FIG. 1

FIG. 2

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METHOD AND MEANS OF ANCHORING AN OBJECT IN THE GROUND

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ABSTRACT OF THE DISCLOSURE

A method and apparatus which provides for the installation of tie anchoring and/or reinforcing rods in soil adjacent construction areas such as building foundations which includes utilizing a rotative and/or percussive power feed to drive a drill rod string carrying a rod anchor into the soil and capable of penetrating rock therein and a drill tube string enclosing the drill rod string and having an outer diameter less than the rod anchor; with the combined drill rod string and drill tube string providing means for injecting washing fluid to said anchor during drilling and means for injecting grouting into the drilled hole through the tube string and out the lower end thereof around the drill rod string and anchor while simultaneously withdrawing the tube string from the drilled hole.

This invention relates to anchoring objects such as sheet piling, building foundations, high tension power masts, suspension bridges, or the like, in the ground by means of tie rods or making reinforced piers in the ground.

One object of the invention is to enable or make possible the insertion of heavy tie rods or reinforcing rods in the ground and the embedding thereof in concrete or the like and anchoring the tie or reinforcing rods in soil of any kind or in bed rock covered by such soil. The invention is particularly suitable in connection with building foundations where very heavy tie rods, capable of taking a tension load of 50 or 100 tons or more, have to be securely anchored in the soil or in the bed rock without removing the overburden. The invention is particularly advantageous in connection with the construction of building foundations where the walls around the excavated cavity for the foundation are formed by sheet piling which has to be anchored by means of tie rods against pressure from the outside by earth masses and/or adjacent buildings. However, the invention may also be used for making reinforced concrete piers capable of taking large loads.

According to this invention, there is provided for driving down a rod string and a tube string enclosing said rod string through the overburden soil to bed rock, if any, by means of a rock drill with a power feed, said rod string carrying a rod anchor with an external diameter in excess of the outer diameter of the tube string and capable of penetrating rock for a suitable distance and means for conveying flushing medium to the bottom of the hole produced by the rod anchor, disconnecting the rod string from the rock drill, closing an end of the tube string adjacent the rock drill, injecting grouting or other soil stabilizing material under pressure through the tube string, successively withdrawing the tube string from the ground while such grouting injection is going on preferably until the tube string is completely withdrawn from the hole, and connecting the rod string to the object when the grouting or the like has settled. The invention also provides the means for driving down and anchoring a rod string as well as the rod string itself. In some instances, particularly in connection with the formation of piles, the tube string may be left in the ground to enclose the concrete or grouting which is injected therein.

The invention is described below and illustrated in the accompanying drawings which show two embodiments of means for carrying out the invention in practice.

FIG. 1 is a diagrammatic view illustrating in vertical section a portion of an excavation for a building foundation surrounded by a wall of sheet piling; FIG. 2 illustrates the injection of grouting or concrete or other soil stabilizing material around a tie rod string; FIGS. 3a and 3b illustrate on a larger scale a wall of sheet piling, a drill wagon and a drill used for driving down a tie rod string and a tube string from a space dug out behind such wall; FIG. 4 illustrates in longitudinal section and partial side view the upper end of a tie rod string and a tube string and connections to a rock drill according to one embodiment of this invention; FIG. 5 is a detail of the rock drill; FIGS. 6a and 6b illustrate a tie rod string and a tube string of another embodiment of this invention; FIG. 6c illustrates a portion of the equipment in FIG. 6a after disconnection of the tie rod string; and FIG. 7 is a detail of the equipment in FIG. 4 used for closing the upper end of the tube string during injection of grouting or the like after disconnection of the tie rod string.

In FIGS. 1, 2, 3a and 3b, a cavity 1 is illustrated which provides space for a drill wagon and other equipment necessary in connection with the construction of a building foundation. The cavity 1 is surrounded by walls of sheet piling 2, which may or may not have been driven all the way down to bed rock 3 and which may be formed as a continuous wall with openings for the tie rod and tube string or the sheet piles may be placed with a distance between them to permit the insertion of the tie rod and tube strings in between the piles. The overburden, which extends down from the original ground level 4, may comprise loose soil, sand, boulders, filling material or the like. 5 indicates boulders or blocks in the overburden soil. 6. The cavity 1 is preferably excavated with a suitable digging machine while the tie rod anchoring goes on so that an upper row of tie rods is positioned before the cavity 1 is dug out to its final low level 7.

