



(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
14.12.2016 Bulletin 2016/50

(51) Int Cl.:
E02D 17/20^(2006.01) B21F 27/14^(2006.01)

(21) Application number: **14880649.0**

(86) International application number:
PCT/ES2014/070073

(22) Date of filing: **03.02.2014**

(87) International publication number:
WO 2015/114177 (06.08.2015 Gazette 2015/31)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(72) Inventor: **TORRES VILA, Juan Antonio**
E-20115 Astigarraga (Guipuzcoa) (ES)

(74) Representative: **Igartua, Ismael**
Galbaian S.Coop.
Polo de Innovación Garaia
Goiru Kalea 1 - P.O. Box 213
20500 Arrasate-Mondragón (ES)

(71) Applicant: **3S Geotecnia y Tecnologia S.L.**
20115 Astigarraga (ES)

(54) **METHOD AND MACHINE FOR PRODUCING MESH SHEETS**

(57) Method and machine for producing mesh sheets, wherein wires are shaped so as to form a spiral with each wire; different adjacent spirals are interlaced with one another, in pairs, to generate a mesh, different meshes are interlaced with one another to generate a mesh assembly (3), a lateral closure is made at both lateral ends (30) of the mesh assembly (3), and the mesh

assembly (3) is subjected to a pre-stressing process, a mesh sheet being obtained. The lateral closures of a mesh assembly (3) are made simultaneously, and each lateral closure is made by generating a plurality of closure knots. Each closure knot is made by twisting one end of one spiral around one end of the other spiral, and by subsequently bending the tips inwards.

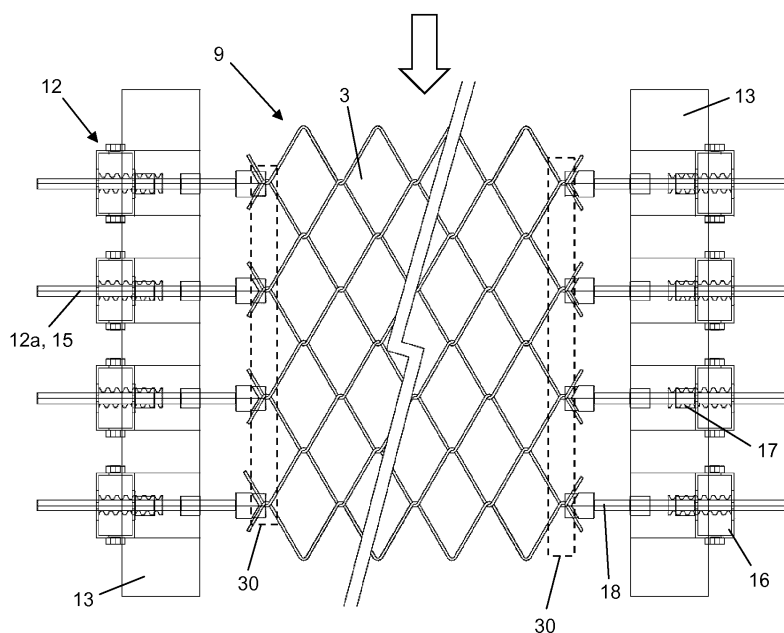


FIG. 7a

Description

TECHNICAL FIELD

[0001] The present invention relates to methods for producing steel wire mesh sheets, more specifically to those methods for producing single twist steel wire mesh sheets, with machines suitable for producing mesh sheets of this type. Furthermore, the present invention also relates to the possible field of application of the steel wire mesh sheets produced from the claimed production method or with the machine.

PRIOR ART

[0002] A steel wire mesh sheet generally consists of a metal framework obtained by braiding or weaving steel wires, there being different types differing from one another generally by their different geometrical configurations, by their production method, by the size of the inner cross-linking, by the use of different wire diameters and strength, or by the use of different types of anti-corrosive protection, among others.

[0003] Steel wire mesh sheets generally constitute an element that is widely used in a large number of applications, background documents relating to different types of steel wire mesh sheets mainly used in enclosures and industrial uses, having no structural function in these cases, being known. Generally and hereinafter, structural function will be understood as the mechanical behavior of the steel wire mesh sheets when, subjected to external actions or forces, it results in a flat stress state of the sheet or in a plurality of mesh sheets when said mesh sheets are connected to one another. Flat stress state of the element is understood as the physical stress state produced therein due to the stresses that are generated and contained in the plane of the mesh sheet which are caused by external actions or forces, which can be applied both in the directions contained in the plane forming the mesh sheet and in the direction perpendicular thereto, or a combination of both.

[0004] Both the mesh sheet alone and mesh sheets connected to one another have a characteristic behavior according to which, in the event of external actions, mainly in the direction perpendicular to the plane containing it, tensile stresses are generated therein in the directions contained in the plane thereof, where the main direction is identified as the longitudinal direction where strength is greater, and the secondary direction is defined as the transverse direction where strength is equal to or less than in the main direction, the behavior thereof possibly resembling that of a structural membrane from the physical and mechanical viewpoint.

[0005] The structural function of a membrane is characterized by the fact that the element must have such a tensile strength that it allows withstanding those external actions to which it will be subjected according to a controlled stress-deformation behavior, which means that

strain levels must be low for the high stress levels caused by external actions or forces. Structural membranes are generally two-dimensional, which means that two dimensions predominate over a third one, which is negligible.

[0006] Generally, within the different types of steel wire mesh sheets, ones comprising hexagonal inner grid patterns are known are usual, commonly known as double or triple twist meshes.

[0007] Steel wire mesh sheets of this type are produced by weaving, having an inner grid pattern formed by individual hexagons resulting from the repeated twist weaving of two wires with one another in alternating directions, so these twisted wires run in the longitudinal direction of the braiding and diagonally from one side to the other until producing the mesh sheet made of steel wire.

[0008] In this case, the type of wire is limited to the use of ductile steel, which has the quality of being easily bent, making it suitable according to the aforementioned method of production by weaving, which causes plastic strain on the wire due to repeated twisting without recovering its original shape once the production action forming it has ended.

[0009] The tensile strength of the wire used for allowing this type of production generally reaches about 550 MPa, with wire diameters being generally less than or equal to a 3.0 mm. These features are what allow producing the mesh sheet by bending and twisting the wires forming it as described, without breaking the wires or undoing the weave of the sheet once it is produced.

[0010] This type of mesh sheet is characterized by being flat or two-dimensional, given the type of framework and production method by weaving, which would tentatively make it suitable for use as a structural membrane. Nevertheless, in the event of external actions it presents very high strain, so it is not suitable for being used as a structural membrane.

