April 8, 1969 G. LAGERSTRÖM 3,436,923

METHOD AND EQUIPMENT FOR MAKING TENSION ANCHORS

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Fig. 1

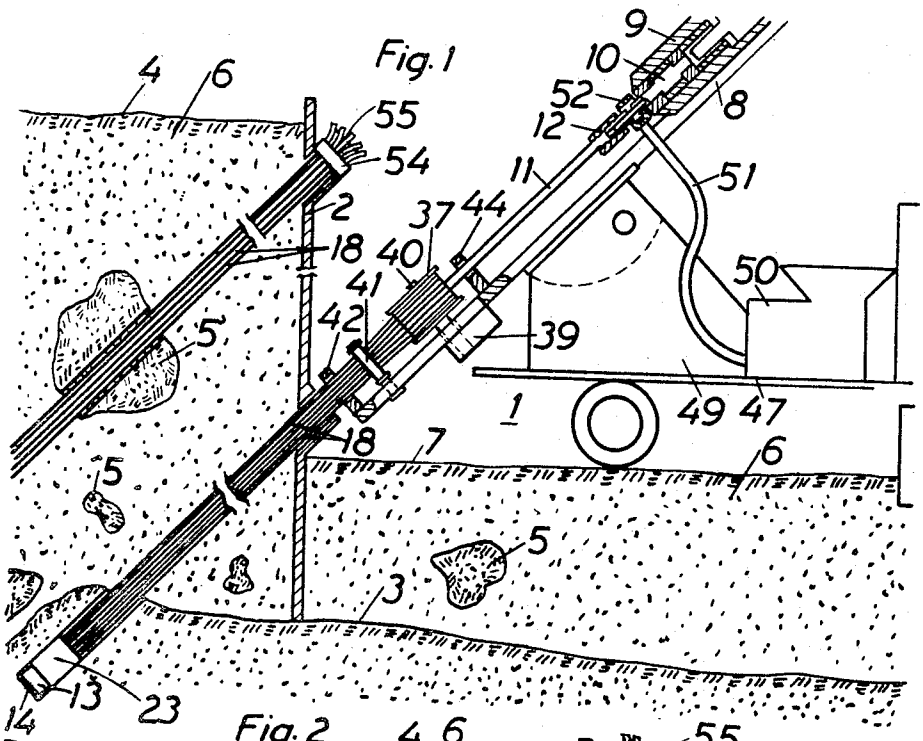
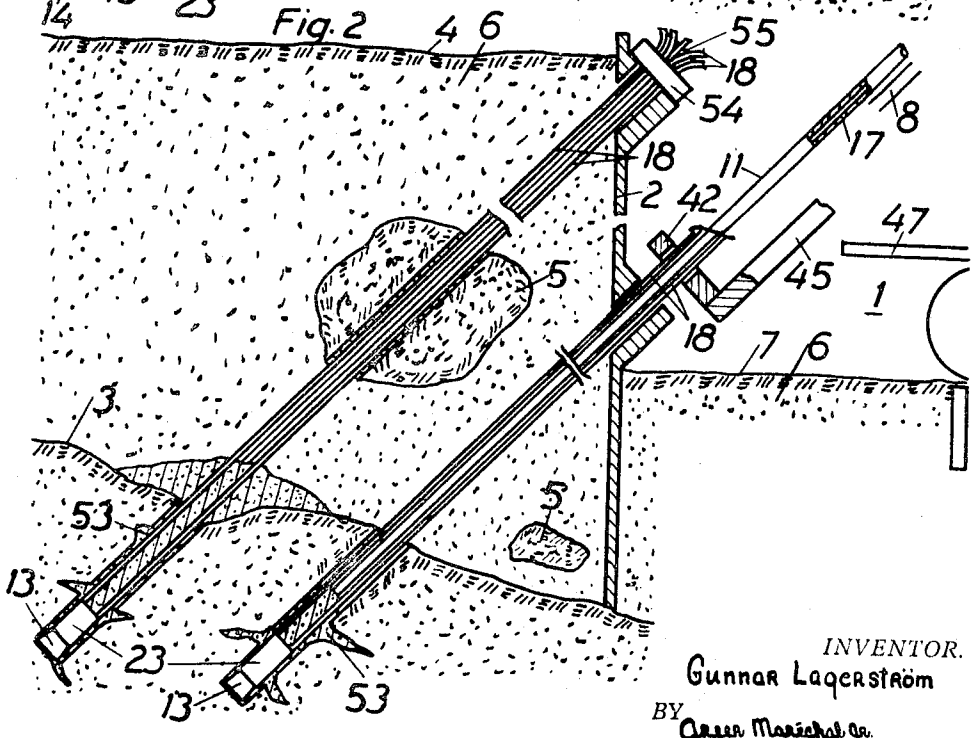


