion 601, and accordingly the penetration of the plates 40 through wall SW, to be further facilitated.

[0040] Fig. 5 shows the anchorage device 1 in an intermediate penetration configuration in which the plates 40 take on a fourth intermediate angular position between the first angular position (Fig. 3) and the second angular position (Fig. 6). More specifically, in the fourth angular position in Fig. 5, the plates 40 take on an intermediate angular position between the third angular position (Fig. 4) and the second angular position (Fig. 6). It may be noted in Fig. 5 that the plates 40 are more penetrated through wall SW with respect to the configuration in Fig. 4. Moreover, the plates 601 and plate 203 in Fig. 5 are more spaced apart from one another with respect to the configuration in Fig. 4 and are also both more spaced apart from the contrast base 50 and from the bottom BW of hole H with respect to the configuration of device 1 shown in Fig. 4.

[0041] Continuing to input the pressurized fluid into chamber 201 from the configuration in Fig. 5, device 1 reaches the anchorage configuration in Fig. 6. As may be noted in Fig. 6, according to a preferred embodiment, in the anchorage configuration, the stroke end wall 602 abuts against the abutment wall 205 so as to stop the penetrating and anchorage plates 40 in the second angular position while the plates 40 are arranged orthogonal or substantially orthogonal with respect to direction X1, i.e. with respect to the translation direction of body 20.

[0042] Practically, summarizing the above in relation to the operation of device 1, by inputting the pressurized fluid F into chamber 201, device 1 goes from the rest configuration, in which the penetrating and anchorage plates 40 preferably are parallel or substantially parallel to the jacket 204 of the hydraulic cylinder, to the final anchorage configuration, in which the plates 40 have performed their kinematism and are penetrated in the side wall SW of hole H. Once the anchorage device 1 has taken on the anchorage configuration, a cement mixture may be injected into hole H, thereby plugging the ground and filling at least the stretch anchored, i.e. the stretch corresponding to device 1, with the cement mixture.

[0043] Referring now to Fig. 7, such a drawing shows an anchorage device for anchorage tie rods according to a second embodiment, which is indicated as a whole with numeral 1A. The anchorage device 1A in Fig. 7 is shown in a respective rest configuration similar to the rest configuration of device 1 shown in Fig. 3. It is worth noting that the anchorage device 1A differs from the anchorage device 1 essentially in that it has a hydraulic cylinder having a slightly different cylinder body 20A with respect to body 20, in that it has a longer cylinder rod 30A with respect to rod 30 and in that it has a movement mechanism 60A for allowing the movement of the penetrating and anchorage plates 40 which is slightly different with respect to the movement mechanism 60.

[0044] In particular, body 20A comprises a first end portion 202A of cylinder for connecting the hydraulic cylinder to the aforesaid anchorage tie rod 5, an opposite second end portion 203A of cylinder, or connection plate 203A, suitable for being operatively crossed by rod 30A, and a cylinder side wall 204B, 204C, interposed between the first and second end portions 202A, 203A of cylinder. In the example, the portions 202A and 203A are identical to the portions 202, 203 of device 1 in Fig. 1. Body 20A comprises at least one intermediate wall 203B which is arranged transversally to rod 30A and is arranged in an intermediate position between the first and the second end portion 202A, 203A of cylinder. The intermediate wall 203B is operatively crossed by rod 30A. According to a preferred embodiment, seal elements (not depicted) are operatively interposed between the intermediate wall 203B and rod 30A. As may be noted in Fig. 7, body 20A comprises a first hollow portion 20B of cylinder and a second hollow portion 20C of cylinder. The first hollow portion 20B comprises a cylinder chamber 201A, or expansion chamber 201A, suitable for receiving the pres-

surized hydraulic fluid F. Chamber 201A is delimited by the end portion 202A, by the opposite intermediate wall 203B, and by a first portion 204B of side wall of the side wall 204B, 204C. The first portion 204B is interposed between the end portion 202A and the intermediate wall 203B.

[0045] Rod 30A comprises a first end portion 301B of rod received in chamber 201A and a second end portion 302A of rod, which is opposite to the first end portion 301B. The aforesaid contrast base 50 is associated with the second end portion 302A.

[0046] The second hollow portion 20C extends from the intermediate wall 203B and is coaxial with portion 20B. In particular, the second hollow portion 20C is defined by the intermediate wall 203B, by the opposite second end portion 203A of cylinder and by a second portion 204C of side wall of the side wall 204B, 204C. Portion 204C is interposed between the intermediate wall 203B and the second end portion 203A of cylinder.

[0047] Again with reference to Fig. 7, it is worth noting that mechanism 60A differs from mechanism 60 only in that it provides a sleeve member 610A which is arranged in a different manner with respect to the sleeve member 610, and accordingly has a partly different operation with respect to the operation of the sleeve member 610. Indeed, in the example the sleeve member 610A structurally is identical to the sleeve member 610 of device 1.

[0048] In particular, like the sleeve member 610, the sleeve member 610A is integral with the mechanism portion 601 of mechanism 60A and comprises the aforesaid stroke end element 602 which is suitable for abutting against an abutment portion 205A, or abutment wall 205A, to stop the penetrating and anchorage plates 40 in an anchorage configuration similar to the anchorage configuration of device 1 shown in Fig. 6. The sleeve member 610A is coaxial to rod 30A and is slidably mounted to the second end portion 203A. Rod 30A is suitable for sliding through the sleeve member 610A. The substantial difference between mechanism 60 and mechanism 60A is that the sleeve member 610A is arranged outside chamber 201A. In particular, the sleeve member 610A is arranged partly within the second hollow portion 20C and does not define a movable wall of chamber 201A.

[0049] It is also worth noting that in the case of the anchorage device 1A, the sleeve member 610A does not also perform the function of distancing the end portion 203A and the portion 601 of mechanism 60A from each other. Indeed, in the case of device 1A, such a function is performed only by the aforementioned brake 70.

[0050] The operation of the anchorage device 1A generally substantially is identical to the operation of the anchorage device 1. The only operating difference between device 1 and device 1A lies essentially in the fact that, as mentioned above, the distancing between the portion 601 of mechanism 60A and the connection plate 203A is due only to brake 70. In other words, in the case of device 1A, the sleeve member 610A absolves the func-

tion of stroke end by means of the stroke end element 602, while it does not absolve the function of distancing portion 601 and the connection plate 203A from each other. Practically, from the rest configuration of device 1A shown in Fig. 7, the function of brake 70 is that of initially putting up a calibrated resistance to the translation of body 20A in direction X1. Namely, from the configuration in Fig. 7, a translation is caused of body 20A in direction X1 when fluid F is input into chamber 201A since rod 30A cannot slide towards bottom BW due to the fact that the contrast base 50 is contrasting with bottom BW. Due to brake 70, initially portion 601 remains stopped (as well as the sleeve member 610A which is integral with the latter), while plate 203A moves away from portion 601 translating in direction X1 so as to allow the penetrating and anchorage plates 40 to take on a configuration similar to the configuration of device 1 shown in Fig. 4. From the latter configuration, continuing to input fluid F into chamber 201A, body 20A continues to translate in direction X1 together with the plates 40 and portion 601 until device 1A takes on an anchorage configuration similar to the anchorage configuration of device 1 shown in Fig. 1 and Fig. 6. In particular, during such a translation of body 20A, since portion 601 is partly braked by brake 70, the connection plate 203A and portion 601 continue moving away from each other so as to allow the umbrella opening of the penetrating and anchorage plates 40, and accordingly the penetration of the penetrating and anchorage plates 40 through the side wall SW. It is worth noting that the umbrella opening of the plates 40 is also facilitated by the pressure of the plates 40 on the side wall SW in the configuration similar to the configuration in Fig. 4. It is also worth noting, as described above in relation to the operation of the anchorage device 1, during the translation of body 20A in direction X1, the penetrating and anchorage plates 40 penetrate the wall SW of hole H diagonally, i.e. both laterally and in direction X1. Once the installation of device 1A is complete, as in the case of device 1, the injection may be proceeded with, thus plugging the ground and filling at least the anchored stretch with cement mixture. Generalizing the above description, a process has therefore been described for anchoring anchorage tie rods, comprising:

A) a step of providing an anchorage device (1; 1A) and an anchorage tie rod (10) connected to the anchorage device (1; 1A), the anchorage device (1; 1A) comprising:

- a hydraulic cylinder comprising a cylinder body (20; 20A) and a cylinder rod (30; 30A) slidably mounted to the cylinder body (20; 20A), the cylinder body (20; 20A) comprises a cylinder chamber (201; 201A) suitable for receiving a pressurized hydraulic fluid (F), the cylinder rod (30; 30A) comprises a first end portion (301; 301A) of rod received in the cylinder chamber (201;

201A) and a second end portion (302; 302A) of rod opposite to the first end portion (301; 301A) of rod, said cylinder body (20; 20A) comprises a first end portion (202; 202A) of cylinder for connecting the hydraulic cylinder to said at least one anchorage tie rod (10), an opposite second end portion (203; 203A) of cylinder suitable for being operatively crossed by the cylinder rod (30; 30A) and a cylinder side wall (204; 204B, 204C) interposed between said first and second end portions (202, 203; 202A, 203A) of cylinder;

- at least two penetrating and anchorage plates (40) hinged to the cylinder body (20; 20A), each penetrating and anchorage plate (40) having a free end portion (401) of penetration;
- a contrast base (50) associated with said second end portion (302; 302A) of rod to allow the anchorage device (1; 1A) to be rested on a bottom (BW) of a perforating hole (H);
- a movement mechanism (60; 60A) for allowing the movement of the penetrating and anchorage plates (40), said movement mechanism (60; 60A) comprising a mechanism portion (601) which is operatively connected to the penetrating and anchorage plates (40) and is suitable for being operatively crossed by the cylinder rod (30; 30A) so as to allow a relative sliding between such a mechanism portion (601) and the cylinder rod (30; 30A), said mechanism portion (601) being arranged between said contrast base (50) and said second end portion (203; 203A) of cylinder;

said anchorage device (1; 1A) being suitable for taking on a relatively compact rest configuration, in which the penetrating and anchorage plates (40) take on a first angular position in which they are facing the cylinder side wall (204; 204B, 204C); and an anchorage configuration which is relatively unfolded with respect to the rest configuration, in which the penetrating and anchorage plates (40) take on a second angular position, different from the first angular position;

in which the anchorage device (1; 1A) comprises an abutment portion (205; 205A) and the movement mechanism (60; 60A) comprises a stroke end element (602) which is integral with said mechanism portion (601) and which is suitable for abutting against said abutment portion (205; 205A) in order to stop the penetrating and anchorage plates (40) in said anchorage configuration; in which the movement mechanism (60; 60A) comprises at least one distancing element (610, 70) operatively connected to

said mechanism portion (601) and arranged so as to allow said mechanism portion (601) to move away from the second end portion (203; 203A) of cylinder when the hydraulic fluid (F) is input into the cylinder chamber (201; 201A);

B) a step of inserting the anchorage device (1; 1A) connected to said tie rod (10) into said perforating hole (H) and resting said contrast base (50) on the bottom (BW) of said perforating hole (H);

C) a first step of inputting said hydraulic fluid (F) into said cylinder chamber (201; 201A) so as to move said mechanism portion (601) away from said second end portion (203; 203A) of cylinder by means of said distancing element (610, 70), in order to cause said penetrating and anchorage plates (40) to take on a third intermediate angular position between said first and second angular position, the free ends (401) of penetration of the penetrating and anchorage plates (40) pressing or partly penetrating the side wall (SW) of the perforating hole in said third angular position;

and

D) a second step of inputting said hydraulic fluid (F) into said cylinder chamber (201; 201A) so as to cause a translation of the cylinder body (20; 20A), said mechanism portion (601) and the penetrating and anchorage plates (40) in the distancing direction (X1) from the bottom (BW) of the perforating hole (H) so as to allow the penetrating and anchorage plates (40) to further penetrate through the side wall (SW) of the perforating hole (H) and so as to cause such plates (40) to take on said anchorage configuration.

