Feb. 10, 1970 G. JORGE 3,494,134

GROUND ANCHOR

Filed April 26, 1968 4 Sheets-Sheet 1

Fig.1

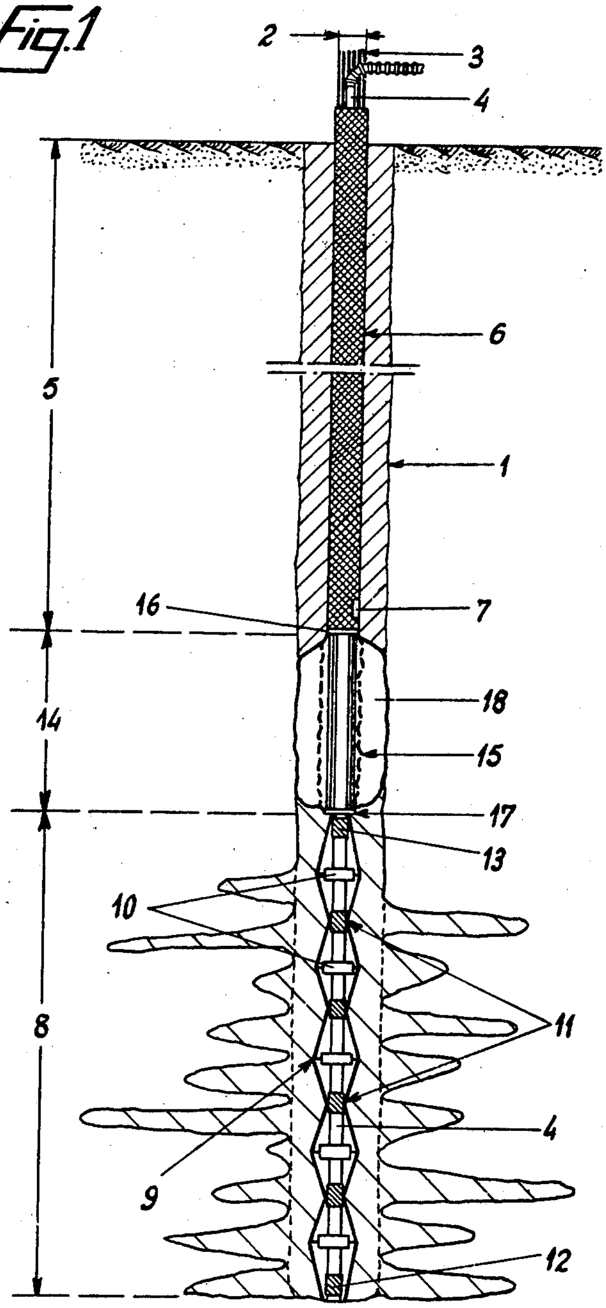


Fig. 2

