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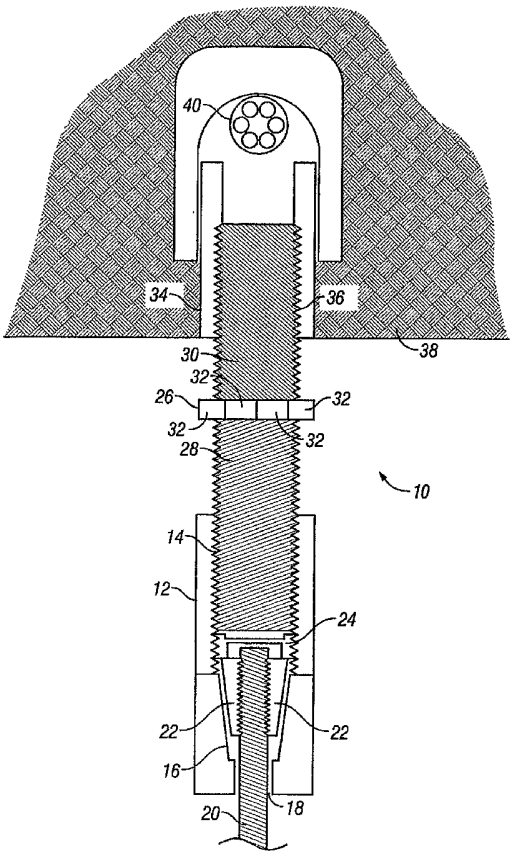
[Continued on next page]

(54) Title: TENSIONING ANCHOR SUITABLE FOR BLIND-HOLE TENDON ANCHORING AND TENDON REPAIR



(57) Abstract: A tendon anchor system includes an anchor body adapted to receive a tendon through one end. The anchor body has a threaded coupling at the other end. A retaining device is disposed within the anchor body for retaining the tendon within the anchor body. An anchor is disposed within an anchoring structure. The anchor has a threaded coupling. The threaded coupling in the anchor has an opposite thread direction to the threaded coupling in the anchor body. A jack screw threadedly engages with both the threaded coupling in the anchor body and in the anchor.

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TENSIONING ANCHOR SUITABLE FOR BLIND-HOLE TENDON ANCHORING AND TENDON REPAIR

Cross-reference to related applications

Not applicable.

Statement regarding federally sponsored research or development

Not applicable.

Background of Invention

Field of the Invention

[0001] The invention relates generally to the field of concrete reinforcing systems. More particularly, the invention relates to devices used to anchor a reinforcing tendon in a blind hole in a concrete structure, and also relates to devices used to repair or extend reinforcing tendons.

Background Art

[0002] Concrete construction techniques frequently make use of cables or tendons for various purposes, including forming barriers and for structural concrete reinforcement such as prestressing and post tensioning.

[0003] Cable barriers, such as those used for pedestrian safety lines disposed beside parking garage ramps and parking garage vehicle barriers, are commonly built so that tendons or cables traverse a span between building structures such as concrete pillars. Spanning pillars using a cable or tendon is typically performed by providing, at an endmost pillar, a tube that extends completely through the pillar from one side to a countersink formed in the other side of the pillar. The tube and countersink are formed during creation of the concrete pillar by locating a plastic tube so that it almost spans the distance between side forms used in constructing the pillar, and by removably locating a

countersink form at one end of the tube. Thus, when concrete is poured into the forms the tube becomes embedded and forms a portion of the structure itself once the concrete sets. In erecting a cable to such a pillar it is passed through the tube and secured under tension to an anchoring device mounted in the countersink in the opposite side of the pillar. The countersink itself is then filled with concrete so as to cover the anchoring device. The just described cable erection procedure has long proven to be difficult to conduct and far from satisfactory. For example, the construction of the pillar itself is impeded by having to provide it with the tube and countersink at the time it is formed. In addition, concrete must be made available for application to the pillar after it has been formed and a cable anchored to it. Furthermore, in the event the cable is to be taken down from the pillar, the countersink must be chiseled out of the concrete in order to regain access to the anchor to release the cable. Fresh concrete must thereafter be applied to refill the chiseled out section.

[0004] The foregoing barrier construction technique has proven impracticable for use where one side of the concrete pillar is not accessible. Such is the case where the cable or tendon is to be anchored into a wall or similar barrier rather than a pillar. Frequently, one side of such wall is inaccessible, and thus the tendon must be anchored in a blind hole. One solution to the foregoing construction problem is disclosed in U.S. Patent No. 4,899,499 issued to Hoekstra. An anchor device disclosed in the '499 patent includes a threaded rod rotatably coupled at one end to one end of a tendon anchor body. The other end of the tendon anchor includes devices, such as conventional anchor wedges, used to lock the tendon in place within the anchor body. The threaded rod may be freely rotated with respect to the anchor body without changing the longitudinal position of the rod with respect to the anchor body. The other end of the threaded rod is threadedly coupled into a mating threaded receptacle that is cast into the concrete structure to which the tendon is to be anchored. It has been observed in actual use that the anchor device in the Hoekstra '499 patent is subject to the threaded rod binding in the anchor body such that free rotation of the threaded rod with respect to the anchor body is not possible.