[0011] Those steel wire mesh sheets commonly referred to as single twist meshes are also common and known. In this case, the production process uses technology that is also conventional and well known, just as in triple or double twist mesh sheets. In this case, the steel wire is bent, which thereby allows forming individual spirals from the wire which, when placed in the direction transverse to the forward movement of production of the mesh sheet, are interlaced with one another in pairs to generate meshes and these are interlaced, the final configuration of a steel wire mesh sheet being produced.

[0012] The production process starts with the formation of the individual spirals from the steel wire, said spirals being produced by bending the wire around a tool which rotates with a spiral groove, said tool pulling on the wire to form the spiral, which is characterized by a lead angle, height, pitch length and inner lumen of the spiral achieved by the configuration of the production tool. The variation of these parameters allows producing different geometrical configurations.

[0013] Therefore, the features of the type of wire used

are such that the ductility of the steel must allow producing spirals by bending the wires forming them, steel wires having a diameter of up to 5.0 mm and a tensile strength generally not exceeding 1,000 MPa being able to be used.

[0014] This type of mesh sheet is characterized by being three-dimensional, given the type of framework and the production method by braiding. The three-dimensional nature of the framework is defined by the inner lumen of the spiral that is produced. This three-dimensional nature means that if it is used as a structural membrane, in the event of external actions generating a stress state in the steel wire mesh sheet, said sheet will present very high strain due to reversion of the three-dimensional nature of the element, so it is not suitable for being used as a structural membrane.

[0015] Particularly, steel wire mesh sheets of this type or the attachment of several individual sheets, when said sheets are subjected to external actions they present the aforementioned problem of high strain, which is mainly controlled by the three-dimensional nature of the mesh sheet, among other factors. This phenomenon becomes more pronounced the greater the toughness of the wire, which makes it even more difficult to bend it and therefore does not allow reducing the inner lumen of the spiral. Therefore, this strain due to the action of external loads is too much to allow the use of these single twist mesh sheets made of steel wire or the attachment of several sheets as a structural membrane.

[0016] Generally, the strain of a single twist mesh sheet due to external actions has three components, the first component being a function of the production method and of the shape obtained by the framework itself of the mesh sheet and conferring it a three-dimensional nature. Particularly, in single twist mesh sheets produced by individually bending spirals and interlacing same, this phenomenon is controlled by means of reducing the inner lumen of the individual spirals and by means of reducing the radius of curvature of the vertexes of the spirals when subjected to external actions which cause tensile stresses in the mesh sheet. This strain component is permanent and the sheet cannot recover from it after the external actions are no longer applied because when the mesh sheet is subjected to stresses it is plastically deformed, the inner lumen of the spirals forming the mesh sheet and the radius of curvature of the vertexes of the spirals being reduced, resulting in permanent strain in the main direction of the mesh sheet.

[0017] The second component is a function of the type of lateral closure knots of the spirals used in the production of the mesh sheet. This strain component is permanent and the sheet cannot recover from it after the external actions are no longer applied because when the mesh sheet is subjected to stresses, at the same time the inner lumen of the spirals and the radius of curvature in the vertexes of the spirals are reduced, the lateral closure knots of the spirals also tend to open, and this results in introducing strain in the main direction of the mesh sheet.

It is commonly known that ends closed by bending the wires over themselves have been used for producing single twist-type steel mesh sheets. This type of closure does not allow interconnecting mesh sheets or applying important stresses transverse to the line of attachment, if two mesh sheets are attached along the line of knots.

[0018] The third component is an elastic component due to the strain of the steel under the stresses caused by applying external actions. The sheet can recover from this strain component provided that the elastic behavior range of the materials is not exceeded, and this strain is controllable, from the physical viewpoint since it is a function of the magnitude of the external actions applied on the mesh sheet and of the mechanical characteristics of said mesh sheet.

[0019] Therefore, conventional single twist mesh sheets can present a suitable tensile strength due to their geometrical configuration and the type and diameter of the steel wire used, but they have a creep strain phase as they are subjected to external actions. This phenomenon is characterized by a strain from which the sheets cannot recover for low increments of the external load or action when it first starts to be applied. This strain is a function of the structure of the framework of the steel wire mesh sheet, particularly of the inner lumen of the spirals, as well as the type of lateral closure of the spirals.

[0020] The existence of single twist mesh sheets produced with steel wire with a high elastic limit is particularly highlighted, with a steel wire strength that can reach up to 2,200 MPa. The production of these mesh sheets requires a complex production process and specific technology due to the difficulty in bending and producing flat spirals with steel wire having a high elastic limit given the lack of steel wire ductility and the excessive fragility of said steel wire as a result of its high toughness. Although these mesh sheets have a high tensile strength, in practice they present problems with creep strain when subjected to external actions as a function of the structure of the framework of the mesh sheet made of steel wire determined by the inner lumen of the spirals and by the type of lateral closure of the spirals. Furthermore, they have specific problems induced by the fragility of the wire, which leads to them breaking or failing for loads that are smaller than those for which they are theoretically conceived in the event of point or concentrated external actions.

[0021] In the field of the geotechnics, and particularly when dealing with slopes and hillsides, applications are known in which structural membranes are used in a mechanical system constituting a flexible system for stabilizing and protecting slopes.

[0022] The purpose of these systems is to prevent the terrain from moving since they fix the instable masses of soil and rocks in their original position, preventing them from moving, where the structural membrane is formed by different sheets connected to one another in a continuous manner for the purpose of withstanding the stresses generated by possible movements and lateral earth pres-

sure, combining said structural membrane with anchoring bolts in the ground driven deeply into the stable area of said ground.

[0023] Said structural membrane is subjected to actions of the ground resulting in tensile stresses and requiring it to be linked to the anchoring bolts by means of bracing elements and plates that allow the transmission of these stresses, offering a cover for the surface of the ground, and working as a stabilizing pressure supporting or distribution element.

[0024] This structural membrane produced by the application of a mesh sheet or the attachment of different mesh sheets, for which they are efficient in the system in which are used from the mechanical viewpoint, must be characterized in that since it acts like a membrane, it must offer high tensile strength but with low strain in the event of lateral earth pressure. Therefore, the type of the sheet must specifically be adapted to the demands of the structural membrane described above, particularly to the demand of offering high tensile strength with a low associated strain level. This means that the mesh sheets made of steel wire produced by conventional production processes are not suitable for this application due to their excessive strain under the action of external loads, so they have traditionally been used as a structural membrane mesh sheets made of steel cable nets, and when steel wire mesh sheets produced by conventional processes have been used, they have given rise to slope collapse failures due to the high strain of the element used as a structural membrane. Furthermore, mesh sheets must individually allow being securely connected, assuring the transmission of stresses. To that end, when using steel wire mesh sheets as a structural membrane, the lateral closure knot of the spirals must be located at the edge of the sheets, such that it does not introduce strain into the structural system or fail under the action of external loads, furthermore allowing the connection between adjacent mesh sheets.

