

[54] **ROCK BOLT FOR REMOTE
INSTALLATION**

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[22] Filed: **Apr. 25, 1972**

[21] Appl. No.: **247,396**

Related U.S. Application Data

[63] Continuation of Ser. No. 60,427, Aug. 3, 1970,
abandoned.

[52] U.S. Cl. **61/35; 61/45 B**
[51] Int. Cl.² **E21D 20/02**
[58] Field of Search 61/45 B, 39, 36, 35, 63;
85/74, 75, 79

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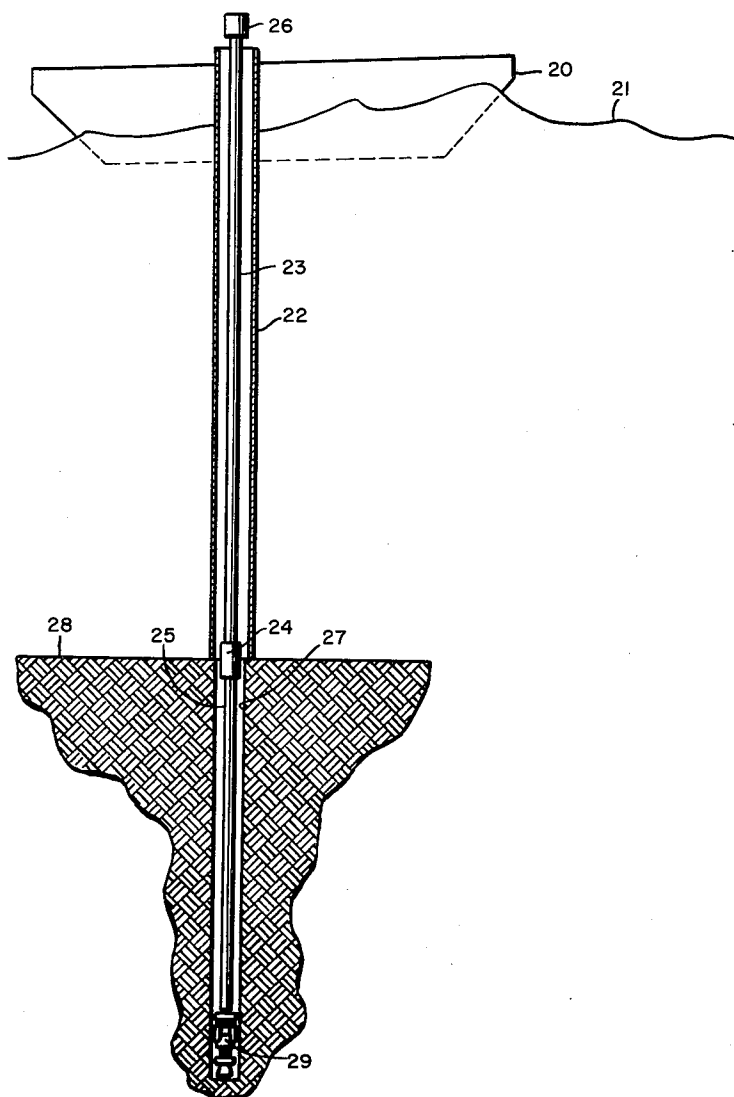
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[57] **ABSTRACT**

A rock bolt having an anchor device set by rotation of the bolt rod, and incorporating means for inhibiting back-rotation of the bolt rod out of the anchor device as reverse torque is applied in disengaging a threaded coupling to disconnect the bolt rod from an actuating rod operated from a remote position.