[0051] Based on the above description, it may be understood how an anchorage device according to the present invention is such as to resolve the above-mentioned drawbacks with reference to the known art.

[0052] The features of an anchorage device according to the present description indeed meet the need to increase the efficiency of transferring loads to the ground while almost completely eliminating the extraction problems of the tie rod. Indeed, the anchoring no longer occurs by relying on the friction resistance due to the mortar-ground adhesion, rather it is ensured by the mechanical resistance of the penetrating and anchorage plates which are first driven into the walls of the perforating hole and then embedded with slurry. Therefore, with such a device, it will be more than sufficient to penetrate about 3 to 4 meters into the active stretch (thus drastically reducing the active length which as mentioned above, generally may also reach 40 meters for conventional tie rods), proceed with opening by actuating the cylinder rod and once penetration is complete, inject cement grout.

[0053] Once anchored, the system can no longer be removed because the penetrating and anchorage plates,

which are now spread and penetrated in the side wall of the hole, have an open diameter which is much greater than the diameter of the perforation, thus achieving, as mentioned, a mechanical type anchoring and no longer a friction anchoring.

[0054] With reference now to Fig. 8, such a drawing shows an assembly of parts which is indicated as whole with numeral 100E. The assembly of parts 100E comprises an anchorage tie rod 5 preferably including at least one strand 10, and more preferably a plurality of strands 10, for example two strands 10 as shown in Fig. 8. According to a preferred embodiment, the part of the tie rod 5 corresponding to the free length of the tie rod 5 is protected by a smooth sheath 6.1 of the type in itself known, while the part of the tie rod 5 corresponding to the active length of the tie rod 5 is protected by a corrugated sheath 6.2 of the type in itself known. Moreover, assembly 100E comprises an anchorage device 1E for anchorage tie rods according to a further embodiment, and a head plate 15, or anchorage head 15, for anchoring the aforesaid tie rod 5. The head plate 15, preferably made of metal material, is arranged at an input opening T1 of a perforating hole H made in a ground G. Hole H has a side wall SW of hole and a bottom BW of hole. In the example shown in the accompanying drawings, hole H is made both through a contrast structure P1, such as e.g. a reinforced cement wall, a partition wall, a bearing wall, etc., and through ground G. In particular, the head plate 15 is arranged at the input opening T1 to allow the transfer of the stresses onto the contrast structure P1.

[0055] The anchorage device 1E is suitable for being inserted into the perforating hole H to allow anchoring the aforesaid anchorage tie rod. It is worth noting, as indicated above, that the anchorage tie rod 5 in the example embodiment is a tie rod with strands, i.e. a tie rod comprising, or consisting of, one or more strands 10. However, the teachings of the present description may be applied in general to all types of anchorage tie rods, such as for example and not limited to, bar tie rods, cable tie rods, tube tie rods, etc.

[0056] The anchorage tie rod 5, the anchorage device 1E and the head plate 15 in Fig. 8 are depicted in the respective final anchoring configuration. As may be noted in Fig. 8, the tie rod 5 has a respective end fixed to the anchorage device 1E and an opposite end fixed to plate 15, preferably by means of at least one locking clamp 16. In other words, each of the strands 10 in the example has a respective end fixed to the anchorage device 1E and an opposite end fixed to plate 15, preferably by means of a respective locking clamp 16. With reference to figures Fig. 8 to Fig. 11, the anchorage device 1E comprises a hydraulic cylinder having a middle axis Z1. Such a hydraulic cylinder comprises a cylinder body 20E and a cylinder rod 30E slidably mounted to the cylinder body 20E. The middle axis Z1 practically corresponds to the translation direction of body 20E or of rod 30E. The cylinder body 20E comprises a first cylinder chamber 201E, or first expansion chamber 201E, suitable for receiving

a pressurized hydraulic fluid F (such a fluid is depicted by means of small lines in Fig. 8 and Fig. 11). Fluid F may be input into the first chamber 201E preferably by means of at least one tube (not depicted) communicating with chamber 201E. The cylinder rod 30E comprises a first end portion 301E of rod received in the first cylinder chamber 201E and a second end portion 302E of rod, which is opposite to the first end portion 301E. The cylinder body 20E comprises a first end portion 202E of cylinder, an opposite second end portion 203E of cylinder suitable for being operatively crossed by rod 30E, and a cylinder side wall 204E interposed between said first and second end portions 202E, 203E of cylinder. Preferably, the first end portion 202E comprises an end plate 202E of cylinder. The anchorage device 1E comprises at least two penetrating and anchorage plates 40, preferably four plates 40 opposed two-by-two as shown in Fig. 9. Each penetrating and anchorage plate 40 has a free end portion 401 of penetration. The anchorage device 1E further comprises a contrast base 50 associated with the second end portion 302E of rod to allow the anchorage device 1E to be rested on a bottom BW of hole H. Again, the anchorage device 1E comprises a movement mechanism 60E operatively connected to the hydraulic cylinder to allow the movement of the penetrating and anchorage plates 40. The movement mechanism 60E comprises a mechanism portion 601E, preferably a mechanism plate 601E, to which the penetrating and anchorage plates 40 are hinged and to which the anchorage tie rod 5 is suitable for being connected. Portion 601E is arranged facing the first end portion 202E of cylinder.

[0057] The anchorage device 1E is suitable for taking on a relatively compact rest configuration (Fig. 10). In such a rest configuration, the penetrating and anchorage plates 40 project from the mechanism portion 601E on the opposite side with respect to the contrast base 50. Moreover, in such a rest configuration, the plates 40 take on a first angular position in which they are arranged parallel or substantially parallel to the middle axis Z1 of the hydraulic cylinder.

[0058] The anchorage device 1E is also suitable for taking on an anchorage configuration (Fig. 8) which is relatively unfolded with respect to the rest configuration (Fig. 10). In the anchorage configuration, the penetrating and anchorage plates 40 take on a second angular position, different from the first angular position. According to one embodiment, in the anchorage configuration, the plates 40 are extended orthogonally or substantially orthogonally with respect to the middle axis Z1 of the hydraulic cylinder.

[0059] Again with reference to Fig. 8 to Fig. 11, the movement mechanism 60E comprises at least one distancing element 610E operatively connected to the mechanism portion 601E. The distancing element 610E is arranged so as to operatively cross the first end portion 202E of cylinder and to allow the mechanism portion 601E to move away from the first end portion 202E of cylinder when the hydraulic fluid F is input into the first

cylinder chamber 201E so as to allow the movement of the penetrating and anchorage plates 40.

[0060] According to one embodiment, the at least one distancing element 610E comprises a hollow longitudinal member 610E, or sleeve 610E, which is integral with the mechanism portion 601E. The hollow longitudinal member 610E is coaxial to rod 30E and delimits the first cylinder chamber 201E on the opposite side with respect to the second end portion 203E of the cylinder. When the anchorage device 1E takes on the rest configuration, the hollow longitudinal member 610E is suitable for receiving a portion of rod 30E comprising the first end portion 301E of rod 30E. Preferably, member 610E has a respective end 612E fixed, for example welded, directly to portion 601E. Preferably, such an end 612E of member 610E is a wall 612E which closes an end of the cavity of the hollow longitudinal member 610E.

[0061] According to one embodiment, the hollow longitudinal member 610E comprises a radially projecting longitudinal portion 611E of member which defines a movable wall of the first cylinder chamber 201E.

[0062] According to one embodiment, the movement mechanism 60E comprises a plurality of connection linkages 620 interposed between the first end portion 202E of cylinder and the penetrating and anchorage plates 40. In particular, in the rest configuration, said penetrating and anchorage plates 40 are arranged radially internal and said connection linkages 620 are arranged radially external with respect to said penetrating and anchorage plates 40.

[0063] According to a convenient embodiment, the movement mechanism 60E comprises a first and a second connection hinges 621, 622 arranged to connect each connection linkage 620 to said first end portion 202E of cylinder and to one of said penetrating and anchorage plates 40, respectively. In particular, each penetrating and anchorage plate 40 comprises a seat 402 suitable for at least partly receiving said second connection hinge 622 so as to reduce or eliminate the radial projection of the second connection hinge 622 beyond the respective penetrating and anchorage plate 40 in the rest configuration of the anchorage device 1E. This advantageously allows the radial volume of the anchorage device to be reduced in the rest configuration.

[0064] It is worth noting that since rod 30E does not completely cross member 610E and the mechanism portion 601E, the thrust surface of member 610E may be wholly taken advantage of. Thereby, the opening and complete penetration of the plates 40 is obtained, thus reducing the stroke of device 1E itself. All this results in having a particularly short cylinder body 20E and therefore, in essence, the whole device 1E being particularly short.

[0065] Moreover, it is worth noting that with the arrangement of member 610E, it becomes possible to fasten the end 612E thereof to portion 601E to which the plates 40 are hinged, while the linkages 620 may be hinged to the first end portion 202E of cylinder. The ad-

vantage obtained is that, being beyond the first end portion 202E of cylinder, portion 601E may be narrower than the outer diameter of the cylinder body 20E so that in the rest configuration of device 1E, the radial volume of the plates 40, linkages 620 and hinges 621, 622 does not exceed, or exceeds to a limited extent, beyond the outer diameter of the cylinder body 20E. This results in a particularly reduced radial volume of the whole device 1E.

