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(54) **Pile for strengthening and/or lifting buildings and other constructions**

(57) A pile for strengthening and/or lifting buildings and other constructions, having a straight main line of extension and comprising a main part (2) extending along the main line of extension for most of the length of the pile (1) and comprising a lower end, designed in use to be driven into the ground (3), and an upper end (6); an upper head (4) connected to the upper end (6) and designed in use to be constrained to a foundation (5) of a building; and a connecting unit (7) which connects the upper head (4) to the upper end (6) and which allows variation of the distance between the upper head (4) and the upper end (6). The upper head (4) comprises at least an expandable body (18) designed in use to anchor to a foundation (5), and at least an actuator element (19) operatively coupled to the expandable body (18) and movable relative to the expandable body (18) between a first position corresponding to a non-expanded condition of the expandable body (18), and a second position corresponding to an expanded condition of the expandable body (18). The pile is used in a strengthening method.

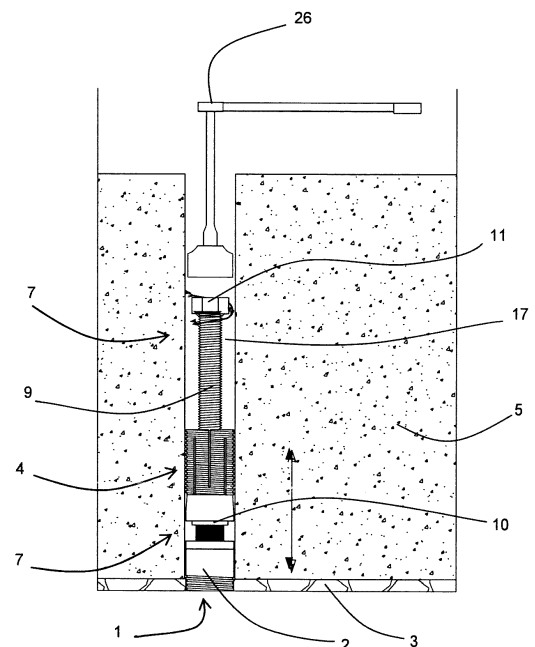


FIG. 15

Description

[0001] This invention relates to a pile for strengthening and/or lifting buildings and other constructions, of the type intended to be fixed to the foundations for discharging the loads of the building or a different construction on the most resistant layers of the ground.

[0002] In particular, this invention may be used either for existing foundations or for new foundations.

[0003] In the former case the strengthening action becomes necessary when the ground below the foundations subsides. In the latter case the strengthening is generally preventive, to prevent subsequent subsidence in the case of ground which is not compact enough and/or not settled.

[0004] At present, the most widespread strengthening techniques are based on either only injecting expanding resins below the foundations, or on driving piles to which the foundations are anchored, or mixed techniques. This invention relates to all of the techniques involving the use of piles. According to the prior art, piles are always driven in at or near to the foundations. In the former case, the pile is driven into the ground through a through hole previously made in the foundation. In general, once the main part of the pile has been driven into the ground, and its upper head is at the foundation, the head is rigidly connected to the foundation in such a way that the pile and the building form a rigid body.

[0005] The head of the pile is normally fixed to the foundation using mechanical fixing systems such as plates, welds, bolts or screws, or by securing the head to the foundation using concrete or resins (especially if the head is in a through hole made in the foundation). In this latter case, the head is usually a bar with outer grooves, which is coaxial with the rest of the pile.

[0006] However, in most cases, when the pile is fixed to the foundation none of the weight of the building rests on it. In contrast, the pile begins acting as a support for the building when the ground on which the building stands subsides further.

[0007] However, this prior art technology has several disadvantages.

[0008] In particular, the main disadvantage is the fact that the piles have a compressibility which means that, after installation, as the weight resting on them increases (following subsidence of the foundation ground), and once a predetermined threshold has been exceeded, the piles yield and are shortened. Consequently, in many cases there is the risk that, at least initially, the building will keep yielding despite the strengthening action taken. In fact, said phenomenon tends to stop when the pile has undergone shortening which is usually equivalent to around 2 to 5 mm (value valid in particular for so-called micro-piles, that is to say, piles with a relatively small cross-section for which such shortening is obtained with axial compressions of around 20 tons).

[0009] Using this technology, the only way to attempt to overcome such a disadvantage is to install an over-

designed number of piles, in such a way that the maximum weight which can rest on each pile is such that it cannot cause significant shortening of the pile. Obviously, this has a negative impact on installation costs.

[0010] In an attempt to overcome that disadvantage, other solutions have been proposed, involving pre-compressing the piles before fixing them to the foundation. For that purpose, once the pile has been driven into the ground, before proceeding with fixing the head to the foundation, a hydraulic cylinder is installed between the foundation and the pile and applies the required force to the pile (for example, it applies a force equivalent to that of a weight of 20 tons). When the pile is sufficiently compressed and therefore equilibrium has been reached between the force applied by the cylinder and the reaction of the pile, the head is fixed to the foundation. However, until the head is definitively fixed to the foundation, the cylinder must continue to apply its action.

[0011] However, even this solution is not without disadvantages, mainly linked to installation.

[0012] In fact, on one hand use of the cylinder, the need to anchor it to the foundation and the need to keep it pushing on the pile until the head has been rigidly connected to the foundation, result in significant implementing complexity, considerably lengthening installation times.

[0013] Even more negative is the effect on overall strengthening times, since, unless two or more cylinders are available (with consequent purchase and maintenance costs) those operating are forced to install one pile at a time. Furthermore, the times both for installation of the individual pile and for the entire strengthening are extended out of all proportion if the head must be fixed to the foundation using concrete or resins. In fact, in that case the cylinder cannot be removed until the concrete or resin has set completely. Finally, it must be emphasised that problems similar to those described above may also occur if the pile is not used as a support for the weight of the building, but acts as a tie rod. Obviously, in that case, everything is linked to lengthening of the pile rather than its compression.

[0014] In this context, the technical purpose which forms the basis of this invention is to provide a pile for strengthening and/or lifting buildings and other constructions which overcomes the disadvantages indicated.

[0015] In particular, the technical purpose of this invention is to provide a pile for strengthening and/or lifting buildings and other constructions which allows the avoidance of subsequent pile settling yielding and which therefore allows the number of piles used for each intervention to be minimised.

[0016] A further technical purpose of this invention is to provide a pile for strengthening and/or lifting buildings and other constructions which is quick and easy to install and which therefore allows intervention times to be the minimised.

[0017] The technical purpose specified and the aims indicated are substantially achieved by a pile for strength-

ening and/or lifting buildings and other constructions as described in the appended claims.

[0018] Further features and the advantages of this invention are more apparent in the detailed description of a preferred, non-limiting embodiment of a pile for strengthening and/or lifting buildings and other constructions illustrated in the accompanying drawings, in which:

- Figure 1 is a schematic side view of several parts of a pile made in accordance with this invention;
- Figure 2 shows the parts of Figure 1 in longitudinal and axial section;
- Figure 3 is a longitudinal axial section of an upper end of a pile in accordance with this invention;
- Figure 4 is a side view, partly in section, of a first element illustrated in Figure 1;
- Figure 5 is a side view of a second element illustrated in Figure 1;
- Figure 6 is a longitudinal axial section of a third element illustrated in Figure 1;
- Figure 7 is a schematic side view, partly in section, of a basic module of a main part of a pile made in accordance with this invention;
- Figure 8 is a schematic side view of a fourth element illustrated in Figure 1;
- Figure 9 shows the element of Figure 8 seen according to the arrow IX;
- Figure 10 is a cross-section of the element of Figure 9 according to the line X - X; and
- Figures 11 to 16 show a sequence of steps for installation of a pile made in accordance with this invention.