3 Claims, 11 Drawing Figures



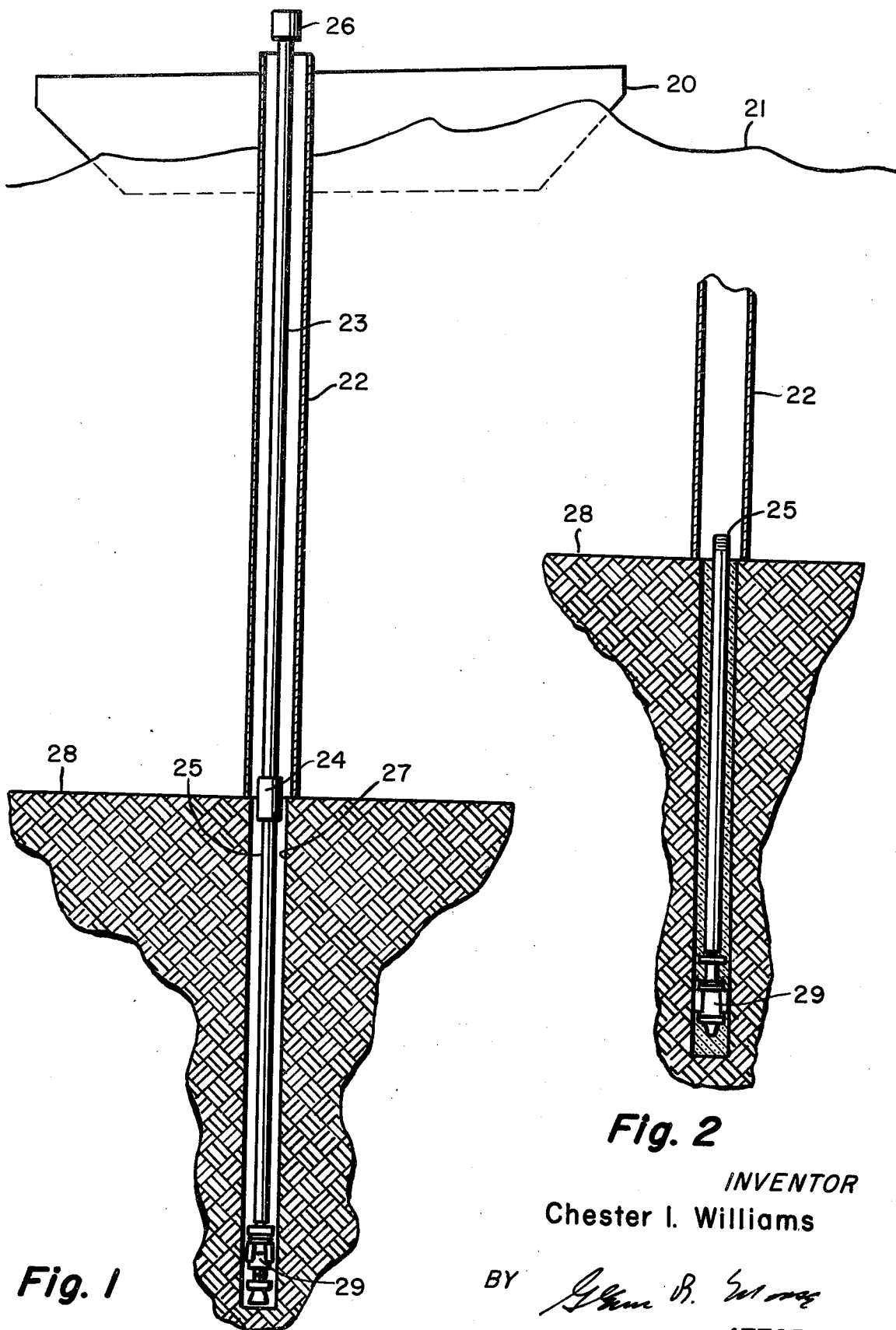


Fig. 1

Fig. 2

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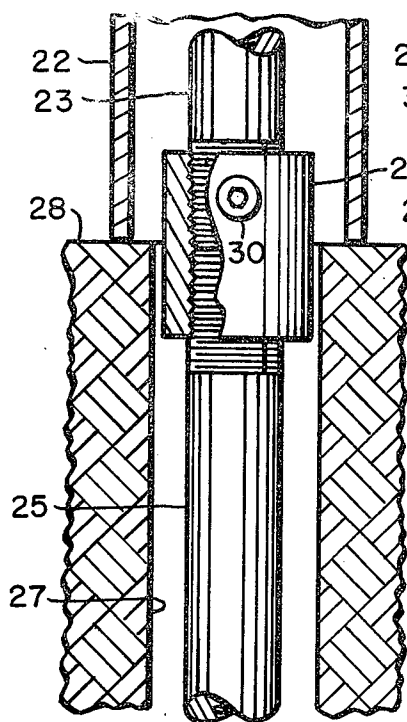