[0066] According to a convenient embodiment, the cylinder body 20E comprises a second cylinder chamber 207E suitable for receiving the pressurized hydraulic fluid F. The second chamber 207E is opposite to the first cylinder chamber and is delimited by the distancing element 610E on the side opposite to the first end portion 202E of cylinder. The distancing element 610E is arranged so as to allow the mechanism portion 601E to move close to the first end portion 202E of cylinder when the hydraulic fluid F is input into the second cylinder chamber 207E so as to allow the movement of the penetrating and anchorage plates 40 to cause the anchorage device 1E to take on the rest configuration. It is worth noting that the space or distance between the radially projecting portion 611E and the first end portion 202E of cylinder in Fig. 8 was depicted significantly enlarged with respect to the actual condition so as to be able to depict the second chamber 207E. However, in the configuration in Fig. 8, portion 611E is abutting or substantially abutting against the first end portion 202E of cylinder.

[0067] In essence, according to a convenient embodiment, the anchorage device 1E comprises a dual effect hydraulic cylinder which, as will be better understood below in the description, in the case of erroneous placement of the anchorage device 1E (obviously before the injection with grout), allows bringing it back to the rest configuration and extracting it from hole H.

[0068] According to a preferred embodiment, the anchorage device 1E comprises a resistance 70E, or brake 70E, to the relative sliding between the cylinder body 20E and rod 30E. Brake 70E is integral with the cylinder body 20E, and more preferably is integral with the second end portion 203E of cylinder, and is suitable for engaging or operatively contacting rod 30E. For example, brake 70E may comprise a pair of jaws rigidly connected to the second end portion 203E and suitable for tightening rod 30E so as to contrast the relative sliding between rod 30E and the cylinder body 20E. Preferably, brake 70E is arranged between the second end portion 203E of cylinder and the contrast base 50.

[0069] The structure of the anchorage device 1E and assembly 100E being described, now there is described a method of using device 1E with reference to the embodiment shown in the accompanying Figures 8 to 11.

[0070] First, the anchorage device 1E, connected to the tie rod 5, is inserted into the perforating hole H by resting the contrast base 50E on bottom BW of such a hole. Once rested on bottom BW, device 1E takes on the rest configuration in Fig. 10. Device 1E is actuated by initially inputting the pressurized fluid F into the first cham-

ber 201E. The pressure of fluid F on the thrust surface of rod 30E and on the thrust surface of the hollow longitudinal member 610E has as effect the relative sliding of rod 30E with respect to member 610E, with member 610E translating in direction X1.

Indeed, since the contrast base 50 contrasts with the bottom BW of hole H, rod 30E does not have the possibility to move and therefore the aforesaid sliding may only cause a translation in direction X1 of member 610E.

Portion 601E, which is integral with member 610E, translates in direction X1 due to the effect of the translation in direction X1 of member 610E itself. Then, as will be better explained below, also the cylinder body 20E starts to translate in direction X1. Such a rectilinear motion in direction X1 of the first end portion 202E of cylinder and of portion 601E induces the umbrella opening of the linkages 620 and of the penetrating and anchorage plates 40.

[0071] In essence, there is a kinematism which transforms the rectilinear motion in direction X1 of the cylinder body 20E and of member 610E both into a translation in direction X1 of the linkages 620 and of the plates 40 and a spreading of such linkages 620 and plates 40 towards the side wall SW of hole H.

[0072] The function of brake 70E is that of initially putting up a calibrated resistance to the translation of cylinder body 20E in direction X1. Namely, considering that the thrust surface of the hollow longitudinal member 610E preferably is about 5 to 8 times greater than the thrust surface of rod 30E, and also since the translation of the cylinder body 20E is initially locked by brake 70E, due to the translation of member 610E, the result is, in a first step, only the spreading takes place of the linkages 620 and of the penetrating and anchorage plates 40 which press the side wall SW of hole H. At this point,

device 1E takes on for example, the configuration in Fig. 11. Then, continuing to input fluid F into the first chamber 201E, once the resistance of brake 70E is overcome, and due also to the fact that the plates 40 press against the side wall SW of hole H, also the cylinder body 20E starts to slide in direction X1 in addition to member 610E. Accordingly, due to the opposition of the contrast base 50 and to the pressure of the penetrating and anchorage plates 40 on the side wall SW of hole H both in direction X1 and in radial direction, the penetration thereof in hole H is facilitated.

[0073] Therefore, by inputting the pressurized fluid F into the first chamber 201E and due to the above-mentioned action of brake 70E, the anchorage device 1E goes from the rest configuration in Fig. 10, in which the plates 40 and the linkages 620 are parallel to the middle axis Z1, to an intermediate configuration (Fig. 11), in which penetrating and anchorage plates 40 take on a third intermediate angular position (Fig. 11) between the first angular position (Fig. 10) and the second angular position (Fig. 8). In such a third angular position, the free ends 401 of penetration of the penetrating and anchorage plates 40 press or partly penetrate the side wall SW of the perforating hole.

[0074] From the aforesaid intermediate configuration of device 1E, continuing to input the pressurized fluid F into the first chamber 201E, fluid F, acting as already mentioned above on the thrust surfaces of the hollow longitudinal member 610E, causes the translation of member 610E in direction X1. As already mentioned above, also the cylinder body 20E translates in direction X1 up to bringing device 1E into the anchorage configuration in which the penetrating and anchorage plates 40 have performed their kinematism and are penetrated in the side wall SW of hole H.

[0075] Once the installation of device 1E is complete, the injection with cement mixture into hole H may be proceeded with, thus plugging the ground and filling the stretch anchored with cement mixture.

[0076] It is worth noting that due to the fact of providing the second chamber 207E, if, during the placement operations of device 1E, and in any case before injecting cement grout, the operator realizes to have made a mistake during the installation of the tie rod 5 in hole H and would like to extract it, device 1E has the features to allow this to be done.

[0077] Indeed, by inputting pressurized fluid F into the second chamber 207E, the pressure of fluid F has the effect of exerting a thrust on the radially projecting portion 611E of member 610E, thus causing the translation of member 610E in opposite direction with respect to direction X1, i.e. towards the bottom BW of hole H, and the discharge from the first chamber 201E of fluid F in such a first chamber 201E. Accordingly, since portion 601E is fixed to the hollow member 610E, the plates 40 move up to taking on an identical or substantially identical angular position to that in Fig. 10. To this end, it is worth noting however that by inputting the pressurized fluid F into the second chamber 207E, only the translation of member 610E is induced in the direction opposite to direction X1, and not also the translation of the cylinder body 20E in direction opposite to direction X1. Thus, the effect of the retraction of member 610E which is integral with portion 601E only closes the plates 40. In other words, once the plates 40 are closed again, rod 30E will still be extracted from the cylinder body 20E. At this point, the tie rod 5 and device 1E may be extracted from hole H. Once device 1E has been extracted from hole H, to bring device 1E itself into the initial rest configuration, brake 70E is to be loosened and rod 30E is to be returned, e.g. manually, into the cylinder body 20E.

[0078] Generalizing the above description in relation to the anchorage device 1E, a process has therefore been described for anchoring anchorage tie rods, comprising:

A) a step of providing an anchorage device (1E) suitable for being inserted into a perforating hole (H) made in a ground, and an anchorage tie rod (5) connected to the anchorage device (1E), the anchorage device (1E) comprising:

- a hydraulic cylinder having a middle axis (Z1) and comprising a cylinder body (20E) and a cylinder rod (30E) slidably mounted to the cylinder body (20E), the cylinder body (20E) comprises a first cylinder chamber (201E) suitable for receiving a pressurized hydraulic fluid (F), the cylinder rod (30E) comprises a first end portion (301E) of rod received in the cylinder chamber (201E) and a second end portion (302E) of rod opposite to the first end portion (301E) of rod, said cylinder body (20E) comprises a first end portion (202E) of cylinder, an opposite second end portion (203E) of cylinder suitable for being operatively crossed by the cylinder rod (30E) and a cylinder side wall (204E) interposed between said first and second end portions (202E, 203E) of cylinder;
- at least two penetrating and anchorage plates (40), each penetrating and anchorage plate (40) having a free end portion (401) of penetration;
- a contrast base (50) associated with said second end portion (302E) of rod to allow the anchorage device (1E) to be rested on a bottom (BW) of said hole (H);
- a movement mechanism (60E) operatively connected to the hydraulic cylinder for allowing the movement of the penetrating and anchorage plates (40), said movement mechanism (60E) comprising a mechanism portion (601E) to which the penetrating and anchorage plates (40) are hinged and to which said anchorage tie rod (5) is suitable for being connected, said mechanism portion (601E) being arranged facing said first end portion (202E) of cylinder;

said anchorage device (1E) being suitable for taking on

a relatively compact rest configuration, in which the penetrating and anchorage plates (40) project from said mechanism portion (601E) on the side opposite to said contrast base (50) and in which they take on a first angular position in which they are arranged parallel or substantially parallel to the middle axis (Z1) of the hydraulic cylinder; and an anchorage configuration which is relatively unfolded with respect to the rest configuration, in which the penetrating and anchorage plates (40) take on a second angular position, different from the first angular position; in which the movement mechanism (60E) comprises at least one distancing element (610E) operatively connected to said mechanism portion (601E) and arranged so as to operatively cross the first end portion (202E) of cylinder and to allow said mechanism portion (601E) to move away from

the first end portion (202E) of cylinder when the hydraulic fluid (F) is input into the first cylinder chamber (201E) so as to allow the movement of the penetrating and anchorage plates (40);

B) a step of inserting the anchorage device (1E) connected to said tie rod (5) into a perforating hole (H) and resting said contrast base (50) on a bottom (BW) of said perforating hole (H);

C) a first step of inputting said hydraulic fluid (F) into said first cylinder chamber (201E) so as to move said mechanism portion (601E) away from said first end portion (202E) of cylinder by means of said distancing element (610E), in order to cause said penetrating and anchorage plates (40) to take on a third intermediate angular position between said first and second angular position, the free ends (401) of penetration of the penetrating and anchorage plates (40) pressing or partly penetrating a side wall (SW) of the perforating hole (H) in said third angular position; and

D) a second step of inputting said hydraulic fluid (F) into said first cylinder chamber (201E) so as to cause a translation of the cylinder body (20E), said mechanism portion (601E) and the penetrating and anchorage plates (40), in the distancing direction (X1) from the bottom (BW) of the perforating hole (H) so as to allow the penetrating and anchorage plates (40) to further penetrate through the side wall (SW) of the perforating hole (H) and so as to cause such plates (40) to take on said anchorage configuration.