Fig. 2



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METHOD AND EQUIPMENT FOR MAKING TENSION ANCHORS

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Fig. 3

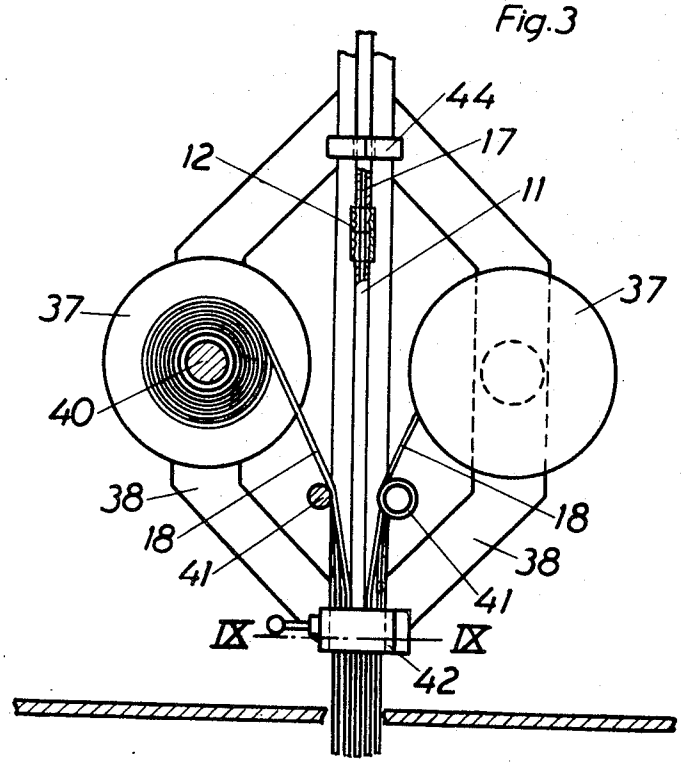

Fig. 8

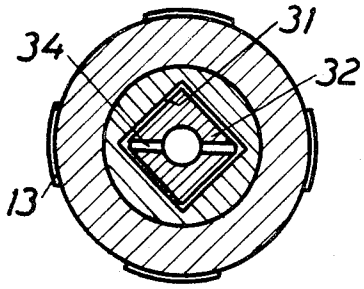

Fig. 9

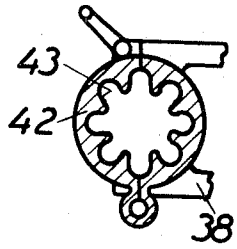

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Fig. 4

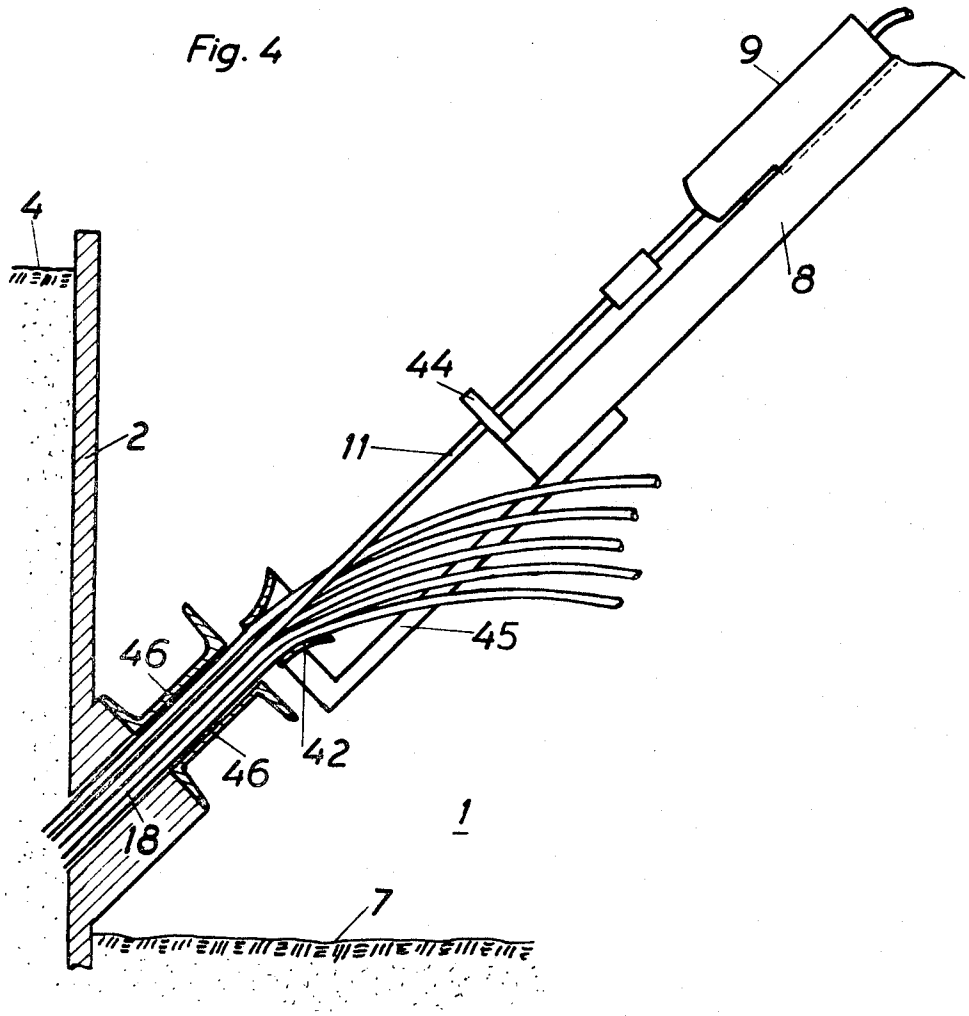

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Fig. 6

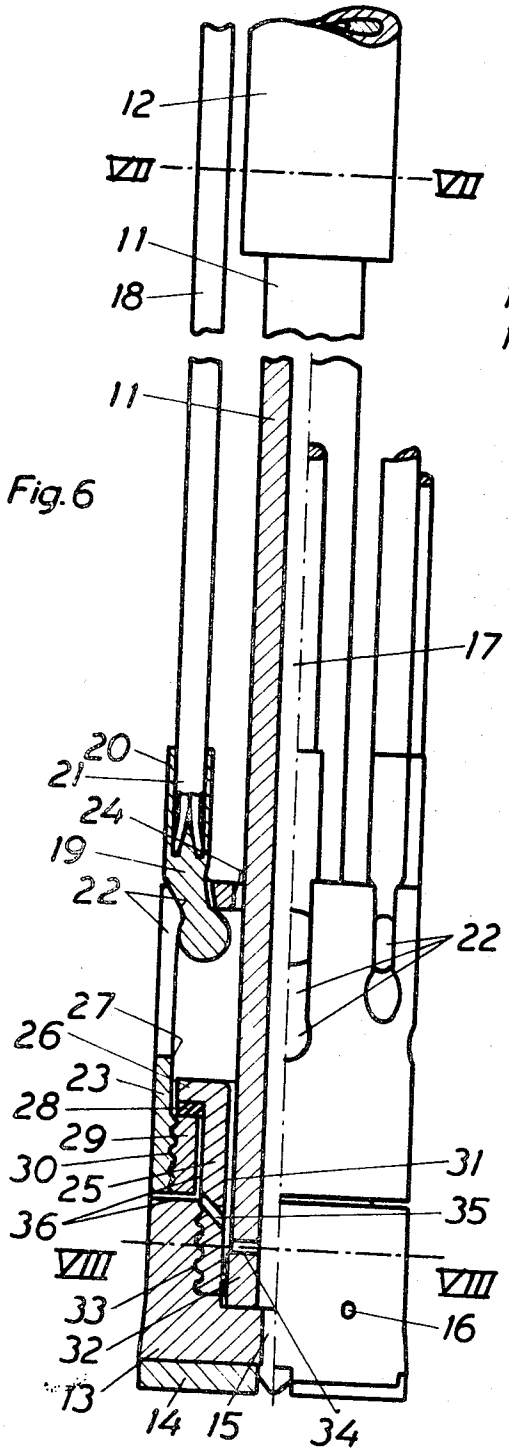


Fig. 7

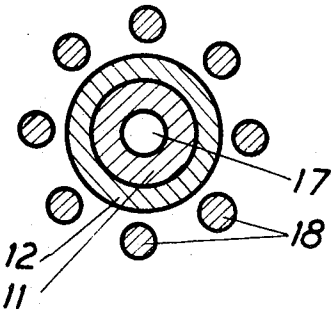
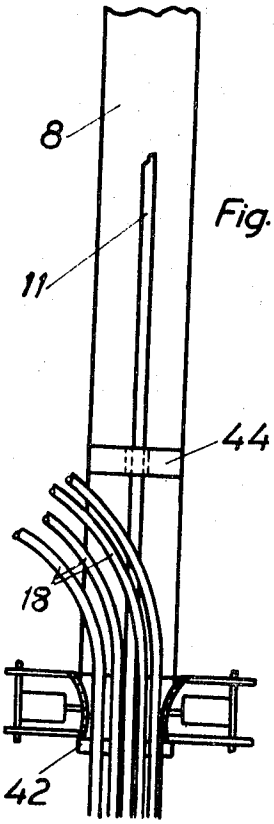


Fig. 5



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3,436,923

METHOD AND EQUIPMENT FOR MAKING TENSION ANCHORS

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U.S. Cl. 61—53.52
9 Claims

ABSTRACT OF THE DISCLOSURE

A method and apparatus is provided for making a tension anchor in the ground which utilizes drilling equipment for simultaneously drilling the hole for the anchor and drawing down into the hole a bundle of tension wires for the anchor by disposing the draw member for the tension wires adjacent the drill bit, and by using a tubular drill rod through which grouting is injected into the drill hole and around the tension wires simultaneously as the rod is withdrawn from the hole. In addition, the draw member is rotatable with respect to the drill bit and rod, and the drilling equipment including the drill bit is capable of drilling through rock as well as earth.