Fig. 3

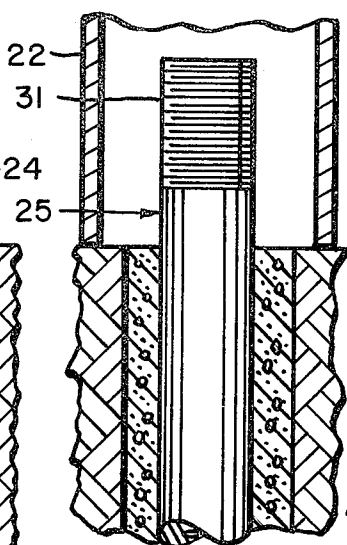


Fig. 5

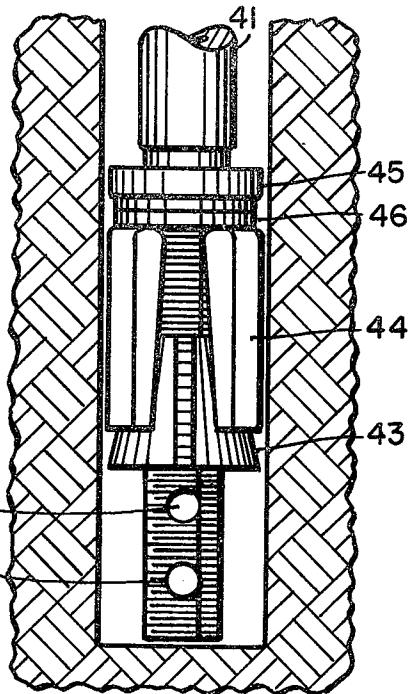


Fig. 7

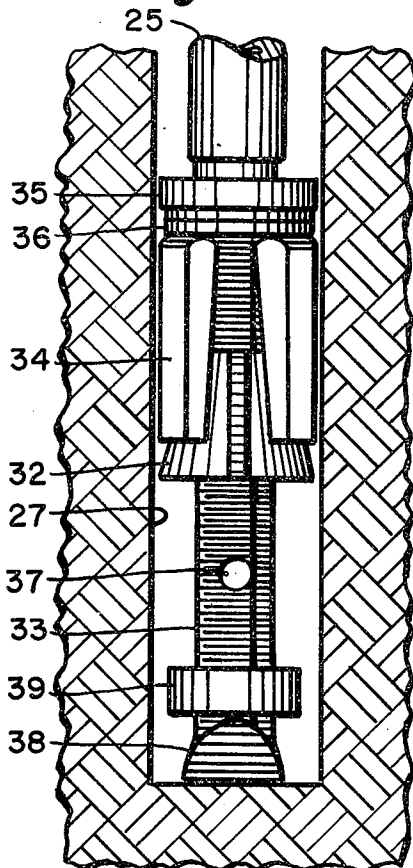


Fig. 4