[0079] The features of the anchorage device according to the present invention meet the need to increase the efficiency of transferring loads to the ground while almost completely eliminating the extraction problems of the tie rod. Indeed, the anchoring no longer occurs by relying on the friction resistance due to the mortar-ground adhesion, rather it is ensured by the mechanical resistance of the plates which are first driven into the walls of the hole and then embedded with slurry. Therefore, with such a device, it will be more than sufficient to penetrate about 3 to 4 meters into the active stretch (thus drastically reducing the active length which, as mentioned above, generally may also reach 40 meters for conventional tie rods).

[0080] Once anchored, the system can no longer be removed because the metal fins, which are now spread and penetrated in the walls of the hole, have an open diameter which is much greater than the diameter of the perforation, thus achieving, as mentioned, a mechanical type anchoring and no longer a friction anchoring.

[0081] Due to the anchorage achieved with the driving in of the penetrating and anchorage plates, the traditional and uncertain action of bulbs obtained with injections may be eliminated. The metal fins actuated by sliding the cylinder rod have a significant penetration force which allows them to be inserted into any type of ground. The

flexibility of the system not only also allows the device proposed to be applied to anchorage tie rods, but also to any other type of deep foundation.

[0082] In particular, the embodiment described with reference to Fig. 8 to Fig. 11 allows for example, obtaining the following advantages in terms of execution times, safety, the environment, and in terms of being economical and practical:

- 10 - shorter perforation lengths which result in a reduction both of costs and unforeseen events and problems associated with the execution thereof;
- reduced diameter of perforation;
- smaller quantities of cement mortar per injection;
- 15 - improved environmental impact because a shallower excavation depth corresponds to a smaller volume of debris to be disposed of;
- shorter active lengths result in simplicity of movement, storage at the site and transport;
- 20 - decreased execution times at the site, with advantages in terms of being economical and workplace safety;
- injection only of the active part; while in commonly-used tie rods, primary, secondary injections of the filling bag, etc. become necessary;
- 25 - application substantially in all types of ground, from the poorest to the most solid ones;
- elimination of uncertainties associated with the friction hold of the foundation bulbs because the mechanical hold of the present device provides increased guarantees.

[0083] It is apparent that modifications and/or variants may also be made to the above description disclosed above by way of example.

[0084] For example, it is worth noting that the accompanying drawings to the present description are only given by way of example. Indeed, for example the dimensions both of the penetrating and anchorage plates and of the relative connection linkages (width, length and thickness) which in essence determine the contrast surface with the ground, may also be sized each time according to the type of ground itself. It is apparent that the less the resistance of the ground, the greater the contact surface is to be, and vice versa.

[0085] The principle of the invention being understood, the embodiments and manufacturing details may largely vary with respect to those described and disclosed by mere way of non-limiting example, without departing from the scope of the invention as defined in the appended claims.

Claims

- 55 1. An anchorage device (1; 1A) for anchorage tie rods, suitable for being inserted into a perforating hole (H) made in a ground to allow anchoring an anchorage

tie rod (5), comprising:

- a hydraulic cylinder comprising a cylinder body (20; 20A) and a cylinder rod (30; 30A) slidably mounted to the cylinder body (20; 20A), the cylinder body (20; 20A) comprises a cylinder chamber (201; 201A) suitable for receiving a pressurized hydraulic fluid (F), the cylinder rod (30; 30A) comprises a first end portion (301; 301A) of rod received in the cylinder chamber (201; 201A) and a second end portion (302; 302A) of rod opposite to the first end portion (301; 301A) of rod, said cylinder body (20; 20A) comprises a first end portion (202; 202A) of cylinder for connecting the hydraulic cylinder to said anchorage tie rod (5), an opposite second end portion (203; 203A) of cylinder suitable for being operatively crossed by the cylinder rod (30; 30A) and a cylinder side wall (204; 204B, 204C) interposed between said first and second end portions (202, 203; 202A, 203A) of cylinder;

- at least two penetrating and anchorage plates (40) hinged to the cylinder body (20; 20A), each penetrating and anchorage plate (40) having a free end portion (401) of penetration;

- a contrast base (50) associated with said second end portion (302; 302A) of rod to allow the anchorage device (1; 1A) to be rested on a bottom (BW) of said hole (H);

- a movement mechanism (60; 60A) for allowing the movement of the penetrating and anchorage plates (40), said movement mechanism (60; 60A) comprising a mechanism portion (601) which is operatively connected to the penetrating and anchorage plates (40) and is suitable for being operatively crossed by the cylinder rod (30; 30A) so as to allow a relative sliding between such a mechanism portion (601) and the cylinder rod (30; 30A), said mechanism portion (601) being arranged between said contrast base (50) and said second end portion (203; 203A) of cylinder;

said anchorage device (1; 1A) being suitable for taking on a relatively compact rest configuration, wherein the penetrating and anchorage plates (40) take on a first angular position wherein they are facing the cylinder side wall (204; 204B, 204C); and an anchorage configuration which is relatively unfolded with respect to the rest configuration, wherein the penetrating and anchorage plates (40) take on a second angular position, different from the first angular position; wherein the anchorage device (1; 1A) comprises an abutment portion (205; 205A) and

the movement mechanism (60; 60A) comprises a stroke end element (602) which is integral with said mechanism portion (601) and which is suitable for abutting against said abutment portion (205; 205A) in order to stop the penetrating and anchorage plates (40) in said anchorage configuration; wherein the movement mechanism (60; 60A) comprises at least one distancing element (610, 70) operatively connected to said mechanism portion (601) and arranged so as to allow said mechanism portion (601) to move away from the second end portion (203; 203A) of cylinder when the hydraulic fluid (F) is input into the cylinder chamber (201; 201A) .

2. An anchorage device (1; 1A) according to claim 1, wherein said movement mechanism (60; 60A) comprises a sleeve member (610; 610A) which is integral with said mechanism portion (601) and comprising said stroke end element (602), said sleeve member (610; 610A) being coaxial to the cylinder rod (30; 30A) and being slidably mounted to the second end portion (203; 203A) of cylinder, the cylinder rod (30; 30A) being suitable for sliding through said sleeve member (610; 610A).
3. An anchorage device (1) according to claim 2, wherein said distancing element (610, 70) comprises said sleeve member (610), said sleeve member (610) being partly extended within the cylinder body (20) and comprising a portion (611) of sleeve member which defines a movable wall of the cylinder chamber (201).
4. An anchorage device (1) according to any one of the preceding claims, wherein said movement mechanism (60; 60A) comprises a plurality of connection linkages (620) interposed between said mechanism portion (601) and said penetrating and anchorage plates (40), and a first and a second connection hinges (621, 622) arranged to connect each connection linkage (620) to said mechanism portion (601) and to one of said penetrating and anchorage plates (40) respectively, each penetrating and anchorage plate (40) comprising a seat (402) suitable for at least partly receiving said second connection hinge (622) so as to reduce or eliminate, in said rest configuration, the radial projection of said second connection hinge (622) beyond the respective penetrating and anchorage plate (40).
5. An assembly of parts (1, 5, 15; 1A, 5, 15) comprising an anchorage tie rod (5), an anchorage device (1) as defined in any one of the preceding claims, and a head plate (15) for said tie rod (5).

6. A process for anchoring anchorage tie rods, comprising:

A) a step of providing an anchorage device (1; 1A) and an anchorage tie rod (5) connected to the anchorage device (1; 1A), the anchorage device (1; 1A) comprising:

- a hydraulic cylinder comprising a cylinder body (20; 20A) and a cylinder rod (30; 30A) slidably mounted to the cylinder body (20; 20A), the cylinder body (20; 20A) comprises a cylinder chamber (201; 201A) suitable for receiving a pressurized hydraulic fluid (F), the cylinder rod (30; 30A) comprises a first end portion (301; 301A) of rod received in the cylinder chamber (201; 201A) and a second end portion (302; 302A) of rod opposite to the first end portion (301; 301A) of rod, said cylinder body (20; 20A) comprises a first end portion (202; 202A) of cylinder for connecting the hydraulic cylinder to said anchorage tie rod (5), an opposite second end portion (203; 203A) of cylinder suitable for being operatively crossed by the cylinder rod (30; 30A) and a cylinder side wall (204; 204B, 204C) interposed between said first and second end portions (202, 203; 202A, 203A) of cylinder;

- at least two penetrating and anchorage plates (40) hinged to the cylinder body (20; 20A), each penetrating and anchorage plate (40) having a free end portion (401) of penetration;

- a contrast base (50) associated with said second end portion (302; 302A) of rod to allow the anchorage device (1; 1A) to be rested on a bottom (BW) of a perforating hole (H);

- a movement mechanism (60; 60A) for allowing the movement of the penetrating and anchorage plates (40), said movement mechanism (60; 60A) comprising a mechanism portion (601) which is operatively connected to the penetrating and anchorage plates (40) and is suitable for being operatively crossed by the cylinder rod (30; 30A) so as to allow a relative sliding between such a mechanism portion (601) and the cylinder rod (30; 30A), said mechanism portion (601) being arranged between said contrast base (50) and said second end portion (203; 203A) of cylinder;

said anchorage device (1; 1A) being suitable for taking on a relatively compact rest configuration, wherein the penetrating and anchorage

plates (40) take on a first angular position wherein they are facing the cylinder side wall (204; 204B, 204C); and an anchorage configuration which is relatively unfolded with respect to the rest configuration, wherein the penetrating and anchorage plates (40) take on a second angular position, different from the first angular position; wherein the anchorage device (1; 1A) comprises an abutment portion (205; 205A) and the movement mechanism (60; 60A) comprises a stroke end element (602) which is integral with said mechanism portion (601) and which is suitable for abutting against said abutment portion (205; 205A) in order to stop the penetrating and anchorage plates (40) in said anchorage configuration;

wherein the movement mechanism (60; 60A) comprises at least one distancing element (610, 70) operatively connected to said mechanism portion (601) and arranged so as to allow said mechanism portion (601) to move away from the second end portion (203; 203A) of cylinder when the hydraulic fluid (F) is input into the cylinder chamber (201; 201A);

B) a step of inserting the anchorage device (1; 1A) connected to said tie rod (5) into said perforating hole (H) and resting said contrast base (50) on the bottom (BW) of said perforating hole (H);

C) a first step of inputting said hydraulic fluid (F) into said cylinder chamber (201; 201A) so as to move said mechanism portion (601) away from said second end portion (203; 203A) of cylinder by means of said distancing element (610, 70), in order to cause said penetrating and anchorage plates (40) to take on a third intermediate angular position between said first and second angular position, the free ends (401) of penetration of the penetrating and anchorage plates (40) pressing or partly penetrating the side wall (SW) of the perforating hole in said third angular position;

and

D) a second step of inputting said hydraulic fluid (F) into said cylinder chamber (201; 201A) so as to cause a translation of the cylinder body (20; 20A), said mechanism portion (601) and the penetrating and anchorage plates (40) in the distancing direction (X1) from the bottom (BW) of the perforating hole (H) so as to allow the penetrating and anchorage plates (40) to further

penetrate through the side wall (SW) of the perforating hole (H) and so as to cause such plates (40) to take on said anchorage configuration.