[0005] Reinforcing concrete structures using post tension reinforcing devices is another application for cables or tendons within concrete structures. Post tensioning includes

anchoring a tendon under tension between ends of a concrete structure. See, for example, U.S. Patent No. 5,072,558 issued to Sorkin et al. In a typical tendon tensioning anchor assembly used in such post-tensioning devices, there are provided anchors for anchoring the ends of the tendons suspended therebetween. In the course of tensioning the tendons in a concrete structure, a hydraulic jack or the like is releasably attached to one of the exposed ends of each tendon for applying a predetermined amount of tension to the tendon, which extends through the anchor. When the desired amount of tension is applied to the tendon, wedges, threaded nuts, or the like, are used to capture the tendon at the anchor plate and, as the jack is removed from the tendon, to prevent relaxation of the tendon and to hold it in its stressed condition.

[0006] There are many post-tension systems that use intermediate anchorages, where the length of the concrete structure is too long to tension with a single pair of anchoring devices. In these systems, an intermediate anchor is interposed between a live end and a dead end anchor. In the construction of such intermediate anchorage systems, the tendon extends for a desired length to the intermediate anchor. A portion of the sheathing is removed from the tendon in the vicinity of the intermediate anchor. The intermediate anchor is installed onto a form board in accordance with conventional practice.– The unsheathed portion of the tendon is received by a tensioning apparatus, such that the tendon is stressed in the area between the dead end anchor and the intermediate anchor. After stressing the tendon, concrete is poured over the exterior of the sheathed tendon and over the dead end anchor and intermediate anchor. The remaining portion of the tendon extends from the intermediate anchor to either another intermediate anchorage or to the live end anchor at the opposite side of the concrete structure. Intermediate anchorage systems are used in particular whenever the concrete structure is so long that it is cast in sections, or frictional losses would be so great that having a tendon extend from a single live end anchor to a single dead end anchor is inadequate.

[0007] A problem that can affect intermediate anchorage systems is the inability to effectively prevent liquid intrusion into the unsheathed portion of the tendon. Normally, the unsheathed portion will extend outwardly, for a distance, from the intermediate anchor in the direction toward the dead end anchor. Additionally, another unsheathed

portion will extend outwardly at the intermediate anchor toward the live end anchor. In normal practice with a single dead end and single live end anchor, and without intermediate anchors, a liquid-tight tubular member is placed onto an end of the anchor so as to cover the unsheathed portion of the tendon. This is relatively easy to accomplish since the length of the tendon is minimal at the live end. However, it is a considerable burden to attempt to slide such a tubular member along the entire length of the tendon so as to form the liquid-tight seal at the intermediate anchorage. In normal practice, tape, or other corrosion protection materials, are applied to the exposed portion of the tendon adjacent the intermediate anchorage. Extensive practice with this technique has shown that it is generally ineffective for preventing liquid intrusion into the interior of the tendon or into the interior of the intermediate anchorage. As such, a great need has developed in which to protect the exposed areas of the tendon adjacent the intermediate anchorage.

[0008] A problem inherent in such continuous tendon intermediate anchorage systems is the difficulty of installation. Conventionally, in order to install the great lengths of tendon associated with such an intermediate anchorage systems, it is necessary for the worker at the construction site to thread the anchor along the length of the tendon so as to place the anchor in a desired position. Often during this "threading" of the anchor onto the tendon, nicks and damage can occur to the sheathing on the tendon. Often, components of the intermediate anchorage system are omitted or the installation is carried out in an ineffective manner because of the large amount of manual manipulation that is required for the installation of the system. Inherently, each of the intermediate anchors will be located in a joint of the concrete structure. As such, each of the anchors will be exposed to the corroding elements in this location. The liquid resistance of the intermediate anchorage system must be particularly good so as to prevent any damage to the exposed portions of the tendon.

[0009] It is also known in the art to repair failed tendons. Tendon repair may be made necessary due to localized corrosion effects or mechanical damage to a section of tendon, and where it is impractical to replace an entire tendon. Repair is performed by crating an opening in the concrete structure in the location where the tendon is to be repaired. The

tendon is cut to create spliceable ends where the repair is to be made. Then a splice chuck or similar device is used to connect the cut ends of the tendon. To effect such repairs, and to provide an improved system for connecting tendon ends in order to overcome limitations of intermediate anchorage systems known in the art, one type of splice chuck is disclosed in U.S. Patent No. 6,176,051 issued to Sorkin.

[0010] The splice chuck disclosed in the Sorkin '051 patent can be used for repair of a tendon only in the case where the live end of the tendon is accessible, and can be re-stressed after the repair. It is frequently the case that the live end of the tendon is not accessible, or such access is impractical. In such cases, a splice chuck that can also provide stress to the tendon is desirable.