[0025] In the field of geotechnics, retaining and protection kits against rock landslides and impacts of the dynamic shield or barrier type are also known, composed by a structure anchored to the ground and an element or capture surface connected to the aforementioned structure, among other solutions, steel wire mesh sheets serving as an interposition element against possible landslides and lateral earth (and/or snow) pressure. Any surface that interpositions, bears and retains possible landslides or impacts is understood as a capture surface.

[0026] Generally in these systems, the strain of the capture element is not a limiting aspect in the use of solutions of this type, but the mesh sheets to be used require a solid connection between individual mesh sheets to withstand impacts. Furthermore, there is often the need, which has not been resolved up until now, for the strain in the event of an impact to be controlled and limited, or the lateral earth and/or snow pressure in a retaining structure must be limited, so in these cases a low-structural strain membrane must be used as a capture element.

[0027] Given the considerations described above in relation to the current prior art in connection with the use of mesh sheets made of steel wire produced directly using conventional or industrial production processes, said steel wire mesh sheets cannot be applied directly as a structural membrane, given the significant effect that both the type of lateral closure knot of the spirals forming it and the three-dimensional structure controlled by the inner lumen of the spirals configuring the framework have on their stress-strain behavior.

[0028] The document ES 2374127 A1 belonging to the same applicant discloses a method for producing pre-stressed mesh sheets so that said mesh sheets do not present structural strains.

DISCLOSURE OF THE INVENTION

[0029] An object of the invention is to provide a method of producing mesh sheets as defined in the claims.

[0030] In the production method of the invention at least one plurality of steel wires are shaped to form, with each wire, an individual spiral having a specific width, different adjacent spirals are interlaced with one another to generate a mesh having a specific width every two spirals, different meshes are interlaced with one another a mesh assembly being generated, a lateral closure is made at both lateral ends of the mesh assembly, and said mesh assembly is pre-stressed producing a pre-stressed mesh sheet.

[0031] In the method, furthermore, the two lateral closures are made simultaneously, and each lateral closure is made by generating a plurality of closure knots, one closure knot being generated for each mesh and said closure knot being made by means of twisting one end of one of said spirals around one end of the other spiral by means of subsequently wrapping one end around the other end at a turning angle such that it allows keeping the tips of said ends in the plane of the mesh, and by subsequently bending said tips towards the inner part of the mesh assembly, and once the lateral closures are generated, in the method the mesh assembly is subjected to a pre-stressing process by controlled loaded drawing in the direction perpendicular to the meshes coinciding with the longitudinal direction of the mesh assembly, the mesh sheet being produced.

[0032] Closure knots not susceptible to strain are produced with the method of the invention, which thereby allow performing a suitable pre-stressing to produce a mesh sheet that can act, for example, as a structural membrane (which requires a controlled stress-strain behavior with low strain levels under external actions or an external load on the mesh sheet) or as a capture surface with controlled strain, since the closure knots are not affected during pre-stressing as a result of not being susceptible to strain due to how they are made, and they even allow an easy and robust attachment of different mesh sheets to one another to increase the size of the structural membrane and/or retaining kit.

[0033] Furthermore, the produced closure knot prevents the phenomenon of the knot coming undone due to stresses generated in the mesh sheet by the application of external actions, once said mesh sheet is in the field. Said stresses bring about a tendency to reverse the twisting that was done, and due to the bending of the tips, in the closure knots produced during the method of the invention the twisting is tightened towards the inner part of the mesh assembly (mesh sheet in this case), the closure knot being prevented from becoming undone, even acting in an opposite manner on said closure knot since this action tends to further tighten the closure knot, thereby conferring greater strength to the said closure knot and therefore making it so that it is not susceptible to strain.

[0034] Furthermore, as a result of the combination of the closure knots thus generated and the pre-stressing of the mesh assembly, a mesh sheet is produced having a reduced three-dimensional nature due to the reduction of the inner lumen and of the radius of curvature of the vertexes of the individual spirals. Additionally, as a result of the tips of the ends of the spirals forming a mesh remaining in the plane of the mesh once they are twisted, the mesh sheets can be easily transported and handled since said tips getting caught on something or creating uncomfortable situations are prevented, and they furthermore make it easier to install the mesh sheets for their final application since said tips do not have to be taken into account during said installation.

[0035] Another object of the invention is to provide a machine in which the mesh sheet production method like the one described above can be implemented. Therefore, as a result of the machine a mesh sheet comprising at least the aforementioned advantages is produced.

[0036] Another object of the invention relates to different possible applications of the mesh sheet produced with the method of the first object of the invention and/or with the machine of the second object of the invention, such as for example use thereof as a stabilization and slope protection flexible system (like a structural membrane), as the three-dimensional nature of the mesh sheet is avoided primarily as a result of the type of closure knots, or as a retaining and protection kit against rock landslides and impacts (as a capture surface with controlled strain).

[0037] These and other advantages and features of the invention will become evident in view of the drawings and the detailed description of the invention.

DESCRIPTION OF THE DRAWINGS

[0038]

Figure 1 a shows a spiral formed according to a preferred embodiment of the method of the invention.

Figure 1b shows a mesh formed by the interlacing of two adjacent spirals of Figure 1a, during the pre-

ferred embodiment of the method of the invention.

Figure 1c shows a mesh assembly formed by the interlacing of a plurality of meshes according to Figure 1b, during the preferred embodiment of the method of the invention.

Figure 2 shows a lateral end of a mesh, with the two ends of the spirals forming it.

Figure 3a schematically depicts the application of a twisting motion of the end of one spiral around the end of the other spiral of Figure 2, when forming a closure knot according to a first embodiment of the method of the invention, where resulting tips of each end are shown.

Figure 3b schematically depicts bending the tips of Figure 3a for forming the closure knot according to the first embodiment of the method of the invention.

Figure 4a schematically depicts the application of a twisting motion on the end of one spiral around the end of the other spiral of Figure 2, when forming a closure knot according to a second embodiment of the method of the invention, where resulting tips of each end are shown.

Figure 4b schematically depicts bending the tips of Figure 4a for forming the closure knot according to the second embodiment of the method of the invention.