[0019] With reference to the accompanying drawings, the numeral 1 denotes in its entirety a pile for strengthening and/or lifting buildings and other constructions in accordance with this invention.

[0020] Similarly to prior art piles, the pile 1 according to this invention has a straight main line of extension and comprises a main part 2 intended in use to be driven into the ground 3, and an upper head 4 designed in use to be constrained to a foundation 5 of a building.

[0021] The main part 2 extends along the main line of extension for most of the length of the pile 1, and comprises a lower end (not visible in the accompanying drawings), designed in use to be driven into the ground 3 and an upper end 6 to which the upper head 4 is connected. In the preferred embodiments, in the known way, therefore not described in detail and not illustrated, the main part 2 of the pile 1 consists of a plurality of modules 27 with reduced length, which are connected end-to-end, advantageously by screwing. Moreover, as shown in Figures 3 and 7, the main part 2 is advantageously grooved on the outside (advantageously helically - which can be achieved by rolling) to increase adherence to the ground 3, and is hollow inside. Moreover, in the preferred embodiment, in which the main part 2 consists of a plurality of modules 27 (one of which is shown in Figure 7), each

of them has a first, male-shaped end 28 and a second, female-shaped end 29 (usually the upper end - in the embodiment illustrated, the upper end 6 of the main part 2 consists of the second, female end 29 of one of the modules 27), both threaded in such a way that they can be screwed to the corresponding ends 28, 29 of other modules 27. Moreover, preferably, the helical outer groove 30 of each module 27 and the thread of the end intended to be the lower end in use (the first, male-shaped end 28 in the embodiment illustrated) extend in opposite winding directions. In fact, during driving of the module 27 into the ground 3, the interaction between the helical outer groove 30 of the module 27 and the ground 3 may cause rotation of the module 27 (which is therefore driven into the ground by rotary driving). However, if that happens, thanks to the fact that the thread of the lower end (the male-shaped end in the accompanying drawings) extends in the opposite direction to the helical outer groove 30, rotation of the module 27 tends to increase its tightening on the module 27 below. If, in contrast, the two were to extend in the same direction, there could be the risk of at least partial unscrewing of the module 27 from the one below.

[0022] According to a first innovative aspect of this invention, unlike what happens in traditional systems where the connection is direct, in the pile 1 the upper head 4 is not directly connected to the upper end 6, but the pile 1 comprises a connecting unit 7 which connects the upper head 4 to the upper end 6. Said connecting unit 7 is advantageously made in such a way as to be able to allow a variation in the distance between the upper head 4 and the upper end 6. In particular, it is such that it allows a variation in said distance even when the pile 1 is driven into the ground 3 and the upper head 4 is at the foundation 5 of a building and fixed to it (provided that the fixing is such that it allows suitable access to the connecting unit 7).

[0023] In fact, in this way, by increasing or reducing the distance between the upper head 4 and the upper end 6, it is possible respectively to compress or put under tension the pile 1 (putting the pile 1 under tension in any case requires the first end of the pile 1 to be constrained to the ground 3 without the possibility of moving).

[0024] Moreover, preferably, the connecting unit 7 allows translation, one relative to the other, of the upper head 4 and the upper end 6, without the need for them to be subjected to rotations relative to one another or relative to other elements, around the main line of extension.

[0025] In the preferred embodiments, the connecting unit 7 is screwed to the upper end 6 and/or to the upper head 4 and therefore allows variation of the distance between the upper head 4 and the upper end 6 by screwing it in or unscrewing it relative to the part to which it is screwed.

[0026] However, advantageously, the connecting unit 7 extends along the main line of extension and comprises, aligned along the main line of extension, a threaded

bar 8 and an actuator bar 9.

[0027] The threaded bar 8 is screwed or screwable to the upper end 6 of the main part 2 of the pile 1, whilst the actuator bar 9 rotates together with the threaded bar 8 and extends on the other side of the upper head 4 relative to the threaded bar 8. For that purpose, advantageously the connecting unit 7 extends through the upper head 4.

[0028] In the embodiment illustrated in the accompanying drawings (Figure 2 and 5), moreover, the threaded bar 8 and the actuator bar 9 are constituted of one piece which also forms an annular shoulder 10 whose purpose is described below. In other embodiments, the annular shoulder 10 may even be located in other positions, and there may be two or more of them and it may be fixed to the rest of the connecting unit 7 in a different way (that is to say, not being made in one piece with it).

[0029] Even if in the accompanying drawings the threaded bar 8 is shorter than the actuator bar 9 and if the latter is threaded, these are example embodiments and are absolutely not limiting.

[0030] Advantageously, to facilitate rotation of the connecting unit 7, the free end of the actuator bar 9 is equipped with a grip element which, in the embodiment illustrated, is a nut 11 screwed onto the actuator bar 9 and welded to it (this is the only reason why in the embodiment illustrated the actuator bar 9 is threaded on the outside - in other embodiments it may therefore be smooth on the outside). As is explained in more detail below, using a suitable wrench it is therefore possible to act on the nut 11 to rotate the entire connecting unit 7.

[0031] In the preferred embodiment illustrated in the accompanying drawings, in which the main part 2 of the pile 1 preferably comprises a plurality of modules which are all the same, screwed to one another, the threaded bar 8 is not directly screwed into the threaded hole 12 made in the upper end 6 of the main part 2 (which is a hole sized to allow the connection of a further module), but the connecting unit 7 also comprises a bushing 13 which is interposed between the threaded bar 8 and the main part 2 of the pile 1. The bushing 13 comprises an outer thread 14 and an inner thread 15 (Figure 4). The outer thread 14 is screwed or screwable into the threaded hole 12, whilst the threaded bar 8 is screwed or screwable into the inner thread 15. As shown in Figure 4, in the case illustrated the inner thread 15 is cylindrical, whilst the outer thread is conical and ends at a radial projection 16 of the bushing 13, which in use rests against the upper end 6 of the main part 2, making the bushing 13 a sort of cap for the main part 2.

[0032] When, as in the case illustrated in the accompanying drawings, the pile 1 is designed to be able to be compressed by means of the connecting unit 7, the outer thread 14 and the inner thread 15 advantageously have opposite screwing directions. In fact, in this way the rotation which causes compression of the pile 1 tends to also cause further tightening of the bushing 13 on the main part 2. In contrast, if the two were the same, the rotation which causes compression of the pile 1 would

tend to also cause uncoupling of the bushing 13 from the main part 2.

[0033] In contrast, if the pile 1 is designed to be able to be put under tension by means of the connecting unit 7, the outer thread 14 and the inner thread 15 will advantageously have the same screwing direction. In fact, in this way the rotation which causes the pile 1 to be put under tension tends to also cause further tightening of the bushing 13 on the main part 2.