This invention relates to a method and equipment for making tension anchors particularly in the ground. Such anchors are used for anchoring objects such as sheet piling walls, building foundations, high tension power masts, suspension bridges, hydro power plant dams, or the like. The invention is particularly related to the provision of tension anchors for heavy loads. Such anchoring is often carried out by means of a bundle of heavy wires or cables which are anchored in the ground, for instance in bed rock or in the overburden soil, in holes in which the wire or cable bundles are inserted and anchored by injection of grouting or similar material around the wires or the like. Tension anchors may often have to take a load of several hundred tons and in such cases it has been found uneconomical to use tie rods since such rods for these heavy loads are very expensive. It is in many cases more economical to use wire or cable bundles or bundles of other flexible members, such as flexible steel rods or steel bands or the like, which form a bundle anchored in a hole in the soil or in bed rock in which grouting or other stabilizing material is injected. So far, bundles of wires or cables have been inserted through a casing into a hole which, however, is an expensive and cumbersome affair.

The present invention comprises making a tension anchor in the ground by drilling a hole into the ground by means of drilling equipment comprising a tubular drill string carrying a drill bit, drawing a bundle of flexible tension members down into the hole by a draw member carried down by and preferably simultaneously with the drilling equipment, and injecting grouting or similar material around at least a portion of said bundle. Preferably a non-rotating draw member is used which is coupled to the drill bit in such a manner that the drill bit may rotate without rotating the draw member and carries the draw member and the tension members down into the hole simultaneously during drilling whereupon the flexible tension members such as wires, cables, steel bands or thin steel rods are fixed by injection of grouting. When the drill bit has been drilled down through the overburden and prefreably some distance into bed rock the drill rod can be withdrawn and simultaneously grouting or the like is injected through the hollow drill rod to fill out the empty spaces in the bundle of wires or the like and also to fill out cavities in the ground around the hole so

that a satisfactory anchorage is obtained. When the grouting has settled the tension anchor is tested by means of hydraulic jacks in conventional manner.