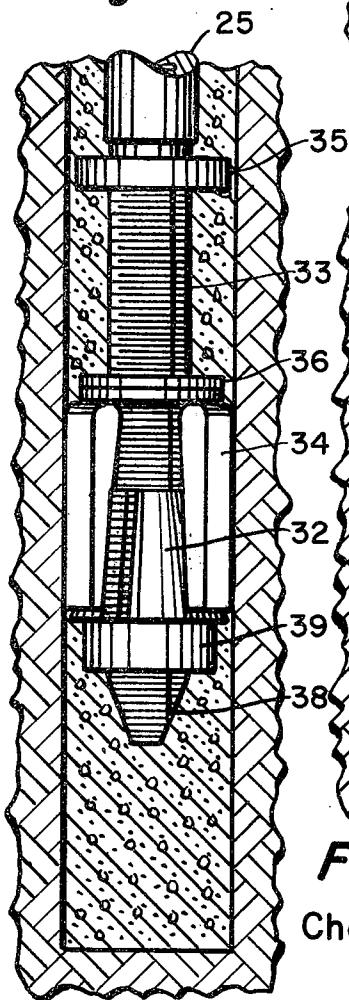


Fig. 6

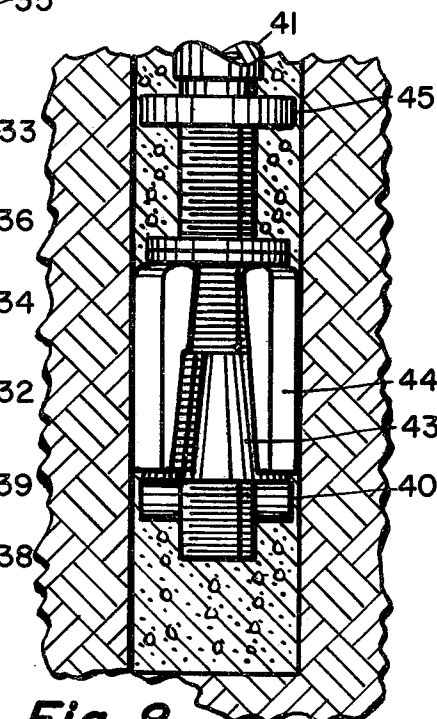


Fig. 8

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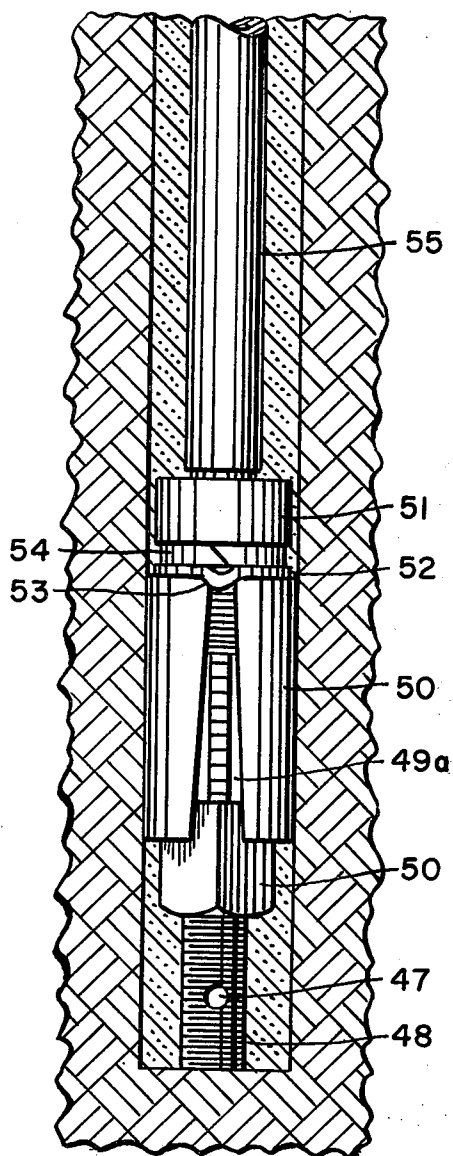


