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(54) **Novel technique for stay cable system**

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Système de haubanage

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- **MONTENS S: "LE FRANCHISSEMENT DE L'ISERE PAR L'AUTOROUTE A 49" TRAVAUX, no. 666, 1 June 1991, pages 16-40, XP000216585**
- **SVENSSON: "Die Schrägkabelbrücke über den Mississippi bei Burlington,USA" STAHLBAU., vol. 63, no. 7, 1994, pages 193-197, XP002093577 BERLIN DE**

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EP 1 001 089 B1

Description

[0001] The invention relates to the field of stay cable system for cable-stayed bridges.

[0002] Stay cable system consists basically of tendon member, protection member, the member of anchorage sockets as well as the member of cable-girder and cable-pylon attaching structures. These members relate and influence with each other. Stay cables normally govern the useful life and construction progress of cable-stayed bridges with the following factors: resistance to fatigue loading and corrosion, ease of transportation and erection, allowance of inspecting as well as ability of eventual replacement. The attaching structures influence the safety, economy and aesthetics of whole bridge sensitively by the reliability and compact of their arrangement.

[0003] DE 3 723 795 A discloses a stay cable system with all the features of the preamble of claim 1.

[0004] The tendons with parallel strands are more and more widely used in stay cable systems, because of their advantages of easy transportation and erection. But at present there are three serious problems in such kind of cable systems.

Problem A - anchorage socket.

[0005] Two types of anchorage socket are now currently used for such kind of cables:

1. In anchorage zone a grouted tube section, in which all strands are bonded together, is added to reduce the fatigue loading on normal strand jaws [Die Schrägkabelbrücke über den Mississippi bei Burlington, USA, H. Svensson and K. Humpf, Stahlbau 63(1994), Heft 7, p. 196, Fig. 8, 9]. Disadvantage of such kind of anchorage is that individual strand replacement is tremendously difficult to perform under cable service condition.

2. A special kind of jaws has been created to withstand both the static and fatigue load for anchorage. Therefor, individual strand replacement becomes much easier at any moment [Brochure: Freyssinet STAY CABLES May 1994, p.10 and 11, Fig.19]. But, the special jaws must be ensured by very high level of technology and quality control. Otherwise, big risk will be faced.

It is ideal to keep the ability of individual strand replacement while to avoid the necessity of extremely high strand jaws.

Problem B - corrosion protection.

[0006] At present the most current corrosion protecting method for such kind of cables is to cover the individual multilayer protected strands by a sheath pipe [Brochure: Freyssinet STAY CABLES MAY 1994 p.14,

Fig.22], [Brochure: VSL STAY CABLE SYSTEM 200 SSI section "Corrosion Protection" and "Outer Stay Pipe"]. Easy to erect and replace strands is the main advantage of this method. But a great problem of the method is that if there is water and moisture inside sheath pipe, it is difficult to discover them and clear them away. It is necessary that water and moisture inside sheath pipe can be surveyed and cleared away.

10 Problem C - attaching structures.

[0007] In concrete cable-stayed bridges, web thickness of girder is usually bigger than diameter of cable anchorage head, so, cable anchorage socket is easy to go through the girder web and to be reliably anchored at the bottom of the girder. In composite cable-stayed bridges, web thickness of steel I-girder, which is the most economical type of steel girder, is much smaller than diameter of cable anchorage head, so, attaching structures become complicated. At present three imperfect types of attaching structure are normally used in composite cable-stayed bridges:

25 Type 1. Cable anchorage socket is arranged above bridge deck and anchored on a steel plate, which is welded to the top part of steel girder holding its axis coincided with girder web [Separate: Annacis Bridge Superstructure - A major composite cable-stayed bridge, P. R. Taylor, CBA - Buckland and Taylor consulting engineers Vancouver, B.C., December 6, 1985, Fig.2]. Main disadvantages of the structure are 1) large tensile and shear stress in weld and certain tensile stress in concrete deck. 2) Distance between damper and anchorage socket is too small, which reduces damper efficiency. 3) Cable can not be tensioned on girder site.

30 Type 2. Cable anchorage socket is arranged on one side of girder web and anchored at the lower part of girder on two stiffening steel plates that are welded to the girder web to avoid tensile force at top part of girder and to get sufficient distance between damper and anchorage socket [Separate: Cable-Stayed Houston Ship Channel Crossing, Holger S. Svensson and Thomas G. Lovett, Transportation Research Record No. 1290, Leonhardt, Andrä und Partner, p. 5, Fig. 7]. Basic disadvantage of the structure is that there is certain eccentricity between axes of cable and girder web, which forms additional moment in transverse beam and large stress in welds. Cable also can not be tensioned on girder site.

35 Type 3. Cable anchorage socket is arranged above bridge deck and anchored on two extended steel plates, which are welded or bolted to the bottom part of steel girder holding cable axis coincide with girder web and avoiding tensile force at top part of girder [Die Schrägkabelbrücke über den Mississippi bei Burlington, USA, H. Svensson and K. Humpf, Stahl-

bau 63(1994), Heft 7, p. 194, Fig. 4, 5, p. 197, Fig. 10]. Disadvantage of the structure is that the extended steel plates are heavy and bigger place occupied. Again, distance between damper and anchorage socket is too small and cable can not be tensioned on girder site.

Although arrangement of attaching structures in the stay cable system with parallel strands is easier to perform than that of other systems, the problem has still not been solved. It will be perfect if a light and handy way can be created to keep axes of cable and girder web in a same plane and to reliably arrange anchorage socket at bottom of steel I-girder.

[0008] This invention will solve the entire Problem A, Problem B and Problem C at the same time.

[0009] Figure 1 illustrates the general layout of the novel stay cable system, which is exclusively for the tendons with parallel strands (I) covered by a sheath pipe (Ib). The system comprises five parts:

1. Main anchorage socket (1).

Anchoring holes in the socket are divided into two symmetrical groups. Axis of two symmetrical groups of strands (I) and the centre plane of web(s) of any kind of girders (II or IId) can coincide while the socket can be arranged under the bottom of the girders.

2. Auxiliary anchorage socket (2).

It comprises a pair of half-cylindrical anchorage sockets arranged on both sides of the web in steel I-girder (II), in anchoring tie beam (3) or in steel anchoring bed (4). In the sockets (2) strands can individually be anchored or bonded to withstand fatigue loading.

3. Anchoring tie beam (3) with I-section in pylon (III).

4. Steel anchoring bed (4) in pylon (III) instead of anchoring tie beam (3) as well as under the girders (IId) other than steel I-girder (II).

5. Cable protection system, which consists mainly of dry air entrances (5a), dry air transmission pipes (5b), dry air exits (5c) vent holes (5d), vent pipes (5e), wet air exits (5f) and dehumidification plant (5g).

Detail of each part is respectively described as follows.

Part 1 - novel arrangement of anchorage holes.

[0010] In current stay cable system with parallel strands, monostrand anchored holes on anchor head are normally arranged with odd number (for example 61). In this invention (see Figure 2), monostrand anchored holes on main anchor head (1) are always arranged with even number (for example 60), and are separated into two symmetrical groups (1a and 1b). The minimum central distance D_g between the two groups of holes is $D_g = T_w$ (thickness of web IIa of steel I-girder

II) + D_h (diameter of monostrand anchored hole 2c and 2d in auxiliary anchorage sockets 2a and 2b) + $2A_t$ (thickness of inside wall of auxiliary anchorage sockets 2a and 2b). Thus, those two groups of strand (Ie and If) can easily pass through the I-girder (II) along both side of girder web respectively keeping axes of cable and girder web in a same plane then can reliably be anchored in a main anchor head (1) under the bottom of the girder (II). In pylon anchoring room, the strands (Ia) outside main anchorage socket (see Figure 1) do not be cut off after the final jacking, for it will be convenient for eventual individual strand replacement and the strands will be under protecting of dehumidification system (see Part 5).

[0011] Advantages of such arrangement are:

1) There is no eccentricity between axes of cable and girder web.

2) Approximately 60% of cable jacking force transfers directly to girder web by compression stress while the rest force transfers by four stiffening steel plates (3) and eight shear welds, very reliable.

3) Strands within the area of girder web and stiffening steel plates can be touched when cover plates (IIc, see Figure 3, 5) are removed, which facilitates strand erection, surveillance and replacement, furthermore, fatigue resistant facilities (left auxiliary anchorage socket 2a and right auxiliary anchorage socket 2b) can be arranged within this area (see the following part).