The use of tie rods facilitates moving around of the various equipment necessary for excavating and for the work required for fitting the tie rods. In FIGS. 1, 2, and 3, 8 indicates a drill wagon which is illustrated more diagrammatically in FIGS. 1 and 2 and more in detail in FIG. 3a and which is of a known type which provides a feed bar 9 which may be swung up or down relative to the substructure of the drill wagon and fixed in any desired angle with regard to the substructure by means of telescopic supports 10.

This drill wagon is basically of substantially conventional design and is provided with a rock drill 11 which may be a hammer drill as illustrated or a rotary drill of any suitable type which drill may be moved up and down the feed bar 9 by means of a chain 12 and a
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The rock drill may be of any heavy type, provided with a powerful rotation mechanism driven by a separate reversible feed motor 14 of sufficient power to rotate a large rod anchor and a tube. The drill wagon is furthermore provided with a winch 15 which has a steel wire cable 16 running over a sheave 17 at the top end of the feed bar 9 and provided for pulling tubes or rods out of a hole in the ground.

The associated equipment which is driven down into the ground consists of a string of tie rod elements 18 which may be hollow or solid and which should have sufficient tensile strength to take up the heavy tension applied to them when they are anchored in place and loaded. The tie rod elements are screwed together at both ends and are preferably provided with so-called pin threads fitting into coupling sleeves 20 threaded in a corresponding way and preferably provided with axially extending wings 21. The uppermost tie rod element is screwed into a socket 22 of a shank adapter 23, FIG. 6a, which may be of conventional design for fitting into a drill chuck 24 as in FIG. 5 with a portion having so-called Leyner wings or splines 25 which may be inserted axially and then rotated through a small angle in the drill chuck 24 so as to be axially locked therein in a conventional manner. The shank adapter may be provided with a flushing fluid passage 26 in the corresponding flushing fluid passage 32 in the tie rod element 18. Flushing fluid may be supplied through a hose 27 and a tube 28 (FIG. 3a) extending through the drill and communicating with the passage 26 in the shank adapter 23 in conventional manner. Optionally flushing fluid may be supplied to the shank adapter through a hose connection 29 and a swivel bushing 30 communicating through passages 31 with the flushing fluid passage 26, FIG. 4.

Flushing fluid passing through the shank adapter may flow through the passages 32 in the tie rod elements down to a tie rod anchor 33 through passages 34 in the tie rod anchor opening at the bottom of the hole. The tie rod anchor 33 in this case has a number of wings 35 carrying radially extending inserts 36 preferably of tungsten carbide or other material suitable for penetrating the type of rock in which the tie rod elements and anchor is going to be inserted. The tie rod anchor 33 is furthermore provided with guiding wings 37 extending axially from the tie rod anchor and serving to guide the tie rod anchor in the lower open end of a string of tube elements 38. When a rotary drill is used the rod anchor may, of course, be of other design and in certain types of ground so-called tricone bits or similar types of rod anchors may be used.

The tube elements 38 are connected to form a string of tube elements by means of threaded couplings 39 which couplings are preferably provided with so-called rope type threads fitting into similar threads 40 in the ends of the tube elements 38. The couplings 39 are preferably provided with a wrench grip 41 and similar wrench grips 42 are provided on the rod elements in order to facilitate assembling and disassembling of the tie rod string or reinforcing rod string and the tube string. The wings 41 on the rod couplings are of such dimensions that they can pass axially clear of the inner wall of the couplings 39. The uppermost tie rod element 38 is screwed to a sleeve 43 which has a radial flange 44 for facilitating withdrawal of the tube string from the hole. In FIG. 6a the sleeve 43 is screwed to a flushing head 45 which flushing head is screwed to the shank adapter 23 by means of screw threads 46 as also illustrated in FIG. 6b. The threaded portion on the head 45 is shorter than the rope threaded portion 19 on the rod elements and has higher lead than the threads 19 in order to come apart easier than any of the rod couplings. The flushing head 45 is surrounded by a swivel bushing 47 provided with a hose connection 48 communicating with a flushing medium passage 57. The swivel bushing 47 is kept in place on the flushing head 45 by means of a locking ring 49.

In the embodiment of FIG. 4 the sleeve 43 is not screw-threaded to the shank adapter 23, but instead a flushing head or bushing 50 is inserted in the sleeve 43 with a rotary and axially slidable fit so that the bushing 50 can be moved down until it rests with an annular flange 56 on the flange 44 of sleeve 43. The flushing head 50 has a connected equipment 52 from the supply of flushing fluid from a suitable source, said fluid connection 52 communicating through a check valve 53 with a passage 51 leading to a fluid passage 69 between the tie rod string and the tube string. The shank adapter 23 in FIG. 4 has a flange 74 which through an annular bearing surface rests on the upper end of the bushing 50.