[0011] There continues to be a need for improved devices for anchoring tendons within blind openings, for splicing tendons and retensioning tendons without the need to access the tendon end.

Summary of Invention

[0012] One aspect of the invention is a tendon anchor system. A tendon anchor system according to this aspect of the invention includes an anchor body adapted to receive a tendon through one end. The anchor body has a threaded coupling at the other end. A retaining device is disposed within the anchor body for retaining the tendon within the anchor body. An anchor is disposed within an anchoring structure. The anchor also has a threaded coupling, however, the threaded coupling in the anchor has an opposite thread direction to the threaded coupling in the anchor body. A jack screw threadedly engages with both the threaded coupling in the anchor body and in the anchor, such that rotating the jack screw draws the anchor body longitudinally toward the anchor. When rotation of the jack screw is reversed, the anchor body is moved longitudinally away from the anchor.

[0013] Another aspect of the invention is a tendon coupling system. According to this aspect of the invention, a tendon coupling system includes a first anchor body adapted to receive a first tendon through one end. The first anchor body has a threaded coupling in

an internal wall at the other end. A first retaining device is disposed within the first anchor body for retaining the first tendon within the first anchor body. A second anchor body is adapted to receive a second tendon through one end. The second anchor body has a threaded coupling formed in an internal wall thereof at the other end. The threaded coupling in the second anchor body has an opposite thread direction to the threaded coupling in the first anchor body. A second retaining device is disposed within the second anchor body for retaining the second tendon within the second anchor body. A jack screw is directly threadedly engaged with the threaded coupling in both the first anchor body and the threaded coupling in the second anchor body.

[0014] Some embodiments of the anchor system and the tendon coupling system include a strain gauge on the jack screw to determine when a selected tension is applied to the jack screw.

[0015] Other aspects and advantages of the invention will be apparent from the following description and the appended claims.

Brief Description of Drawings

[0016] Figure 1 shows an embodiment of a tendon anchor for anchoring a tendon in a blind hole in a concrete structure.

[0017] Figure 2 shows an embodiment of a tendon splice (repair) device.

[0018] Figure 2A shows a prior art tendon splice.

[0019] Figure 3 shows an embodiment of a set screw used to hold an anchor wedge inside an anchor body.

[0020] Figure 4 shows an alternative embodiment of the tendon anchor of Figure 1.

[0021] Figures 5 through 8 show alternative embodiments.

Detailed Description

[0022] Figure 1 shows one embodiment of a tendon anchor system 10 that can be used to anchor a tendon 20 within a blind opening in an anchoring structure, that is, where an opposite side of the anchoring structure is inaccessible. The tendon 20 is typically made from steel or other high strength material. The tendon anchor system 10 includes an anchor body 12, which may be formed from steel or other high strength material.

[0023] The anchor body 12 includes a device to retain the tendon 20 within, such that under tension, the tendon 20 is restrained from longitudinal movement out of the anchor body 12. The device in the present embodiment can include a generally tapered wedge receiving bore 16, and a wedge 22 adapted to be applied to the exterior of the tendon 16 and to fit within the receiving bore 16. The wedge 22 may include a threaded interior surface or similar arrangement of gripping elements to grip the outer surface of the tendon 20, and may be formed from a plurality of wedge segments, according to structures well known in the art. See, for example, U.S. Patent No. 5,072,558 issued to Sorkin et al. When inserted into the anchor body 12, and when the wedge 22 is applied to the tendon 20, the tendon 20 is effectively restrained from axial movement in one direction by the action of the wedge 22 against the receiving bore 16, which causes the wedge 22 to grip the outer surface of the tendon 20.

[0024] Anchor systems known in the art, such as shown in the Sorkin et al. '558 patent, require a substantial amount of axial tension to be applied to the tendon to properly seat the wedge such that it tightly grips the tendon. In some contemplated applications of an anchor according to the invention, it may be impracticable to apply tension to the tendon 22 prior to seating the wedge 22 in the bore 16. In the present embodiment, the wedge 22 may be tightly bound to the tendon 20 prior to axial tensioning by using a set screw 24 or similar device to axially compress the wedge 22 into the bore 16. The set screw 24 will be further explained below with reference to Figure 3, however, the set screw 24 can be moved axially along the anchor body 12 by threaded engagement with a threaded opening 14 in the anchor body 12.

[0025] The threaded opening 14 may also provide threaded engagement with one end of a jack screw 26. The jack screw 26 threadedly couples the anchor body 12 to an anchor

34 cast into an anchoring structure 38. The anchor 34 may be similar in configuration to a blind opening anchor disclosed, for example, in U.S. Patent No. 4,899,499 issued to Hoekstra. The anchor 34 can include an internally threaded opening 36 adapted to threadedly engage the other end of the jack screw 26. The jack screw 26 may include wrench flats 32 or similar tool engagement surface for enabling the jack screw 26 to be rotated. The anchor 34 may be supported in the anchoring structure 38 by reinforcing bar 40 or the like, as is known in the art.