[0034] Moreover, in the embodiment illustrated, the outer thread 14 advantageously has a pitch which is at least double that of the inner thread 15. In fact, in this way, during screwing of the pre-assembled connecting unit 7 to the main part 2 (achieved by screwing the bushing 13 into the threaded hole 12), the resistance offered by the outer thread 14 is less than that offered by the inner thread 15 and screwing of the bushing 13 into the threaded hole 12 offers less resistance than unscrewing of the threaded bar 8 from the bushing 13 (it should be remembered that opposite directions are used).

[0035] For corresponding reasons, if the pile 1 is designed to be put under tension, the inner thread 15 and the outer thread 14 will, in contrast, have the same screwing direction.

[0036] Since, as explained below, in the embodiment illustrated compression of the pile 1 is achieved by unscrewing the threaded bar 8 relative to the main part 2, initially the threaded bar 8 will advantageously be completely screwed to the main part 2.

[0037] In contrast, in the embodiments in which the pile 1 is intended to be put under tension, since the tension is achieved by screwing the threaded bar 8 to the pile 1, initially the threaded bar 8 will advantageously be partly unscrewed relative to the main part 2.

[0038] The upper head 4 is made in such a way that it can be fixed to the foundation 5, preferably by means of mechanical fastening.

[0039] However, advantageously, according to this invention the upper head 4 is made in such a way that it can grip the inner surface of a through hole 17 made in the foundation 5 and which is advantageously slightly larger than the upper head 4.

[0040] In particular, in the preferred embodiments the upper head 4 comprises at least an expandable body 18 designed in use to anchor to the foundation 5, and at least an actuator element 19 operatively coupled to the expandable body 18 and movable relative to the expandable body 18 between a first position corresponding to a non-expanded condition of the expandable body 18, and a second position corresponding to an expanded condition of the expandable body 18.

[0041] In the embodiment illustrated, as shown in Figures 8 to 10, the expandable body 18 is advantageously a sleeve (therefore, hereinafter also labelled 18) positioned with an axis of it parallel with the main line of extension and which is provided with one or more longitudinal cuts 20, 21 passing through the entire thickness of its lateral wall.

[0042] Preferably, each cut 20, 21 present extends from an end edge 22, 23 of the sleeve 18 and along most of the length of the sleeve 18, but not along the entire length. It should be noticed that in Figure 8, as in all of the other figures in which the sleeve 18 is shown in side view, the two cuts 20, 21 starting from the left-hand edge of the sleeve 18 are deliberately shown only schematically and not correctly. In contrast, in Figures 9 and 10, all of the cuts 20, 21 are correctly shown, extending radially relative to the axis of the sleeve 18.

[0043] Moreover, in the preferred embodiment, the sleeve 18 comprises both first cuts 20 extending from a first edge 22 of it, and second cuts 21 extending from a second edge 23 of it which is opposite to the first. As shown in Figures 8 to 10, the first cuts 20 and the second cuts 21 are offset from one another along an annular trajectory which surrounds the main line of extension, advantageously in a regular way (every 60° relative to the central axis in the accompanying drawing - Figure 9).

[0044] Thanks to the presence of the cuts 20, 21, in the lateral wall of the sleeve 18 several tabs 24 are identifiable which can easily be deformed outwards to allow fastening of the expandable body 18 to the inner surface of the hole made in the foundation 5. In fact, thanks to the action of the actuator element 19, the upper head 4 can act as an expandable fixing plug. To increase its grip on the inner surface of the hole, the outer surface of the expandable body 18 is grooved (advantageously by rolling).

[0045] With reference to the actuator element 19, in the embodiment illustrated it is a wedge-shaped body (therefore hereinafter also labelled 19) inserted or insertable in the expandable body 18, and which in the second position is inserted further into the expandable body 18 than it is in the first position. In particular, as shown in Figure 6, the wedge-shaped body 19 mainly has a hollow frustoconical shape, with the smaller base of the truncated cone towards the expandable body 18 (said end, more precisely, always advantageously being inserted in the expandable body 18).

[0046] In the preferred embodiment, the sleeve 18 has an inner cavity tapered in a similar way to the wedge-shaped body 19. Thanks to that shape and to the special alternating of the first cuts 20 and second cuts 21, the sleeve 18 shown in the accompanying drawings can expand while keeping a substantially cylindrical shape, therefore distributing on practically all of its outer surface the action for holding it in the hole made in the foundation 5.

[0047] Moreover, in the preferred embodiment the connecting unit 7 is operatively coupled to the actuator element 19, and either the screwing or unscrewing of the threaded bar 8 causes a thrust on the actuator element 19 towards the second position. This, in the embodiment illustrated, is the function of the shoulder 10 with which the connecting unit 7 is equipped, and which is sized and positioned in such a way as to act in contact against the actuator element 19 to push it into the expandable body

18.

[0048] It should be noticed that whilst in the case illustrated, in which the pile 1 is intended to be pre-compressed, the actuator element 19 is inserted in the expandable body 18 from its side facing towards the threaded bar 8, and the shoulder 10 is positioned between the actuator element 19 and the threaded bar 8, in the case in which the pile 1 is intended to be put under tension, the actuator element 19 is inserted in the expandable body 18 from its side facing towards the actuator bar 9, and the shoulder 10 is positioned between the actuator element 19 and the grip element. However, in this latter case, to counter the effects of gravity when the pile 1 is positioned vertically, the connecting unit 7 must advantageously comprise a stop element (for example a further shoulder) which prevents the descent of the expandable body 18 beyond a predetermined limit.

[0049] This invention also relates to a building or other construction comprising at least one foundation 5 to which at least one pile 1 made according to what is described above has been rigidly connected (therefore, the pile 1 will be driven into the ground 3 and its upper head 4 will be constrained to the foundation 5).

[0050] Figures 11 to 16 show use of the pile 1 described above for strengthening a foundation 5, in accordance with a strengthening method which is also part of the subject matter of this invention.

[0051] In general, the method comprises the following operating steps:

making one or more through holes in a foundation 5 of a building to be strengthened, in order to reach the ground 3 below;

for each hole, taking a pile 1 made in accordance with this invention; through each hole driving into the ground 3 the main part 2 of the pile 1 until the upper head 4 is at the foundation 5;

constraining each upper head 4 to the foundation 5; and

acting on each connecting unit 7 to vary the distance between the respective upper head 4 and the respective main part 2 in such a way as to compress or put under tension the respective pile 1, depending on requirements.

[0052] In more detail, according to the preferred method, once the hole has been made in the foundation 5, after detaching the connecting unit 7 from the main part 2, first the main part 2 is driven into the ground 3 until its upper end 6 is close to the lower part of the foundation 5 (Figure 11). Driving in can be performed in any known way, for example by hammering, hydraulic thrust or rotary driving in.

[0053] At that point the connecting unit 7 is inserted in the through hole 17 (Figure 12) and is constrained to the main part 2. In the case of the embodiment illustrated, in particular, the bushing 13 is completely screwed into the threaded hole 12 and the threaded bar 8 is completely

screwed into the bushing 13 (Figure 13). At that point, the wedge-shaped body 19 rests on the shoulder 10 and the expandable body 18 is partly fitted, and rests, on the wedge-shaped body 19.

[0054] If the pile 1 were intended to be put under tension, in contrast, during the step just described, on one side the threaded bar 8 would only be partly screwed into the bushing 13, and on the other side the wedge-shaped body 19 would be located above the sleeve 18.

