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(54) **METHOD, MEMBER, AND TENDON FOR CONSTRUCTING AN ANCHORING DEVICE**

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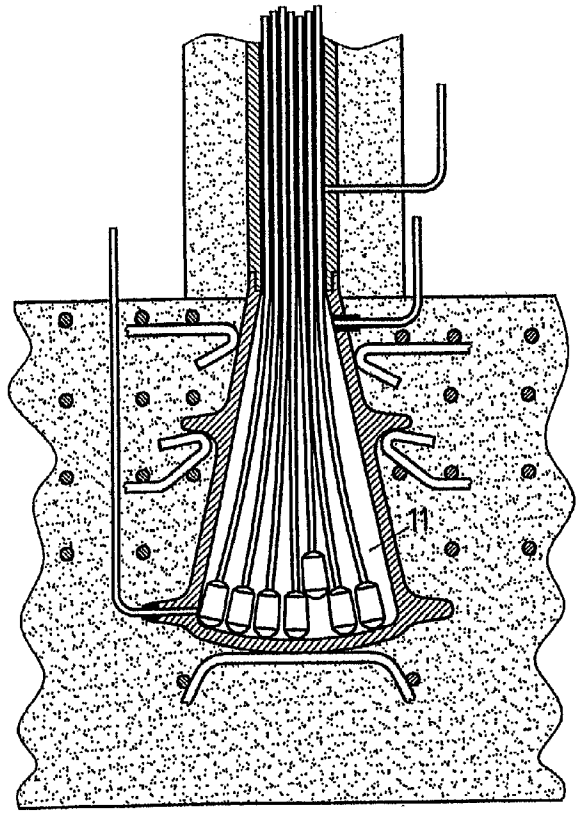
(57) **ABSTRACT**

An anchoring device not accessible from one of its sides can be produced by making a cavity (**11**) of a particular shape and using tendons (**4**), each of which has an end portion (**41**) of adapted shape. The cavity may be made in different ways, especially by concreting an anchor member (**1**) having an opening (**12**) at one end, the anchor member and the cavity it contains each having an adapted shape. After the anchor member has been concreted and the tendons inserted in the cavity, the cavity is filled with an embedding mortar in order to block the ends of the tendons therein.