[0026] In the present embodiment, the jack screw 26 is threaded in one direction on the anchor body end 28, and in the opposite direction on the anchor end 30. Thus, by turning the jack screw 26 in one direction, the anchor body 12 may be pulled toward the anchoring structure 38 without rotating the anchor body 12. In use, the jack screw 26 is turned until a selected amount of tension is applied to the tendon 20. The length of the jack screw 26,and corresponding threaded interior openings 14, 36 in the anchor body 12 and anchor 34, respectively, can be selected to provide a contraction length for the anchor system 10 that can provide the selected amount of tension to the tendon 20. Because the jack screw 26 is threaded at both ends, the anchor system of the invention may be tensioned more quickly that prior art anchors that include threading at only one end.

[0027] Another embodiment, shown in Figure 2, may be used to splice tendon segments for repair. The embodiment in Figure 2 can include a tendon 20 to be spliced or coupled to another such tendon, anchored at ends of a concrete structure 38A using terminal anchors 21 known in the art. Suitable anchors are described, for example, in the Sorkin '558 patent referred to above. An opening 38B in the concrete structure 38A provides access to the portion of the tendon 20 to be coupled. One end of the tendon 20 has coupled thereto a first anchor body 12, substantially as explained above with reference to Figure 1. A jack screw 30A similar to the jack screw of Figure 1 and including opposed direction threads on each axial end, is threaded into the first anchor body 12. A second anchor body 12, having an internal opening (not shown in Figure 1) threaded in a same direction as the thread on the proximate end of the jack screw 30A is adapted to threadedly engage that end of the jack screw 30A. Other than the direction of the internally threaded opening, the second anchor body 12A may be substantially internally

the same as the first anchor body 12, and thus be able to be fastened to the end of the tendon 20 to be coupled. In the present embodiment, rotating the jack screw 30A in one direction pulls the anchor bodies 12, 12A toward each other, thus tensioning the tendon 20. The jack screw 30A is rotated until a desired amount of tension is applied to the tendon 20.

[0028] A tendon splice known in the art is shown in Figure 2A in order to illustrate several possible advantages of a tendon splice chuck according to the invention. The prior art splice chuck includes an anchor body 12B having therein a tapered receiving bore 16 for holding an anchor retaining wedge 22. The wedge 22 grips a tendon 18 conventionally, and as explained above with reference to Figure 1. The prior art splice includes a threaded bushing 12BB adapted to mate to an internally threaded surface 14 in the anchor body 12B. The bushing 12BB may include a tool engagement surface 13A such as wrench flats to rotate the bushing 12BB. The bushing 12BB is externally threaded at one end 13C. The externally threaded end 13C is adapted to mate with the internal threads 14 in the anchor body 12B. The bushing 12BB is generally threaded into place to a torque intended to prevent the bushing 12BB backing out of the anchor body 12B, after the tendon 18 and wedge 22 are inserted into the opposite end of the anchor body 12B. A jack screw 30B includes a threaded end 28B adapted to mate with an internally threaded opening 13B in the bushing 12BB. The jack screw 30B may include a tool engagement surface 32B. Not shown in Figure 2A are another such anchor body, and an associated bushing having therein an opposed direction internal threaded opening adapted to mate with an opposite threaded end 28C of the jack screw 30B. Other forms of the prior art splice may substitute for the jack screw 30B a centrally located, long hex nut (generally in the position of 32B in Figure 2A) having opposed threads on each longitudinal end. Each end of the hex nut is adapted to engage one end of a threaded rod (located as shown in Figure 2A at 28B and 28C). Each threaded rod at its other end engages a corresponding one of the bushings 12BB. The threaded rods may be formed integrally with the bushings 12BB, or may thread into or otherwise be affixed to the bushings 12BB. Functionally, the two forms of the prior art splice chuck are

substantially the same: the device is longitudinally retracted or extended by rotating the jack screw or the central hex nut.

[0029] Operationally, the prior art splice is similar to the splice of the present invention, however there are several detail differences in the structures, which may provide substantial benefit to a splice chuck according to one aspect of the invention. First, the prior art anchor body, in order to retain the jack screw (or the threaded rods) and to be assembled to the tendon and wedge, requires the bushing (or similar threaded coupling assembled to each anchor body). Necessarily, the thread diameter of the jack screw threaded ends (or threaded rods) must be smaller than the internal threads in the anchor body because of the presence of the bushing (or similar adapter). It has been observed that the prior art tendon splice of Figure 2A has proven less able to meet amended building code standards as to tensile strength than the splice of the present invention. Frequently, tensile failure has been observed at the juncture of the threaded end of the jack screw (or threaded rod) and the internal opening in the bushing when testing the prior art splice to amended building code standards. Further, a splice according to the prior art consists of at least five major components: two anchor bodies; two bushings and a jack screw, or alternatively, a hex nut, two threaded rod/bushing assemblies, and two anchor bodies. It may be impractical to increase the sizes of the components of the prior art splice to obtain improved tensile strength because of the limited work space in splicing applications.