Fig. 9

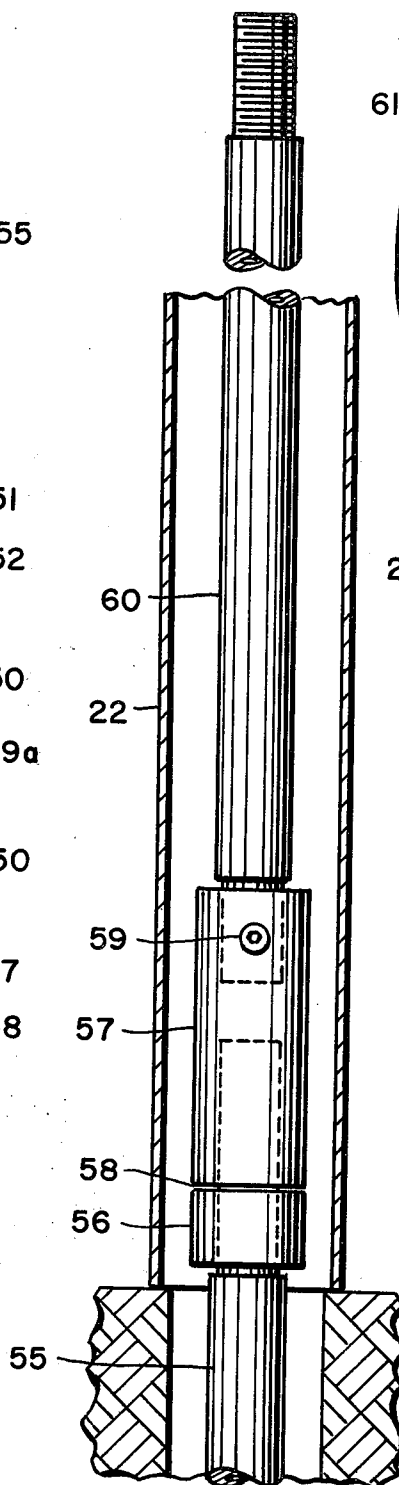


Fig. 10

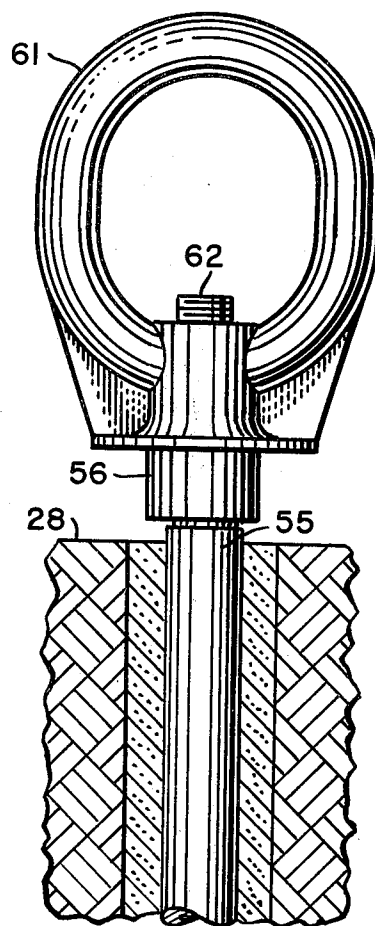


Fig. 11

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ROCK BOLT FOR REMOTE INSTALLATION

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of Ser. No. 60,427 filed Aug. 3, 1970, now abandoned.

BACKGROUND OF THE INVENTION

Rock bolts have been developed as a means of securing the relative position of the laminae of a rock formation, and to provide anchoring points for securing structure or cables. The primary difference between rock bolt assemblies associated with these two fields of utility is in the components secured to the bolt rod at the point of emergence from the ground formation. Where the intent is to secure the rock formation in position, a relatively large bearing plate is installed to transfer the bolt stresses over to the adjacent rock surface. A bolt used primarily as an anchoring point need only be fitted with a ring or some form of coupling. In both cases, the inner extremity of the rod is normally provided with an anchor device expanded against the walls of the hole in which the bolt is installed. The pressure at this point is sufficient to create forces of sufficient magnitude to withstand the forces tending to pull the bolt out of the hole. The action of the anchor device is commonly supplemented by the presence of grout, which is a cementitious mixture injected in liquid form into the bolt hole to fill the space surrounding the rock bolt assembly. The most effective form of rock bolt involves the use of a hollow bolt rod which may become a passage for the flow of the liquid grout. Once the grout has set, the bonding action between the bolt rod and the surrounding rock formation is itself normally sufficient to withstand the loading on the bolt rod. In addition to the stress-transfer characteristic of the grout, it forms a protective sheath around the rock bolt assembly, and tends to unify the adjacent ground formation.