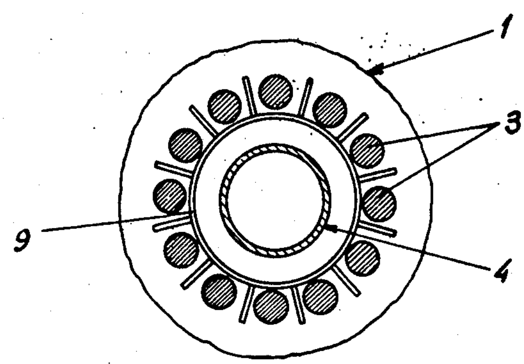


Fig. 3

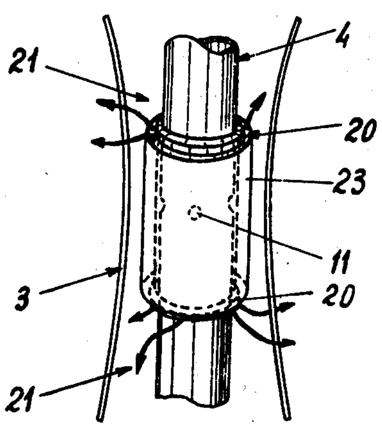


Fig. 4

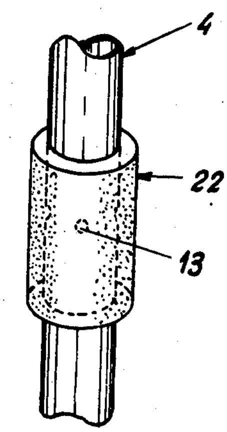
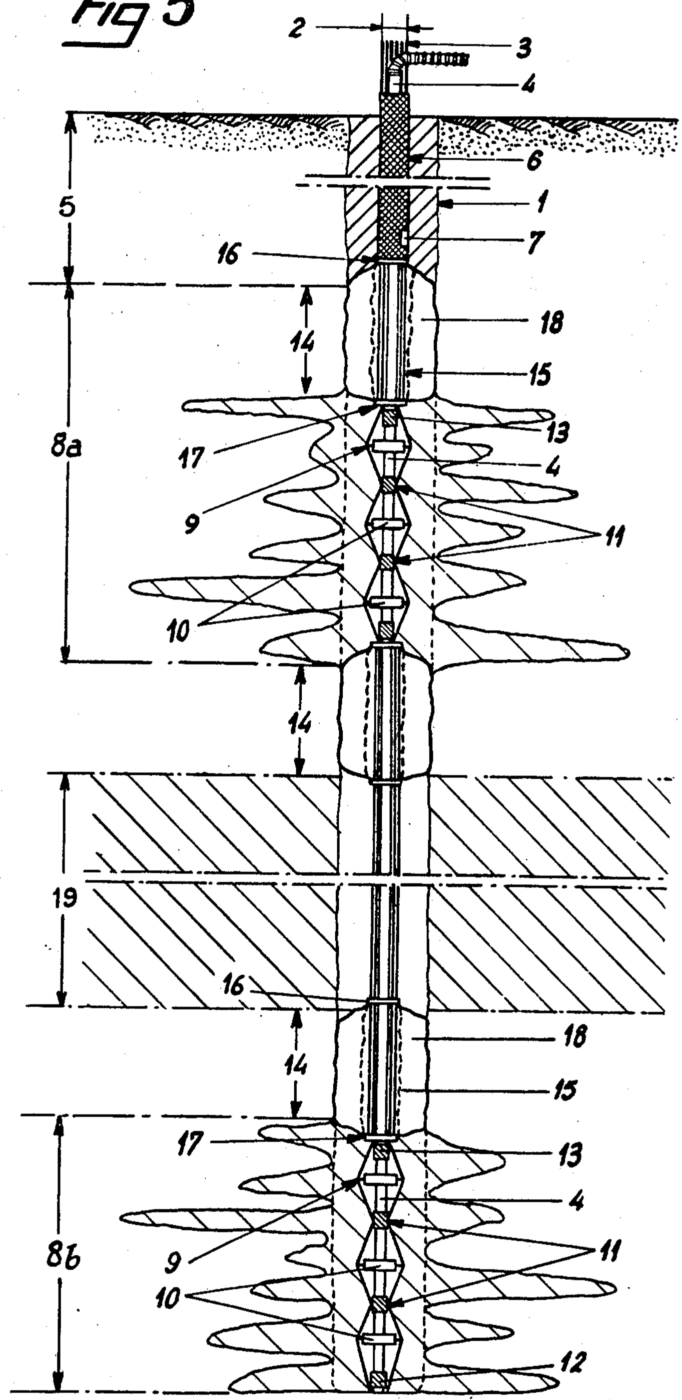