[0030] The splice of the invention consists essentially of three parts: two anchor bodies and a jack screw. The splice of the present invention may be easier to use in practice, may have greater tensile strength, may be less expensive to manufacture, and finally, because of the larger diameter threads on the jack screw, may be less susceptible to thread binding during installation.

[0031] Figure 3 shows an end view of one embodiment of the set screw 24 previously shown in Figure 1. The set screw 24 may be formed from a selected length of threaded rod, and have an interior opening 24A such that the tendon (20 in Figure 1) may freely pass through. A tool opening 24A may be shaped such that a mating tool (not shown)

may be used to rotate the set screw 24 to apply axial compression to the wedge (22 in Figure 1) as explained above with reference to Figure 1.

[0032] An alternative embodiment to the anchor system of Figures 1 and 2 is shown in Figure 4. The alternative anchor system 10A includes an anchor body 13 having an opening 18A at one end for receiving a tendon 20, as in the previous embodiments. The present embodiment includes a tendon retaining device, which, as in the previous embodiments, may include a wedge 22 received in a mating, tapered receiving bore 22 in the interior of the anchor body 13. In the present embodiment, the exterior surface of the anchor body includes threads 19 adapted to mate with corresponding threads 29 on an interior surface of one end of a jack screw 27.

[0033] The present embodiment does not show the set screw (24 in Figure 1) used to retain the wedge 22 prior to tensioning the tendon 20, however, other implementations may use such a wedge retaining device.

[0034] The other end of the jack screw 27 includes internal threads 31 that are in a direction opposite to the threads 29 on the first end of the jack screw 27. The opposed direction threads 31 can mate with corresponding threads (not shown) on an externally threaded anchor body or on an anchor (34 in Figure 1) disposed in an anchoring structure (38 in Figure 1). An advantage of the embodiment of Figure 4 is that the anchor body 13 may be made relatively compact in a longitudinal direction, while providing relatively long movement of the anchor body 13 toward the anchor (34 in Figure 1). Operation of the present embodiment is substantially the same as the embodiments shown in Figures 1 and 2.

[0035] Other embodiments of a tendon anchor system or tendon splicing device according to the various aspects of the invention may include one or more of the following features to facilitate installation and use of the anchor system or splice.

[0036] Figure 5 shows a jack screw 30 and the anchor body 12 that can be used in an anchor system for blind openings or one anchor body in a splice. The jack screw 30 includes a scribe mark 31A or other type of match indicator on the one side thereof, corresponding to a similar scribe mark 33A or match indicator on the mating anchor body

12. The scribe marks 31A, 33A are used to indicate mating direction threads on the jack screw 30 and anchor body 12 so that the user may more easily identify the correct threaded direction anchor body during installation.

[0037] Figures 6, 7 and 8 show various embodiments of strain gauge included with the jack screw 30. The purpose of the strain gauge is to provide the user with an indication that a correct amount of tension on the anchor system or tendon splice has been applied by operating the jack screw. The embodiment of Figure 6 includes scribe marks 35 located a selected distance apart from each other. The scribe marks 35 may be calibrated with respect to applied tension and distance therebetween. Figure 7 shows the strain gauge in the form a gauge groove 37, preferably formed to have a rounded profile as shown to avoid creating a stress riser in the jack screw 30. The width of the gauge groove 37 can be calibrated to tension on the jack screw. Figure 8 shows a gauge hole 39 adapted to be measured with a gauge pin 41. When an elongation of the gauge hole 39 reaches a certain amount, as indicated by the gauge pin 41, the correct tension is applied to the jack screw 30. In one embodiment of the strain gauge shown Figure 8, the gauge hole 39 is elliptically shaped prior to tensile elongation of the jack screw 30, wherein the long direction of the ellipse is transverse to the longitudinal axis of the jack screw. When properly tensioned, the gauge hole 39 will become round, admitting the gauge pin 41. Excessive elongation of the gauge hole 39 will cause the transverse dimension of the gauge hole 39 to contract, stopping insertion of the gauge pin 41. Thus, the gauge pin 41 will enter the gauge hole 30 only at the correct tension on the jack screw 30.

[0038] For purposes of describing the scope of this invention, the internally threaded coupling surface in the anchor and anchor body of Figure 1, and the corresponding externally threaded surface of the jack screw of Figure 1 each may be referred to as a "threaded coupling." Similarly, the externally threaded surface of the anchor body, and corresponding internally threaded surface of the jack screw in the embodiment of Figure 4 also may be referred to as a threaded coupling. It is only necessary for purposes of the invention that the thread directions be opposed on opposed ends of the jack screw, and corresponding mating threads on the respective anchors and anchor bodies.

[0039] Anchor systems according to the invention may have a reduced number of components and thus be less expensive to manufacture, may be less susceptible to thread binding, may be better able to comply with modern building code requirements, may be easier to use, and have higher strength without increasing the overall physical size of the anchor system.