Figure 5 shows a lengthening that is generated in a mesh assembly during a pre-stressing process of the method of the invention for obtaining a mesh sheet according to the invention.

Figure 6 schematically shows an embodiment of a machine according to the invention.

Figures 7a - 7c show a knotting unit according to the machine of Figure 6, with different stages of the pre-stressing process of the method of the invention.

Figure 8 shows a detail of a connection of an embodiment of a mesh sheet of the invention used in a stabilization and slope protection system with a point connection.

Figure 9 shows a detail of a connection of an embodiment of a mesh sheet of the invention used in a stabilization and slope protection system with a bracing line.

Figure 10 shows a detail of a connection of an embodiment of a mesh sheet of the invention used in a stabilization and slope protection system with two

bracing lines.

DETAILED DISCLOSURE OF THE INVENTION

[0039] A first aspect of the invention relates to a steel wire mesh sheets producing method. The method starts with shaping a plurality of steel wires so as to form, with each wire, a spiral 1 having a specific width A such as the one shown by way of example in Figure 1a, by means of a spiral forming process in which preferably at least two wires are shaped simultaneously, which provides a higher output than conventional methods where a single wire is used.

[0040] The process then continues by interlacing different adjacent spirals 1 with one another, in pairs, as shown by way of example in Figure 1b, to generate with each interlacing between two spirals 1 a mesh 2 with a width equal to the specific width A, as shown by way of example in Figure 3a, and the different successive meshes 2 are interlaced with one another generating a mesh assembly 3 like the one shown by way of example in Figure 1c.

[0041] The produced spirals 1 are automatically interlaced with other spirals, making up mesh assemblies 3 with a width A defined by the length of the spiral 1, preferably being between about 2.0 meters and about 3.5 meters as this is the standard measurement for the most common applications (for example as a structural membrane or protection kit, which will be discussed below), widths other than this width being possible in any case.

[0042] Once the mesh assembly 3 is produced, a lateral closure for the same is made at both lateral ends 30. Each lateral closure is made by knotting the spirals 1 sharing one and the same mesh 2 to one another. In this phase, the lateral closure is made simultaneously at both lateral ends 30 of the mesh assembly 3, a plurality of high-strength lateral closure knots 7; 7' not susceptible to strain being generated in each lateral closure. Each closure knot 7; 7' is formed first by twisting the ends 5 of two spirals 1 sharing one and the same closure knot 7; 7', and to that end one end 5 of one spiral 1 is wrapped around the end 5 of the other spiral 1. Then, the resulting tips 6 of the spirals 1 generated after twisting are bent towards the inner part of the mesh assembly 3.

[0043] The closure knot 7; 7' thus produced prevents the phenomenon of the knot coming undone as a result of stresses generated in the final mesh sheet 4 due to the application of external actions, once said mesh sheet 4 is in the field, bring about a tendency to reverse the twisting that was done since, due to the bending of the tips 6, the twisting is tightened towards the inner part of the mesh assembly 3 (mesh sheet 4 in this case), preventing the knot from becoming undone, even acting in an opposite manner since this action tends to further tighten the closure knot 7; 7', thereby conferring greater strength to said closure knot 7; 7' and therefore making it so that it is not susceptible to strain.

[0044] In a first embodiment, one end 5 of one spiral

1 is wrapped around the end 5 of the other spiral 1 to generate a closure knot 7 at about 360°. The method of generating the closure knot 7 according to the first embodiment is shown in Figures 3a - 3b from the state shown in Figure 2.

[0045] In a second embodiment, one end 5 of one spiral 1 is wrapped around the end 5 of the other spiral 1 to generate a closure knot 7' at about 180°, and the tips 6 are fixed to the mesh assembly 3, specifically to the corresponding spiral 1, by electric welding or by means of another equivalent attachment method. Therefore, the degree of twisting determined by wrapping one end 5 around the other end can be reduced to about 180° with respect to the first embodiment. In this case, it is the wrapping, bending and electric welding all together that helps prevent the phenomenon of the closure knots 7' from opening, preventing the closure knot 7' from coming undone. The method of generating the closure knot 7' according to the second embodiment is shown in Figures 4b-4c from the state shown in Figure 2.

[0046] In the two described embodiments, the process forming the closure knots 7; 7' is performed automatically and simultaneously.

[0047] In any of the embodiments of the method of the invention, once the closure knots 7; 7' are made, the pre-stressing process is performed by controlled loaded drawing of said mesh assembly 3, the mesh sheet 4 being produced as a result of the pre-stressing. In this phase of the production method, structural strain of the framework due to the three-dimensional nature thereof is eliminated due to reducing the inner lumen of the spirals 1 and reducing the radius of curvature of the vertexes of said spirals 1 forming the mesh sheet 4. Said treatment is possible due to the previous formation of the closure knots 7; 7' not susceptible to strain as described above. Therefore, the closure knots 7; 7' are made as described above, and they allow carrying out the pre-stressing process by controlled loaded drawing of the mesh assembly 3 for producing the mesh sheet 4 due to the fact that they are not susceptible to strain and due to their high strength.

[0048] Pre-stressing allows eliminating the strain component of the structure of the mesh sheet 4, permanently reducing the strain effect due to the three-dimensional nature of said mesh sheet 4, and it consists of subjecting the mesh assembly 3 to a straining process preferably under a controlled stress load in the longitudinal direction of the mesh assembly 4, the width A of the mesh assembly 3 remaining unchanged due to restriction of the movement in the transverse direction and support in the high-strength closure knots 7; 7' that are not susceptible to strain, which allows reducing the inner lumen of the spirals 1 and the radius of curvature of the vertexes of the spirals 1 forming the mesh sheet 4, and a lengthening ΔL in the main direction of the mesh assembly 3 coinciding with the pre-stressing application direction being caused as shown in Figure 5, and finally a mesh sheet 4, where said lengthening ΔL and a reduction of the inner lumen of the spirals 1 and of the radius of curvature of

the vertexes of said spirals 1 with respect to the mesh assembly 3 have been produced, being provided. The length of the mesh sheets 4 has no limitation, and it is generally variable and takes specific needs into account, generally being established by the maximum weight required of the mesh sheet 4 that is produced, which can furthermore be subsequently rolled up for transport.

[0049] In summary, any of the embodiments of the described production method allows controlling the load-strain properties of the produced mesh sheet 4 and thereby producing high-strength and low-strain steel wire mesh sheets 4, under the application of external actions in any direction subjecting the mesh sheet to a flat stress state, use thereof as a structural membrane being possible. Furthermore, the obtained closure knots 7; 7' allow attaching different mesh sheets 4 to one another in a juxtaposed manner by the line of closure knots 7; 7', thereby being able to use mesh sheets 4 thus produced and attached to one another as a continuous structural membrane.