Fig 5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8a
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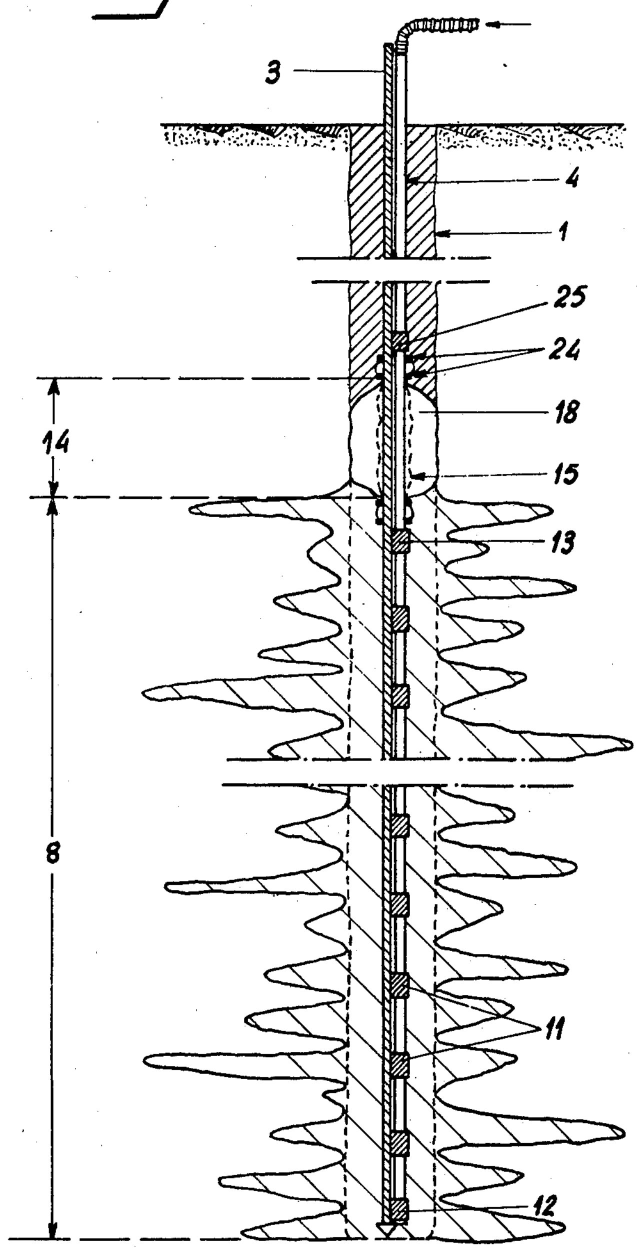
8b
9
11
10
12

Fig. 6



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3,494,134
GROUND ANCHOR

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Int. Cl. E02d *5/38, 5/54*
U.S. Cl. 61—35 7 Claims

ABSTRACT OF THE DISCLOSURE

The invention relates to ground anchors for sealing into the ground. The ground anchor has a stay and an injection tube extending the length of the stay. The injection tube is formed with openings, through which a grout can be forced, and one at least of the openings is surrounded by a jacket. After the anchor is placed in the bore, grout is forced through the opening surrounded by the jacket to expand the jacket outwards against the wall of the bore to form a barrier. Further grout is then forced through an opening in the tube below the barrier to seal the anchor into the bore, the barrier preventing the further grout from escaping to the surface or into parts of the bore which are unsuitable for sealing purposes.

It has long been known that the earth supporting properties of walls, curtains of piles, etc. can be improved by the use of ground anchors which transmit thrusts to which the wall is subjected to a set-back zone of the ground which is known to be strong and in which the stays are sealed.

The ground anchor is only as strong as its seal with the ground, and many methods have been patented which all seek to utilise the strength of the ground into which the anchor is sealed to the best possible effect.

All these methods consist in injecting an appropriate grouting material into the soil in various ways. After hardening the grouting produces between the anchor and the soil a connection capable of transmitting to the soil the tractions to which the stay is subjected.

Clearly the load bearing capacity of the anchor will be improved if first, the grouting material used is not washed away by ground water present in the bore, second friction forces between the stay and the hardened grouting surrounding it, are large and unaffected by falling-in which can occur in the bore, and third, and most important, the pressure at which the grouting material is injected, is limited only by the risk of bursting of the ground, so that according to the ground encountered, there can be achieved either perfect adhesion between the soil and the grouting or an intimate penetration of the grouting into the soil to form a solid integral mass.