4) Cable can be tensioned on girder site, when necessary.

5) Distance between damper and anchorage socket is sufficient.

Part 2 - novel double half-cylindrical auxiliary anchorage sockets.

[0012] As mentioned above, within the area of girder web and stiffening steel plates, there is plenty of space to arrange fatigue resistant facilities-auxiliary anchorage sockets, which will help the main anchorage socket to withstand fatigue load (see Figure 2). Consequently, it becomes sufficiently safe to use ordinary jaws in main anchorage socket. Since auxiliary anchorage socket works for traffic load only, its construction ought and can be calmly arranged after the final cable force adjustment. Besides the fatigue resistant criterion, another design criterion for auxiliary anchorage sockets is that strands must be individually anchored in the sockets to ensure the possibility of individual strand replacement. Two types of auxiliary anchorage socket are created for selecting.

1. Auxiliary anchorage socket 1.

Structure of the socket is showed in Figure 3 and Figure 4. In the socket there are auxiliary jaws (2j) with smaller bevel angle to anchor strands indi-

vidually. Edge of teeth on auxiliary jaw is circular to prevent injury and big stress concentration on the anchored strand (I).

1.1 Construction procedure of auxiliary anchorage socket 1 is: 5

- 1) Guide rails (2f) are erected and fixed on girder web (IIa). 5
- 2) Fastening plates (2e₁), on which auxiliary jaws (2j), nylon positioners (2k) and nylon washers (2l) as well as fastening threaded bars (2h) have been fixed, auxiliary anchor heads (2a₁) and nuts (2i) are erected along the guide rails (2f) in proper order. 10
- 3) Main anchorage socket (1, see Figure 2) and strands (I) are erected, stressed and anchored. 15
- 4) When the final cable force adjustment has been done, triple cylinder hydraulic jacks (2m) are erected and then guide rails (2g) are fixed on stiffening plates (IIb) of girder. 20
- 5) Triple cylinder hydraulic jacks (2m) are driven to design force then nuts (2i) are tightened. 25
- 6) Triple cylinder hydraulic jacks (2m) are released and taken off together with guide rails (2g). 30
- 7) Cover plates (IIc) are erected and fixed onto stiffening plates (2b). 35

1.2 Procedure of eventual individual strand replacement of auxiliary anchorage socket 1 is: 35

- 1) Cover plate (IIc) is removed. Then nuts (2i) are released. 40
- 2) The strand, which should be replaced, is released by a single strand jack in pylon and removed. 45
- 3) A new strand is erected, stressed and anchored on main anchor head by a single strand jack. Then the procedure 4) to 7) aforementioned is repeated. 50

2. Auxiliary anchorage socket 2.

Structure of the socket is showed in Figure 5 and Figure 6. In the socket (2a₂) there are coned holes for each individual strands. Epoxy, zinc powder and quartz sand mixture (2q) is injected into the coned holes after the final tensioning of cable. 50

2.1 Construction procedure of auxiliary anchorage socket 2 is: 55

- 1) Guide rails (2f) are erected and fixed on girder web (IIa).

2) Isolation plates (2n), isolation plates (2o), auxiliary anchor heads (2a₂), fastening plates (2e₂), on which fastening threaded bars (2h) have been fixed and release agent (2t) has been smeared, isolation plates (2p) and nuts (2i) are erected along the guide rails (2f) in proper order.

3) Main anchorage socket (1, see Figure 2) and strands (I) are erected, stressed and anchored.

4) When the final cable force adjustment has been done nuts (2i) and isolation plates (2p) are tightened.

5) Epoxy, zinc powder and quartz sand mixture (2q) is injected into auxiliary anchorage sockets (2a₂) at grout hole (2r - in pylon) and (2s - under girder) until the mixture jets out from vent hole (2s - in pylon) and (2r - under girder). The mixture (2q) is then solidified in heating condition.

6) Cover plates (IIc) are erected and fixed onto stiffening plates (IIb).

2.2 Procedure of eventual individual strand replacement of auxiliary anchorage socket 2 is:

1) Cover plate (IIc) is taken off. Then nuts (2i) are released.

2) The strand, which should be replaced, is released by a single strand jack in pylon and by heating on the strand individually in both auxiliary anchorage sockets. At the same time fastening plate (2e₂) is pried open from auxiliary anchor head (2a₂). Then the strand is removed.

3) A new strand is erected, stressed and anchored on main anchor head by a single strand jack.

4) The mixture (2q) in grout holes (2s) is drilled away.

5) The nuts (2i) are tightened again while new mixture (2q) is injected into the coned hole through grout holes (2s). The new mixture is then solidified in heating condition.

6) Cover plates (IIc) are erected and fixed onto stiffening plates (IIb).

Part 3 - novel anchoring tie beam in pylon.

[0013] In order to arrange the double half cylindrical auxiliary anchorage sockets, anchoring tie beams in pylon (III) can be simplified to the most economical type of I-beam (3), web and stiffening plates of which are also signed with (IIa) (IIb) respectively as in I-girder. The structures mentioned in Part 1 and Part 2 are valid in Part 3. Tie beam with I-section can be extensively used for inclined cable plane by the helping of tie bars (3a)

(see Figure 6).

Advantages of the structure are:

- 1) Basic internal force in the structure is axial tension, which is totally withstood by the steel tie beams (3) and tie bars (3a), while no large moment and shear force happens.
- 2) Mass of pylon top can be reduced.
- 3) Operating space in pylon top becomes roomy in case of inclined cable plane.

Part 4 - novel steel anchoring bed.

[0014] In case the girders (II d) other than steel I-girder or the anchoring structures in pylon (III) other than tie beam are adopted and in order to arrange the double half cylindrical auxiliary anchorage sockets, the conventional anchoring bed can be replaced by a novel steel anchoring bed (4), web and stiffening plates of which are also signed with (IIa) (IIb) respectively as in I-girder (see Figure 8). The structures mentioned in Part 1 and Part 2 are valid in Part 4.

[0015] Compare with the conventional concrete anchoring bed, advantage of such anchoring bed is that it can simplify the form work of anchoring zone in concrete pylon, therefore mass of pylon top and construction period can be reduced.

Part 5 -- novel cable protection system.

[0016] Dehumidification system has been successfully used on Lillebaelt bridge since 1972. Now the system is being used on more and more bridges to protect steel box girders, saddles and anchoring blocks [Book: East Bridge, The Storebaelt Publications, 1998, P.374,375]. Similar principle is adopted for this novel cable protection system (see Figure 9).

[0017] Two dry air transmission pipes (5b) are erected from the main anchorage plate (4a) in pylon (III) to the cells enclosed by stiffening plates (IIb) and cover plates (IIc) at the bottom of girder (II or II d) and connected to a dehumidification plant (5g), which is installed inside anchoring room at pylon top, by the dry air entrances (5a). When the dehumidification plant (5g) works, air circulates within the whole hollow part of cable. Dry air is blown into the transmission pipes (5b) through dry air entrances (5a), then separates out of dry air exits (5c) mainly at the bottom of sheath pipe (Ib), partly at the guide pipes (Ic) and cells enclosed by stiffening plates (IIb) and cover plates (IIc). At the same time wet air is exhausted out of cable to the plant (5g) through vent holes (5d), vent pipes (5e), which pass through the positioners (Id) of strands (I) in guide pipe (Ic), and wet air exits (5f). Such operation offers to one cable after another with certain hours per day or per couple of days for each cable. Similar operation offers also to anchoring room in pylon by dry air exit (5o) and wet air entrance (5p) of the plant (5g) at regular intervals to protect the

strands (Ia) outside main anchorage socket (see Part 1 also).

[0018] Water concentrates usually at the lowest part of cable and moisture concentrates usually at the highest part of cable. Therefore, strand sample (5k) and humidity measuring point (5i) are arranged in the cells enclosed by stiffening plates (IIb) and cover plates (IIc) at the bottom of girder (II or II d), while strand sample (5l) and humidity measuring point (5h) are arranged in the similar cells in pylon (III) respectively. Strand sample (5k) and/or strand sample (5l) can be checked and tested in laboratory, when necessary. Similar checking and testing can be arranged for sample (5n) of the strands (Ia) outside main anchorage socket. Humidity measuring point (5h) can be connected to the automatic control system of dehumidification plant (5g), if necessary. If there is water inside hollow part of cable, it will flow down through drainage holes (5j) and can be pumped out through the drainage valve (5m).