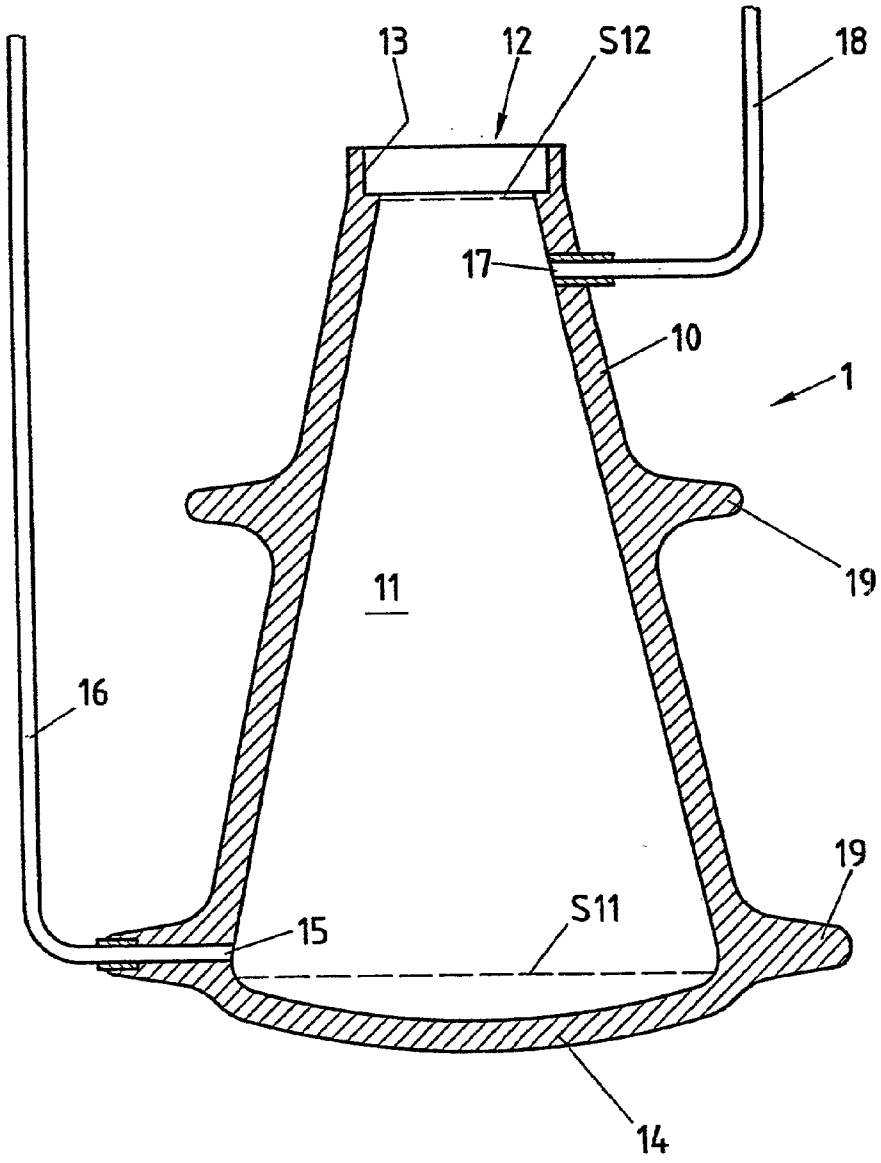


FIG. 1

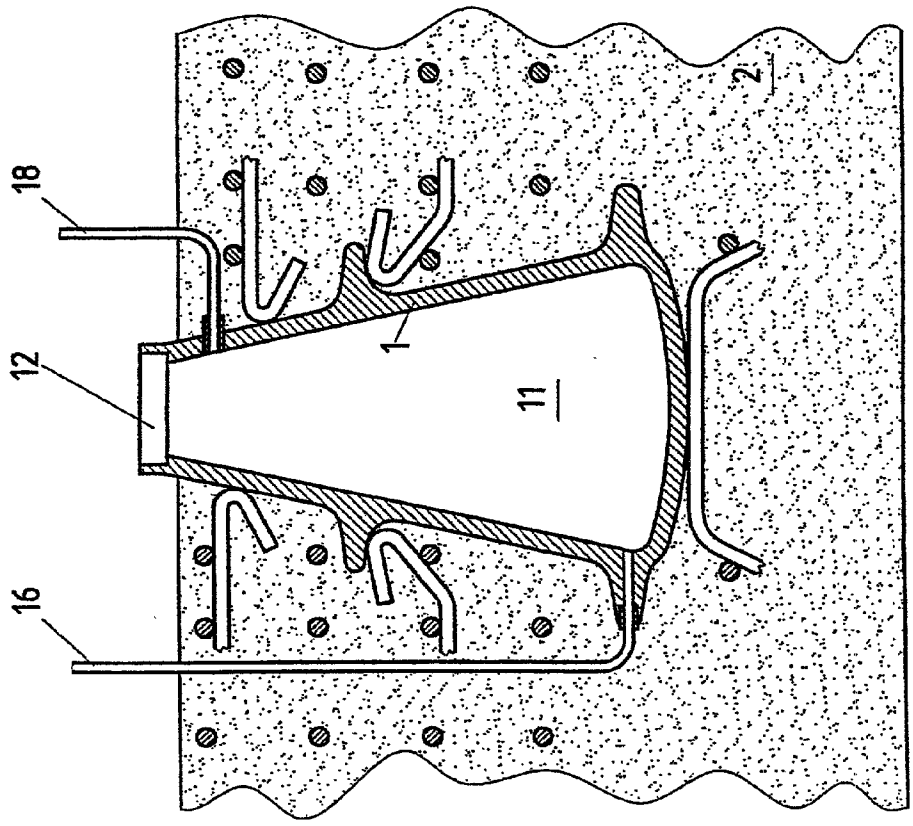


FIG. 2B

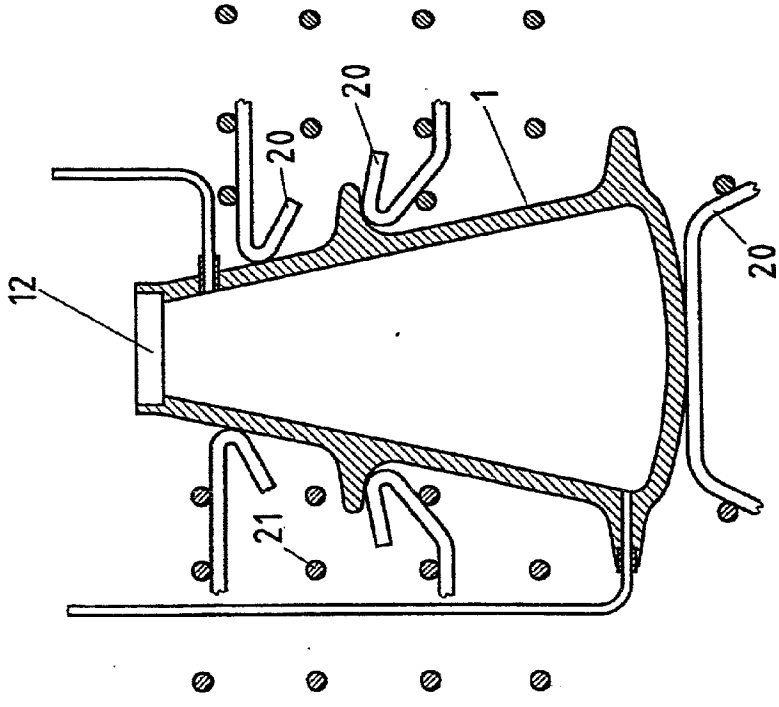


FIG. 2A

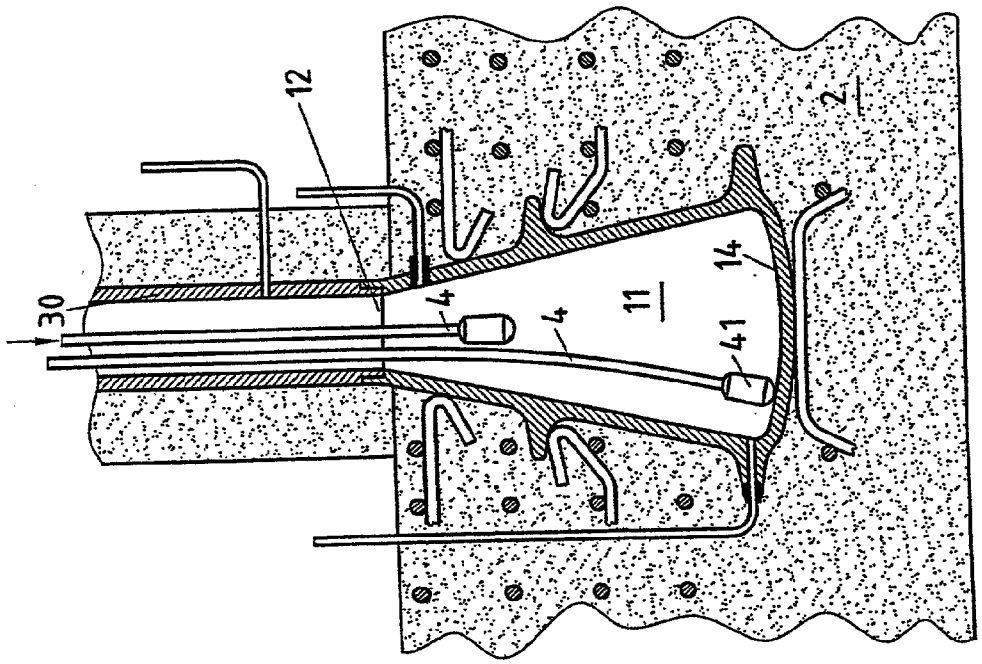


FIG. 2D

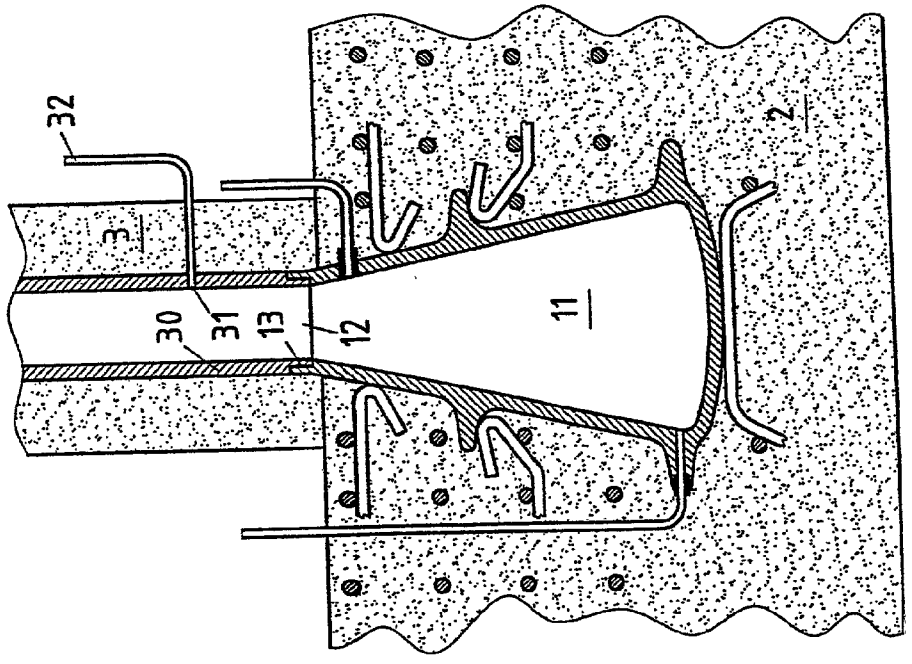


FIG. 2C

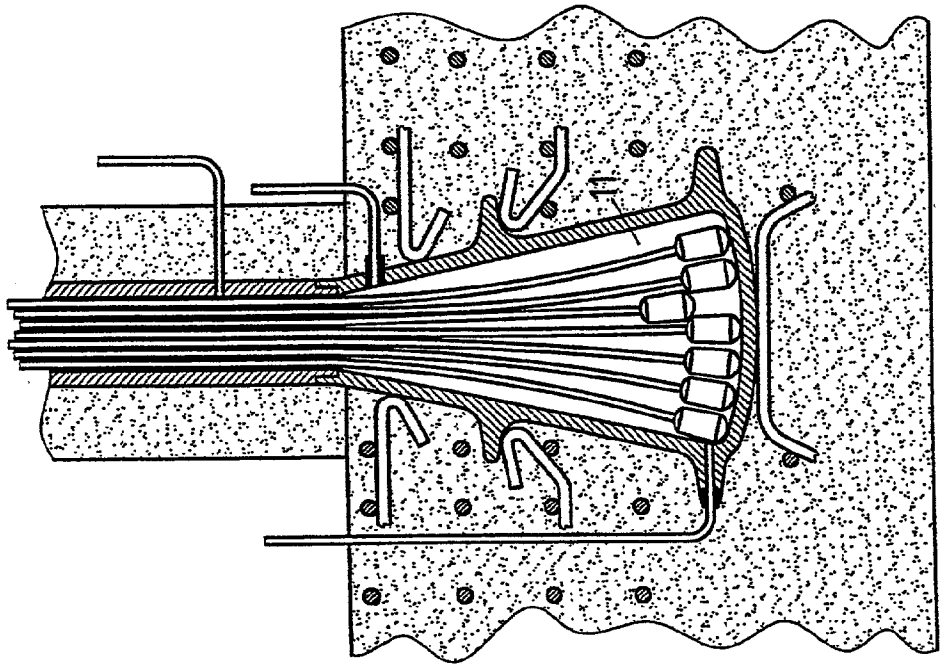


FIG. 2F

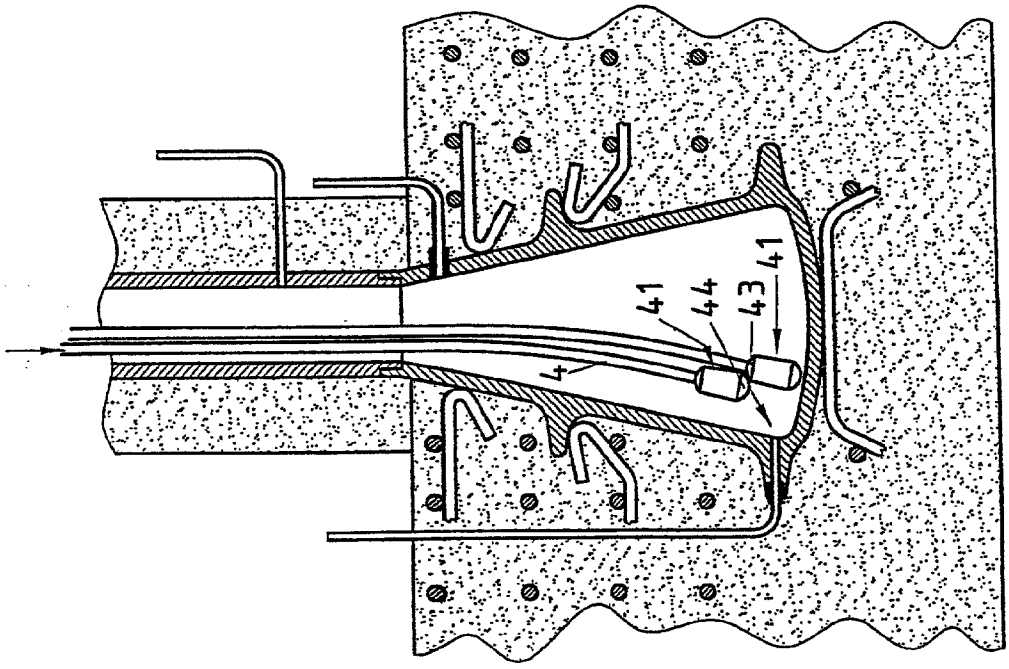


FIG. 2E

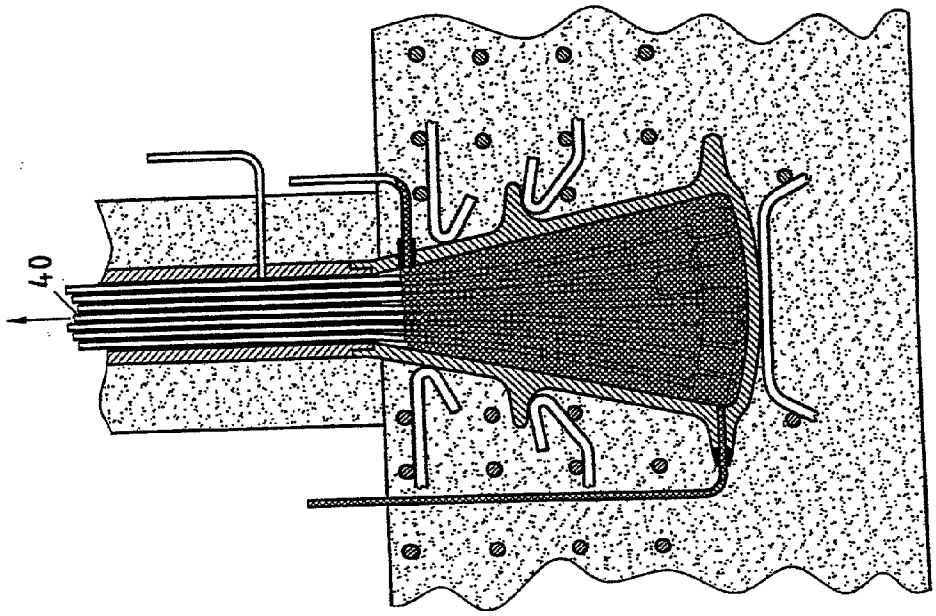


FIG. 2H

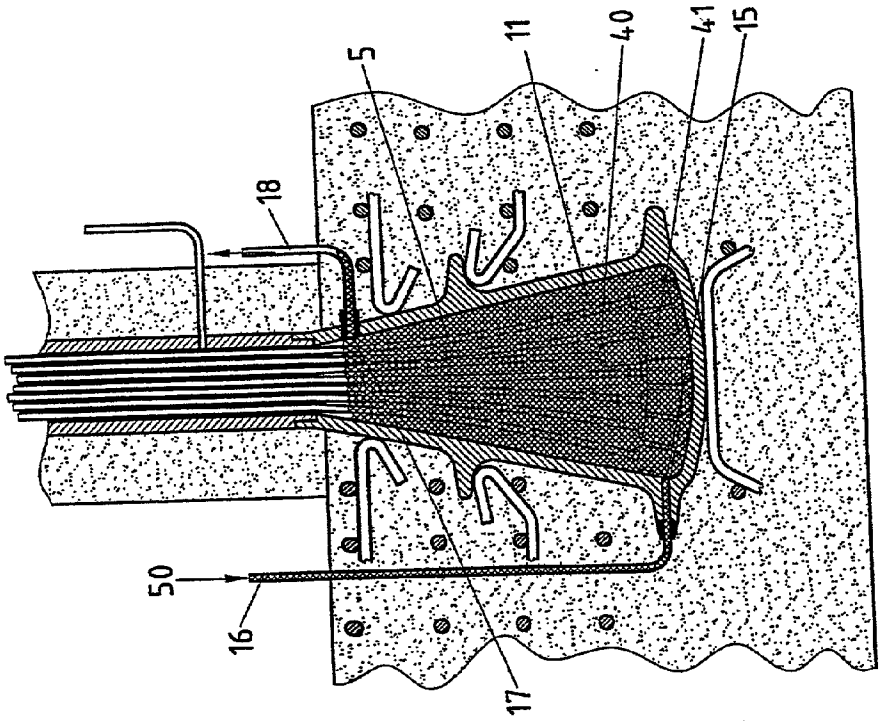


FIG. 2G

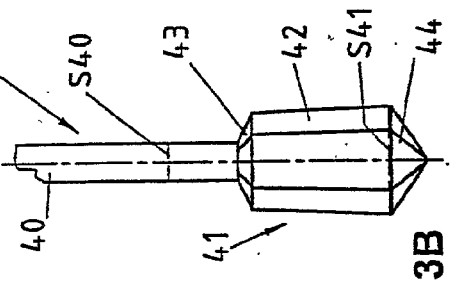


FIG. 3B

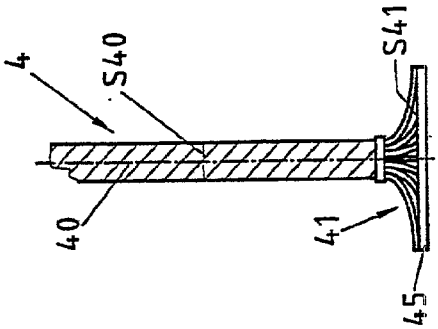


FIG. 3D

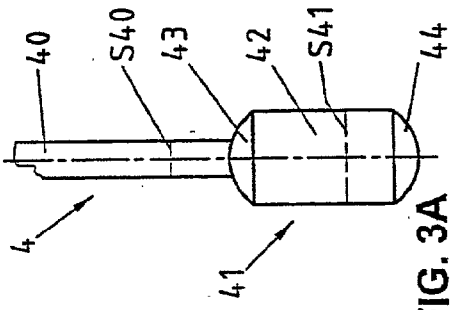


FIG. 3A

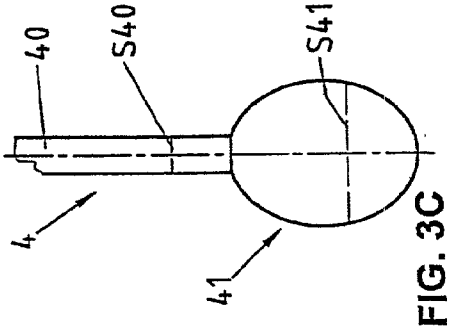


FIG. 3C

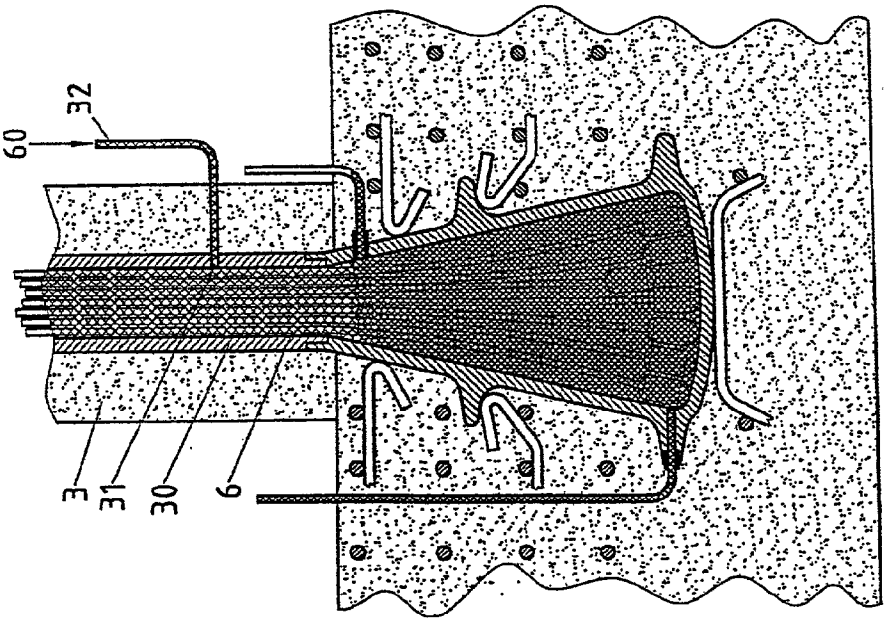


FIG. 2L

METHOD, MEMBER, AND TENDON FOR CONSTRUCTING AN ANCHORING DEVICE

[0001] This application is a division of U.S. Ser. No. 09/799,283, filed Mar. 5, 2001, and currently pending, which is in turn a division of U.S. Ser. No. 09/244,938, filed Feb. 4, 1999, now U.S. Pat. No. 6,216,403 B1, issued Apr. 17, 2001, which in turn claims priority upon European patent application No. 98810096.2, which was filed on Feb. 9, 1998. Each of these applications is incorporated by reference as if fully recited herein.