[0055] As shown in Figure 14, at this point a tubular pressure element 25 is inserted in the through hole 17, said element passing outside the actuator bar 9 and striking the sleeve 18 to press it against the wedge-shaped body 19 thereby causing its initial outward deformation which in turn causes its first adhesion to the inner surface of the through hole 17. If the pile 1 is to be put under tension, the pressure element 25 would in contrast act directly on the wedge-shaped body 19.

[0056] Once the pressure element has been removed 25, an actuator device is inserted in the through hole 17, designed to cause rotation of the actuator bar 9. In the preferred embodiment (Figure 15), the actuator device is a torque wrench 26 which engages on the nut 11 which is the grip element.

[0057] At that point (Figure 15), the actuator device is used to rotate the actuator bar 9 and the threaded bar 8 fixed to it in such a way as to cause unscrewing of the threaded bar 8 from the bushing 13 (or screwing if the pile 1 is to be put under tension).

[0058] After unscrewing, the shoulder 10 starts to move away from the upper end 6 and, during the initial steps, causes a further insertion of the wedge-shaped body 19 in the expandable body 18, with a consequent further deformation of the latter which causes even more secure fixing of the upper head 4 in the through hole 17.

[0059] Once the fixing has become sufficiently secure, the further unscrewing (or respectively screwing) of the threaded bar 8 finally causes compression (or respectively putting under tension) of the pile 1. The use of a torque wrench 26 also allows precise application to the pile 1 of the desired pre-compression force.

[0060] Once the intervention is complete, it is finally possible both to leave the through hole 17 accessible for any subsequent interventions to modify the compression/tension of the pile 1, and, as shown in Figure 16, to close the through hole 17 with a casting of concrete or a resin.

[0061] This invention brings important advantages.

[0062] First, the pile for strengthening and/or lifting buildings and other constructions according to this invention, thanks to pre-compression or putting under tension, allows the avoidance of subsequent pile settling yielding and therefore allows the number of piles used for each intervention to be minimised, since each pile is fully operational from the time of installation.

[0063] Second, the pile according to this invention is extremely quick and easy to install and therefore allows intervention times to be minimised.

[0064] Furthermore, if the through hole made in the foundations is not filled, this invention also allows the same pile to be used to modify the strengthening/lifting even when some time has passed following the first intervention.

[0065] Finally, it should be noticed that this invention is relatively easy to produce and that even the cost linked to implementing the invention is not very high. The invention described above may be modified and adapted in several ways without thereby departing from the scope of the inventive concept. Moreover, all details of the invention may be substituted with other technically equivalent elements and the materials used, as well as the shapes and dimensions of the various components, may vary according to requirements.

Claims

1. A pile for strengthening and/or lifting buildings and other constructions, having a straight main line of extension and comprising:

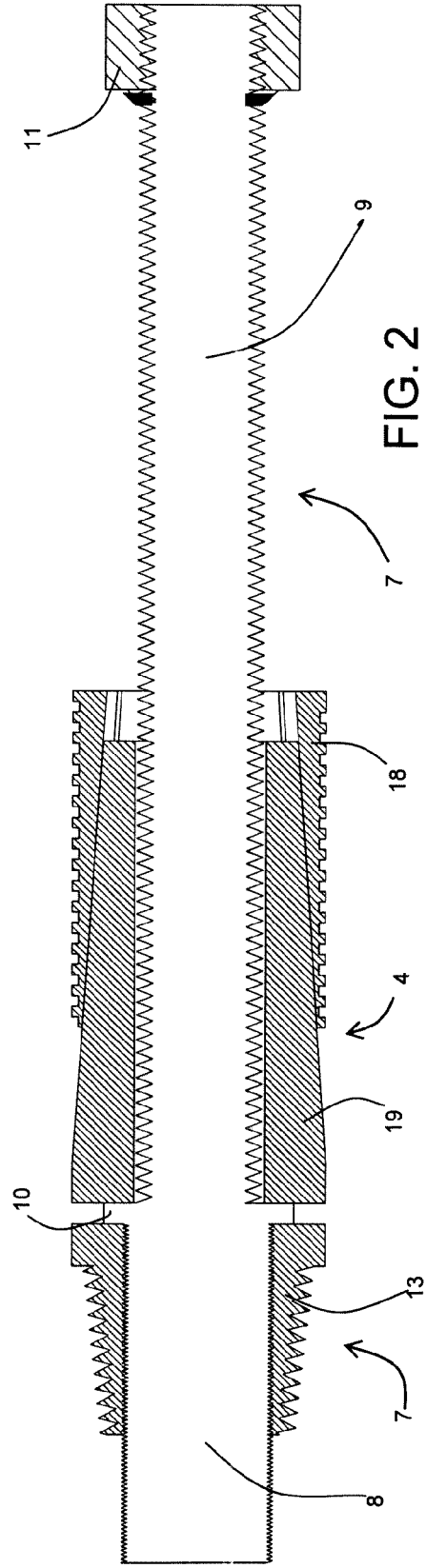
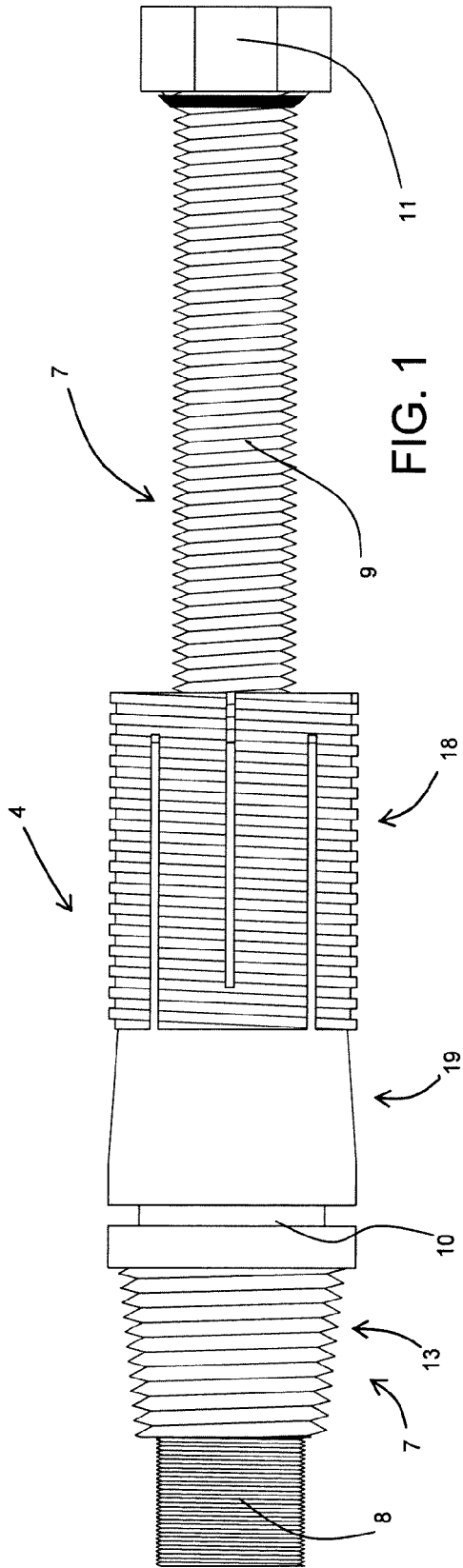
a main part (2) extending along the main line of extension for most of the length of the pile (1) and comprising a lower end, designed in use to be driven into the ground (3), and an upper end (6);

an upper head (4) connected to the upper end (6) and designed in use to be constrained to a foundation (5) of a building; and

a connecting unit (7) which connects the upper head (4) to the upper end (6) and which allows a variation in the distance between the upper head (4) and the upper end (6).