[0019] Advantages of this cable protection system are:

- 1) Its observability, controllability and reliability are higher than those of the current cable protection systems are.
- 2) It is easy for replacing individual strand.
- 3) It is possible to simplify the individual strand protection (for example galvanised only).
- 4) If dehumidification plant can blow warm air into sheath pipe, will melt the ice on the pipe. So that it is possible to solve the problem of ice-wind-induced vibration on cable thoroughly.

Claims

1. A stay cable system exclusively for the tendons with parallel strands (I) covered by a sheath pipe (Ib) comprising a cable protection system, which consists of dry air entrances (5a), dry air transmission pipes (5b), dry air exits (5c), vent holes (5d), vent pipes (5e), wet air exits (5f), dehumidification plant (5g) as well as some other surveying, measuring, controlling and testing facilities, which ensures strands under a observable, controllable and reliable protected condition, said stay cable system being **characterized in that** it further comprises:

- Main anchorage socket (1), in which anchoring holes are divided into two symmetrical groups, which can be arranged under steel I-girder or girders other than steel I-girder) so that the cable axis and the centre plane of girder web coincide. In pylon anchoring room, the strands (Ia) outside main anchorage socket are not cut off after the final jacking, for eventual individual strand replacement and the strands will be under protecting of the said dehumidification sys-

- tem,
- Double half-cylindrical auxiliary anchorage sockets (2) which can be arranged on both sides of the web in steel I-girder (II), in anchoring tie beam (3) or in steel anchoring bed (4). In the sockets, strands can individually be anchored or bonded to withstand fatigue loading and to facilitate eventual individual strand replacement. Based on the help of said double half-cylindrical auxiliary anchorage sockets (2), ordinary jaws can reliably be used in said main anchorage socket,
 - Anchoring tie beams (3) with I-section which can be arranged in pylon (III) to facilitate the arrangement of auxiliary anchorage sockets and extend utilisation from vertical cable plane to inclined cable plane with the help of tie bars (3a), or, instead of said anchorage tie beams,
 - Steel anchoring bed (4) with stiffening plate and web, which facilitates the arrangement of auxiliary anchorage sockets in pylon (III) as well as under the girders (II'd) other than steel I-girder (II), in order to keep axes of cable and web in a same plane.
2. A stay cable system as claimed in Claim 1, **characterised in that** the anchoring holes in main anchorage socket are divided into two symmetrical groups. The minimum central distance (D_g) between the two groups of holes is the sum of the thickness of web (IIa) in steel I-girder (II), in steel tie beam (3) with I-section or in steel anchoring bed (4) + diameter (D_h) of monostrand anchored hole (2c, 2d) in auxiliary anchorage sockets (2a, 2b) + twice the thickness (A_t) of inside wall of auxiliary anchorage sockets (2a, 2b), to facilitate the arrangement of double half-cylindrical auxiliary anchorage socket (2).
3. A stay cable system as claimed in Claim 1, **characterised in that** the double half-cylindrical auxiliary anchorage socket (2) can withstand fatigue loading. Two types of auxiliary anchorage socket are created for selecting. In auxiliary anchorage socket of the first type strands (I) are individually anchored by auxiliary jaws (2j), which can be released when individual strand replacement carries out, without injury and big stress concentration. In the coned holes of auxiliary anchorage socket of the second type, strands (I) are individually bonded by epoxy, zinc powder and quartz sand mixture (2q), which can be milted by heating when individual strand replacement carries out.
4. A stay cable system as claimed in Claim 1, **characterised in that** cable protection system further comprises some other surveying, measuring, controlling and testing facilities. These facilities are: hu-

midity measuring points (5h, Si), drainage holes (5j), strand control and testing samples (5k, 5l) as well as drainage valve (5m). The similar members, dry air exit (5o) and wet air entrance (5p) of dehumidification plant (5g), as well as humidity measuring point (5n) are equipped to protect the strands outside main anchorage socket. When the dry air entrances, the dry air transmission pipes, the dry air exits, the vent holes, the vent pipes, the wet air exits, the dehumidification plant, and the dry air exit and wet air entrance of dehumidification plant (5a-5g 5o, 5p) operate, within all the hollow parts of cable and pylon anchoring room runs the air circulation, which is under the inspecting and controlling of said facilities (5h - 5n).

Patentansprüche

1. Ein Schrägseilsystem, ausschließlich für Strang mit parallelen Litzen (I) gedacht, abgedeckt durch ein Deckrohr (Ib), das ein Kabelschutzsystem einschließt, welches aus Trockenlufteingängen (5a), Trockenluftdurchgangsröhren (5b), Trockenluftausgängen (5c), Luftwechsellöchern (5d), Luftwechselröhren (5e), Feuchtluftausgängen (5f), einer Entfeuchtungsanlage (5g), sowie aus einigen anderen Überwachungs-, Mess-, Kontroll- und Testmöglichkeiten besteht, ist dargestellt. Durch das System soll sichergestellt werden, dass die Drähte eine betriebssichere Schutzumgebung haben, die zulässt, dass sie beobachtet und kontrolliert werden. Das Schrägseilsystem ist weiter **gekennzeichnet durch** einen:

- Hauptverankerungskopf (1), in den Verankerungslöcher in zwei symmetrischen Gruppen angeordnet sind, die unter einem Stahl- I-Träger oder anderen Stahlträgern so angebracht werden können, dass die Kabelachse und die zentrale Ebene des Stahlträgernetzes zusammenpassen. Im Ankerraum für den Mast werden die Litzen (Ia) außerhalb des Hauptankerkopfes nicht abgeschnitten **durch** die abschließende Dehnung, um eventuell einzelne Litzen austauschen zu können. Außerdem werden die Litzen **durch** das oben beschriebene Entfeuchtungssystem geschützt,
- Doppelte halbzyindrische Behelfankerköpfe (2), die auf beiden Seiten der Stahl I-Balken eingerichtet werden kann, in verankerten Bandbalken (3) oder in einer Verankerung in einem Stahlbett (4). In den Sockeln können die Litzen einzeln verankert werden oder gebunden werden, um Ermüdung auszuhalten/ zu widerstehen und um eventuell einzelne Litzen Ersetzung zu ermöglichen. Basierend auf der Hilfe von dem genannten doppelten halbzyindri-

- schen Behelfsankerköpfen (2), gewöhnliche Leisten können verlässlich genutzt werden in den genannten Hauptankerköpfen,
- Der Bandbalken wird (3) mit dem I-Abschnitt verankert, welcher in Pylon (III) angeordnet werden kann, um die Ausrichtung der Behelfsankerköpfe zu erleichtern und um den Gebrauch der senkrechten Kabelebene bis zu einer geeigneten Kabelebene mit der Hilfe von Bandstange (3a) auszuweiten,
 - Das Ankerbett aus Stahl (4) mit Steifleinplatte und Netz/Gewebe, stellt die Anordnung der Behelfsankerköpfe in pylon (III), genauso wie unter den Balken (IIId), anders aber als die Stahl I-Balken (II), her, um die Achsen der Kabel und das Netz/Gewebe in der gleichen Ebene zu halten.
2. Ein Schrägseilsystem, wie in Absatz 1 aufgeführt, ist **dadurch gekennzeichnet, dass** die Ankerbohrungen im Hauptverankerungskopf in zwei symmetrische Gruppen unterteilt sind. Der kleinste Achsenabstand (Dg) zwischen den zwei Bohrungsgruppen ist gleich der Stärke des Netzes (IIa) im Stahl-I-Balken (II), im Stahl-Anker-Bandbalken (3) mit I-Sektion oder im Stahl-Anker-Bett (4) + Durchmesser (Dh) der Einzelstrang-Anker-Bohrung (2c, 2d), im Behelfsankerköpfe (2a, 2b) + doppelte Stärke (At) der Innenwand des Behelfsankerköpfes (2a, 2b), um eine Ausrichtung von doppelten halbzyklischen Behelfsankerköpfen (2) zu ermöglichen.
3. Ein Schrägseilsystem, wie unter 1. beschrieben, zeichnet sich durch eine doppeltzylindrische Behelfsankerköpfe (2) aus, die auch bei Dauerbelastung keinerlei Ermüdungsbrüche aufzeigt. Zwei Typen dieser Behelfsankerköpfen stehen zur Verfügung. Beim ersten Typ Sind die Litzen (I) durch zwei Behelfskeile (2j) gesichert, die bei Bedarf einzeln ohne großen Aufwand entfernt und ersetzt werden können. In den Innerringen der Behelfsankerköpfen des zweiten Typs Sind die Litzen (I) einzeln durch Epoxydharz, Zinkpulver und Quarz (2q) verklebt. Diese Mischung verflüssigt sich beim Erhitzen, so dass die Keile dann ausgetauscht werden können.
4. Ein Schrägseilsystem wie in Abschnitt 1 dargestellt, ist außer durch das Kabelschutzsystem auch weitere Vermessungs-, Mess-, Kontroll- und Testeinrichtungen **gekennzeichnet**. Diese Einrichtungen sind im einzelnen: Feuchtigkeitsmesspunkte (5h, 5i), Entleerungsbohrungen (5j), Strangkontroll- und -test Abschnitte (5k, 5l) als auch Entleerungsventile. Die gleichen Teile, Trockenluftauslass (5o) und Feuchtlufteinlass (5p) des Entfechtungsgerätes (5g), als auch der Feuchtigkeitsmesspunkt dienen dem Schutz der Stränge außerhalb des Hauptan-