[0002] This invention relates to anchoring apparatus used in civil engineering, especially so-called blind anchoring devices accessible from only one side, and more particularly to a method of constructing such a device of the type having more than one tendon, as well as to an anchor member for constructing such a device. The invention further relates to a tendon of the type having one end intended to be inserted into an anchoring cavity of such an anchoring device.

BACKGROUND OF THE ART

[0003] For certain anchoring devices having an anchor head with a tendon, prestressed or not, it is not possible to gain access to the anchoring device from the rear. This situation is encountered particularly in the case of a buried anchoring device where access is possible only from the surface of the ground, or when fluid-tightness or anticorrosion protection must be especially meticulous, so that the rear side of the device must be closed. This requirement prevents the use of a conventional anchor plate where the attachment of the tendon to the plate, e.g., with the aid of anchoring cones, calls for the development of new types of anchoring.

[0004] U.S. Pat. No. 5,056,284 shows an anchoring device accessible from only one side, the drawback of the device described there being that each tendon, hence the tube in which they are inserted, is held solely by longitudinal adhesion, thus greatly limiting the tractive stress which such an anchoring device can withstand and leading to a very great anchoring length to obtain a sufficient adhesion surface.

[0005] Likewise, U.S. Pat. No. 4,043,133 provides a tendon sheathing held solely by longitudinal adhesion to the surrounding earth. The tendons extend from the bottom end of the sheathing and are all attached to an anchor plate; the way in which this plate is inserted in the cavity, and the way in which the tendons are fastened to the plate, are not described. In case this embodiment can be produced, the transmission of the anchor force to the ends of the tendons in the surrounding earth through the injected sheathing is produced solely by longitudinal adhesion, without benefiting from the wedge effect as described below in connection with the present invention.

SUMMARY OF THE INVENTION

[0006] It is an object of this invention to provide a method of constructing an anchoring device accessible from only one side which does not encounter the mentioned drawbacks of prior art anchoring devices, i.e., an anchoring device wherein the tendons are held so that the tractive stress on each of them at the level of the anchoring device is taken over by adhesion, this adhesion being appreciably favored by the confinement induced by the overall shape of the anchoring device, and by longitudinal mechanical blocking of the ends of the tendons due to the particular shape of these ends and their arrangement in a cavity of substantially tapering shape.

[0007] A further object of the invention is to provide an anchor member of a particular shape which, associated with a plurality of tendons also having a particular shape, makes it possible to construct such an anchoring device.

[0008] Still another object of the invention is to enable the construction of such an anchoring device without the direct use of an anchor member.

[0009] To this end, the method of constructing an anchoring device according to the present invention, of the type initially mentioned, includes the steps of making a cavity in a surrounding structure, this cavity having a substantially oblong, tapering shape and having two ends, the area of the cross-section of the end disposed on the accessible side of the anchoring device being less than the area of the cross-section of another portion of the cavity, the cavity comprising an opening on the accessible side of the anchoring device; successively inserting through the opening of one end of each of the tendons, each of these tendons being made up of a traction rod having a first cross-sectional area and an end portion having a second cross-sectional area larger than the first cross-sectional area; and filling the cavity with an embedding material.