2. The pile according to claim 1, **characterised in that** the connecting unit (7) allows translation without rotations, relative to one another, of the upper head (4) and the upper end (6).
3. The pile according to claim 1 or 2, **characterised in that** the connecting unit (7) is screwed to the upper end (6) and/or to the upper head (4) and allows variation of the distance between the upper head (4) and the upper end (6) by screwing it in or unscrewing it.
4. The pile according to any one of the preceding claims, **characterised in that** the connecting unit (7) extends along the main line of extension and comprises, aligned along the main line of extension, a threaded bar (8) screwed or screwable to the upper end (6) of the main part (2) of the pile (1), and an actuator bar (9) which rotates together with the threaded bar (8) and extends on the other side of the upper head (4) relative to the threaded bar (8).

5. The pile according to any one of the preceding claims, **characterised in that** the upper head (4) comprises at least an expandable body (18) designed in use to anchor to a foundation (5), and at least an actuator element (19) operatively coupled to the expandable body (18) and movable relative to the expandable body (18) between a first position corresponding to a non-expanded condition of the expandable body (18), and a second position corresponding to an expanded condition of the expandable body (18). 5
6. The pile according to claim 5, **characterised in that** the expandable body (18) is a sleeve (18) positioned with an axis of it parallel with the main line of extension and **in that** it is provided with one or more longitudinal cuts (20), (21) each extending through a lateral wall of it, over most of its length and starting from an end edge (22) of it. 10
7. The pile according to claim 6, **characterised in that** the sleeve (18) comprises first cuts (20) extending from a first edge (22) of it, and second cuts (21) extending from a second edge (23) of it which is opposite to the first, the first cuts (20) and the second cuts (21) being offset relative to one another along an annular trajectory surrounding the main line of extension. 15
8. The pile according to claim 5, 6 or 7, **characterised in that** the actuator element (19) is a wedge-shaped body (19) inserted or insertable in the expandable body (18), and which in the second position is inserted further into the expandable body (18) than it is in the first position. 20
9. The pile according to claims 6 and 8, or 7 and 8, **characterised in that** the sleeve (18) has an inner cavity tapered in a similar way to the wedge-shaped body (19). 25
10. The pile according to claim 4 and any one of claims 5 to 9, **characterised in that** the connecting unit (7) is operatively coupled to the actuator element (19), and **in that** either the screwing or unscrewing of the threaded bar (8) causes a thrust on the actuator element (19) towards the second position. 30
11. The pile according to claim 4 and any one of the other preceding claims, **characterised in that** the connecting unit (7) also comprises a bushing (13) with an outer thread (14) and an inner thread (15), the outer thread (14) being screwed or screwable into a threaded hole (12) made in the upper end (6) of the main part (2) and the threaded bar (8) being screwable into the inner thread (15), **in that** the outer thread (14) and the inner thread (15) have opposite screwing directions if the connecting unit (7) in use causes the upper head (4) to move away from the upper end (6) or the same screwing direction if the connecting unit (7) in use causes the upper head (4) to move towards the upper end (6), and **in that** the outer thread (14) has a pitch which is at least double that of the inner thread (15). 35
12. The pile according to any one of the preceding claims, **characterised in that** the main part (2) is constituted of a plurality of modules (27), each comprising a lower end (28) and an upper end (29) which are respectively male- and female-shaped and threaded in such a way that they can be screwed to corresponding ends (29), (28) of other modules (27), each module also comprising a helical outer groove (30), the thread of the lower end (28) and the helical outer groove (30) extending in opposite winding directions. 40
13. A building or other construction comprising at least one foundation (5) and at least one pile (1) made according to any one of the preceding claims, driven into the ground (3) and with its upper head (4) constrained to the foundation (5). 45
14. A method for strengthening buildings and other constructions, comprising the operating steps of:
 - making one or more through holes in a foundation (5) of a building to be strengthened, in order to reach the ground (3) below;
 - for each hole taking a pile (1) according to any one of claims 1 to 12;
 - through each hole driving into the ground (3) the main part (2) of the pile (1) until the upper head (4) is at the foundation (5);
 - constraining each upper head (4) to the foundation (5);
 - acting on each connecting unit (7) to vary the distance between the respective upper head (4) and the respective main part (2) in such a way as to compress or put under tension the respective pile (1).
15. The method according to claim 14, **characterised in that** the step of constraining the upper head (4) to the foundation (5) occurs exclusively by means of mechanical fastening of the pile (1) to an inner surface of the respective hole. 50