The usual form of anchor device associated with rock bolts involves some form of a wedge or cone member in threaded engagement with the bolt rod, with this member being movable axially within an expansible shell or group of radially-movable shoes. Rotation of the bolt rod with respect to the wedge member induces relative axial movement between it and the shell or shoes, forcing them radially outward against the walls of the hole in which the rock bolt is installed. The intensity of this pressure is tremendous, as the resulting friction against the wall of the hole will generate a sufficient retention force to withstand the working load of a steel bolt rod commonly from an inch to two inches in diameter. The rotation of the bolt rod to induce the anchor expansion is accomplished from the surface at some position beyond the point of emergence of the bolt rod from the entrance of the hole in which the bolt is installed. Normally a coupling associated with a power wrench can be applied directly at this point, but some installations are of such a peculiar nature that this is not feasible. One such application is that which is encountered in the installation of rock bolts on the sea bottom, where the work barge may be moving around under wave action several fathoms above the point where the bolt rod emerges from the rock at the bottom. Experience has shown that it is necessary to install a rock bolt in such a position as quickly as possible, inject the grout, and then uncouple the rod at a point

close to the bottom before the grout has set. Only in this way is it possible to permit the grout to set without the disturbance inevitably associated with the movement of the bolt and the extension of the bolt rod represented by the length of rod used to actuate the anchor device. The disconnection of the threaded coupling used to interconnect the actuating rod with the installed rock bolt involves a reverse torque from that used to "set" the anchor device. This obviously produces a tendency to unscrew the lower extremity of the rod from the anchor device, as well as disconnecting the coupling. The conventional anchor assembly is inadequate in its construction to prevent the bolt rod from being unscrewed right out of the anchor device, leaving the cone and shell set firmly in position.

SUMMARY OF THE INVENTION

The present invention provides a rock bolt assembly capable of installation from remote positions, and capable of disconnection from the actuating rod prior to the setting of the grout without reducing the security of the installation. Means are incorporated for preventing, or at least inhibiting, a sufficient back-rotation of the anchor rod in the wedge member to permit disengagement, or for establishing a high degree of differential between the torque necessary to unscrew the coupling and the torque involved in back-rotation of the anchor rod out of the wedge member. Provision is also made within the structure for assuring that the out-flow of grout delivered within the hollow interior of the bolt rod shall have points of egress into the hole in the rock formation, regardless of the fact that the end of the rock bolt is normally blocked by the bottom of the hole. An exit port is preferably established by a cross-drilled hole at a point above the extremity of the bolt rod, and in a position that is not obstructed by any of the anchor components in either of the initial or the set positions.

Resistance to back-rotation of the anchor rod out of the wedge member is accomplished either by providing a fixed abutment adjacent the lower extremity of the anchor rod, or by incorporating a differential device that increases the torque required for back rotation, utilizing a component preferably similar to a lock washer operable between the wedge member and an abutment fixed with respect to the anchor rod both axially and rotatably (under the intensity of torque normally encountered).

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic illustration showing the first step in the installation of a rock bolt in a hole drilled in the sea bottom, the installation being actuated from a barge on the surface of the water above the installation.

FIG. 2 is a sectional elevation of the installed and grouted rock bolt.

FIG. 3 is a view on an enlarged scale showing the coupling of the rock bolt to the actuating rod, in the position shown in FIG. 1.

FIG. 4 is a view on enlarged scale of the lower extremity of the rock bolt, showing the anchor device in the condition illustrated in FIG. 1.

FIG. 5 is a view on the correspondingly enlarged scale showing the upper extremity of the installed rock bolt, in the condition shown in FIG. 2.

FIG. 6 is a view showing the condition of the anchor device and the bolt rod after the unit has been grouted and uncoupled, in the condition shown in FIG. 2.

FIG. 7 illustrates a modified form of the invention in which a cross-pin functions as an abutment preventing disengagement of the bolt rod from the wedge member.

FIG. 8 illustrates the condition of the anchor device after the unit has been grouted and uncoupled.

FIG. 9 illustrates a modified form of the invention incorporating provision for increasing the torque involved in back-rotation of the anchor rod with respect to the wedge member, the device being shown in the grouted and coupled condition.

FIG. 10 illustrates a preferred form of coupling producing a minimum torque to back-rotate the coupling on the anchor rod.