[0050] The method of the invention can be carried out in a machine 100 like the one shown by way of example in Figure 6, which corresponds with a second aspect of the invention and will be described in detail below. In this case, the method comprises automatic intermediate steps, corresponding with:

- conveying the mesh assembly 3 from a feed unit 8 of the machine 100 where said mesh assembly 3 is formed to a knotting unit 9 of said machine 100 where the lateral closures are made; and
- conveying the mesh assembly 3 with the lateral closures from the knotting unit 9 to a drawing unit 10 of the machine 100, where said mesh assembly 3 is pre-stressed and the mesh sheet 4 is produced.

[0051] As discussed, a second aspect of the invention relates to a machine 100 in which any of the embodiments of the method according to the first aspect of the invention can be implemented.

[0052] The machine 100 comprises a wire feed unit 8 where individual spirals 1 are formed, where the spirals 1 are interlaced with one another in pairs to generate meshes 2 having a specific width A, and where successive meshes 2 are interlaced with one another creating a mesh assembly 3. The machine 100 further comprises a knotting unit 9, arranged after the feed unit 8, which receives the mesh assembly 3 from the feed unit 8 and where two lateral closures of the mesh assembly 3 are made simultaneously, generating closure knots 7; 7', and a drawing unit 10 arranged after the knotting unit 9, which receives the mesh assembly 3 with the closure knots 7; 7' from said knotting unit 9 and where the pre-stressing process by controlled loaded drawing of the mesh assembly 3 is performed, a mesh sheet 4 with a width A equal to the specific width A of the mesh assembly 3 but with a length that is longer than the length of said mesh assembly 3 (greater ΔL) being produced. The units 8, 9

and 10 are arranged in series and synchronized with one another, such that said machine 100 is suitable for automatically carrying out the method of the first aspect of the invention.

[0053] As shown in Figures 7a-7c, the knotting unit 9 comprises a plurality of twisting tools 12 for each of the lateral ends 30 of the mesh assembly 3, and a stationary structure 13 for each side of the mesh assembly 3. The twisting tools 12 are attached to the corresponding structure 13, said twisting tools 12 having freedom of rotation about their own longitudinal shaft 12a and simultaneous movement towards the spirals 1. Each twisting tool 12 comprises a head 18 holding the ends 5 of the spirals 1 sharing one and the same closure knot 7; 7', a ring 16 whereby it is fixed to the corresponding structure 13, a rotating horizontal shaft 15 introduced in the ring 16 with an inner spiral 17 for allowing the twisting motion on said ends 5 and their simultaneous longitudinal movement out of the mesh assembly 3 without the head 18 being able to move backwards, conferring to the lateral end 30 continuous pressure without being able to reduce same in the rotational and movement direction, which allows knotting without the strain conferred to the ends of the wires 6 of the adjacent and interlaced corresponding spirals 1 being able to be reversed, the twisting tool 12 being suitable for causing a twisting motion of up to 360°, such that it is suitable for causing a twisting motion of 360° (first embodiment of the method of the invention) or a twisting motion of 180° (second embodiment of the method of the invention).

[0054] The twisting tools 12 therefore allow the longitudinal movement thereof to assure moving close to the lateral end 30 of the mesh assembly 3 and to continue with the movement towards the exterior of the mesh sheet while at the same time the corresponding closure knot 7; 7' is formed, pressure on said closure knot 7; 7' being maintained so as to not allow the twisting to be reversed (Figure 7b). The twisting tools 12 are coupled to a motor (not depicted in the drawings) by means of a gear system, for example, providing the motor with sufficient torque for causing the necessary twisting for each pair of wire tips 6 comprised in each closure knot 7; 7' of the lateral end 30 of the mesh assembly 3.

[0055] The heads 18 of the twisting tools 12 allow forming the closure knot 7; 7' as described above, and furthermore allow bending the tips 6 towards the inner part of the mesh assembly 3, the heads 18 comprising a cone- or double wedge-shaped bending tool 18a, which can be pneumatically or mechanically driven for example, which pushes the tips 6 towards the inner part of the mesh assembly 3 and which arrange them parallel to the axis of the corresponding closure knot 7; 7' (Figure 7c).

[0056] The knotting unit 9 further comprises a terminal (not depicted in the drawings) associated with each twisting tool 12, and more specifically with the head 18 of said twisting tool 12 for when the second embodiment of the first aspect of the invention is implemented in the machine 100. Once the tips 6 are bent, the knotting process is

completed with an electric welding phase or an equivalent attachment phase, which is done by means of arranging on the heads 18 that allow bending a similar number of terminals for the electric welding. Said terminals fix the tips 6 of the ends 5 of the spirals to the wires of the corresponding spirals 1 when the two wires are put into contact with one another and a specific current is passed therethrough, forming an arc and allowing the integral and strong attachment therebetween.

[0057] As discussed, once the lateral closures are made, in the machine 100 the mesh assembly is conveyed to the drawing unit 10 where said mesh assembly 3 is drawn as shown in Figure 5, a mesh sheet 4 with an increased length (ΔL) but without reducing or varying the width A, and with a reduced inner lumen of the spirals 1 and a reduced radius of curvature of the vertexes of said spirals 1 being produced.

[0058] The conveying means used in the machine 100 for conveying the mesh assembly 3 from one unit to another can correspond with conventional conveying means that could be used by a person skilled in the art, so they are not described in detail.

[0059] A mesh sheet 4 produced according to the method of the first aspect of the invention or in the machine 100 of the second aspect of the invention can be used, alone or attached to other similar mesh sheets 4, in different applications due to its aforementioned features of not being susceptible to strain.

[0060] An example of application is as a structural membrane for supporting and distributing pressure in a stabilization and slope protection system, combined with a system of bolts, fixing the mesh sheet 4 (or mesh sheets 4) to the ground. The mesh sheets 4 made of wire will be sized according to the required strength level, defining the pitch of the spiral 1 and the diameter and tensile strength of the steel wires forming it, thereby producing a structural membrane with a specific tensile strength level and controlled strain behavior, obtained in the pre-stressing phase of the method by reducing the inner lumen of the spirals 1 and reducing the radius of curvature of the vertexes of said spirals 1 of the mesh sheet 4, and allowing the adjustment of the solution of the structural membrane to be used with respect to the support requirement of the ground.