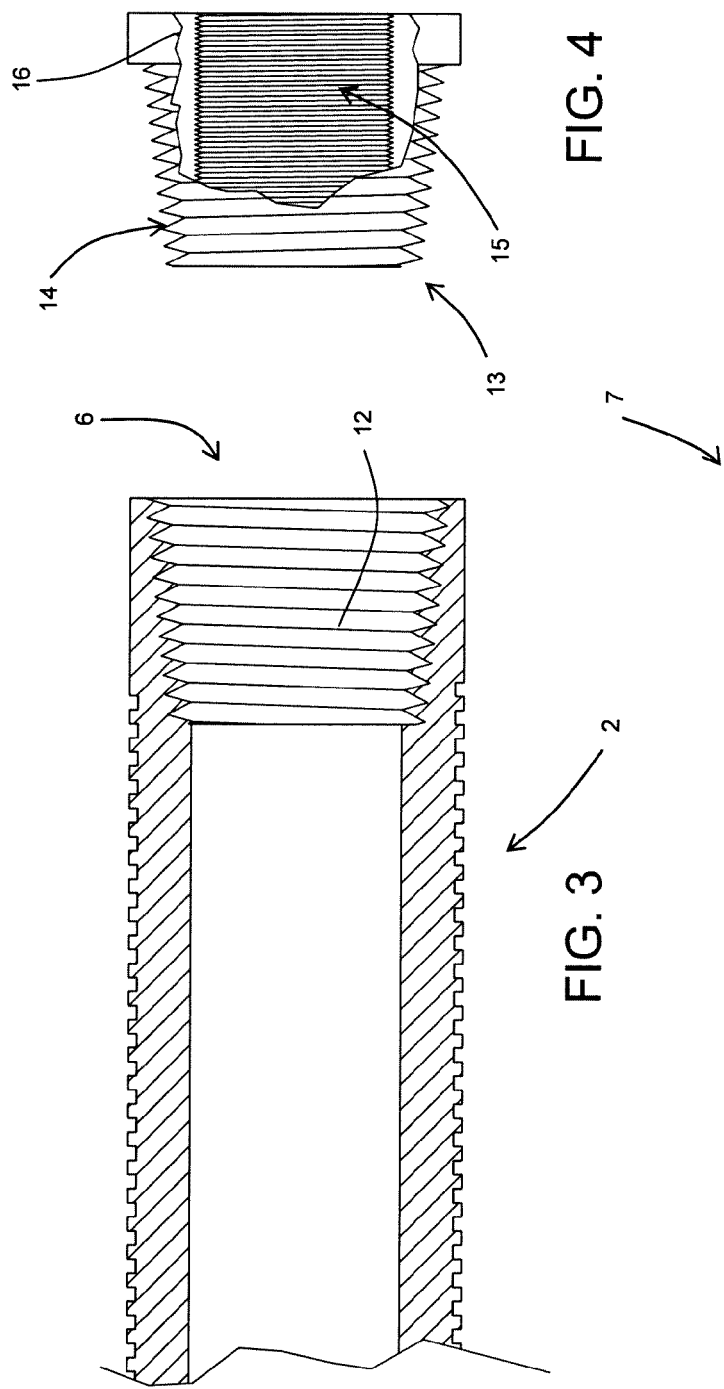


FIG. 4

FIG. 3

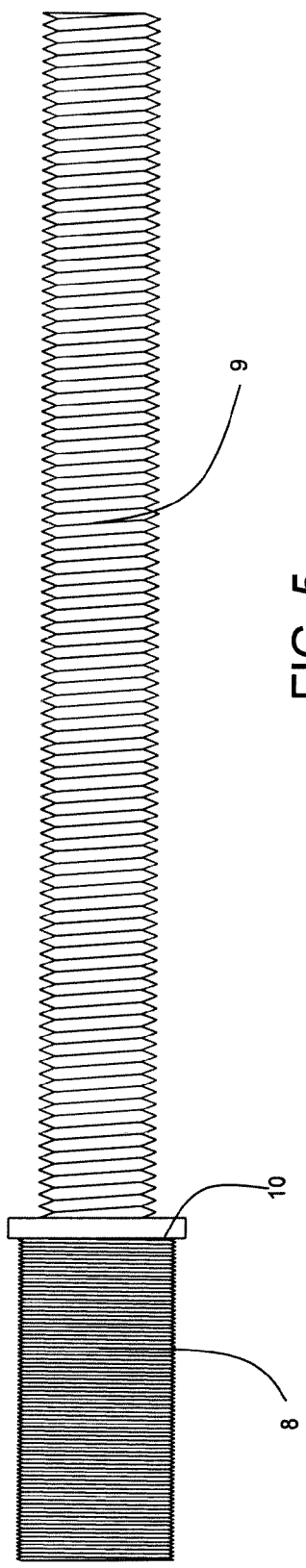


FIG. 5

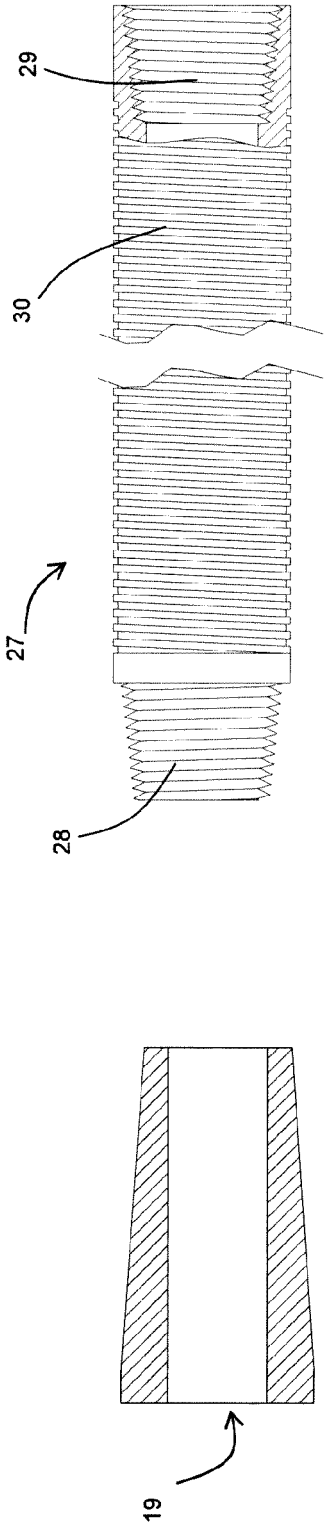


FIG. 6

FIG. 7

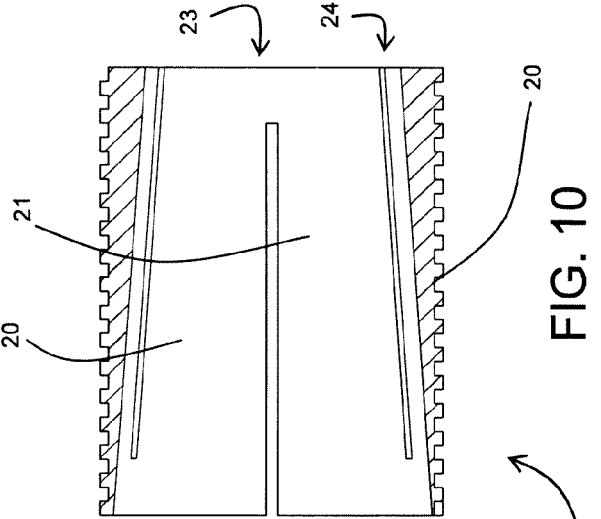


FIG. 10

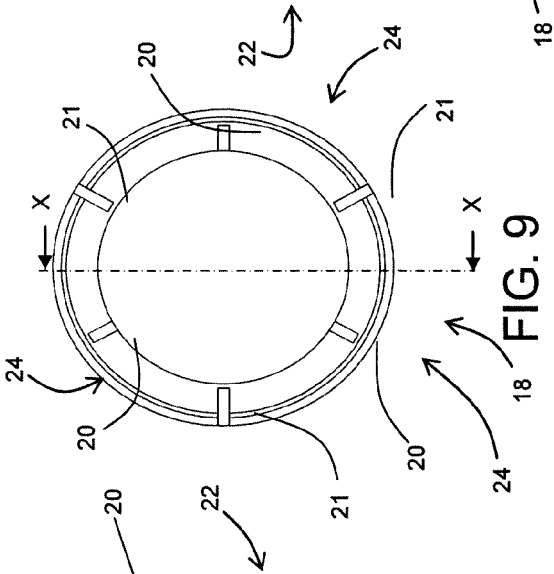


FIG. 9

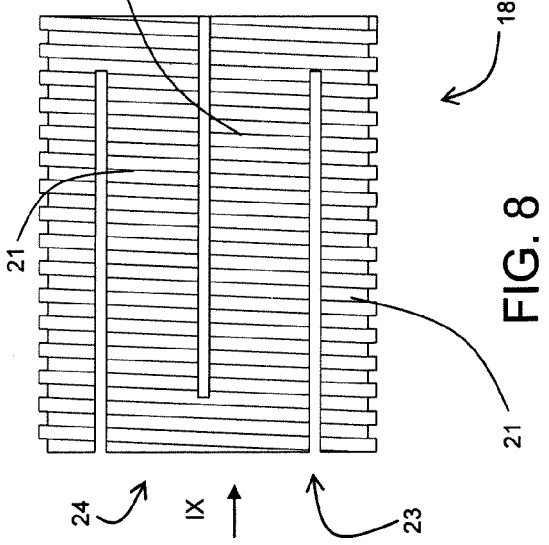