In the accompanying drawings the preferred method and equipment for making tension anchors is illustrated by way of example. 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 is a similar view and illustrates a completed tension anchor and another tension anchor under construction. FIG. 3 is a diagrammatic elevation and partial section illustrating a feeding arrangement for wires used to form a tension anchor. FIG. 4 is a side view partly in vertical section and illustrates means for guiding the wires into the hole, and FIG. 5 is an elevation of the equipment in FIG. 4. FIG. 6 is a longitudinal section and partial side view of the drilling end of the anchoring equipment according to the invention. FIG. 7 is a section on line VII—VII and FIG. 8 a section on line VIII—VIII in FIG. 6. FIG. 9 is a transverse section on line IX—IX in FIG. 3.

In FIGS. 1 and 2 a cavity **1** is illustrated which provides space for drill wagons or other drill carriages and for 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**. Said sheet piling may form a continuous wall with openings for the tension anchors or the piles may be placed at a distance from each other to provide openings in between the sheet piles for the tension anchors. 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 tension anchoring goes on so that an upper row of tension anchors is positioned before the cavity is dug out to its final low level **7**.

8 indicates a conventional feed bar for a conventional hammer drill **9** which may preferably be a heavy hammer drill with separate rotation motor. The hammer drill **9** operates on a shank adapter **10** which is coupled to a hollow drill string comprising tubular drill rods **11** or a single hollow drill rod **11** if the depth of the desired hole is not too large coupled together and to the shank adapter **10** by means of sleeves **12**. At the lower end the drill string **11** which is illustrated on a larger scale in FIG. 6 is provided with a drill bit **13** which may be of substantially conventional design as regards the positioning of hard metal inserts **14** which, however, are only carried out for being able to drill a comparatively short hole in rock, for instance three or four meters. The drill bit **13** is provided with flushing passages **15**, **16** which communicate with a large passage **17** in the drill string dimensioned so that it can be used not only for the transportation of flushing fluid such as air, water or other flushing fluid to the drill bit but also for afterwards being used for transportation of grouting for injecting the hole and the surroundings of the tension anchor. The drill string is surrounded by a number of flexible tension members **18** which in the illustrated embodiment consist of heavy steel wires or cables, for instance half inch steel cables, which at the lower end are provided with wire clamps **19** forming sockets **20** which in conventional manner may be hydraulically secured by being pressed around the ends **21** of the cables or wires **18**. The clamps **19** are inserted and fitted in corresponding recesses **22** in a draw member **23** which forms an annular body or wire head of little less outer diameter than the diameter of the drill bit **13** so that it can follow the drill bit **13** easily down

into the ground and into rock. The draw member **23** forms a central passage **24** through which the drill string **11** may pass. A bushing **25** having an annular external flange **26** fits into the bore **27** in the draw member **23** with ample clearance so as to permit said bushing **25** to rotate relatively to the draw member and also to permit passage of flushing fluid and/or grouting from the passage **17** into the draw member. The lower shoulder of the flange **26** rests on a reinforced nylon ring **28** or a ring of self-lubricating bronze or other material which cooperates with a tubular bushing **29** screwed into the lower end of the draw member **23**, **23** as indicated at **30**. The bushing **25** has a square or otherwise non-circular axial passage **31**, FIGS. 6 and 8, in which the correspondingly shaped lower end **32** fits so that the drill string may rotate the bushing **25** and thereby rotate the drill bit **13** which is screw threaded onto the bushing at **33**. The lower end **32** of the drill string fits in the axial passage **31** in the bushing **25** in such a manner that the drill string may easily be removed out of the bushing **25** by retracting the drill string. The drill string end **32** has further flushing passages **34** which communicate with flushing passages **35** in the bushing **25** and with the clearance **36** between the bushing **25** and the bushing **29** so that said clearance may be well flushed with flushing medium during operation of the equipment. By flushing the clearance **36** the bearing formed between the bushing **29** and the flange **26** may be kept free from dirt and debris.