kersystems. Wenn der Trockenlufteinlass, Trockenluftleitungen, die Trockenluftauslässe, die Entlüfterbohrungen, Entlüfterrohre, die Feuchtluftauslässe, die Enfeuchtungsgeräte, und Trockenluftauslass und Feuchtlufteinlass des Entfechtungsgerätes (5a-5g, 5o, 5p) arbeiten sind alle hohlen Teile des Seil- und des Mast- verankerungsraumes der Luftcirculation erfüllt. Alles unter der Kontrolle der genannten Einrichtungen (5h - 5n).

Revendications

1. Un système de haubanage exclusivement pour les tendons avec des torons parallèles (I) couverts par une tube de couverture (Ib) que contient un système de protection, comprenant des entrées d'air sec (5a), des tuyaux de transmission d'air sec (5b), des sorties d'air sec (5c), des trous de ventilation (5d), des tuyaux de ventilation (5e), des sorties d'air humide (5f), une machine de déshumidification (5g), ainsi que quelques autres facilitées pour résumer, mesurer, contrôler et tester, qu'assurent les torons dans une condition observable, contrôlable et assez protégée, ledit système de haubanage est **caractérisé** aussi par:
 - Un bloc d'ancrage principal (1), dans lequel les tuyaux d'ancrage sont divisés en deux groupes symétriques, que puissent être arrangé sous la poutre d'acier I ou des autres poutres, de sorte que l'axe de câble et le plan principal de la poutre abdomen coïncident. Dans le pylône espace d'ancrage, les torons (Ia) en dehors du bloc d'ancrage principal ne sont pas coupés après le vérin final, car le remplacement de toron individuel et les torons seront sous la protection du ledit système de déshumidification,
 - Des blocs d'ancrage auxiliaires, à moitié cylindrique et double (2) que puissent être arrangé en les deux côtés du tissu (*web*) en poutre d'acier I (II), en ancrer la poutre de bandage (3) ou en ancrage fond d'acier. Basé sur l'aide des blocs d'ancrage auxiliaires, lesdits à moitié cylindrique et double (2), les coins ordinaires peuvent être utilisés sûrement dans le bloc d'ancrage principal,
 - L'ancrage des poutres de bandage (3) avec section I que peut être arrangé en pylône (III) pour faciliter l'arrangement des blocs d'ancrage auxiliaires et pour étendre l'utilisation du plan de câble verticale au plan de câble incliné avec l'aide des bandages tringles (3a),
 - Un ancrage fond de l'acier (4) avec plaque et tissu renforcé, que facilitent l'arrangement des blocs d'ancrage auxiliaires en pylône (III) aussi bien que sous les poutres (IIId) autres que la poutre d'acier I (II), afin de tenir des axes de

câble et tissu dans un même plan.

2. Un système de haubanage suivant la revendication 1, **caractérisé par** une division des trous d'ancrage dans le bloc d'ancrage principal en deux groupes symétriques. La distance centrale minimale (Dg) entre les deux groupes des trous est la même comme la grosseur du tissu (IIa) en poutre d'acier I (II), en bandage poutre d'acier (3) avec section I ou en ancrage fond d'acier (4) + diamètre (Dh) du trou d'ancrage torons (2c, 2d) en blocs d'ancrage auxiliaires (2a, 2b) + deux fois la grosseur (At) du mur intérieur des blocs d'ancrage auxiliaires (2a, 2b), pour faciliter l'arrangement du bloc d'ancrage auxiliaire, à moitié cylindrique et double (2).

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3. Un système de haubanage suivant la revendication 1, **caractérisé en ce que** le bloc d'ancrage auxiliaire, à moitié cylindrique et double peut résister fatigue chargement. Deux types de blocs d'ancrage auxiliaires sont créés pour sélection. Dans le bloc d'ancrage auxiliaire du premier type, les torons (I) sont ancrés individuellement par des coins auxiliaires (2j), que peut être débloqué quand le remplacement du toron individuel s'est accompli, sans blessure et concentration de stress. Dans les trous coniques du bloc d'ancrage de seconde type, les torons (I) sont rattachés par *époxy*, poudre de zinc et un mélange de sable quartz (2q), que se puissent être dissous par chauffage quand le remplacement du toron individuel s'est accompli.

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4. Un système de haubanage suivant la revendication 1, **caractérisé en ce que** le système de protection de câble comprend ensuite des autres facilités pour résumer, mesurer, contrôler et tester. Ces facilités sont : les points de mesurer l'humidité (5h, 5i), les trous de vidanger (5j), les échantillons pour contrôler et tester les torons (5k, 5l), complété avec une valve de vidanger (5m). Les membres similaires, la sortie d'air sec (5o) et l'entrée d'air humide (5p) de la machine de déshumidification (5g), ainsi que le point de mesurer l'humidité (5n) sont outillés pour protéger les torons en dehors du bloc d'ancrage principal. Quand les entrées d'air sec, les tubes de transmission d'air sec, les sorties d'air sec, les trous de ventilation, les tubes de ventilation, les sorties d'air humide, la machine de déshumidification, et la sortie d'air sec et l'entrée d'air sec de la machine de déshumidification (5a - 5g, 5o, 5p) marchent, l'air circule dans toutes les parties creuses du câble et le pylône espace d'ancrage, et la circulation d'air est inspectée et contrôlée par lesdites facilités (5h - 5n).