In order to pull out the tube string from the hole in the ground, a clamp 54 is provided. Said clamp 54 consists of two half ring parts provided with ears 55 adapted to fit into rings 56 through which chain links 58 may be connected to hooks 77 on a slide 59 carrying the rock drill 11 and guided along the face bar and operated by the chain 16 and the feed motor 13. Alternately, the chain 58 may be connected to the cable 16 when it is desired to pull the tube string by means of the winch 15. At the lower end of the feed bar 9, FIG. 5, 3b, communicating with a passage 57 in the swivel bushing 47 is provided with an air hose connector 61 and a fluid hose connector 62 provided with a hose 63 and air hoses for supplying compressed air to the rock drill 11 and to the rotation motor mechanism 14, and 64 and 65 are hoses for supplying flushing water or air to the tie rod string and the tube string. Compressed air hoses supplying compressed air to the rock drill 11 and the controls for said motors are not illustrated since they form no part of the invention and are conventional in drill wagons of the type illustrated.

When the tie rod string and anchor and the tube string have been moved down and in, the rock drill is illustrated in FIG. 3b, through the action of the rock drill and feed on the shank adapter 23, said adapter is unscrewed from the uppermost tie rod element 18 in FIG. 6a whereby a plug 66, FIG. 6c, is inserted in the shank adapter 23 to close the flushing passage 26. To carry out this operation the flushing head 45 is held with a wrench 41 engaging the grip 41. The drill is then rotated in reverse direction which removes shank adapter 23 from flushing head 45, whereupon the drill is retracted so that the tie rod element 18 is accessible for removal from the shank. This retraction is possible due to a clearance 79 between the rod anchor 33 and the lower end of the tube string 35. It may then be suitable but not always necessary to replace the uppermost tie rod element 18 by a slightly longer tie rod element 18a having conventional or trapezoid screw threaded arrangement at the upper end for taking a corresponding nut. The tube string is then withdrawn a short distance by means of the winch 15 and fixed by tightening the clamp 60. The shank adapter with the plug 66 in it is now moved down on the rod 18a which may be hammered down. The shank adapter 23 and flushing head 45 are again connected and the clamp 60 may now be loosened. The connection 48 is illustrated in FIG. 6b, and instead connected to a grouting or concrete injection hose 67 which supplies grouting or the like from a pump 68. Injection and successive withdrawal of tube string 38 can then commence and continue for the length of the feed.

With the device according to FIGS. 6a, b and c operation is then as follows: by means of the feed motor 13
the drill and the tube string is slowly retracted and at the same time grouting or the like is supplied through the connection 48 to the passage 69 between the tube string and the tie rod string, to the lower end of the tube string around the tie rod anchor 33 and as the tube string is retracted grouting is continuously fed around the tie rod string and into cavities in the rock and in the soil so that a continuous body 70 of grouting or concrete is provided as indicated in FIGS. 1 and 2, which figures in their upper parts show various completely anchored tie rods.

With the equipment of FIG. 4 the operations are slightly different insofar that, after withdrawal of the shank adapter 23 from the flushing head 50 and removal of the uppermost tie rod element 18 for instance by means of a pipe wrench inserted between 74 and 76, the flushing head 50 is removed together with sleeve 43, a hollow tie rod element 18a or a solid rod 186 is attached to the tie rod string and a cover 72 is provided in the uppermost tube element 38, FIG. 7. The drill is advanced to be sure that the tie rod anchor is against the bottom of the hole. The grouting hose 67 is connected to hose connection 80 and the clamps 54 are connected to the chains 56, 58 and hook 77 or cable 16. Injection and retraction of tube string can then go on as above described.

The injection of concrete or grouting may be discontinued during retraction of the tube string and it may be controlled so that the grouting or concrete fills the cavities that may surround the tie rod string. When the tube string has been withdrawn completely and as much grouting as desired has been injected, the injection hose, the tube string and the drill wagon are moved away from the tie rod which is now embedded as desired and extends a suitable distance through or from the sheet piling. The embedded tie rod assembly is left for as long as necessary for the grouting to set. The projecting end of the tie rod string is then provided with a suitable nut 71 and washer and tightened down on a horizontal channel or other member extending horizontally along the sheet piling as the case may be. Before the nut on the tie rod string is completely tightened down the tie rod string may be tested in order to check the tension load which it can take. Such operations, however, are not described in further detail since they are conventional in this art.