FIG. 11 illustrates an eye-nut attachment permitting the installed rock bolt to function as an anchoring point for cables or attached structure.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the schematic showing of FIG. 1, a barge 20 on the surface on the water 21 functions as a work station. A protective pipe 22 is normally used surrounding the actuating rod 23 extending from a coupling 24 connecting the actuating rod 23 to rock bolt rod 25. A conventional fitting or adapter 26 provides for the engagement of some standard power-operated wrench capable of delivering the necessary torque to the actuating rod to set the anchor device at the lower extremity of the rock bolt rod 25. The rock bolt is installed in the hole 27 in the sea bottom 28. The setting of the anchor device generally indicated at 29, and the filling of the hole 27 around the rock bolt with grout, followed by disconnection of the coupling 24 from the bolt rod 25, completes the installation as shown in FIG. 2.

The coupling interconnecting the actuating rod 23 with the bolt rod 25 is shown in FIG. 3. This coupling has threaded interengagement with both of these rods, and the presence of the set screw 30 bearing tightly against the engaged end of the actuating rod 23 establishes a preference (on back rotation of the actuating rod 23) for unthreading the coupling from the bolt rod 25 rather than the actuating rod 23 from the coupling. After the coupling 24 has been disconnected, as shown in FIG. 5, the threaded upper end 31 of the rock bolt rod 25 is exposed for the attachment of the eye nut shown in FIG. 11.

FIG. 4 illustrates the position of the components of the anchor device in the FIG. 1 position. Rotation of the rock bolt rod 25 by the actuating rod 23 causes the cone member 32 to move upward, as shown in FIG. 4, as a result of the threaded engagement of this member with the threaded lower end 33 of the bolt rod. This axial movement induces the expansion of the shell 34 into solid engagement with the walls of the hole 27. The threaded portion 33 extends to the position of the thrust ring 35, which is commonly placed at the extremity of this threading. This thrust ring functions as an abutment preventing upward axial movement of the shell 34, so that the expanding action can be generated. The slip rings 36 are interposed between the end of the shell and the thrust ring 35 to minimize the torque transferred between the shell and the thrust ring, and

thus reduce a tendency to rotate the thrust ring to the point of stripping out its threaded engagement.

Both the bolt rod 25 and the actuating rod 23 are hollow, providing a passage for grout to be pumped down into the bottom of the hole 27. Since the entire assembly will normally be resting on the bottom of the hole, a cross-drilled exhaust port 37 intersecting the hollow interior of the bolt rod 25 is provided to assure a passage for the exit of the grout into the surrounding hole in the rock formation. When the actuating rod 23 and the coupling 24 are disconnected from the rod 25 after the grouting operation has been completed, the rod 23 is blown free of grout quickly before the grout has had a chance to set in the rod.

FIG. 6 illustrates the relationship of the components of the anchor device after the uncoupling of the actuating rod while the grout is still in liquid form. Assuming that the torque required to disengage the coupling 24 is sufficient to back rotate the threaded engagement of the rod 25, the first application of back-rotation to the actuating rod 23 will result in unscrewing the bolt rod 25 from the cone member 32 to the extent shown in FIG. 6. Limitation to this unscrewing action is provided by the effect of the deformed section 38 applied to the lower extremity of the bolt rod after the ring 39 has been installed. This ring is preferably also in threaded engagement with the threaded end 33 of the bolt rod. The abutment ring 39 cannot be back rotated off the rod, as a result of the presence of the deformed area 38, and the upper face of the ring 39 is capable of distributing uniform pressure to the bottom face of the cone 32 to function as a stop preventing further axial movement of the bolt rod out of the cone. The illustrated form of anchor device involving a cone and an expansible shell (which is "C"-shaped in cross-section) has been found by applicant to provide the best anchoring functions. Other well-known forms of anchor assembly include separable shoes driven apart by planar wedge surfaces, rather than the conical wedge surfaces. The latter produces a favorable substantially annular distribution of pressure. The movement of the rod to the FIG. 6 position does not interfere with the grouting operation, as the port 37 is uncovered during both the initial and the set condition of the anchor. The sole difference between these positions is in the degree of penetration of the cone member 32 axially into the shell 34.