[0010] The anchor member according to the present invention is of a substantially oblong, tapering shape and has two ends, the area of the cross-section of a first end being less than the area of the cross-section of another portion of the anchor member, the anchor member being made up substantially of a wall bounding a cavity of a shape substantially similar to that of the anchor member and provided with an opening having a first cross-sectional area at the first end of the anchor member and comprising a bottom wall at the second end, another cross-section of the cavity having another area larger than the first area.

[0011] The tendon according to the present invention, of the type initially mentioned, is made up of a traction rod provided at the end thereof intended to be inserted in the cavity with an end portion, the area of the cross-section of which is larger than the area of the cross-section of the traction rod.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] Preferred embodiments of the invention will now be described in detail with reference to the accompanying drawings, in which:

[0013] **FIG. 1** is a sectional view of a preferred embodiment of an anchor member according to the invention,

[0014] **FIG. 2** is a series of sectional views (A-H, L) representing steps in the method of constructing an anchoring device according to the invention,

[0015] **FIG. 3A** is a diagrammatic elevation of part of a tendon in a first embodiment of the invention,

[0016] **FIG. 3B** is a diagrammatic elevation of part of a tendon in a second embodiment of the invention,

[0017] **FIG. 3C** is a diagrammatic elevation of part of a tendon in a third embodiment of the invention, and

[0018] **FIG. 3D** is a diagrammatic view, partially in section, of part of a tendon in a fourth embodiment of the invention.

DETAILED DESCRIPTION OF THE PRESENT INVENTION

[0019] For carrying out the inventive method, an anchoring cavity of a certain shape must first be obtained. The shape of this anchoring cavity is substantially oblong and tapering, with a first open end on the accessible side of the anchoring device and a second closed end on the non-accessible side of the anchoring device. Moreover, the cross-section of the first end of the anchoring device must be smaller than another cross-section of the cavity, whether this section corresponds to that of the second end or to an intermediate section of the cavity.

[0020] Such a cavity may be obtained by several means or devices. A first means consists in using an anchor member comprising a prefabricated interior cavity having the required shape of the anchoring cavity. A preferred embodiment of such an anchor member is illustrated in **FIG. 1**. The anchor member **1** consists essentially of a preferably thin wall **10** bounding an interior cavity **11**. A first end of the anchor member **1**, i.e., the top end of the member as viewed in the drawing, includes an opening **12**, as well as means **13** for fastening a tubular sheath for protecting tendons, the use of which will be described below. The other end of the anchor member **1** is closed by a bottom wall **14**. The outside shape of the anchor member **1**, hence of the interior cavity **11**, is substantially tapering, e.g., frustoconical or frustopyramidal, with the smallest cross-section close to the opening **12** and the largest cross-section close to the bottom wall **14**. An inlet **15** is disposed close to the bottom wall **14**, an injection tube **16** being attached or attachable to inlet **15**. Similarly, an outlet **17** is disposed close to the opening **12**, an exhaust tube **18** being attached or attachable to the outlet **17**. The use of elements **15-18** will be described below.

[0021] The tapering, frustoconical, or frustopyramidal outside surface of the anchor member **1** includes one or more anchor rings **19** disposed at the periphery of this surface, the purpose of which is to improve the transmission and distribution of the anchoring force to the surrounding structure. The embodiment shown in the drawing includes two such rings **19**. The anchor member **1** may be made of synthetic material, of metal, or of concrete, its size depending essentially upon the extent of the anchoring device being considered.

[0022] **FIG. 2A** shows the first step in the inventive method of constructing an anchoring device using such an anchor member. While the surrounding concrete structure has not yet been made, an anchor member **1** is placed at the exact location where the anchoring device is to be constructed, the opening **12** being aimed in the direction of the future tendons. The anchor member **1** is held in place by temporary scaffolding or, preferably, by iron bars **20** of the concrete reinforcement. Preferably, although this is not indispensable to the invention, one or more circular iron bars **21**, forming one or more hoops, are disposed about the anchor member **1** in order to improve the cohesion of the concrete at that location.

[0023] In **FIG. 2B**, it is seen that the concrete structure **2** intended to support the anchoring device has been conventionally poured about the anchor member **1**. The anchor member **1** is thus completely surrounded and held in the concrete structure **2** except for its first end provided with the opening **12** which is flush with the top surface of the concrete structure **2** or, as shown here, projects slightly above that surface, and except for the ends of the injection tube **16** and exhaust tube **18**, which remain accessible outside the concrete structure **2**.

[0024] It will therefore be noted that in this second step of the method, a **20** cavity **11** of a certain shape has been produced within a concrete structure **2**. As described until now, the cavity **11** has been produced using an anchor member **1** provided with a prefabricated cavity. A like cavity **11** in a concrete structure **2** may also be produced in other ways, e.g., by fabricating it in situ. For instance, provision may be made for a form capable of being dismantled, made of wood or some other material, having an outside shape corresponding to the desired shape of the cavity **11**, and placed at the required location, about which form the concrete structure **2** is subsequently poured. As soon as the concrete is hardened, the form is dismantled through the opening **12** and extracted from the cavity **11** through that same opening. In a rather similar manner, a flexible, inflatable component may be used, which after inflation has the desired shape of the cavity **11** and is placed at the required location. After the concrete structure **2** has been poured, the inflatable component is deflated, leaving a cavity **11** of the required shape in the structure **2**. Another procedure would be to produce the cavity **11** by drilling out such a cavity of the required shape in an existing structure **2**. This drilling procedure would be reserved for anchoring directly in the earth or else for the installation of a new anchoring device on an existing structure **2**. The cavity **11**, produced in anyone of the ways described, has two important dimensions, a passage area of the opening **12** designated **S12** and a maximum cross-sectional area designated **S11** (see **FIG. 1**).