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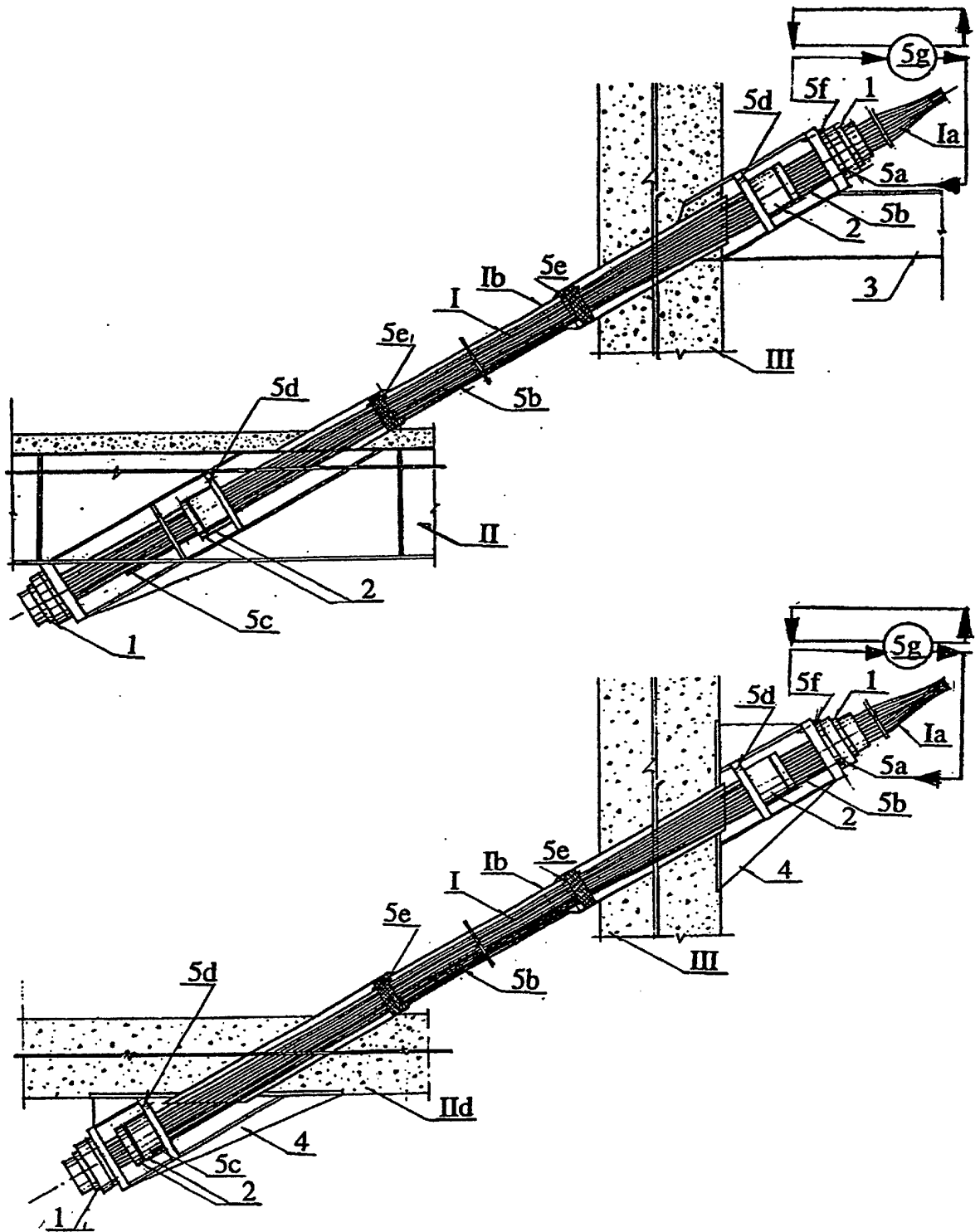


Figure 1.

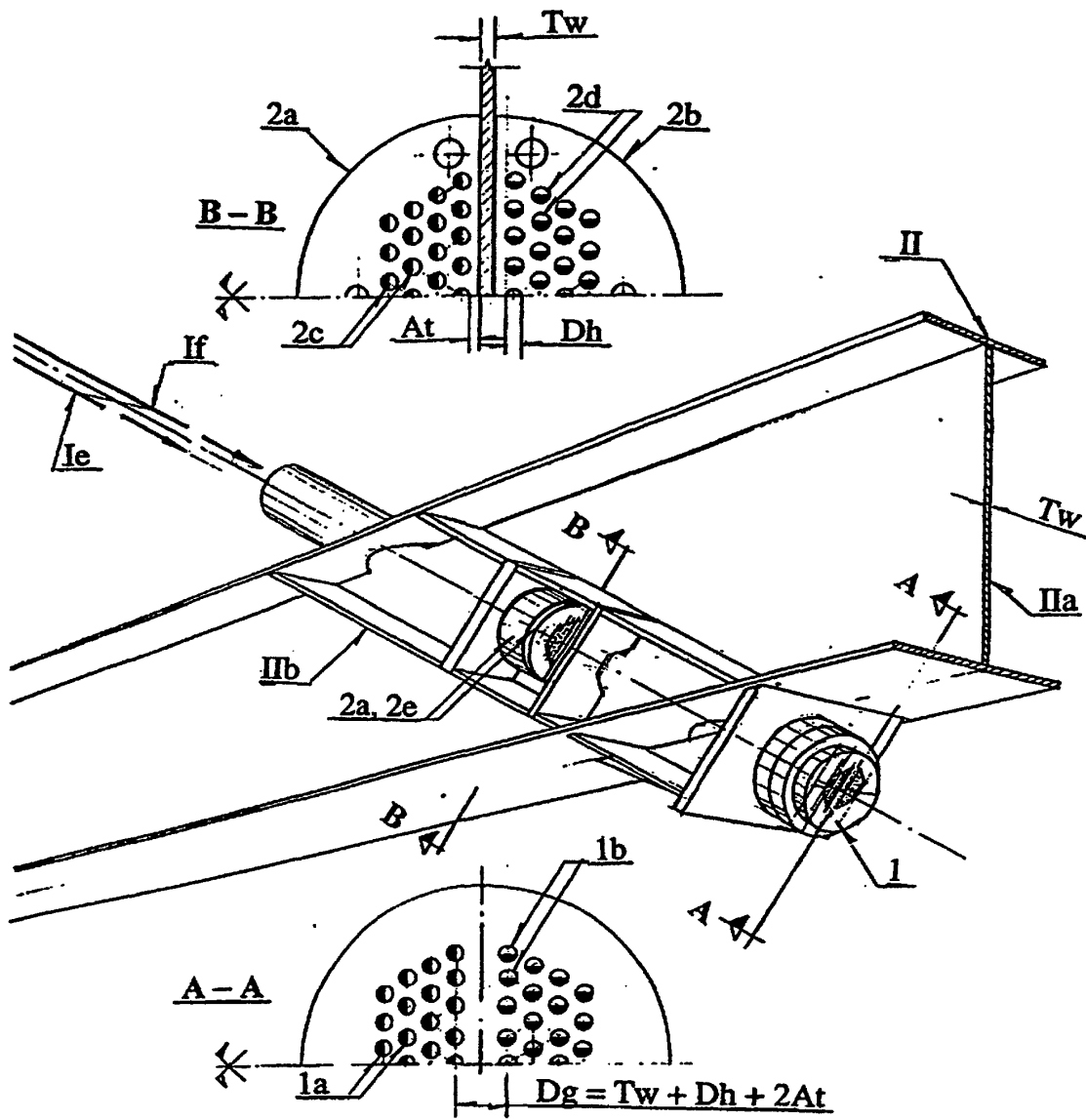


Figure 2.