FIGS. 7 and 8 illustrate a modified form of the invention, in which a cross-pin 40 is installed in a suitably drilled hole in the bolt rod 41. Since this cross-pin will normally block the hollow interior of a rod 41, a port 42 in the form of a similar cross-drilled hole is provided between the abutment pin 40 and the expansion cone 43. The shell 44, the thrust ring 45, and the slip rings 46 are similar in all respect to the assemblies shown in FIGS. 4 and 6. FIG. 8 illustrates the limitation on the back-rotation on the rod out of the cone member provided by the cross-pin 40. In both the FIG. 6 and FIG. 8 versions of the anchor device, the back-rotation of the anchor rod with respect to the cone member will normally carry the thrust ring upwardly along with the rod, since the setting torque will usually jam the thrust ring solidly against the extremity of the threads, and thus require a larger amount of torque to dislodge it than is required to back rotate the anchor rod out of cone.

The modification in the anchor assembly shown in FIG. 9 provides a transverse exhaust port 47 in the bolt

rod 48, as in the previous modifications. The cone member 49 is essentially similar to the cone member 32 and 43, except for the reinforcement provided by the nut-shaped section 49a, which adds to the threaded engagement, and makes it possible to use a material of somewhat greater strength for this reinforcement than the normal cast iron utilized in the cone itself. The shell 50 is similar to the shells 34 and 44, and the thrust ring 51 corresponds to the thrust rings 35 and 45. A washer 52 bears against the upper end of the shell 50, and has a deformity 53 entering into the gap of the C-shaped cross-section of the conventional shell 50. The projection 53 tends to torsionally interlock the washer 52 with the shell 50, so that the lock washer 54 can establish an increased resistance to back-rotation between the shell 50 and the thrust ring 51. This torque differential will normally be sufficient to permit the disengagement of the coupling interconnecting the actuating rod with the bolt rod.

An arrangement for assuring a minimum tendency to jam the coupling against the threaded upper extremity of the bolt rod 55 is shown in FIG. 10. A ring 56 is threaded unto the bolt rod 55 to the limit of the threading provided at the upper end of this rod. The upper face of the ring 56 abuts the lower face of the coupling 57 over a sufficiently large area to minimize the tendency for a frictional jamming action to develop. This action is further inhibited by the presence of either a lubricated slip ring or a coat of high-pressure grease at the interface 58. As in the coupling 24, a set screw 59 is recommended to assure that the actuating rod 60 does not disengage from the coupling during the back rotation. Using the FIG. 11 arrangement, the torque differential established by the assembly shown in FIG. 10 should be adequate to assure that a normal uncoupling takes place without impairing the security of rock bolt installation. Once the uncoupling has been completed, after the grouting, the grout is free to set without disturbance of the bolt rod by the movement of the work barge. The unit is also free to move on quickly to the next installation, without requiring that it wait for the setting of the grout before the uncoupling can be

performed. Obviously, the uncoupling problems would not exist if the grout were permitted to set around the bolt rod. The torsional gripping resulting from the bond of the grout would positively prevent any tendency to unscrew the bolt rod out of the anchor device. After the unit has been fully installed, the eye nut 61 can be threaded on to the upper end 62 of the rock bolt rod, with the ring 56 remaining in position. The presence of this ring also limits a tendency to jam the eye nut in position, and thus facilitates the removal of the nut whenever it becomes desirable to do so.

I claim:

1. A method of setting a rotatively-set rock bolt in a hole in a ground formation from a remote position, said method comprising:

inserting a rock bolt assembly in said hold, said assembly including a bolt rod threaded at the opposite ends thereof, and an anchor device including a cone member in threaded engagement with one of said bolt rod ends, an expansible shell member at least partially surrounding said cone member, and means limiting the axial movement of said shell with respect to said bolt rod;

rotating said bolt rod with an extended torque rod having a coupling in threaded engagement with the other of said bolt rod ends, said rotating continuing to the extent of setting said anchor device; and back-rotating said torque rod to disconnect said coupling, said back-rotating being accompanied by limiting the back-rotation of said bolt rod with respect to said cone member by interengaging said cone member and means secured to said bolt rod.

2. A method as defined in claim 1, wherein said torque rod is connected with said coupling to said bolt rod prior to inserting said rock bolt assembly in said hole.

3. A method as defined in claim 1, wherein said limiting of back rotation is performed by engaging an end of said cone member with means axially fixed with respect to said bolt rod.

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