It is this third point with which the present invention is particularly concerned. In intrinically weak soils, such as plastic clays, muds, marls, failures of ground anchors are frequent due to ineffective sealing with the ground. Similarly, in ground where there are significant cavities, whether man-made or natural, faults or open fissures for example, the grouting can escape instead of being tightly packed around the anchor and again failures are frequent. These failures have been avoidable in the past, either by increasing the length of the seal between the anchor and the ground or by improving the intrinsic properties of the soil and/or filling in any cavities before installing the anchors.

Unfortunately the need for these operations has generally been revealed only well after the anchor has been loaded and there has been no alternative to re-making the work suitably, which incidentally may not even be possible at the same site.

The present invention therefore has the purpose of making it possible, with one piece of equipment and in one operation both to seal an anchor into the ground and to treat the ground by means of injections affecting only a selected zone or zones into which the anchor is sealed, the treatment being effected at pressures which are limited only by the risk of the bursting of the ground.

In accordance with the present invention, a ground anchor for sealing into a bore in the ground, comprises a stay, an injection tube extending substantially the whole length of the stay and formed with openings spaced along its length, and at least one expandable jacket which surrounds the stay and the injection tube at one of the openings and which is arranged to be expanded outwards against the wall of the bore in use by means of a grout introduced under pressure through the one of the openings in the injection tube so that the jacket then forms a barrier isolating from the rest of the bore a part of the bore which forms a sealing zone below the barrier and into which further grout can be injected at high pressure to seal the anchor into the bore.

With this arrangement, parts of the bore which are surrounded by soil of adequate mechanical properties are selected as sealing zones and can be isolated from other parts either adjacent to the surface or having grossly unsatisfactory properties or cavities too large to be filled. The pressures at which grout can then be injected into the sealing zones are not limited by the risk of the grout escaping to the surface or into the other parts of the bore and can therefore be high enough to cause the grout to penetrate the soil in the sealing zones to form the solid mass referred to. It is also possible, should the sealing turn out to be unsatisfactory in any sealing zone, to inject supplementary grout into that zone alone without disturbing the ground anchor or its seal with any other sealing zone.

The ground anchor according to the invention is a true ground anchor in that it transmits tensile forces to which it is subjected specifically to the selected zones and does not subject the soil close to the surface to stress as in a "pinning" operation. It is even possible to excavate the soil between the surface and the sealing zone, or the uppermost sealing zone if there are more than one.

The invention includes a method of sealing a ground anchor into a bore, comprising the steps of inserting the anchor into the bore, expanding the jacket, or each jacket in turn, outwards against the wall of the bore by inserting a double closure device having a supply pipe into the injection tube to a position in which the injection tube is closed above and below the opening surrounded by the jacket, and forcing grouting material under pressure down the supply pipe and through the opening, allowing the grout to set as a barrier forming a sealing zone below the barrier or at least one of the barriers, inserting the double closure device into the injection tube to a position in which the injection tube is closed above and below an opening into the sealing zone and forcing grouting material under pressure down the supply pipe and through the opening into the sealing zone to seal the anchor into the bore.

The injection of grout both into the jackets and into the sealing zones can most conveniently be carried out by the double closure device if each of the openings in the injection tube is fitted with a non-return valve to prevent the return of grouting material into the tube from any part of the bore.

Preferably an opening immediately below the or each jacket is covered by a fine filter which is permeable to water but not to grout whereby in use, water present in the part of the bore below the barrier formed by the jacket when expanded, can escape through the fine filter upon being displaced by the injection of grout at high pressure.

It has been found that the ground anchor according to the invention which can be curved if this is desired, is able to withstand forces of as much as 500 tons.

One example of a ground anchor in accordance with the invention is illustrated in the accompanying drawings, in which:

FIGURE 1 is a general view of the ground anchor;

FIGURE 2 shows the detail of the respective placing of the various components of the anchor in horizontal section;

FIGURE 3 is a perspective view of a valve;

FIGURE 4 is a perspective view of another valve;

FIGURE 5 shows the ground anchor sealed into two ground zones separated by a zone which is left intact; and,

FIGURE 6 shows a modification of the ground anchor.