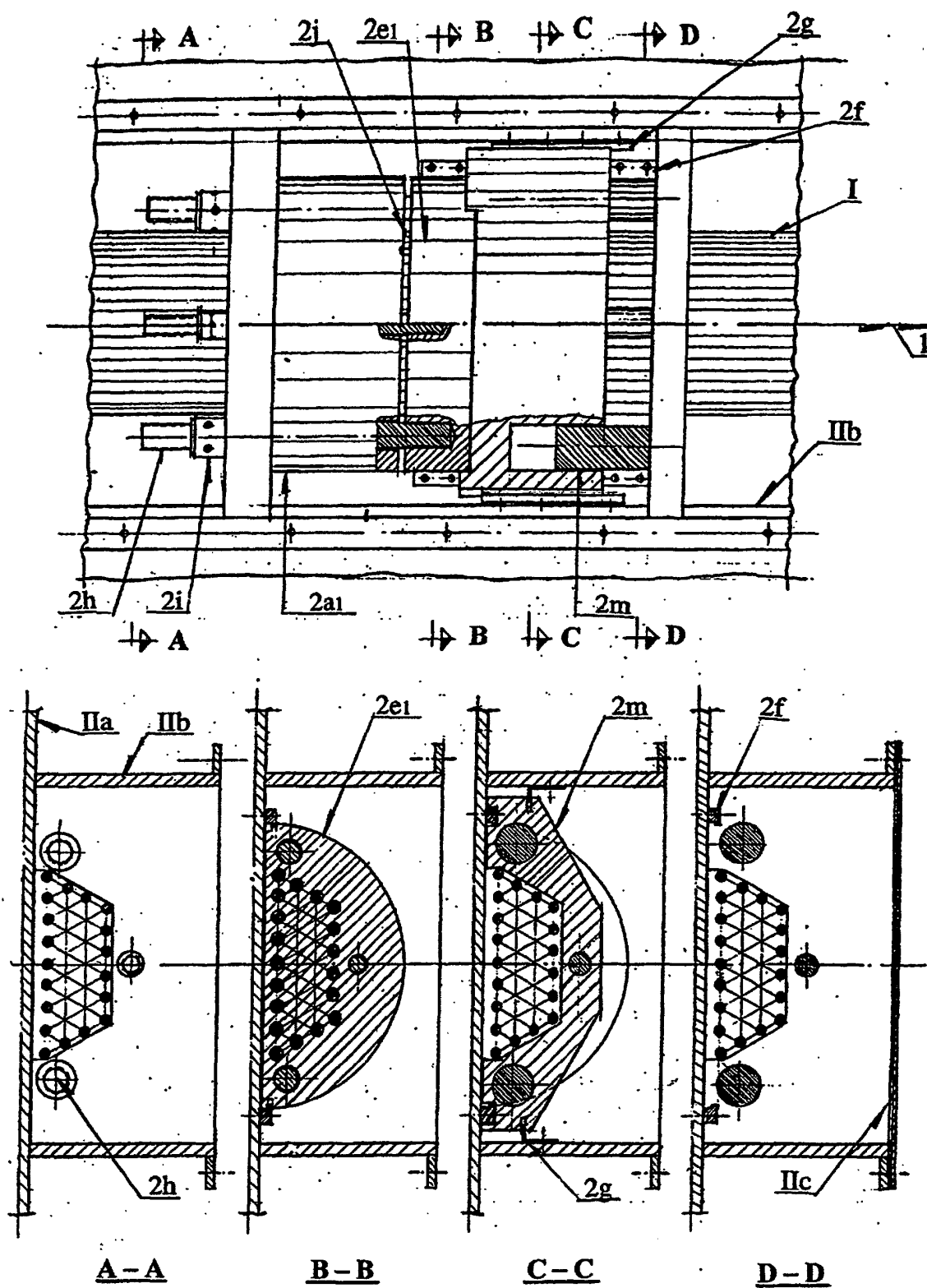


Figure 3.

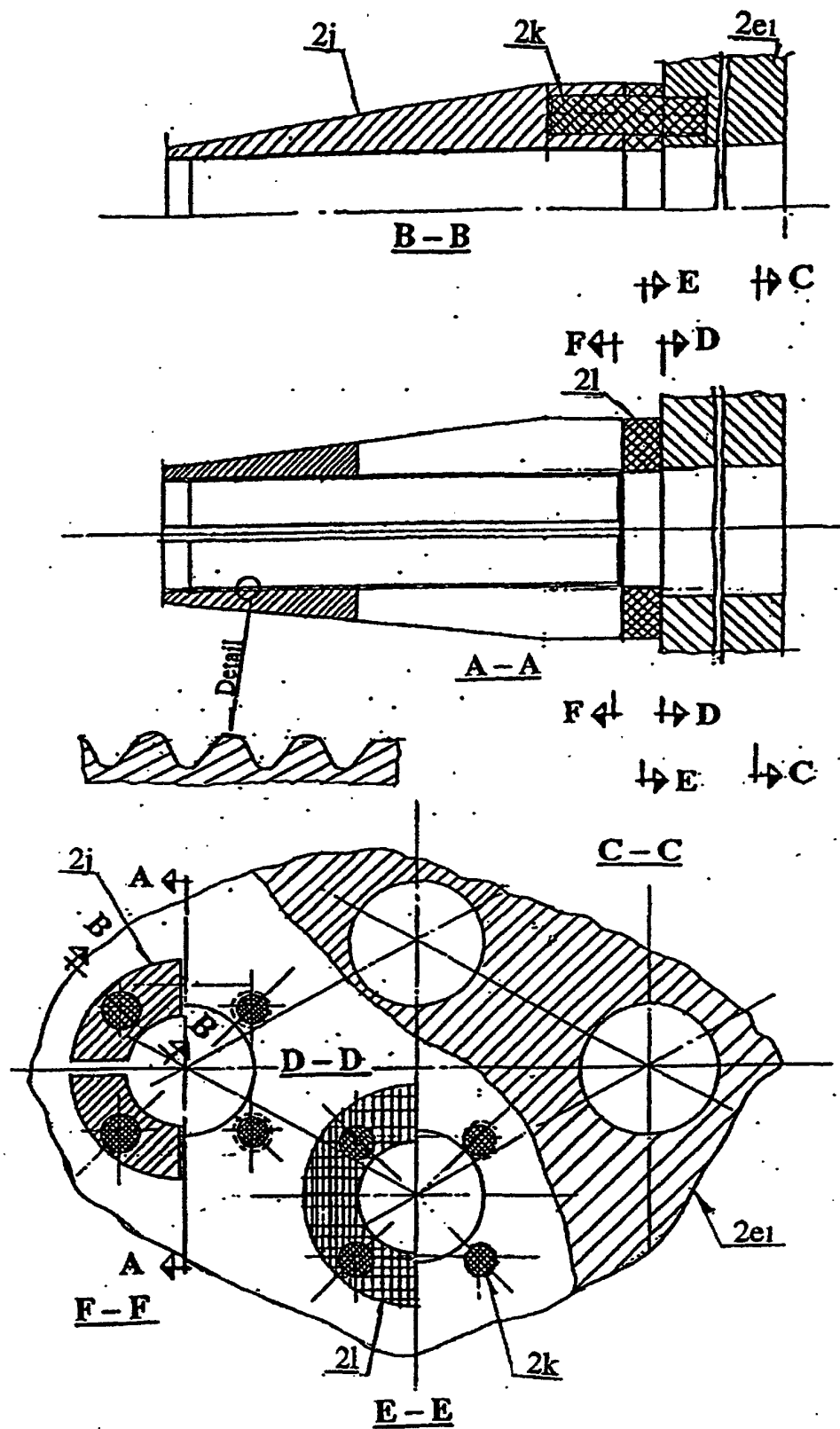


Figure 4.

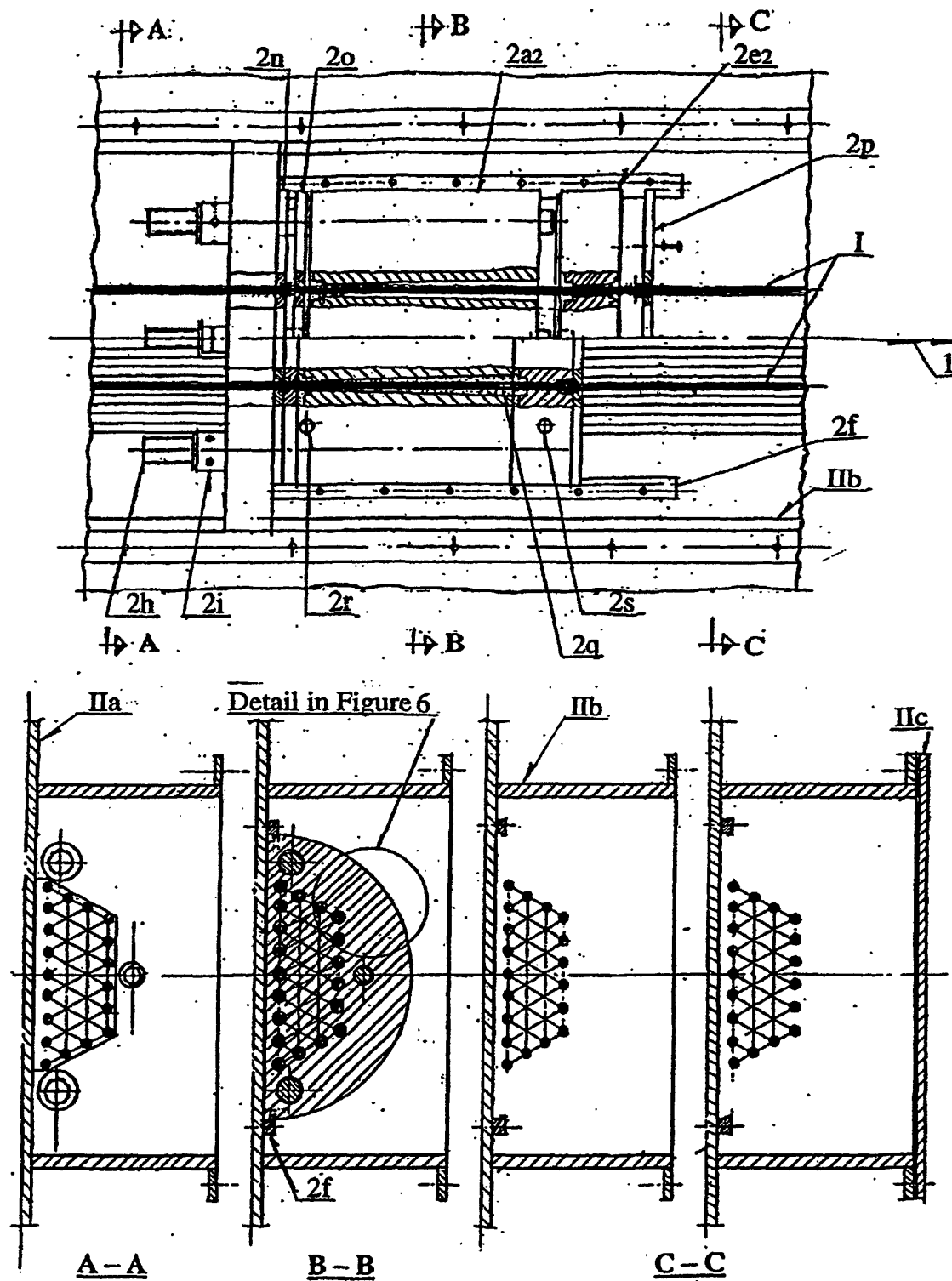


Figure 5.