7. An anchorage device (1E) for anchorage tie rods suitable for being inserted into a perforating hole (H) made in a ground to allow anchoring an anchorage tie rod (5), comprising:

- a hydraulic cylinder having a middle axis (Z1) and comprising a cylinder body (20E) and a cylinder rod (30E) slidably mounted to the cylinder body (20E), the cylinder body (20E) comprises a first cylinder chamber (201E) suitable for receiving a pressurized hydraulic fluid (F), the cylinder rod (30E) comprises a first end portion (301E) of rod received in the cylinder chamber (201E) and a second end portion (302E) of rod opposite to the first end portion (301E) of rod, said cylinder body (20E) comprises a first end portion (202E) of cylinder, an opposite second end portion (203E) of cylinder suitable for being operatively crossed by the cylinder rod (30E) and a cylinder side wall (204E) interposed between said first and second end portions (202E, 203E) of cylinder;

- at least two penetrating and anchorage plates (40), each penetrating and anchorage plate (40) having a free end portion (401) of penetration;

- a contrast base (50) associated with said second end portion (302E) of rod to allow the anchorage device (1E) to be rested on a bottom (BW) of said hole (H);

- a movement mechanism (60E) operatively connected to the hydraulic cylinder for allowing the movement of the penetrating and anchorage plates (40), said movement mechanism (60E) comprising a mechanism portion (601E) to which the penetrating and anchorage plates (40) are hinged and to which said anchorage tie rod (5) is suitable for being connected, said mechanism portion (601E) being arranged facing said first end portion (202E) of cylinder;

said anchorage device (1E) being suitable for taking on

a relatively compact rest configuration, wherein the penetrating and anchorage plates (40) project from said mechanism portion (601E) on the side opposite to said contrast base (50) and wherein they take on a first angular position wherein they are arranged parallel or substantially parallel to the middle axis (Z1) of the hydraulic cylinder; and

an anchorage configuration which is relatively unfolded with respect to the rest configuration, wherein the penetrating and an-

chorage plates (40) take on a second angular position, different from the first angular position;

wherein the movement mechanism (60E) comprises at least one distancing element (610E) operatively connected to said mechanism portion (601E) and arranged so as to operatively cross the first end portion (202E) of cylinder and to allow said mechanism portion (601E) to move away from the first end portion (202E) of cylinder when the hydraulic fluid (F) is input into the first cylinder chamber (201E) so as to allow the movement of the penetrating and anchorage plates (40).

8. An anchorage device (1E) according to claim 7, wherein said at least one distancing element comprises a hollow longitudinal member (610E) which is integral with said mechanism portion (601E), said hollow longitudinal member (610E) being coaxial to the cylinder rod (30E) and delimiting the first cylinder chamber (201E) on the side opposite to the second end portion (203E) of cylinder, said hollow longitudinal member (610E) being suitable for receiving a portion of cylinder rod (30E) comprising the first end portion (301E) of rod when the anchorage device (1E) takes on the rest configuration.

9. An anchorage device (1E) according to claim 8, wherein said hollow longitudinal member (610E) comprises a radially projecting longitudinal portion (611E) of member which defines a movable wall of the first cylinder chamber (201E) .

10. An anchorage device (1) according to any one of claims 7 to 9, wherein said movement mechanism (60E) comprises a plurality of connection linkages (620) interposed between said first end portion (202E) of cylinder and said penetrating and anchorage plates (40), wherein in said rest configuration, said penetrating and anchorage plates (40) are arranged radially internal and said connection linkages (620) are arranged radially external with respect to said penetrating and anchorage plates (40).

11. An anchorage device (1E) according to claim 10, wherein said movement mechanism (60E) comprises a first and a second connection hinges (621, 622) arranged to connect each connection linkage (620) to said first end portion (202E) of cylinder and to one of said penetrating and anchorage plates (40) respectively, each penetrating and anchorage plate (40) comprising a seat (402) suitable for at least partly receiving said second connection hinge (622) so as to reduce or eliminate, in said rest configuration, the radial projection of said second connection hinge (622) beyond the respective penetrating and anchor-

age plate (40).

12. An anchorage device (1E) according to any one of claims 7 to 11, wherein the cylinder body (20E) comprises a second cylinder chamber (207E) suitable for receiving said pressurized hydraulic fluid (F), the second cylinder chamber being opposite to the first cylinder chamber and being delimited by said distancing element (610E) on the side opposite to the first end portion (202E) of cylinder, said distancing element (610E) being arranged so as to allow said mechanism portion (601E) to move close to the first end portion (202E) of cylinder when the hydraulic fluid (F) is input into the second cylinder chamber (207E) so as to allow the movement of the penetrating and anchorage plates (40) to cause the anchorage device (1E) to take on the rest configuration.
13. An anchorage device (1E) according to any one of claims 7 to 12, comprising a resistance (70E) to the relative sliding between the cylinder body (20E) and the rod (30E), said resistance (70E) to sliding being integral with the cylinder body (20E) and being suitable for engaging or operatively contacting the cylinder rod (30E).
14. An assembly of parts (1E, 5, 15) comprising an anchorage tie rod (5), an anchorage device (1E) as defined in any one of claims 7 to 13, and a head plate (15) for said tie rod (5).
15. A process for anchoring anchorage tie rods, comprising:
- A) a step of providing an anchorage device (1E) suitable for being inserted into a perforating hole (H) made in a ground, and an anchorage tie rod (5) connected to the anchorage device (1E), the anchorage device (1E) comprising:
- a hydraulic cylinder having a middle axis (Z1) and comprising a cylinder body (20E) and a cylinder rod (30E) slidably mounted to the cylinder body (20E), the cylinder body (20E) comprises a first cylinder chamber (201E) suitable for receiving a pressurized hydraulic fluid (F), the cylinder rod (30E) comprises a first end portion (301E) of rod received in the cylinder chamber (201E) and a second end portion (302E) of rod opposite to the first end portion (301E) of rod, said cylinder body (20E) comprises a first end portion (202E) of cylinder, an opposite second end portion (203E) of cylinder suitable for being operatively crossed by the cylinder rod (30E) and a cylinder side wall (204E) interposed between said first and second end portions (202E, 203E) of cylinder

der;

- at least two penetrating and anchorage plates (40), each penetrating and anchorage plate (40) having a free end portion (401) of penetration;
- a contrast base (50) associated with said second end portion (302E) of rod to allow the anchorage device (1E) to be rested on a bottom (BW) of said hole (H);
- a movement mechanism (60E) operatively connected to the hydraulic cylinder for allowing the movement of the penetrating and anchorage plates (40), said movement mechanism (60E) comprising a mechanism portion (601E) to which the penetrating and anchorage plates (40) are hinged and to which said anchorage tie rod (5) is suitable for being connected, said mechanism portion (601E) being arranged facing said first end portion (202E) of cylinder;

said anchorage device (1E) being suitable for taking on a relatively compact rest configuration, wherein the penetrating and anchorage plates (40) project from said mechanism portion (601E) on the side opposite to said contrast base (50) and wherein they take on a first angular position wherein they are arranged parallel or substantially parallel to the middle axis (Z1) of the hydraulic cylinder; and an anchorage configuration which is relatively unfolded with respect to the rest configuration, wherein the penetrating and anchorage plates (40) take on a second angular position, different from the first angular position; wherein the movement mechanism (60E) comprises at least one distancing element (610E) operatively connected to said mechanism portion (601E) and arranged so as to operatively cross the first end portion (202E) of cylinder and to allow said mechanism portion (601E) to move away from the first end portion (202E) of cylinder when the hydraulic fluid (F) is input into the first cylinder chamber (201E) so as to allow the movement of the penetrating and anchorage plates (40);

- B) a step of inserting the anchorage device (1E) connected to said tie rod (5) into a perforating hole (H) and resting said contrast base (50) on a bottom (BW) of said perforating hole (H);
- C) a first step of inputting said hydraulic fluid (F) into said first cylinder chamber (201E) so as to

move said mechanism portion (601E) away from
said first end portion (202E) of cylinder by means
of said distancing element (610E), in order to
cause said penetrating and anchorage plates
(40) to take on a third intermediate angular po- 5
sition between said first and second angular po-
sition, the free ends (401) of penetration of the
penetrating and anchorage plates (40) pressing
or partly penetrating a side wall (SW) of the per- 10
forating hole (H) in said third angular position;
and
D) a second step of inputting said hydraulic fluid
(F) into said first cylinder chamber (201E) so as
to cause a translation of the cylinder body (20E), 15
said mechanism portion (601E) and the pene-
trating and anchorage plates (40), in the distanc-
ing direction (X1) from the bottom (BW) of the
perforating hole (H) so as to allow the penetrat-
ing and anchorage plates (40) to further pene- 20
trate through the side wall (SW) of the perforat-
ing hole (H) and so as to cause such plates (40)
to take on said anchorage configuration.