[0040] While the invention has been described with respect to a limited number of embodiments, those skilled in the art, having benefit of this disclosure, will appreciate that other embodiments can be devised which do not depart from the scope of the invention as disclosed herein. Accordingly, the scope of the invention should be limited only by the attached claims.

Claims

What is claimed is:

[c1] A tendon anchor system, comprising:

an anchor body adapted to receive a tendon through one end, the anchor body having a threaded coupling at the other end;

a retaining device disposed within the anchor body for retaining the tendon within the anchor body;

an anchor disposed within an anchoring structure, the anchor having a threaded coupling, the threaded coupling on the anchor having an opposite thread direction to the threaded coupling in the anchor body; and

a jack screw threadedly engaged with both the threaded coupling in the anchor body and the threaded coupling in the anchor.

[c2] The system of claim 1 wherein the retaining device comprises a wedge disposed in a tapered receiving bore in the anchor body.

[c3] The system of claim 2 further comprising a set screw threadedly engaged with the a threaded internal opening in the anchor body so as to compress one longitudinal end of the wedge.

[c4] The system of claim 1 wherein the threaded coupling on the anchor body comprises internal threads, and at least one threaded coupling on the jack screw comprises external threads.

[c5] The system of claim 1 wherein the threaded coupling on the anchor body comprises external threads, and at least one threaded coupling on the jack screw comprises internal threads.

[c6] The system of claim 1 further comprising a strain gauge on the jack screw.

[c7] The system of claim 6 wherein the strain gauge comprises a gauge hole adapted to mate with a gauge pin when a selected tension is applied to the jack screw.

[c8] A tendon coupling system, comprising:

a first anchor body adapted to receive a first tendon through one end, the first anchor body having a threaded coupling in an internal wall at the other end;

a first retaining device disposed within the first anchor body for retaining the first tendon within the first anchor body;

a second anchor body adapted to receive a second tendon through one end, the second anchor body having a threaded coupling formed in an internal wall thereof at the other end, the threaded coupling in the second anchor body having an opposite thread direction to the threaded coupling in the first anchor body;

a second retaining device disposed within the second anchor body for retaining the second tendon within the second anchor body; and

a jack screw directly threadedly engaged with the threaded coupling in both the first anchor body and the threaded coupling in the second anchor body.

[c9] The system of claim 8 wherein each retaining device comprises a wedge disposed in a tapered receiving bore in the respective anchor body.

[c10] The system of claim 9 further comprising a set screw threadedly engaged with an internal surface of each anchor body so as to compress one longitudinal end of each wedge.

[c11] The system of claim 8 wherein the threaded coupling on at least one anchor body comprises internal threads, and at least one threaded coupling on the jack screw comprises external threads.

[c12] The system of claim 8 wherein the threaded coupling on at least one anchor body comprises external threads, and at least one threaded coupling on the jack screw comprises internal threads.

[c13] The system of claim 8 further comprising a strain gauge on the jack screw.

[c14] The system of claim 13 wherein the strain gauge comprises a gauge hole adapted to mate with a gauge pin when a selected tension is applied to the jack screw.