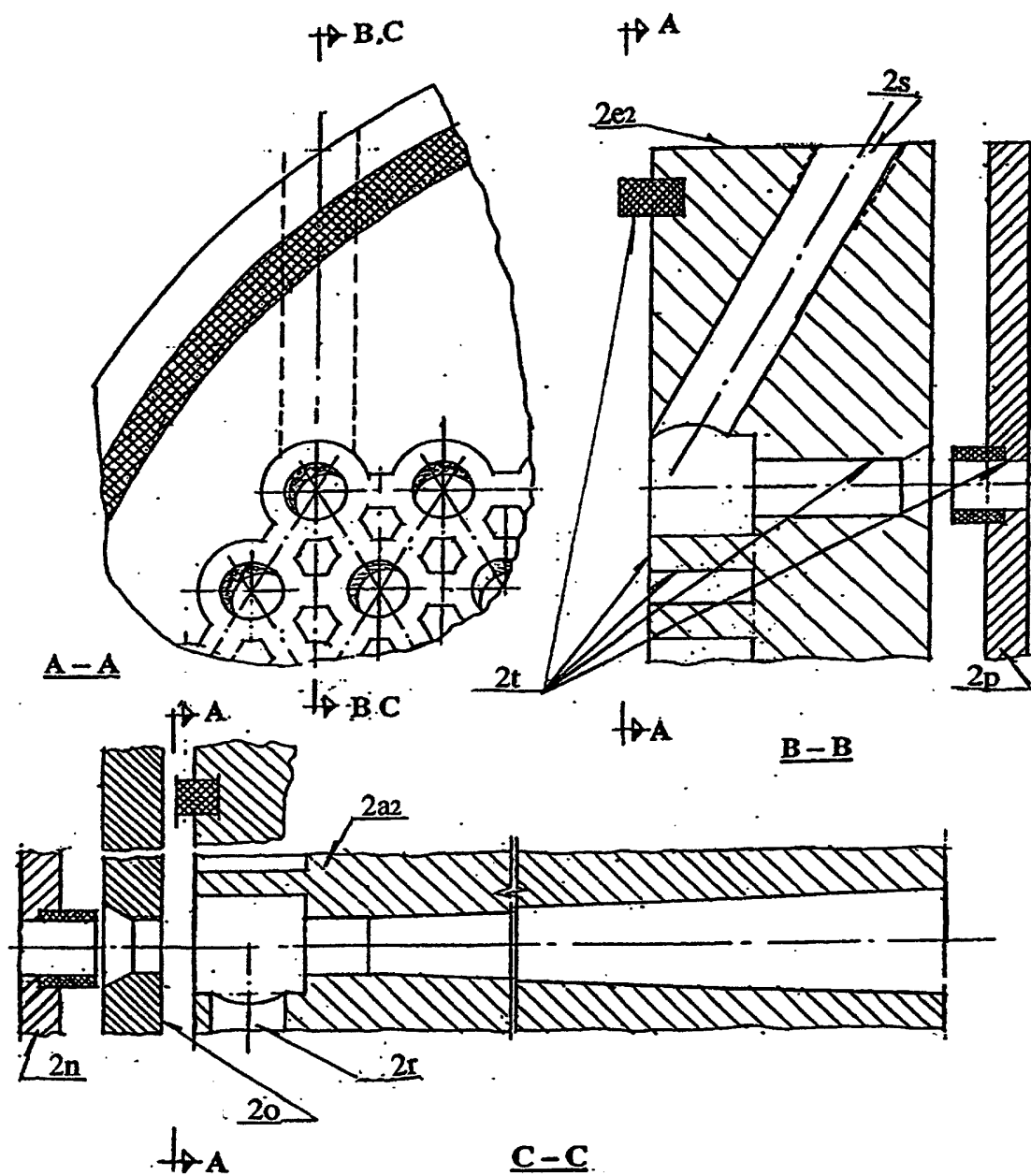


Figure 6.

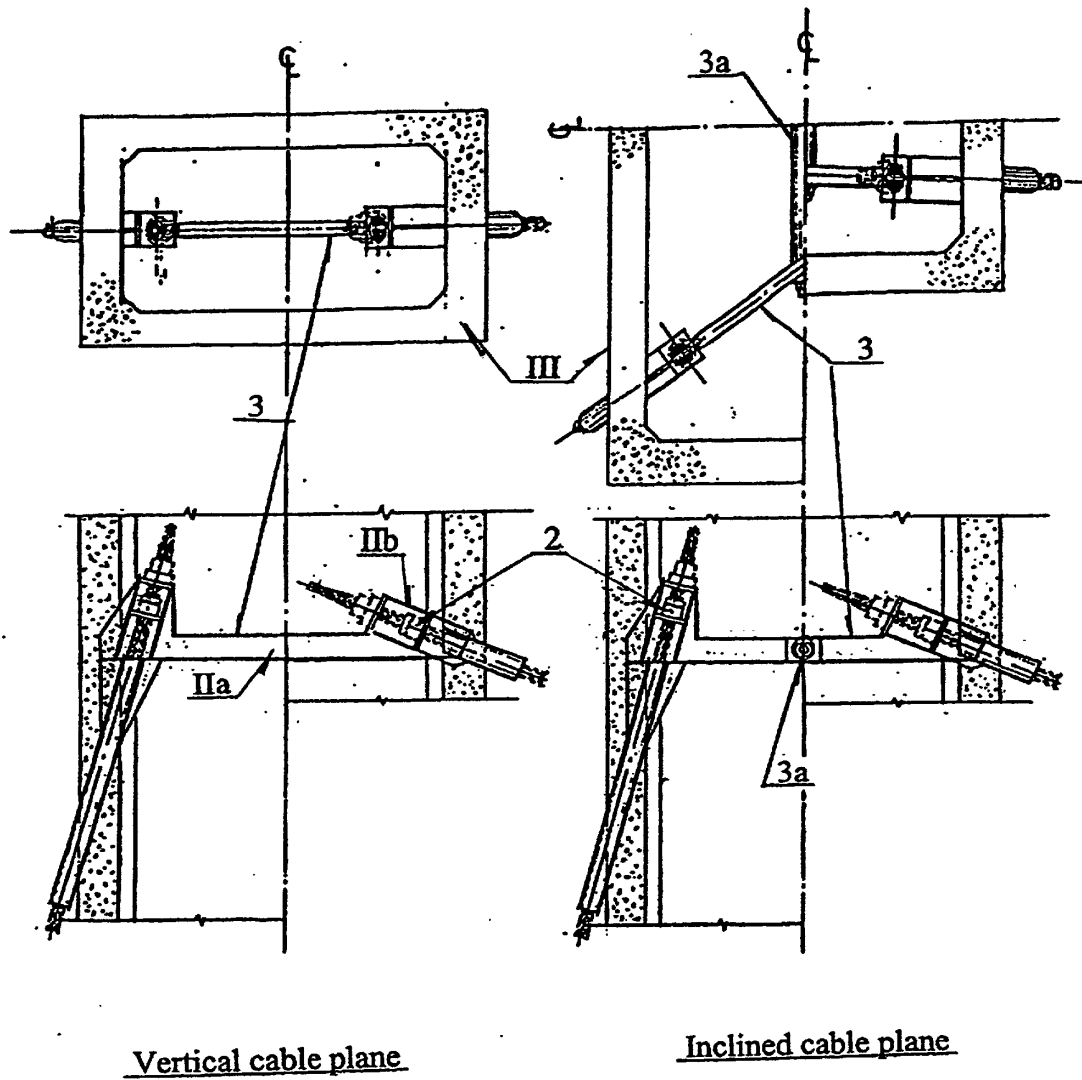


Figure 7.