After a bore **1** has been formed in the ground there is introduced the ground anchor composed of a stay **2**, which itself consists of twisted wires **3** surrounding a fixed central tube **4** of the same length, made of a material strong enough to resist the injection pressures utilised although quite flexible so as to follow deformations of the bore.

An upper unsealed part **5** of the anchor is covered with a protective non-adherent sheath **6** which enables it to slide freely. At its base this sheath is formed with an orifice **7** opposite to which the tube **4** is pierced with an aperture (not shown), the orifice **7** and the aperture being protected by a non-return valve of the type represented in FIGURE 3 and to be described later.

The lower part **8** of the anchor which will be sealed in the soil, is characterised in that the wires **3** (FIGURES 1 and 5) are regularly spaced at **9** from the stay **2** by means of spacers **10**, so as to retain any fallen-in earth, and that the tube **4** is equipped, at intervals corresponding to the spacings **9**, with orifices protected by non-return valves **11**, **12** and **13** represented respectively in FIGURES 3 and 4.

A central part **14** of the anchor is constituted by the stay **2** around which a permeable and extensible jacket **15** is placed in continuation of the sheath **6**, to which it is clamped by a collar **16**. The jacket **15** is also clamped to the stay at **17**. The central part **14** of the tube **4** is also equipped with an orifice (not shown) protected by a non-return valve.

FIGURE 2 represents in horizontal section the stay device at the level of one of the spacers **9**. The wires **3** of the stay **2**, the central tube **4** and the spacer **9** may be distinguished therein, all being surrounded by the walls of the bore. It is seen that there is a space between the tube **4** and the wires **3** and between adjacent wires.

FIGURE 3 is a perspective view of one of the valves **11–12**. The valve has a sleeve **23** which is made of an elastic and semi-rigid material, such as reinforced rubber, and which surrounds the tube **4**. The sleeve covers the orifice or orifices **11** and is held in place by two stop rings **20**. The sleeve compels grouting to travel from the orifice **11** in the direction of the arrows **21**, either towards the wires **3** spaced at **9** (for the case of FIGURES 1 and 5) or towards the rod (for the case of FIGURE 6).

FIGURE 4 represents a design for a valve **13** which is different by virtue of its special function as a fine filter, permitting passage of bore water but preventing passage of the grouting. It is formed as a sleeve **22** surrounding the tube **4** at the level of the orifice or orifices **13** and made of calibrated sand grains coated with synthetic resin.

FIGURE 5 represents a possible example of utilisation of the invention, by sealing in two favourable zones of the ground while avoiding injection into a central zone **19**.

FIGURE 6 represents an application of the invention to the sealing of an anchor having a stay in the form of a steel rod instead of wires.

In this case the injection tube **4** is placed against the rod or stay **3**, which can be equipped with a losable tip. The jacket **15** surrounds the tube and the rod on which it is gripped by means of pairs of collars **24** (between which a certain volume of sealing material can be provided in order to complete the seal).

In use of the invention, the ground anchor is placed in position in the bore. A double closure device of any type equipped with a supply pipe, is then introduced into the tube and is placed to deliver grouting opposite the orifice (not shown) in the zone **14**. The injection of grouting under pressure forces the jacket **15** flat against the walls of the bore **1** to constitute a barrier **18** which after hardening of the grouting forms an absolute partition between the parts **5** and **8** of the bore. Hardening is obtained very rapidly, at the end of a few minutes in the case of a cement-based grouting, because of the permeability of the jacket which permits the water to escape from the mixture, resulting in a pressure drying involving almost instantaneous setting.

The double closure device is then lowered to opposite the lower valve **12** and injection is resumed. The expelled grouting first fills the space between the wires **3** and the tube **4** (see FIGURE 2), and then enters the space between the wires and the walls of the bore. This ensures that the wires, or in the FIGURE 6, the rod, are completely surrounded with the grouting material despite any falling-in of soil. The grouting material then rises upwards and enters the whole of the zone **8** of the bore, expelling any water there which can escape through the permeable valve **13**, the non-return function of which acts only for the grouting.