The tension members **18** which may consist of wires or steel cables or flexible band steel or other similar flexible members pre-cut to suitable length may be wound onto drums **37** which are fitted for rotation on brackets **38** secured to the lower end of the feed bar **8**. **39** is a motor such as a compressed air motor which is in driving connection with the shafts **40** of the drums **37** so that the motor can rotate the drums. The flexible members are guided over rollers **41** into a guide hopper **42** on the feed bar which hopper consists of a split ring with a number of axial grooves **43**, FIG. 9, one for each tension member **18**, so that said members are evenly distributed around the drill string **11**. The hopper **42** is divided in two parts hinged together to be able to be mounted on the bracket **38** and to receive the drill string and the tension member, as obvious from FIG. 9.

If a fairly large guide hopper is provided, as illustrated in FIGS. 4 and 5, the tension members **18** may be fed into said hopper directly from the ground where they may just be put in order before drilling so that they may follow the draw member down into the hole as drilling proceeds. **44** is a conventional drill steel guide of the type commonly used on drill carriages of various types. The hopper **42** and the drill steel guide **44** may be carried by an axially adjustable or movable sliding member **45** which may be operated into various axial positions by means of a power cylinder in similar way as movable drill steel guides are operable on feed bars for drill carriages. Such an arrangement makes it easier to place the hopper **42** at ample distance above a couple of channels **46** or other structure which form supports for the anchor heads on which the wire anchors are intended to rest. The channels **46** also distribute the tension over a number of sheet piles **2** of the sheet pile wall which it is desired to anchor.

47 is a lorry or other transportation means which carries the feed bar **8** on brackets **49** which may be arranged to permit dumping of the feed bars down on the lorry into substantially horizontal position. The lorry also carries pump equipment **50** for supplying flushing water and/or grouting through a hose **51** and a flushing head **52** which is rotatably disposed on the adapter **10** and communicates with the passage **17** in the drill string in a manner which is well known in this art. The number of wires or other tension elements **18** in tension anchors naturally varies according to the load for which the anchors are constructed and the dimension of the wires or other elements available in each case.

The method according to the invention is carried out in the following manner: The drill carriage or lorry **47** with the feed bar **8** is moved to the position at the sheet piling **2** where it is desired to arrange the tension anchor. A drill bit **13** with a suitable draw member **23** fitted thereon is provided on the square end **32** of a drill string **11** and the desired number of wires or cables are drawn from the drums **37** or from the ground where they lie ready for use and inserted in the recesses **22**. The upper half of the hopper is closed and the draw member **23** with the wires is advanced through the hopper **42** and the tension members are brought into position in the various grooves **43** and the wires are stretched. The sliding member **45** is then advanced towards the channels **46** to a position substantially as illustrated in FIG. 4 and thereafter the drill feed is advanced so that the drill bit and the draw member **23** are moved down towards the ground pulling the tension members **18** through the guide hopper **42**. As soon as the drill bit enters the ground flushing air or flushing water supply is provided through the passage **17** and the rock drill **9** is started. The bit is now advanced through the overburden **6** and drills through any boulders or other obstacles which are encountered, as illustrated in FIGS. 1 and 2. The drill bit is advanced, if desired, through the overburden down to bed rock **3**, and such a suitable distance into bed rock as considered necessary for providing a safe anchorage. Usually the bit is drilled into bed rock 3 or 4 meters to be sure that it is bed rock and not a big boulder which has been encountered. During the drilling operation the draw member **23** pulls the tension members **18** along down into the hole but the drill steel rotation is not transmitted to the draw member **23** due to the bearing arrangement **28**. When the drill bit and draw member have been carried down to a desirable depth, drilling is discontinued and flushing is also discontinued and injection of cement grouting or other stabilizing material from the pump equipment **50** starts while the drill string is still in position in the drill bit **13**. In order to provide a perfect anchor the drill string **13** is now slowly retracted and simultaneously cement grouting, or similar material is injected through the passage **17** into the cavities in and around the drill bit **13**, the draw member **23** and the flexible tension members **18** and also into cavities surrounding the hole produced by the drill bit **13**, as is indicated at **53** in FIG. 2. The amount of injected material naturally depends upon the condition of the rock or ground and the tension which it is intended that the tension anchor should be able to carry. Injection may be made just around the lower end of the tension members or all along said members or in certain areas as the case may be. It is also foreseen according to the invention to provide a not illustrated casing around the tension members in which case the drill bit should be of slightly larger diameter than the outer diameter of said casing and in such a way a concrete reinforced pile may be produced which may be particularly of advantage in cases where the ground may adversely affect the material of the tension members **18**. When casing is used it is of course not necessary to draw the draw member and wire or cable bundle down simultaneously with drilling of the hole and driving down of the casing. Instead after driving down a bit and a casing the drill string may be retracted and a special draw member provided thereon to which wires or other tension members are secured and which is then moved down through the casing to the bit by means of the drill feed. Afterwards the casing may be retracted by means of the feed or special winches and injection is made through the drill string as described or through the casing as described in my U.S. application Ser. No. 525,068 filed Feb. 4, 1966. When injection has been finished the drill string is usually completely withdrawn and a suitable anchor head **54**, **55** may be provided at the upper end of the tension members **18** as indicated in FIGS. 1 and 2. After a few days when the