[0061] When a mesh sheet 4 (or of the arrangement of more than single twist mesh sheet 4 made of steel wire) works as a structural membrane in a stabilization and slope protection system, said mesh sheet 4 must assure continued transmission of stresses from one mesh sheet 4 to another mesh sheet 4 when they are arranged adjacent and attached to one another. This is achieved by the existence of the closure knots 7; 7' that are not susceptible to strain which allow transferring stresses from some mesh sheets 4 to other mesh sheets 4, said stresses being transferred to a head of the bolts by means of distribution plates or connection plates, and, in some cases attachment cables and spirals, always with low strain levels of the mesh sheet 4 and without the

opening or strain of the closure knots 7; 7'.

[0062] The connection of the different mesh sheets 4 adjacent to one another to form a continuous structural support membrane is therefore done with connection elements, assuring the transmission of stresses between a mesh sheet 4 and the adjacent one and keeping both mesh sheets 4 integral with one another, preferably using a steel cable or another element assuring a firm connection.

[0063] In any case, the attachment between two adjacent mesh sheets 4 by the corresponding lateral ends 30 with closure knots 7; 7' is assured and guaranteed in the event of the application of external actions generating stresses in the mesh sheets 4, due to the type thereof as described in the present invention, since they are high-strength closure knots 7; 7' that are not susceptible to strain, which assures that, in the event of using a connection element like the one described, there will be no faults in the lateral end 30 due to the closure knots 7; 7' opening under a load.

[0064] The total distribution surface thereby obtained by the repeated attachment described between adjacent mesh sheets 4 must be braced along the entire perimeter of the area to be stabilized. The structural membrane may internally be integrally connected to bolts 22 by means of special connection elements 21; 23, having an inner bore to receive the bolt 22 and allow supporting a connection nut 29, and the assembly may or may not be reinforced by means of bracings 24, which are preferably horizontal, consisting of one or several cables for conferring a higher degree of support to the assembly and determining the geometrical configuration of the connection element 21; 23. Depending on the type and arrangement of the bracings 24 and connection elements 21; 23 to which the structural membrane is fixed to assure the efficient and continuous transmission of stresses from said membrane to the bolts 22 connecting it to the stable area of the ground, the obtained system will have a behavior that is consistent with a geotechnical model that allows establishing the degree of stabilizing support conferred to unstable ground.

[0065] Reference can therefore be made to a stabilizing system with a point connection like the one shown in Figure 8, when the mesh sheet 4 (or attached mesh sheets 4), acting as a structural membrane, is braced around the perimeter in a continuous manner and fixed at points by means of at least one distribution plate 21 directly to the head of the bolts 22 in the inner area thereof, with a density and arrangement thereof that is preferably staggered (not depicted in the drawings) and determined by a result of the geotechnical lateral earth pressure stability calculations.

[0066] Reference can also be made to a reinforced stabilizing system when a mesh sheet 4 (or attached mesh sheets 4), acting as a structural membrane, is braced around the perimeter in a continuous manner and fixed integrally to the head of the bolts 22 in the inner area thereof by means of connection plates 23 and horizontal

reinforcement bracings 24, with a bracing line as shown in Figure 9 or with two bracing lines as shown in Figure 10, preferably high-strength steel cables, which are placed longitudinally along the slope and uniformly spaced along the height thereof. Spirals 25 made of steel wire are preferably used for connecting the reinforcement cables to the structural membrane like the one shown in Figures 9 and 10, said spirals 25 having the same diameter and being of the same type of wire used for producing the mesh sheet 4, with a pitch proportional to that of the mesh sheet 4 to allow the connection thereof as disclosed. Optionally, different mesh sheets 4 could also be connected to one another by means of using a steel cable or another element assuring a firm and continuous connection.

[0067] The different connection sectors for connecting the bracings to the structural membrane can be made independent and alternating, providing solid attachments that prevent, in the case of a connection breaking, the transmission of the failure to the remaining sectors.

[0068] Once this distribution surface is installed, subjected to a load and correctly attached to the ground as a structural membrane of a stabilizing system, due to the low strain level it has when subjected to a load due to the action of lateral earth pressure, said surfaces allows obtaining a system that is suited to the support requirement levels of the ground by adapting the structural membrane to be used in terms of its geometry, the strength of the steel and the diameter of the wire.

[0069] Another example of application is as a structural membrane used as a capture surface in a retaining kit for retaining flows of mud or detritus, lateral earth and/or snow pressure and protection against rock landslides and impacts, suitably fixed to the support structure of the kit such that if a lateral pressure force or an impact transfers the stresses generated on it to the structure consisting of posts, cables and bolts driven into the ground without any opening or strain of the knots and with strain control.

[0070] Generally, the technology of wire mesh sheets 4 existing today, particularly those known as single twist and produced with different diameters and grades of steel, can be applied in general uses but not directly as structural membranes with a strength function, where high strength and low strain are fundamental.

[0071] The mesh sheets 4 of the invention can be subjected to external actions producing a flat stress state therein, but with low strain levels.

[0072] These structural membranes allow, under working conditions, and particularly during their preferred use as a structural support and distribution membrane as part of a slope stabilizing system, as a capture surface of a retaining kit for retaining flows of mud or detritus, lateral snow pressure and protection against rock landslides and impacts, or generally for any application in which a structural function is required, a controlled load-strain behavior with low strain levels for high load levels.

Claims

1. Method for producing steel wire mesh sheets, wherein a plurality of steel wires are shaped so as to form a spiral (1) having a specific width (A) with each wire, different adjacent spirals (1) are interlaced with one another, in pairs, to generate a mesh (2) having a specific width (A), different meshes (2) are interlaced with one another a mesh assembly (3) being generated, a lateral closure is made at both lateral ends (30) of the mesh assembly (3), and the mesh assembly (3) is subjected to a pre-stressing process by controlled loaded drawing in the direction perpendicular to the meshes (2), coinciding with the longitudinal direction of the mesh assembly (3), a mesh sheet (4) being obtained, **characterized in that** in the method, furthermore, the two lateral closures of a mesh assembly (3) are made simultaneously and each lateral closure is made by generating a plurality of closure knots (7, 7'), a closure knot (7; 7') for each mesh (2) and for each lateral closure being generated, and each closure knot (7; 7') being made by twisting one end (5) of one of the corresponding spirals (1) around one end (5') of the other corresponding spiral (1) with a turning angle such that it allows keeping the tips (6, 6') of said ends (5, 5') in the plane of the mesh (2), and by subsequently bending said tips (6, 6') towards the inner part of the mesh assembly (3).
2. Method according to claim 1, wherein the mesh assembly (3) is generated in a feed unit (8), and, in the method, said mesh assembly (3) is moved automatically to a knotting unit (9) where the lateral closures of said mesh assembly (3) are made simultaneously the closure knots (7; 7') being generated, and said mesh assembly (3), with the lateral closures having been made, is moved automatically to a pre-stressing unit (10) where said mesh assembly (3) is pre-stressed, the mesh sheet (4) being generated in said pre-stressing unit (10).
3. Method according to claim 1 or 2, wherein during the pre-stressing process of the mesh assembly (3) the closure knots (7, 7') are laterally supported, only their simultaneous longitudinal movement being allowed, a mesh sheet (4) being obtained in which a longitudinal lengthening (ΔL) and a reduction of the inner lumen of the spirals (1) and of the angle of the vertexes of said spirals (1) with respect to the mesh assembly (3) have taken place while at the same time a constant width (A) is maintained.
4. Method according to any of claims 1 to 3, wherein the turning angle of one end (5) of one spiral (1) with respect to one end (5') of the other spiral (1') of a mesh (2) to generate a closure knot (7) is 360°.