The injection operation is repeated opposite each of the valves **11** in turn, working upwards and finishing with the upper valve **11**. It is then certain that the wires or the rod **3** will be coated over the whole of their surface and their length.

The pressure used must be sufficient to ensure that the grout adheres strongly to the walls of the bore, and if necessary penetrates into them a considerable distance. The use of this high pressure is possible because of the partition **18** which forms a barrier to unwanted upward flow of the grouting material along the stay into the bore around the part **5** of the anchor which would then effect a pinning.

If the pressure applied has not been sufficient, the injections can be recommenced as many times as necessary to treat the soil around the zone **8** of the bore and impart the desired characteristics to it. In fact the tube **4**, by reason of the double closure device traveling there, and by virtue of the valves **12** and **13** with which it is equipped, remains empty after the injection operations.

The operation is terminated by injection under pressure, through the orifice **7**, of a filling grouting which enters the zone **5** of the bore and protects the stay against corrosion.

In the case of FIGURE 5, there is beneath a zone **8***a*, a zone **19** into which it is not intended or possible to inject, for example a cavity or a mud zone. It is sufficient to isolate this new zone by further barriers **18**. Thus the capacities of the two zones **8***a* and **8***b* can be utilised together.

What I claim is:

1. A method of sealing into a bore in the ground a ground anchor of a kind comprising an elongated stay, an injection tube extending substantially the whole length of the stay and formed with openings spaced along its length and at least one expandable jacket surrounding both said stay and said injection tube at one of said openings, the method comprising steps of inserting said anchor into said bore, expanding said jacket outwards against the wall of said bore by inserting a double closure device having a supply pipe into said injection tube to a position in which said injection tube is closed above and below the opening surrounded by said jacket and forcing grouting material under pressure down said supply pipe and through the opening, allowing the grout to set as a barrier forming a sealing zone below said barrier, inserting said double closure device into said injection tube to a position in which said injection tube is closed above and below one of said openings in said sealing zone and forcing grouting material under pressure down said supply pipe and through said opening into said sealing zone to said anchor into said bore.

2. A method according to claim **1**, wherein said jacket is formed from material which is permeable to water but impermeable to the grouting material used, whereby the setting of said grouting material in said jacket is accelerated.

3. A method according to claim **1**, wherein an opening immediately below said jacket is covered by a fine filter whereby bore water present below said barrier in said sealing zone can escape through said fine filter upon being displaced by said grouting material.

4. A ground anchor, adapted to be sealed into a bore in the ground, said ground anchor comprising an elongated stay formed from a plurality of twisted wires spaced around and away from an injection tube extending coaxially with said stay for substantially the whole length thereof, and formed with openings spaced regularly along its length, said openings each incorporating a non-return valve; and at least three longitudinally spaced expandable jackets which surround both said stay and said injection tube at said openings, said jackets being adapted to be expanded outwardly against the wall of said bore in use by means of a grout introduced under pressure through said openings in said injection tube so that each of said jackets then form a barrier across the bore whereby an isolated part of said bore is formed below each barrier.

5. An anchor according to claim **4** in which said injection tube is flexible.

6. An anchor according to claim **4** wherein each jacket is formed from material which is permeable to water.

7. A ground anchor, adapted to be sealed into a bore in the ground, said ground anchor comprising an elongated stay, an injection tube extending substantially the whole length of said stay and formed with openings spaced along its length, and at least one expandable jacket formed from material which is permeable to water which surrounds both said stay and said injection tube at one of said openings, said jacket being adapted to be expanded outwardly against the wall of said bore in use by means of a grout introduced under pressure through said openings by a double closure device, so that the jacket then forms a barrier across the bore; and an opening immediately below said jacket which is covered by a fine filter permeable to water whereby water present in the bore below said barrier, formed by the jacket when expanded, can escape through the fine filter upon being displaced by the injection of grout under pressure by said double closure device.

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JACOB SHAPIRO, Primary Examiner

U.S. Cl. X.R.

52—166; 61—56.5, 53.6, 45, 33; 166—224