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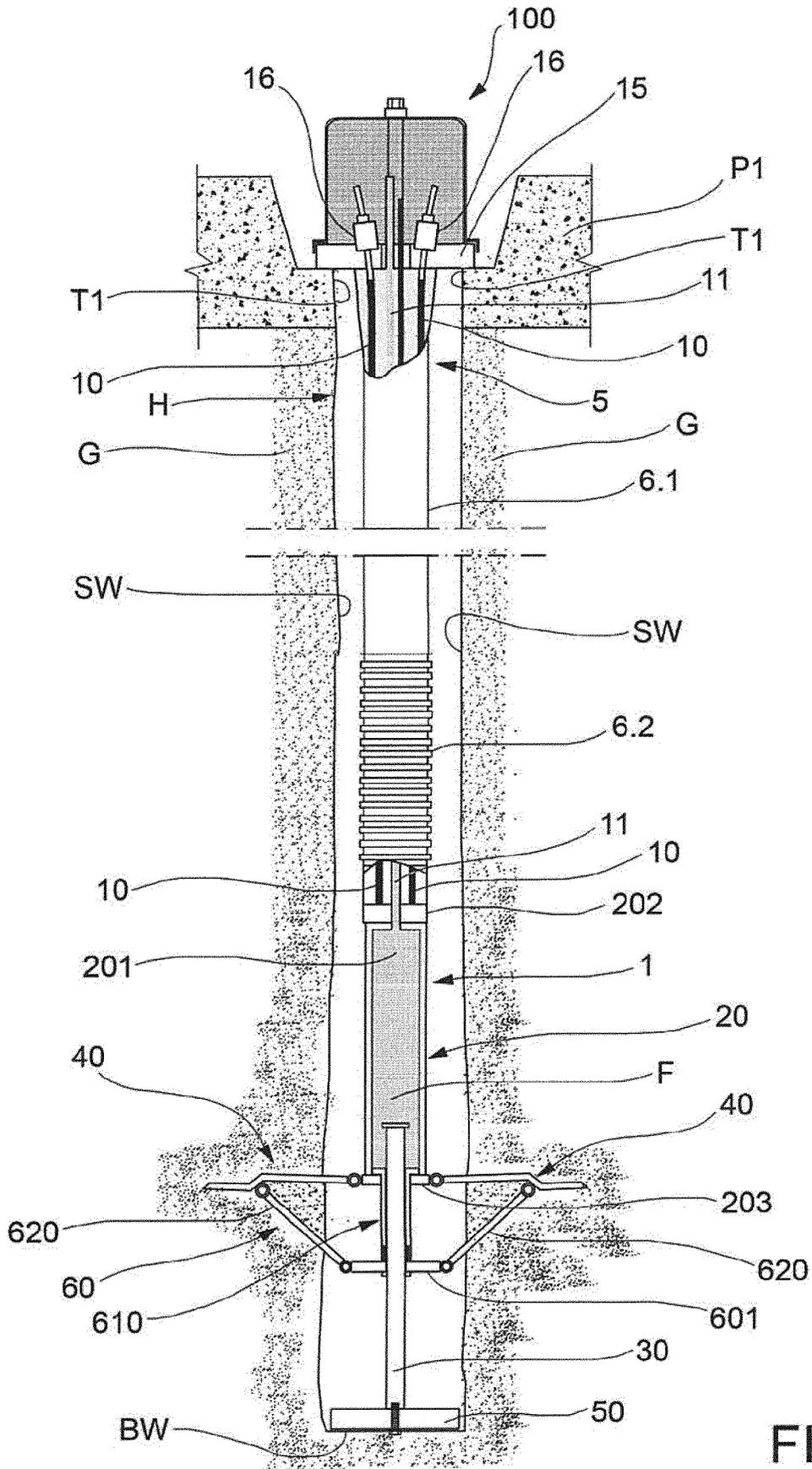
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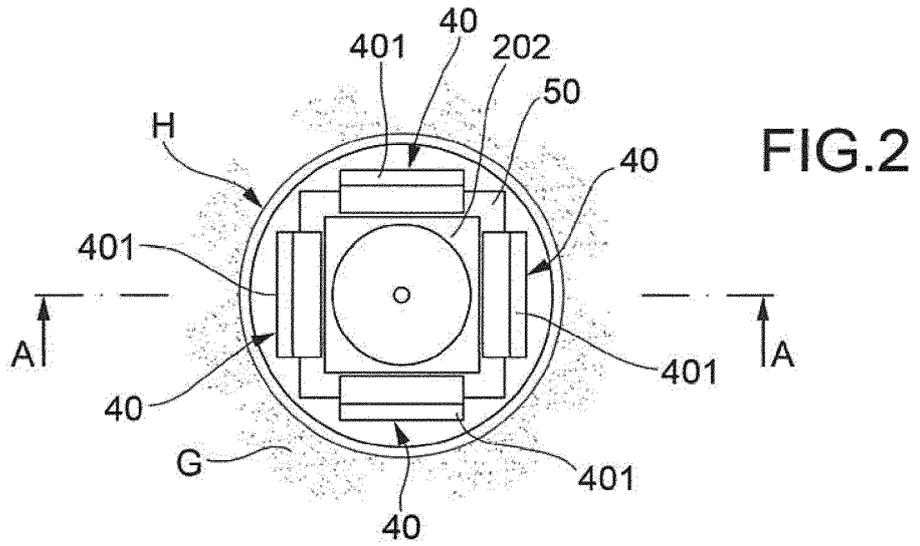