[0025] During the third step of the method, shown in **FIG. 2C**, the structural element **3** to be prestressed is placed or concreted, in a manner **10** known per se, above the concrete structure **2**, the structural element **3** preferably comprising a conduit or a sheathing tube **30**, one end of which is situated opposite the opening **12** to be attached to the fastening means **13** adjoining the opening **12**. The cross-section of the sheathing tube **30** or of the conduit contrived in the structural element **3** for the tendons corresponds substantially to the cross-section of the opening **12** of the cavity **11**. The tube **30** or corresponding conduit includes at least one injection port **31** connected to an injection tube **32**, at least one of the ports **31** preferably being disposed near the end of the tube **30** close to the opening **12**, as well as at least one outlet connected to an exhaust tube, at least one of the outlets being disposed near **20** the other end (not visible in the drawing) of the tube **30**, hence near the structural element **3**.

[0026] The fourth step, shown in **FIG. 2D**, consists in inserting the tendons. Here reference is made to FIGS. **3A-3D** showing, by way of non-limiting examples, four designs of such a tendon **4**. This tendon is substantially made up of a traction rod **40** and an end portion **41**. The end portion **41** on the rod **40** is so designed that it has a cross-sectional area **S41** larger than the cross-sectional area **S40** of the traction rod **40**, for reasons to be explained below.

The other end of the rod **40** has no end portion of this kind and is made up for a normal anchoring device as known in the art.

[**0027**] The traction rod **40** may be of any known type, consisting either of an undivided strand or of a plurality of strands assembled helically in order to constitute a traction cable. The undivided strand or the strands assembled into the traction rod **40** may be of steel, preferably of a steel having high resistance to traction, or of synthetic material, e.g., carbon-fiber- or Kevlar-based.

[**0028**] The end portion **41** may be an end piece **41** of metal or synthetic material which is firmly fixed to the end of the traction rod **40**. The choice of material of which piece **41** is made, as well as the way it is fixed to the traction rod **40**, depend essentially upon the material and the manner in which the traction rod **40** is made. The end piece **41** essentially includes a central body **42** bounded by an upper portion **43** and a lower portion **44**. The body **42** may have the shape of a right cylinder, with a circular cross-section as in **FIG. 3A** or a polygonal cross-section, or else a frustoconical or frustopyramidal tapering shape, with a circular cross-section or a polygonal one as shown in **FIG. 38**. In the case of a tapering shape, the part with the smaller cross-section is that adjacent to the upper portion **43**. The two portions **43** and **44** are preferably domed or formed of inclined planes so as to facilitate the sliding of an end portion being installed on another end portion already installed, as will be seen below.

[**0029**] In another design, the end portion **41** may be formed by deformation or machining directly on the end of the traction rod **40**. **FIGS. 3C and 3D** show examples of end portions of this type. In **FIG. 3**C, the traction rod **40** is made up of an undivided strand, and the end portion **41** is obtained by deformation, e.g., by forging, dieing, or stamping, of the end of the traction rod **40**. **FIG. 3D** shows an example of an end portion **41** on a traction rod **40** made up of assembled strands. In this example, the end of each strand has been displaced from its normal position, it being possible to provide a ring or a binding just before this displacement in order to prevent the rest of the traction cable from untwisting. The displaced ends of the strands may be held in position by a supplementary holding part **45**, e.g., a circular disk soldered or fixed in any other way under the displaced strands, or they may be left free. In a design not shown, the part for holding the displaced strands may consist of an element having the shape of two conical portions coupled at their bases, a first conical portion being inserted between the strands to displace them, while the second conical portion is used for the same purpose as the lower portion **44** described above. Thus, in any design of the end portion **41**, it may also have a circular or polygonal shape and include upper and lower portions **43** and **44**, as described previously.

[**0030**] The described examples of end pieces **41** or of deformed end portions **41** are not limiting as regards either their shape or the way in which they are produced; any means may be envisaged for increasing the area of the cross-section of the end portion of the traction rod **40**. When the following description speaks of end piece **41**, it shall be understood that this may also be an end portion as described above.

[**0031**] Returning to **FIG. 20**, it will be seen that a first tendon **4** has been pushed into the guide tube **30**, then into the cavity **11**, until its end piece **41** comes in contact with the bottom surface of the cavity **11**. A second tendon **4** is being installed in the same way.

[**0032**] **FIG. 2E** shows the usefulness of the domed or inclined shape which may be provided on the upper and lower portions **43, 44** of the end piece **41**. When a tendon **4** is being installed, it is quite possible for its end piece **41** to come up against another end piece of a tendon already installed. Owing to the domed or inclined shape of these portions, the second end piece does not jam against the first one but is moved away from it and slides against it until it arrives at its final position beside the first piece.

[**0033**] **FIG. 2F** shows that after a number of tendons have been installed, a new end piece to be installed may not have room at the bottom of the cavity **11**; in that case, in order for the tendon in question to play its full part later on, it suffices if the end piece is pushed down as far as possible in the cavity until it comes up against one or more pieces already installed or against the sidewall of the cavity.

[**0034**] In order to anchor the guying or the prestressed element, a certain number N of tendons **4** must be inserted in the cavity **11**. Knowing that the cross-section of each traction rod **40** has an area **840** and that the maximum area of the cross-section of the end piece **41** equals **841** (see **FIGS. 3A, 38, 3**C, and **30**), the following relations should exist:

[**0035**] to allow the insertion of the last tendon **4**, i.e., to allow the last end piece **41** to pass into the guide tube **30** and into the opening **12**:

$$[(N-1)\times S40]+S41<S12$$

[**0036**] wherein S**12** is the area of the cross-section of the opening **12** (**FIG. 1**).

[**0037**] to allow the end pieces **41** to be disposed properly on the bottom of the cavity **11**:

$$(N\times S41)<S11$$

[**0038**] wherein S**11** is the area of the cross-section of the cavity **11** having the largest area (**FIG. 1**).