injected material has settled sufficiently the tension anchors are tested for the desired tension with sufficient margin as may be stipulated for the particular job.

The method above described and illustrated in the drawings as well as the equipment illustrated should only be considered as examples and may be modified in various different ways within the scope of the following claims. The method may for instance be used for various other purposes than for anchoring sheet piling, such as for anchoring power line masts, suspension bridges, dam structures and casings for harbours and water power stations and other building structures.

What I claim is:

1. Tension anchor equipment comprising a drill string including a drill bit and a drill rod means arranged for transmitting rotation and percussion energy to said drill bit and to be withdrawn from said bit, a bundle of tension members surrounding said drill rod, a draw member in which said tension members are fixed, means for coupling said drawn member to the drill string for advancing the draw member into the hole but not rotating the draw member, means for advancing said equipment into the ground, and means for supplying grouting around the tension members.

2. Tension anchor equipment according to claim 1, in which the drill rods are tubular and provided with means for injection of grouting or the like through said rods.

3. Tension anchor equipment according to claim 1, in which the drill bit is coupled to the draw member by a coupling which permits rotation of the bit relative to the draw member but which carries the draw member forward together with the bit when the bit is fed forward by a drill feed.

4. Tension anchor equipment according to claim 1, in which a number of tension members are wound on a drum carried by a drill feed and fed from the drum into the hole to form an anchor together with the draw member.

5. Tension anchor equipment according to claim 1, in which a guide hopper having a number of axially extending internal grooves for guiding tension members is provided at the forward end of a drill feed.

6. Apparatus as described in claim 1 in which each of said tension members includes a socket and a pertaining coupling head pressure fitted thereon at one end, said coupling head being formed to engage said draw member.

7. A method for making a tension anchor in the ground by means of drilling equipment including a tubular drill string carrying a drill bit, the steps which comprise drilling a hole into the ground by means of said drilling equipment, surrounding said drill string by a bundle of flexible tension members, simultaneously drawing said bundle of flexible tension members down into said hole by a draw member disposed adjacent said bit, and injecting grouting around at least a portion of said bundle.

8. A method of making a tension anchor in the ground by means of drilling equipment including a tubular rotatable drill string carrying a drill bit capable of penerating rock, the steps which comprise drilling a hole into the ground by means of said drilling equipment, surrounding said drill string with a bundle of flexible tension members, drawing said bundle of flexible tension members down into the hole by a draw member rotatable relative to said drill string and said drill bit, and said draw member being carried down by said drilling equipment simultaneously with said drill bit during the drilling of said hole.

9. A method for making a tension anchor in the ground by means of drilling equipment including a tubular drill string carrying a drill bit and a drill wagon carrying a feed bar for said drill, the steps which comprise drilling a hole into the ground by means of said drilling equipment, providing one or more reels on said drill wagon on which a number of flexible tension members are wound for being fed in one or more bundles into said hole as drilling proceeds, simultaneously drawing said bundles of flexible tension members down into said hole by a draw member disposed adjacent said drill bit, and injecting grouting around at least a portion of said bundles.

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JACOB SHAPIRO, *Primary Examiner.*

U.S. Cl. X.R.

52—156; 61—39, 45