FIG. 2

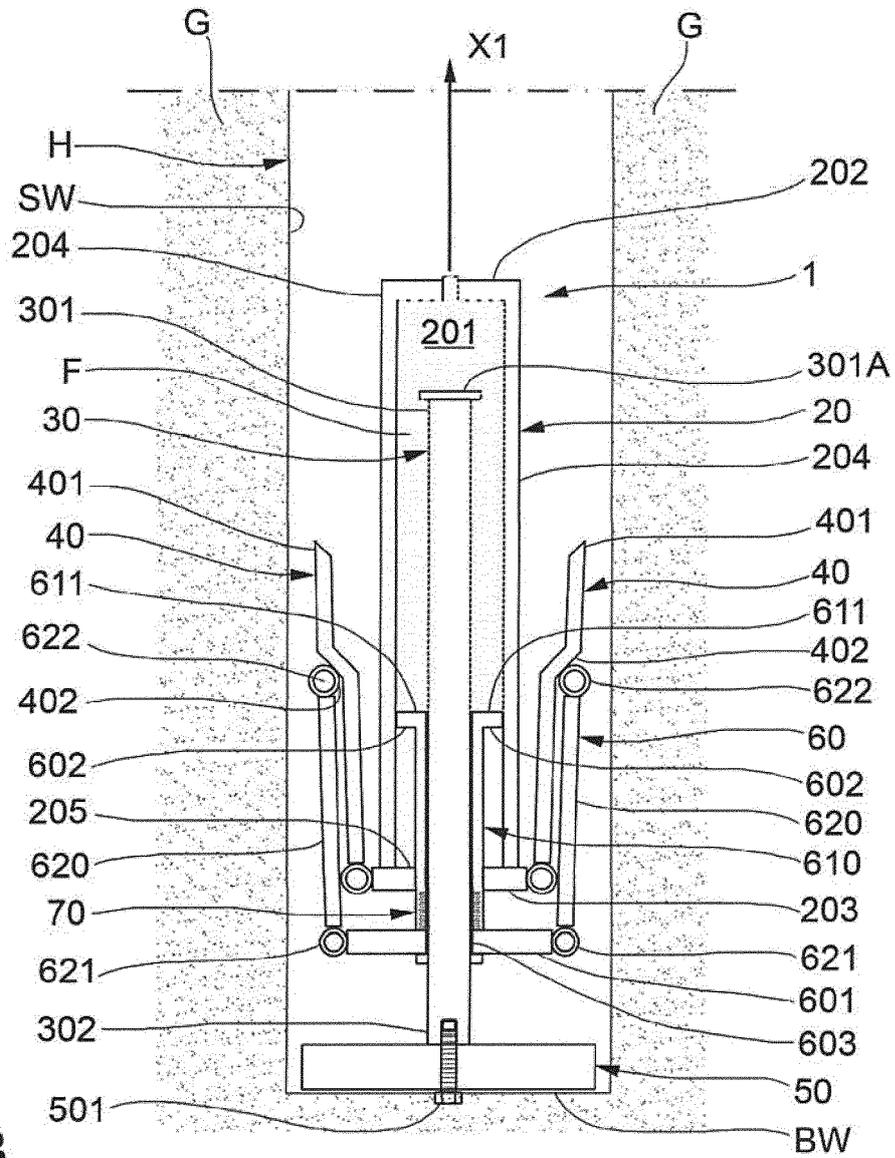


FIG. 3

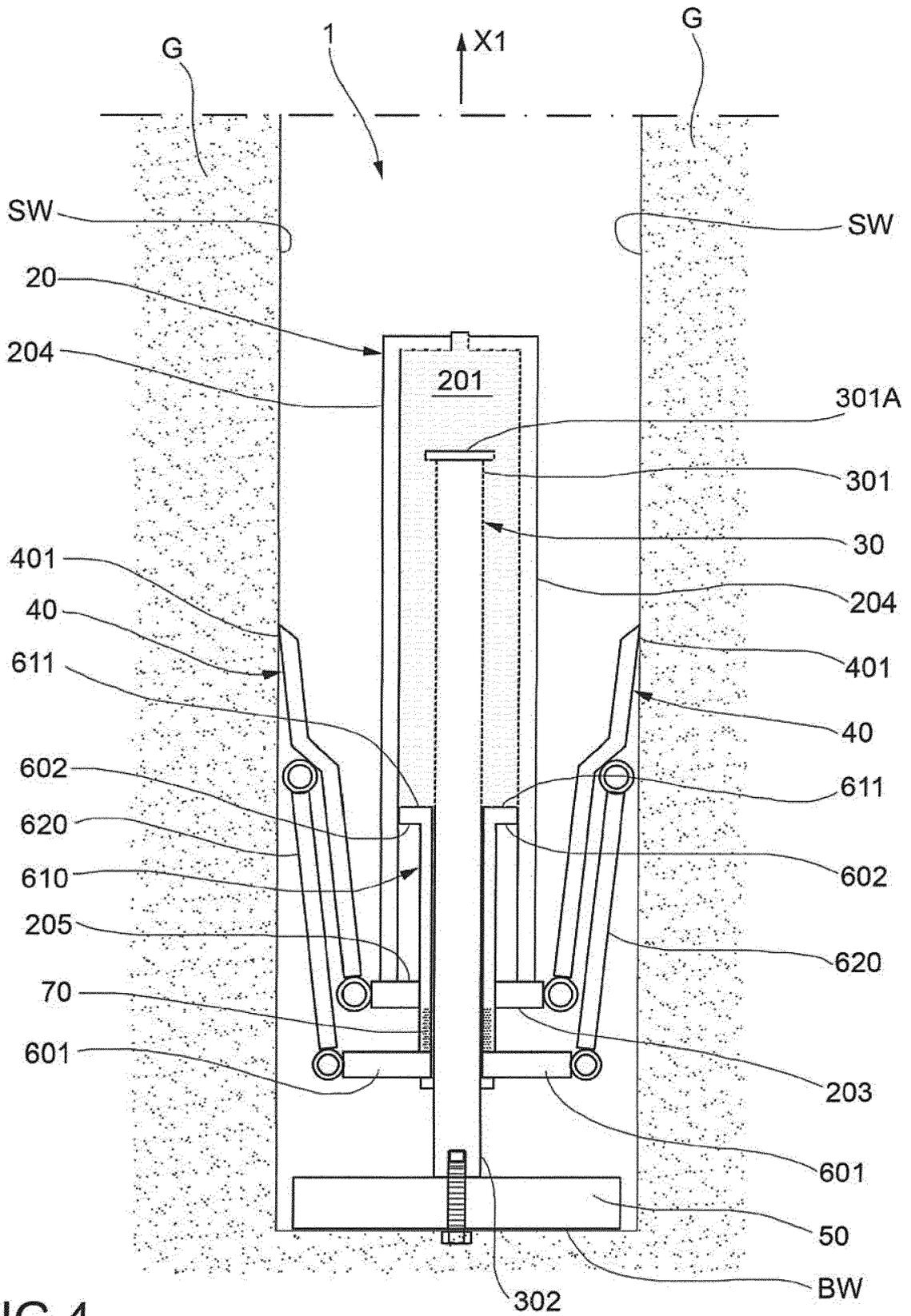


FIG.4

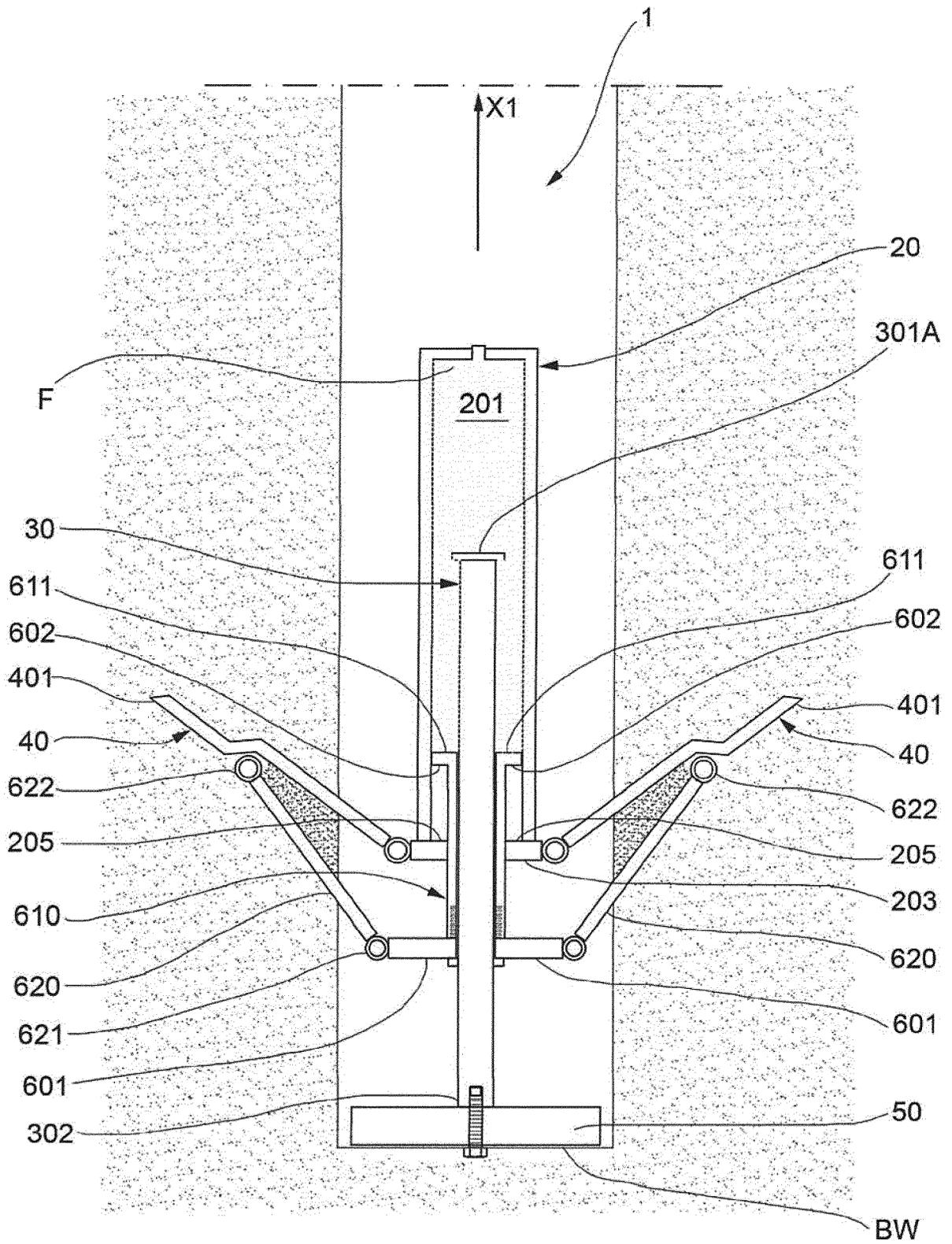
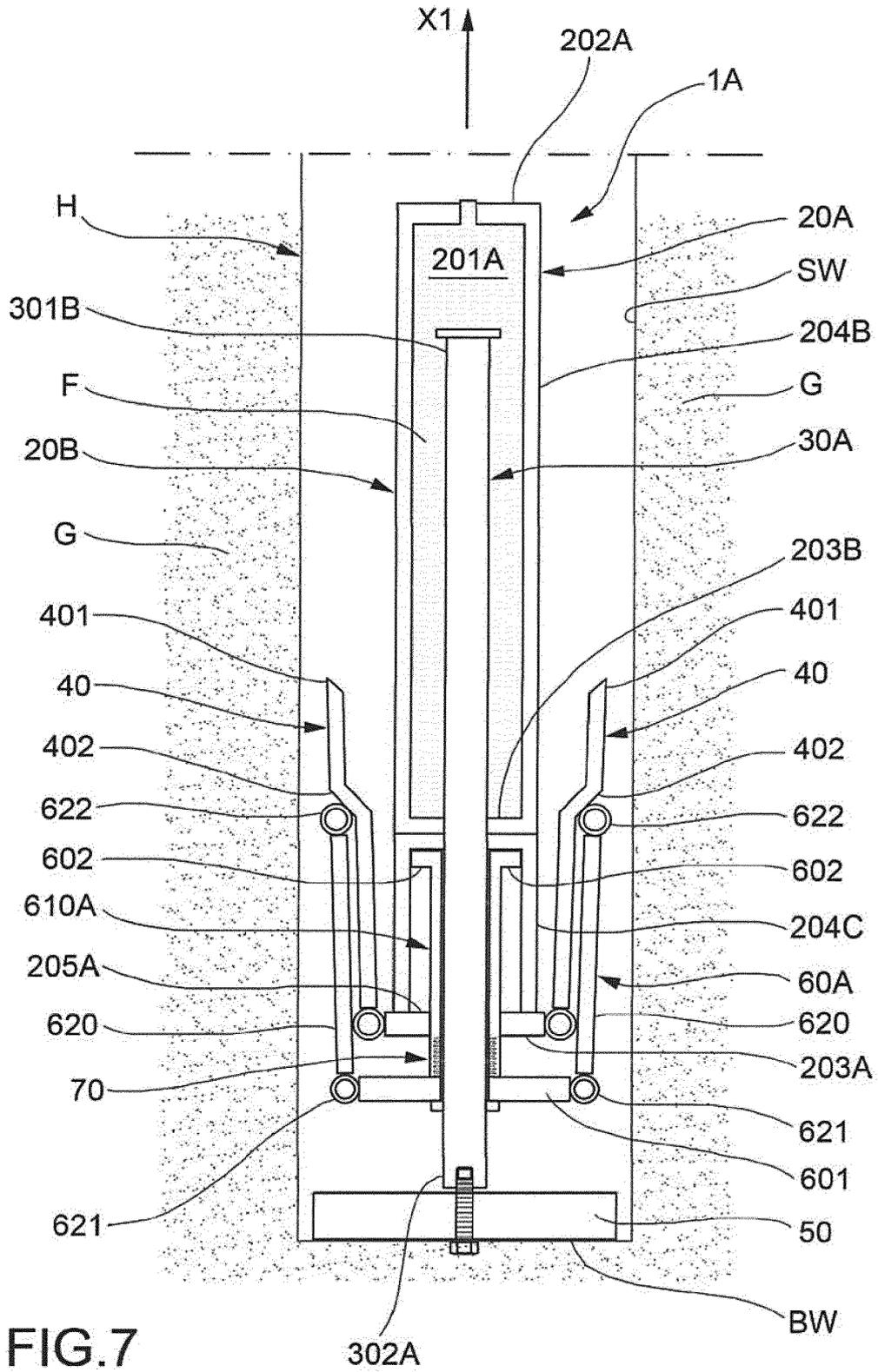