5. Method according to any of claims 1 to 3, wherein the turning angle of one end (5) of one spiral (1) with respect to one end (5') of the other spiral (1') of a mesh (2) to generate a closure knot (7') is 180°, and wherein the bent tips (6, 6') are attached to the corresponding spiral (1) by electric welding or by means of another equivalent attachment method.
6. Machine for producing steel wire mesh sheets, comprising a wire feed unit (8) where individual spirals (1) are formed, where the spirals (1) are interlaced with one another in pairs to generate meshes (2) having a specific width (A), and where successive meshes (2) are interlaced with one another a mesh assembly (3) being created, **characterized in that** it further comprises a knotting unit (9) arranged after the feed unit (8), which receives the mesh assembly (3) from the feed unit (8) and where the two lateral closures of said mesh assembly (3) are made simultaneously, the closure knots (7, 7') being generated, and a drawing unit (10) arranged after the knotting unit (9), which receives the mesh assembly (3) with the closure knots (7, 7') already made from said knotting unit (9) and where the pre-stressing process is performed by controlled loaded drawing of said mesh assembly (3), a mesh sheet (4) being produced, said units (8, 9, 10) being arranged in series and synchronized with one another.
7. Machine according to claim 6, wherein the knotting unit (9) comprises one twisting tool (12) for each of the closure knots (7, 7') and a fixed structure (13) for each lateral closure of the mesh assembly (3), all the twisting tools (12) being associated with one and the same lateral closure of the mesh assembly (3) attached to the corresponding structure (13) with freedom of rotation about its own transverse shaft (12a) and with freedom of simultaneous transverse movement, each twisting tool (12) comprising a head (18) for holding a closure knot (7; 7'), a ring (16) fixed to the corresponding structure (13), a transverse shaft (12a), an inner spiral (17) for allowing the twisting motion of the twisting tool (12) around the ends (5) of the corresponding closure knot (7; 7') and their simultaneous longitudinal movement towards the inner part of the mesh assembly (3) without the head (18) of the twisting tool (12) being able to move backwards and for conferring a specific pressure to the corresponding closure knot (7; 7') in the rotational and movement direction which allows the knotting without the strain conferred to the tips (6) of the ends (5) of the spirals (1) sharing said closure knot (7; 7') being able to be reversed, the twisting tool (12) furthermore being suitable for rotating a predetermined turning angle of at least 360°.
8. Machine according to claim 7, wherein the head (18) of the twisting tools (12) comprises a cone or double wedge shape pneumatically or mechanically driven for bending the tips (6) of the ends (5) of the corresponding closure knot (7; 7') into the mesh sheet (4).
9. Machine according to claim 8, wherein the head (18) of the twisting tools (12) is suitable for causing the attachment of said bent tips (6) to the mesh sheet (4), preferably by electric welding.
10. Steel wire mesh sheet **characterized in that** it is produced with the method according to claims 1 to 5 and/or with the machine according to claims 6 to 9.
11. Stabilization and slope protection flexible system, **characterized in that** it comprises at least one mesh sheet (4) according to claim 10 as a structural membrane in a mechanical system in which the production process allows controlling the strain level under possible external actions caused by lateral earth pressure.
12. Retaining and protection kit against rock landslides and impacts, **characterized in that** it comprises at least one mesh sheet (4) according to claim 10 as a capture surface with controlled strain.