[**0039**] When all the tendons **4** have been pushed through the conduit of the tube **30** so that all their end pieces **41** are accommodated in the cavity **11** as indicated above, the next step may be undertaken as shown in **FIG. 2G**. During this step, a liquid embedding material **50** is inserted through the injection tube **16**; this embedding material enters the cavity **11** through the inlet **15** and fills the empty spaces between the end pieces **41** and the ends of the traction rods **40** in the cavity **11** until it fills the cavity **11** at least partially. During this operation, the outlet **17** and the exhaust tube **18** serve to exhaust the air contained in the cavity **11** during its filling, as well as to check the filling level of the cavity **11**. The cavity **11** is preferably filled until the liquid mass inserted reaches the level of the outlet **17**. The embedding material contained in the cavity **11** then hardens into a rigid block **5** of high mechanical strength in which the end pieces **41** and the ends of the traction rods **40** are encased.

[**0040**] In the following step, shown in **FIG. 2**H, each of the tendons **4** is subjected to traction until the prescribed prestresssing tension is reached. This application of traction takes place in a conventional manner by acting on the other end of each tendon **4**, i.e. , of each traction rod **40**, the

tendons being pretightened simultaneously or in sequence. As may be seen in the drawing, the frustoconical or pyramidal tapering shape of the cavity **11**, hence of the hardened mass in which the end pieces **41** and the ends of the rods **40** of the tendons **4** are encased, permits efficient wedge-shaped anchoring in the surrounding concrete structure. Contrary to the prior art devices mentioned earlier, this wedge shape prevents any possible axial movement of the hardened mass **5** and causes transmission of the anchoring forces into the surrounding structure **2** by axial compression and not by simple adhesion. The length of this anchoring device is therefore favorably reduced.

[**0041**] Additional anchoring security is ensured by the particular arrangement of the end pieces **41** within the cavity **11**. Considering that the end pieces **41** are disposed in a bundle in the cavity **11**, the area of the cross-section generated by the casing of the bundle of assembled end pieces **41** is greater than the area of the opening **12** of the cavity **11**. The bundle of end pieces **41** is therefore blocked in the cavity **11** .

[**0042**] Reverting to the expressions given above,

[**0043**] for enabling blockage of the tendons **4** in the cavity **11** by preventing the mutually blocked end pieces **41** from coming out through the opening **12**, the relation should be:

$$(N\times 841)^{*}>812$$

[**0044**] wherein (N×841)* represents generally the surface generated by the casing of the bundle of the N assembled end pieces, each having a cross-sectional area **S41**. In order to take into account that one or two end pieces **41** may possibly not have found their proper place, as indicated with respect to **FIG. 2**H, the individual sections **S41** and the passage section **S12** must be of a size to block the end pieces **41** when the tractive force is exerted simultaneously on all the tendons **4**.

[**0045**] It should be noted that the step of pretightening the tendons **4** as just described may be carried out differently, especially in the case of simple guying, not pretightened.

[**0046**] In a final step of the method, illustrated in **FIG. 2**L, the empty space within the sheathing tube **30**, or within the conduit made in the structural element **3**, may be filled with a sealant **60** through the injection tube or tubes **32** and the inlet or inlets **31** in order to preserve the fluid-tightness of the pretightened system and to prevent corrosion of the pretightening elements. This last step is also optional, depending upon whether such protection **6** is required or necessary.

[**0047**] It will therefore be noted that a very effective anchoring device is thus obtained, the longitudinal tractive force of each tendon **4** being taken over mainly by its end piece or portion **41** and transferred to the hardened block **5** of embedding material having high mechanical strength. Efficient transmission of this force is possible owing to the firm attachment of the end piece **41** on the traction rod **40**; since this attachment may take place in the factory, its mechanical strength is very high. This force is then transferred by the oblique walls of the cavity **11** to the surrounding structure **2**. By disposing one or more anchor rings on the anchor member **11** it is even possible to improve the mentioned anchoring effect in the surrounding structure **2**. As mentioned, hoops **21** may be provided in order further to improve the cohesion of the surrounding structure **2** about the cavity **11**. In addition to the mentioned longitudinal strength—each end of a traction rod **40** being held in the block **5** of embedding material-each rod **40** is held by radial compression as well.

[**0048**] This type of anchoring device lends itself particularly well to prestressed anchoring of a prestressed structural element **3**. It may also lend itself to anchoring of non-prestressed tendons, e.g., guys for staying a mast or pylon, in which case the guys need not be protected by a protective tube **30**. Likewise, it is not indispensable for the cavity **11** to be contrived in a surrounding structure of concrete; a borehole in the earth or in rock whereby a cavity as required may be obtained might be provided instead.

[**0049**] The foregoing description pertains to a cavity having a substantially vertical longitudinal axis, with its opening **12** at the top. Other geometric arrangements are also possible; the dimensions of the cavity **11** are to be adapted in order to obtain sufficient filling of the cavity **11** by the embedding material **50**.

What is claimed is:

1. An anchoring device in a structure, the device having an opening accessible from a single side of the structure, comprising:

an anchoring member secured in the structure, the anchor member comprising a well member, bounding a cavity of a substantially oblong, tapering shape with two ends, the first end comprising the opening, a cross-sectional area of the first end being smaller than a cross-sectional area of another portion of the anchor member, and a bottom wall at the second end; and

a plurality of tendons, each said tendon comprising a traction rod having a first end and an intermediate portion with a first cross-sectional area and a second having an end portion with a second cross-sectional area larger than said first cross-sectional area, N such tendons inserted into the anchor member with the second ends in the cavity and the first ends and intermediate portions extending outwardly therefrom,

wherein the first and second cross-sectional areas of the traction rods and the cross-sectional area of the opening are related such that when N traction rods are in place, the N traction rods cannot be arranged at the opening to allow the second cross-sectional area of one additional traction rod to pass through the opening

2. The anchoring device of claim 1, wherein the cavity has at least one cross-sectional area that is greater than the sum of the maximum cross-sectional areas of the N second ends.

3. The anchoring device of claim 1, wherein the cross-sectional area of the opening of the cavity is less than the sum of the cross-sectional areas of the second ends of the N tendons inserted in said cavity.

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