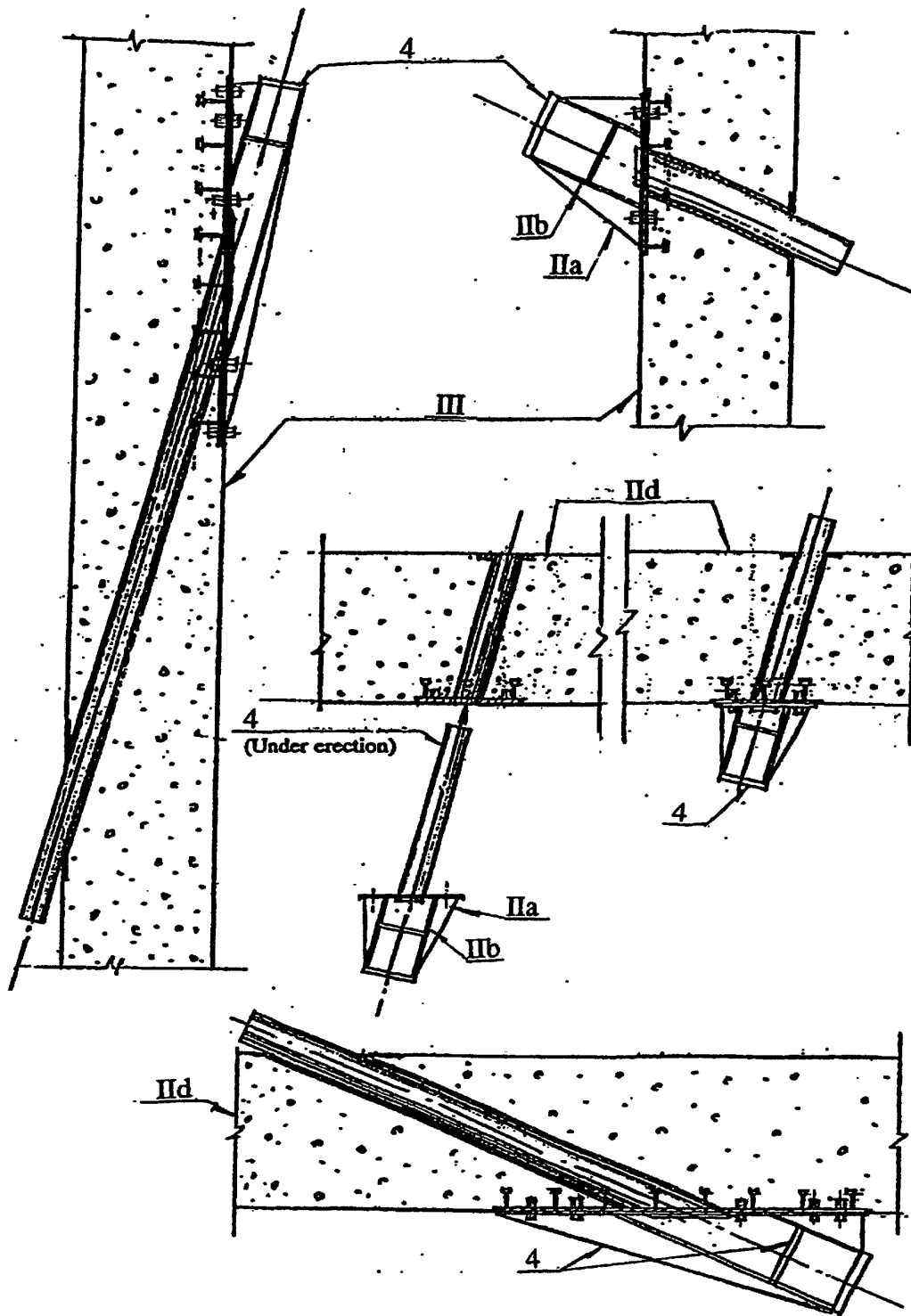


Figure 8.

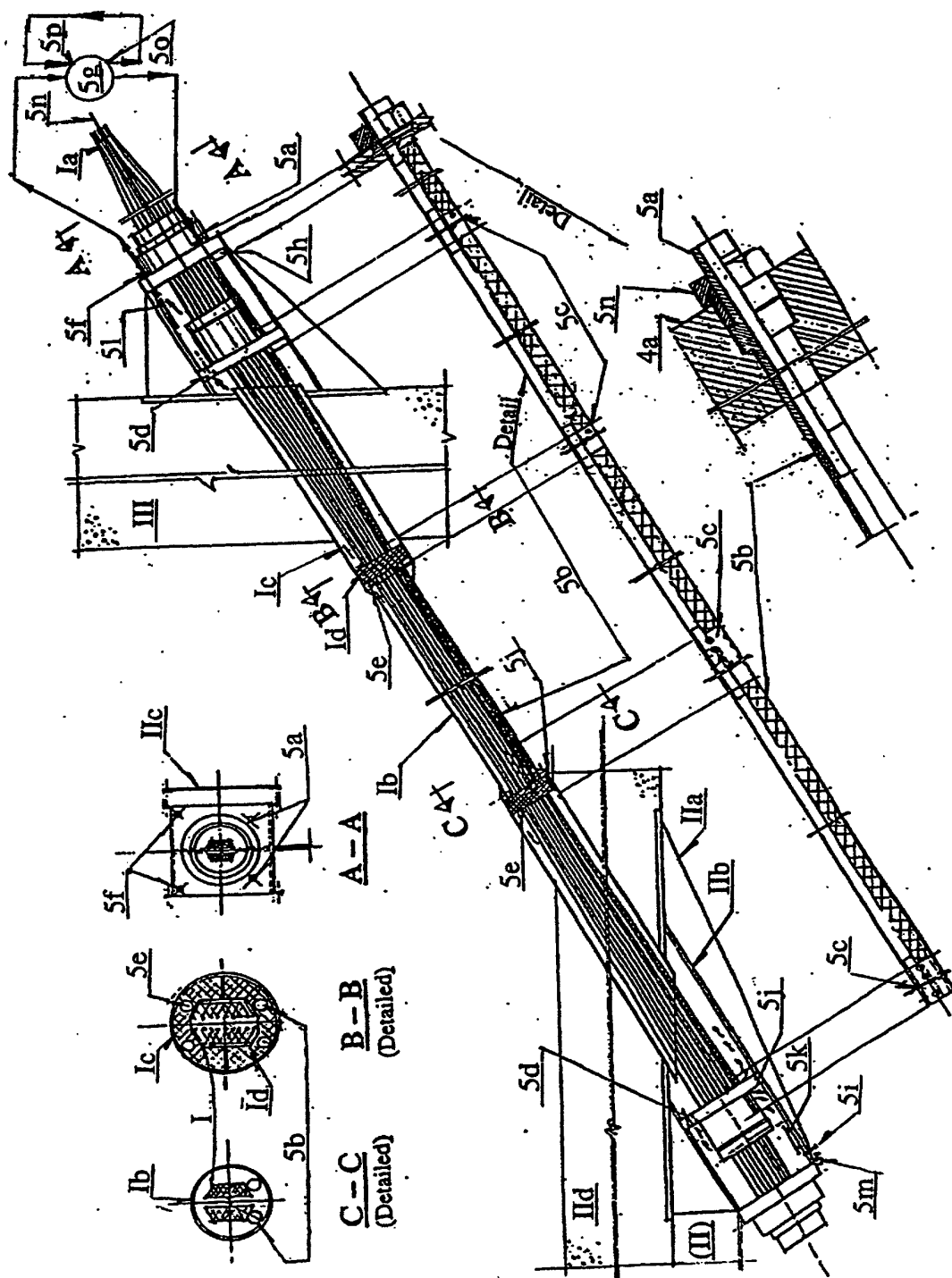


Figure 9.