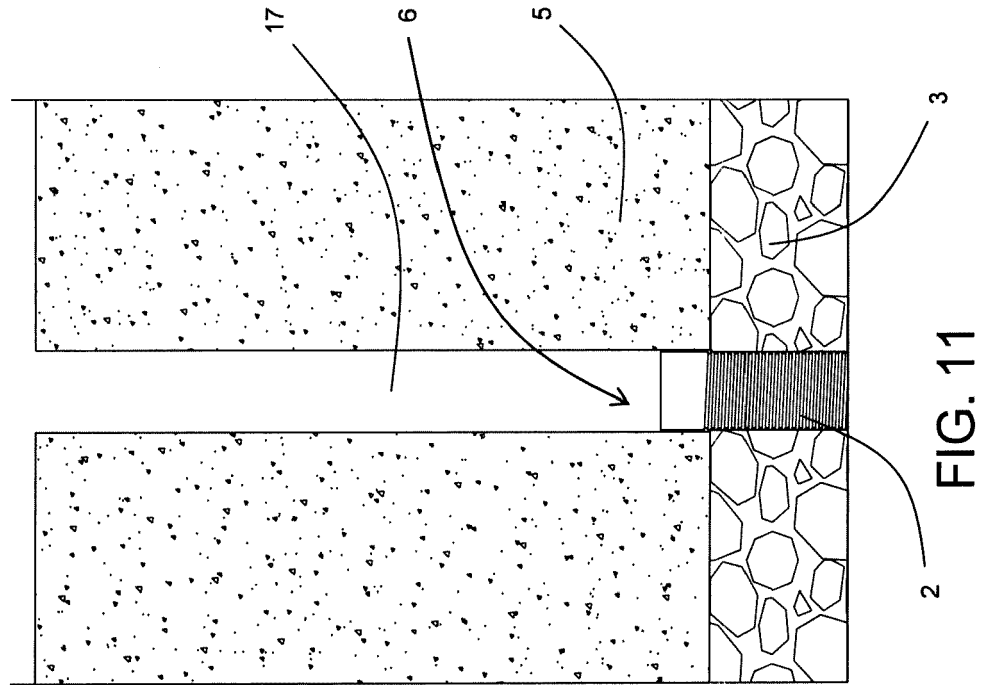
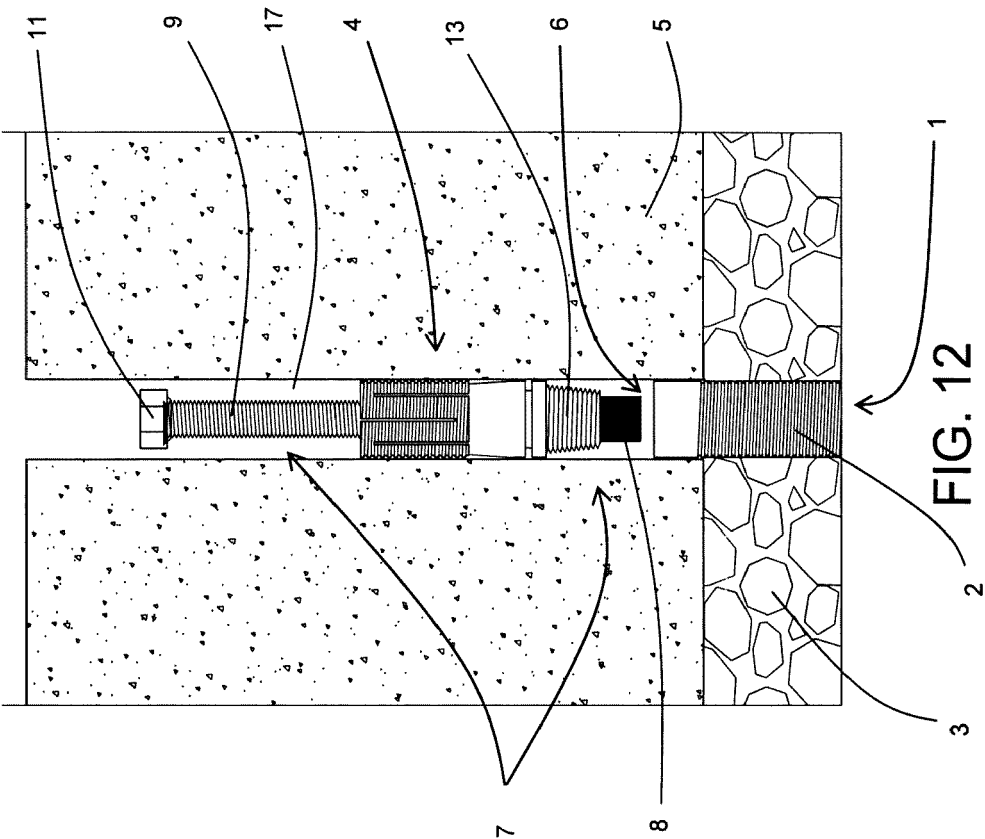
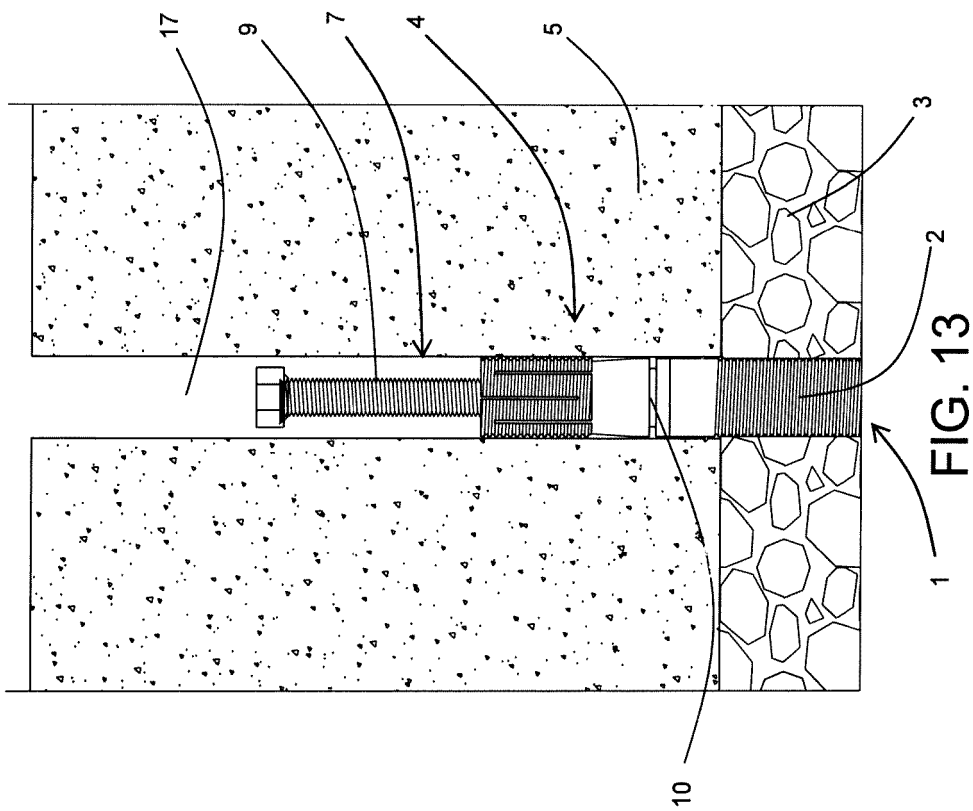
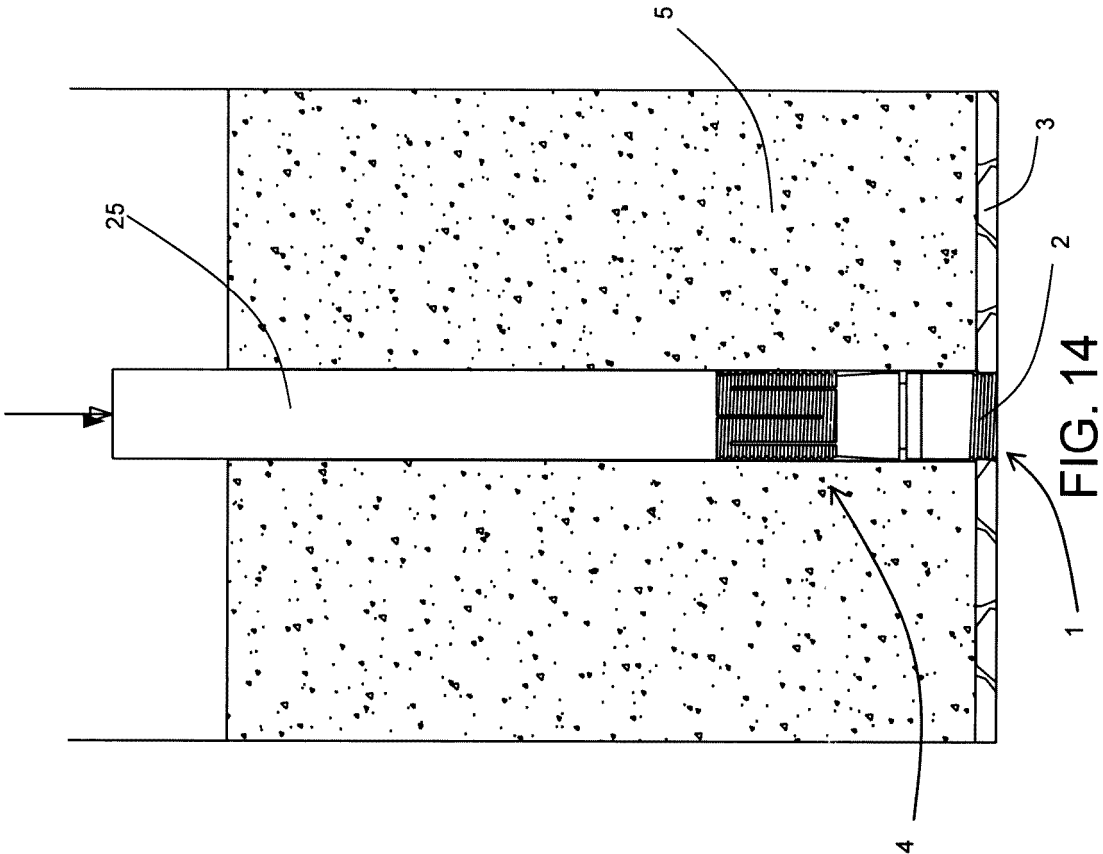
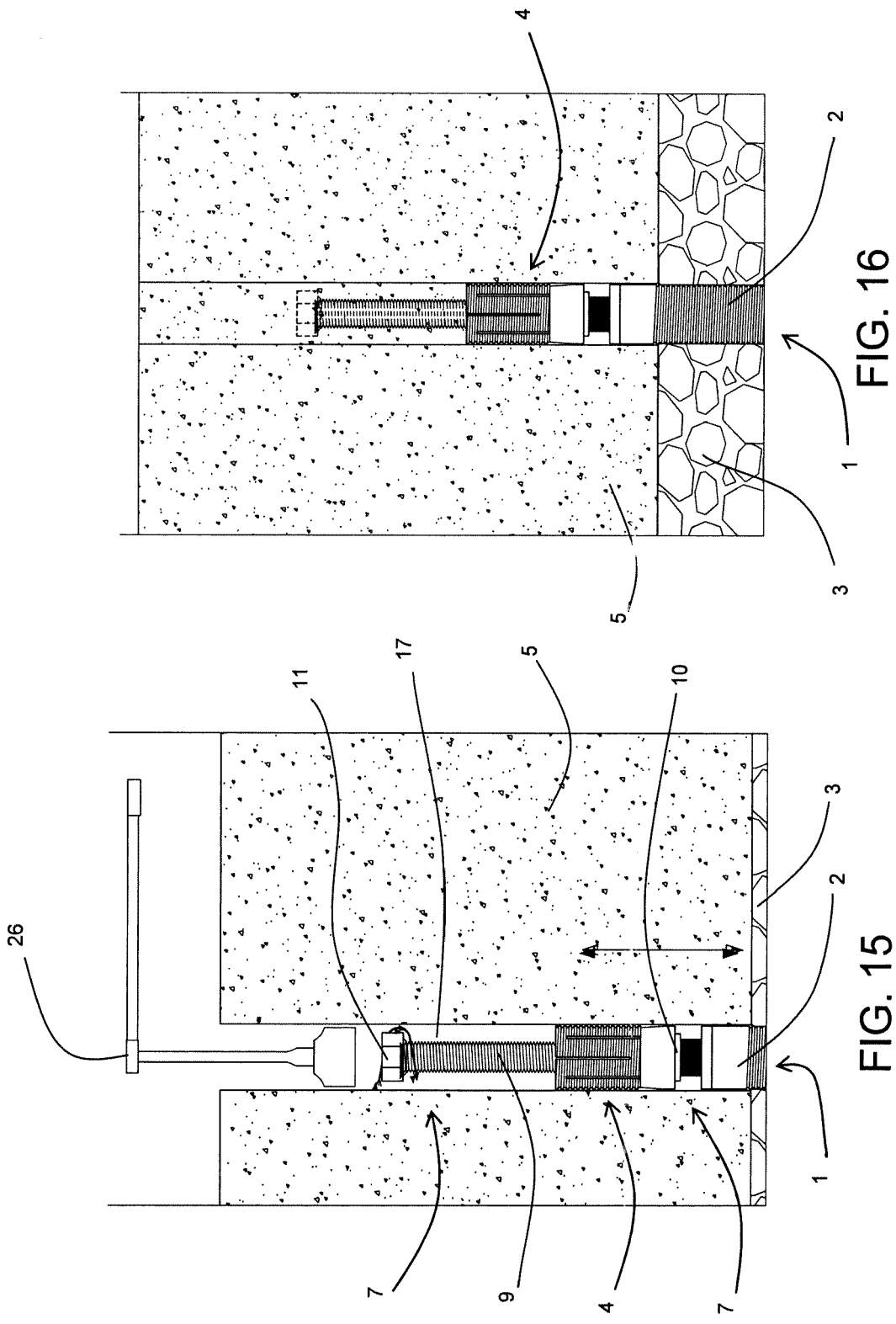


FIG. 8









EUROPEAN SEARCH REPORT

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A	3 June 2004 (2004-06-03) * the whole document * -----	14,15	
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			E02D
Place of search		Date of completion of the search	Examiner
Munich		11 August 2014	Geiger, Harald
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11-08-2014

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