During the withdrawal of the tube string, it may be necessary, according to the length of the tube string, to disconnect one or more of the tube elements, and during that operation the clamps 60, 61 are used to keep the tube element which just comes out of the sheet piling in position while other tube elements are removed and sleeve 43 and flushing head 45 or the cover 72 are removed and afterwards fitted on the clamped tube element.

The above described method and means for producing the rod anchoring means may naturally be varied in many different ways according to prevailing conditions and objects which are to be anchored and particularly according to the kind of soil and bed rock which is encountered in connection with operations of the above indicated type. The described method provides a convenient way of anchoring a tie rod string and a tie rod anchor. Also, couplings between the tie rod elements or may be well anchored within a body of concrete or the like which, when it has set, forms a very efficient anchoring for the sheet piling or other objects. All the above embodiments as above described should only be considered as examples and may be varied in different ways within the following claims. Naturally, a tie rod string and a tube string may under certain conditions comprise one single tie rod and one single tube of proper length. As mentioned above, the invention relates to the provision of more or less vertical rod strings which may form the reinforcement of a pile of concrete or the like injected or cast in the tube string which may be left in the ground.

1. The method of anchoring an object such as sheet piling, a building foundation, a concrete pile, and the like in the ground by means of rods and comprising the steps of driving a rod anchor and a rod string and an enclosing tube string substantially circular in cross section into the ground and into bed rock if any exists by means of a rock drill with power feed which feeds the rod string as well as the tube string, said rod string carrying said rod anchor and said rod anchor having an external diameter in excess of the outer diameter of said tube string and being adapted to penetrate rock and including means for conveying fluid medium to the bottom of the hole produced by said rod anchor, disconnecting said rod string from said rock drill, closing an end of said tube string adjacent said rock drill, injecting grouting under pressure through said tube string around said rod string for anchoring said rod anchor and said rod string in the ground, and connecting said rod string to said object when said grouting has set.

2. The method according to claim 1 which also includes the steps of withdrawing said tube string from the ground and from around said rod string as said grouting is being injected.

3. The method according to claim 2 in which said grouting is injected through the upper end of the said tube string and is expelled around said rod anchor and said rod string during a part only of said withdrawal of said tube string.

4. The method according to claim 1 in which said grouting is injected through the upper end of said tube string and is expelled around said rod anchor and said rod string while said tube string is left in the ground.

5. The method according to claim 1 in which after disconnection of said rod string from said rod anchor an extra rod element is added to said rod string, then pulling said rod string further to the bottom of the hole by means of said drill feed, and simultaneously pulling the tube string up a short distance with a winch to assure that said rod anchor is at the bottom of the hole when injection of grouting is started.

6. The method according to claim 1 in which an axial clearance is provided between the lower end of said tube string and said rod anchor during driving down of said anchor.

7. The method as described in claim 1 which includes the steps of applying both percussive and rotative force to said drill rod string and said drill tube string and in which said tie rod string includes a plurality of elements having means for transmitting said percussive force to said tie rod anchor, said elements being coupled together with tie rod couplings having means for anchoring in said grouting when set.

8. Apparatus for anchoring a rod string in the ground comprising the combination of a drill wagon having a rock drill, a feed bar, reversible means for moving said drill up and down said feed bar, a rod string means for connecting said drill to one end of said rod string, a rod anchor at the opposite end of said rod string from said drill and adapted to penetrate rock for a short distance under the action of said drill, a string of tube substantially circular in cross-section enclosing said rod string and having an outer diameter less than the other diameter of said rod anchor, means for forcing said tube string into the ground following said rod anchor as said anchor penetrates into the ground, means for closing the upper end of said tube string after short retraction of said tube string relative to said rod string, and means for injecting grouting through said closed end of said tube string and to expel said grouting at the open opposite end of said tube string.

9. Apparatus according to claim 8 in which said rod anchor has guiding wings extending axially and in guiding cooperation with the inner wall of said tube string.
10. Apparatus according to claim 8 in which said rod string comprises separate rod elements and rod couplings for connecting together said rod elements, said couplings having axially extending guiding means for forming anchoring means to be enclosed by said grouting and having a running clearance with respect to the inner walls of said tube string.

11. A tie rod string and anchor as recited in claim 8.

12. The apparatus as set forth in claim 8 in which said rod string is solid.

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