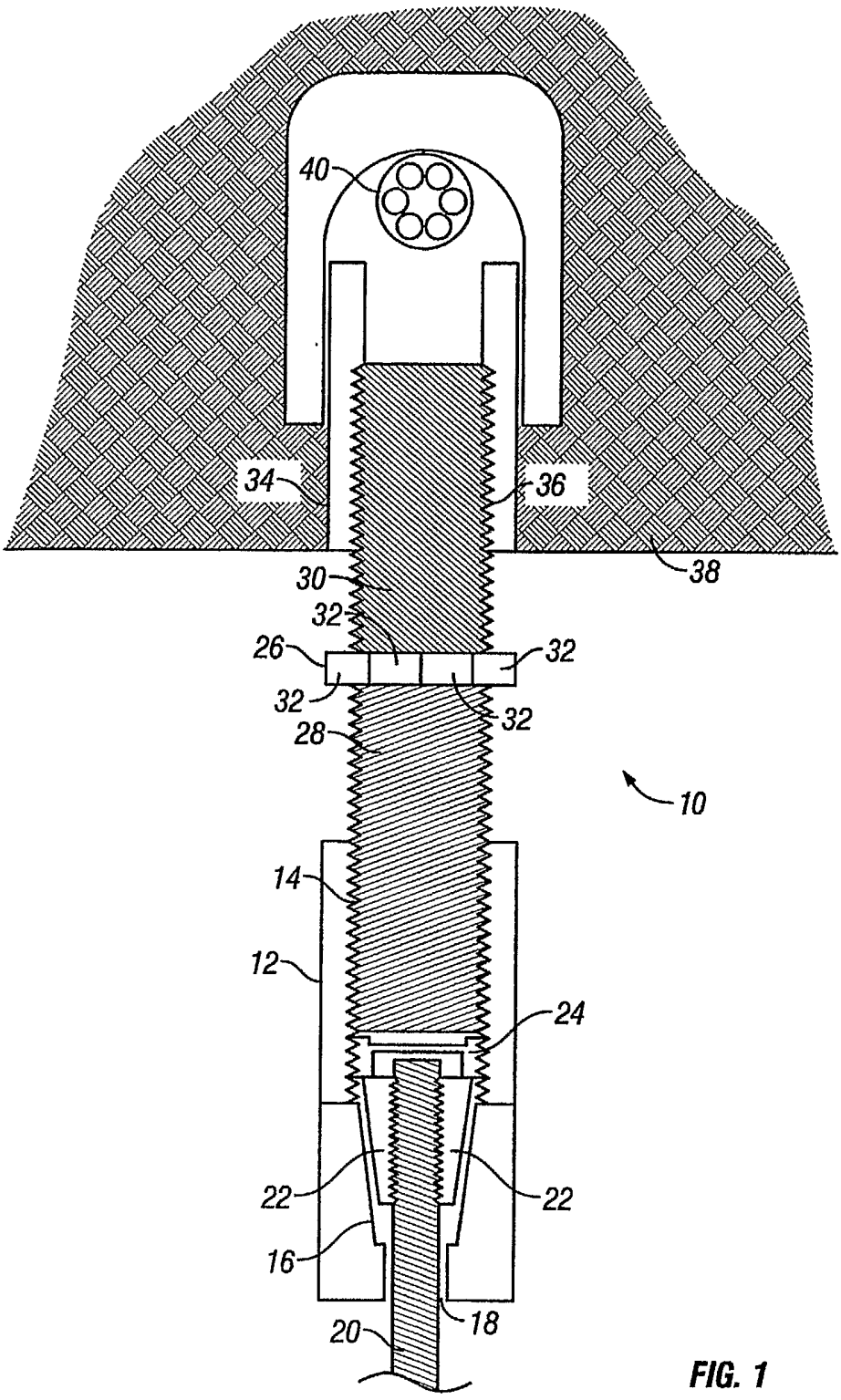

FIG. 1

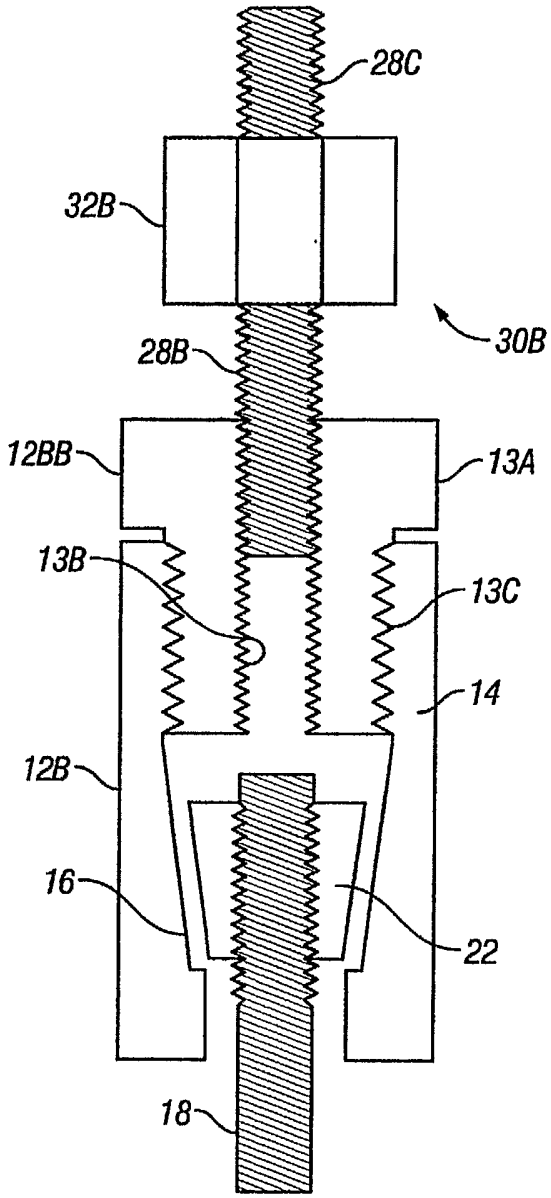

FIG. 2A
(Prior Art)