FIG.5



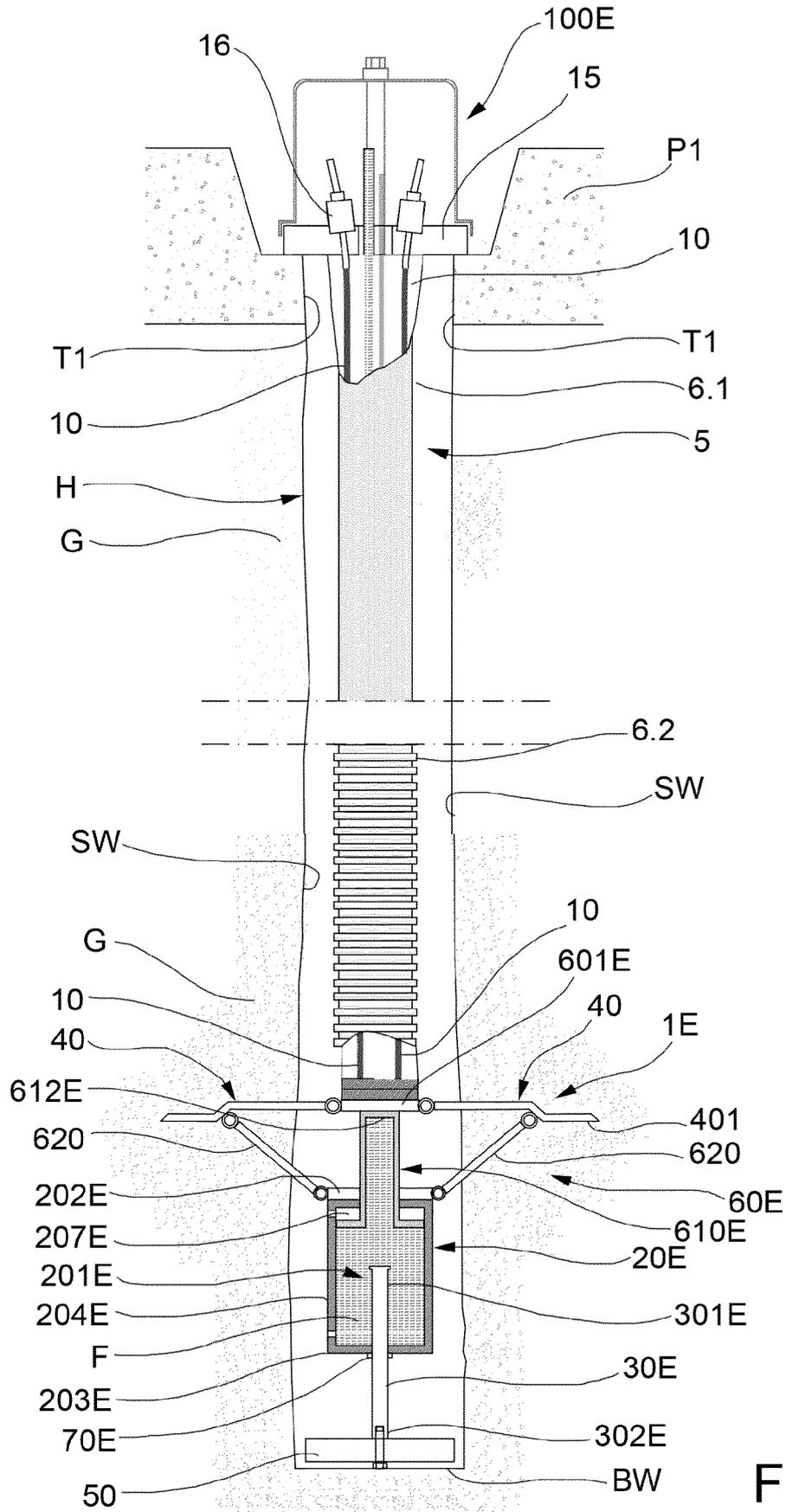


FIG.8

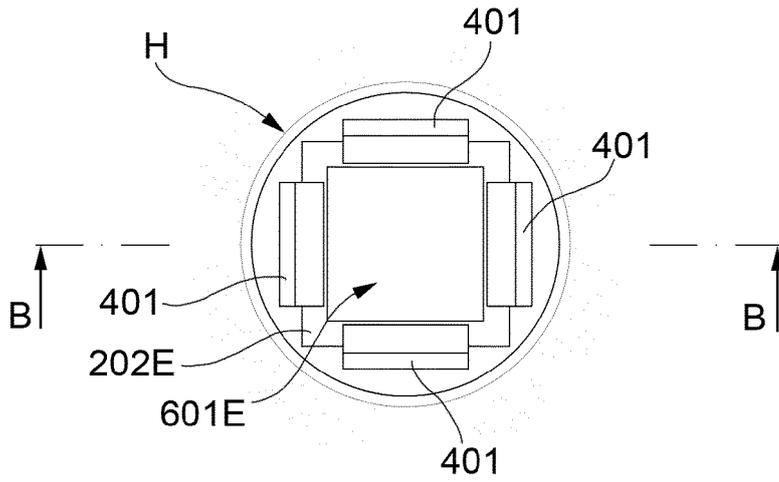


FIG. 9

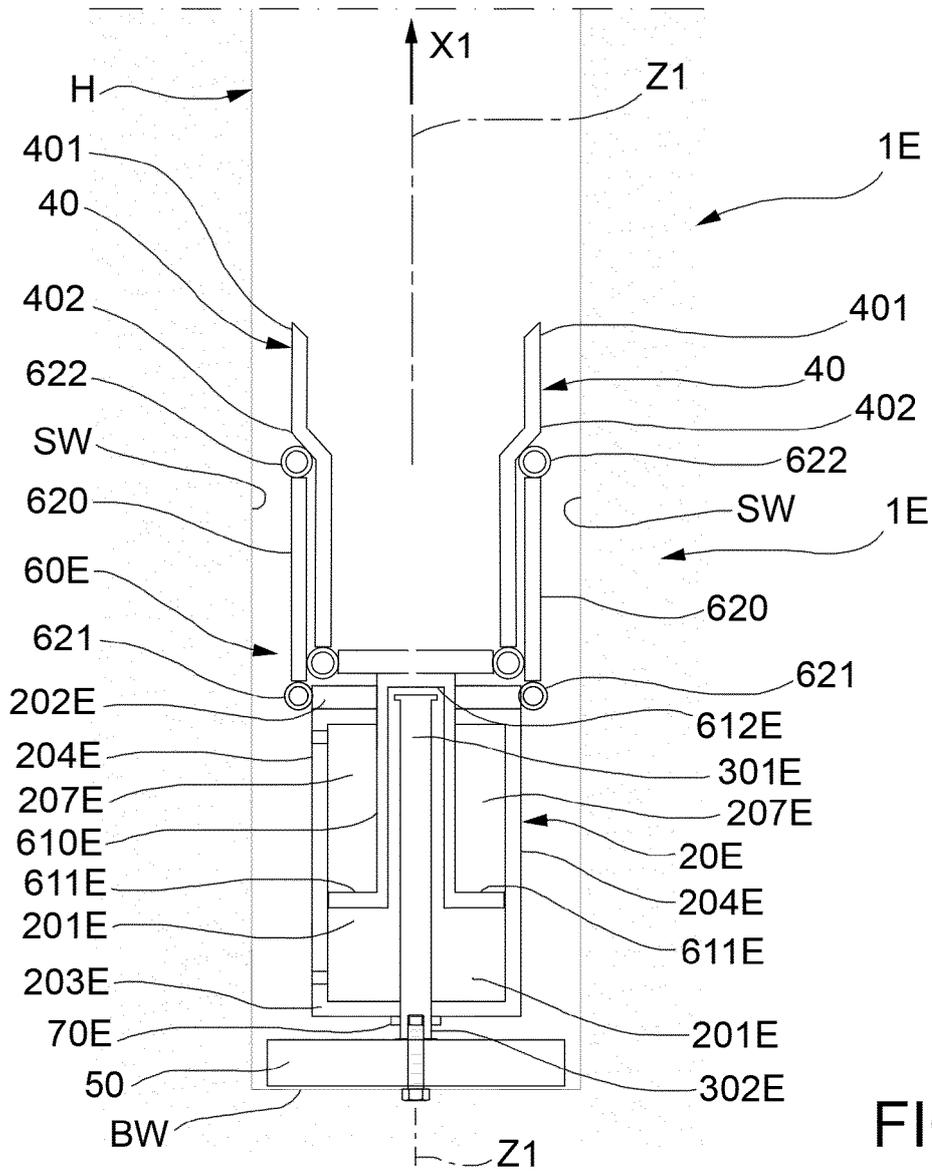


FIG. 10

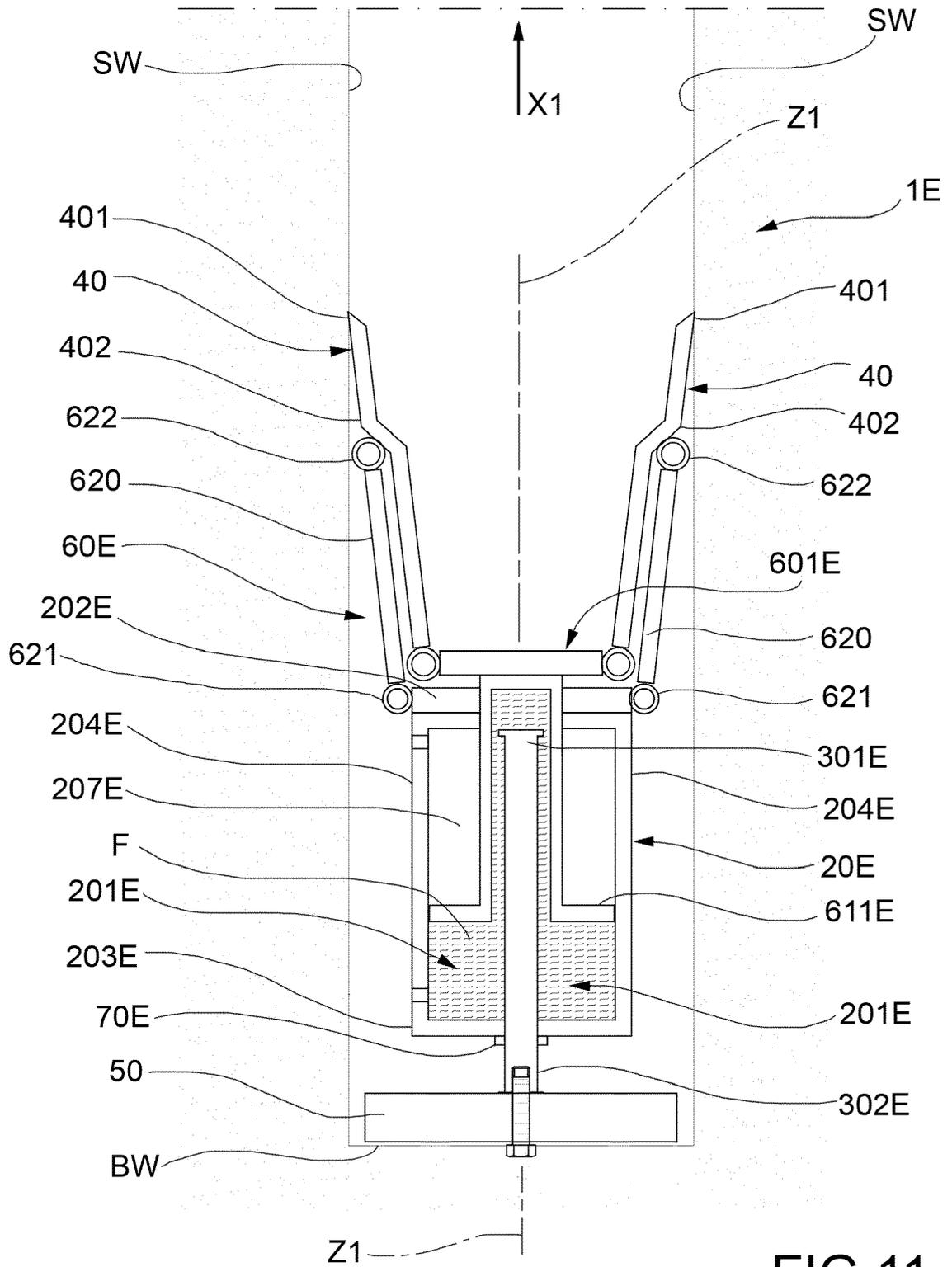


FIG. 11



EUROPEAN SEARCH REPORT

Application Number
EP 17 19 4799

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			E02D E04C
Place of search		Date of completion of the search	Examiner
Munich		21 February 2018	Friedrich, Albert
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