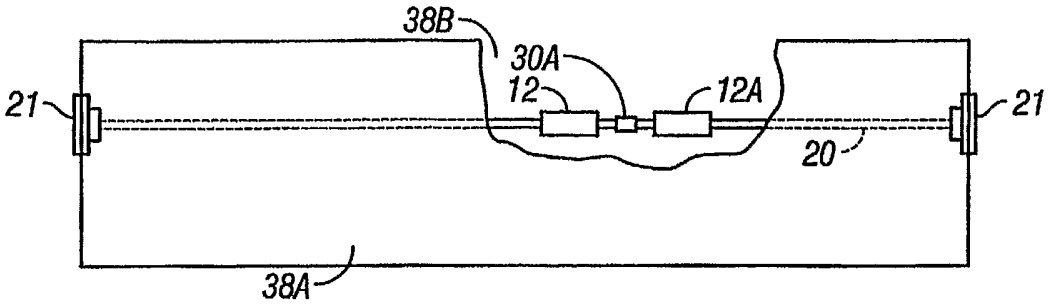

FIG. 2B

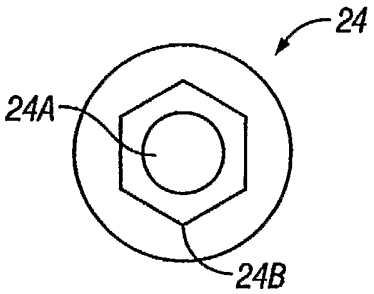

FIG. 3

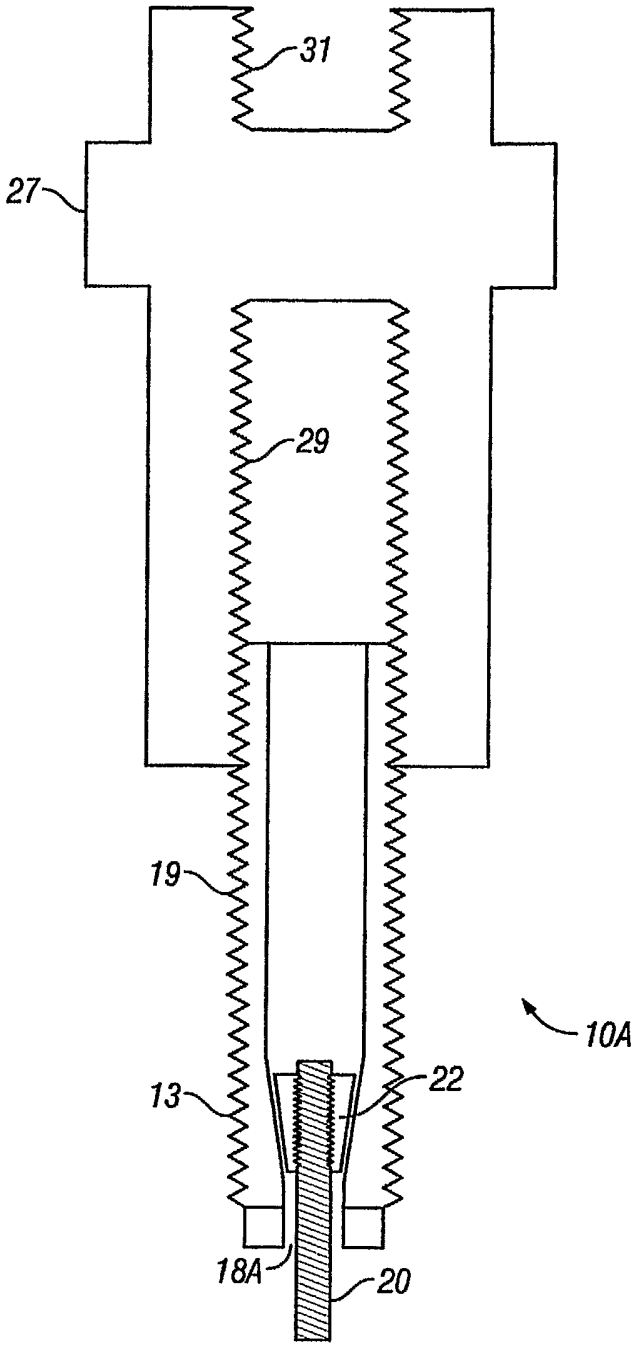

FIG. 4

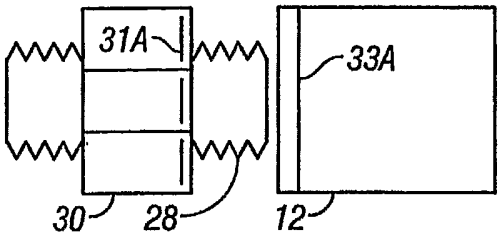

FIG. 5

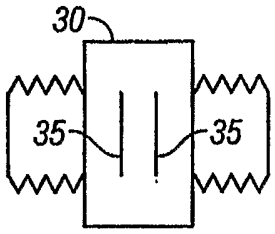

FIG. 6

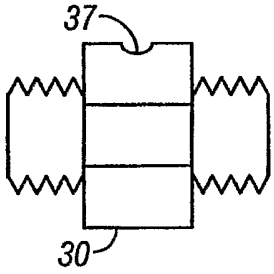

FIG. 5

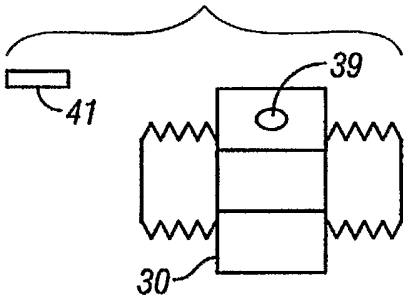

FIG. 6