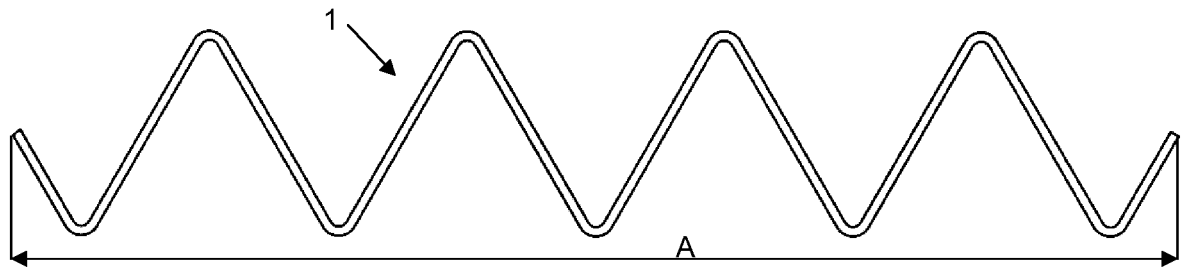


FIG. 1a

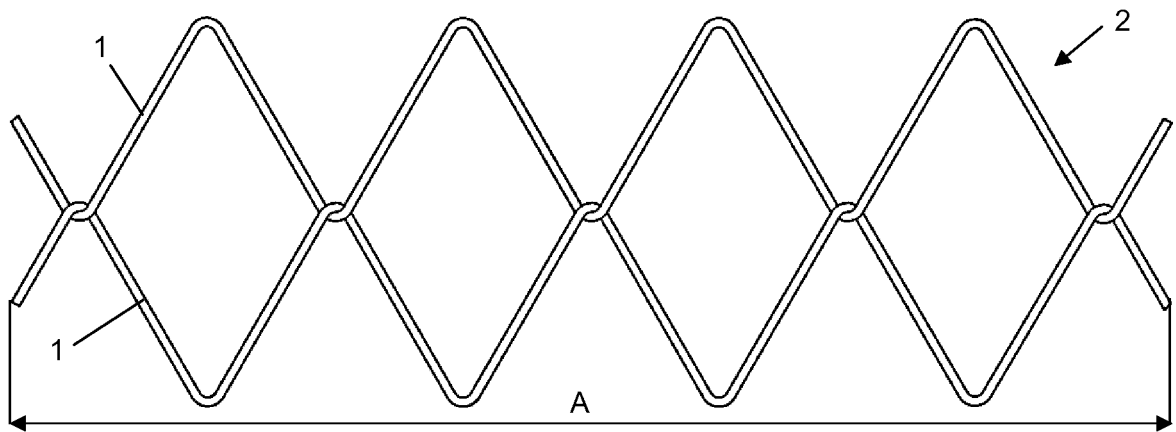


FIG. 1b

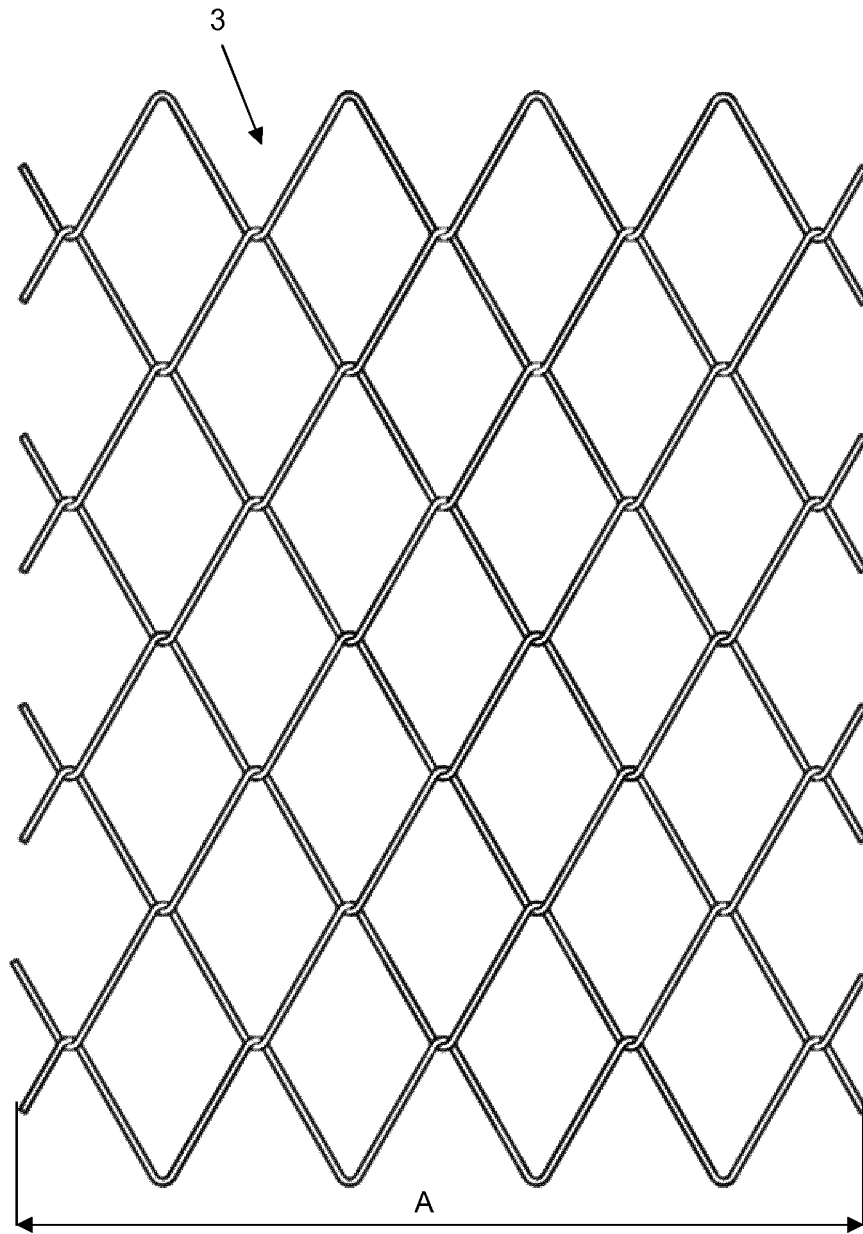


FIG. 1c

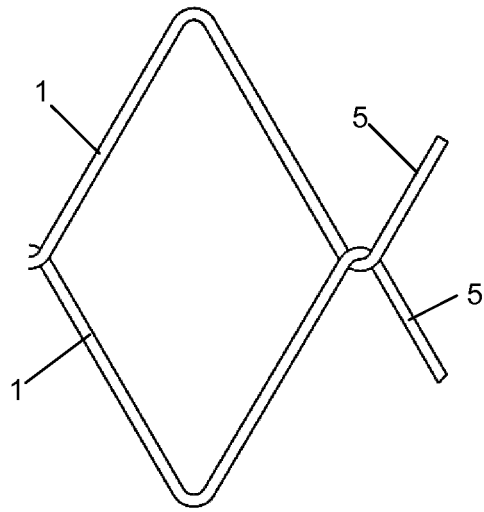


FIG. 2

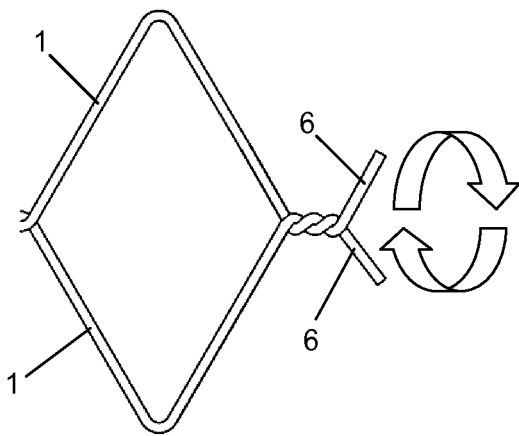


FIG. 3a

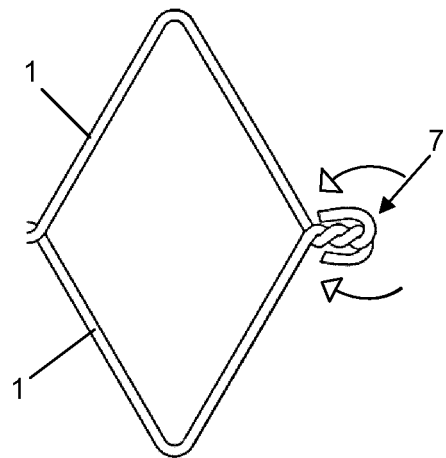


FIG. 3b

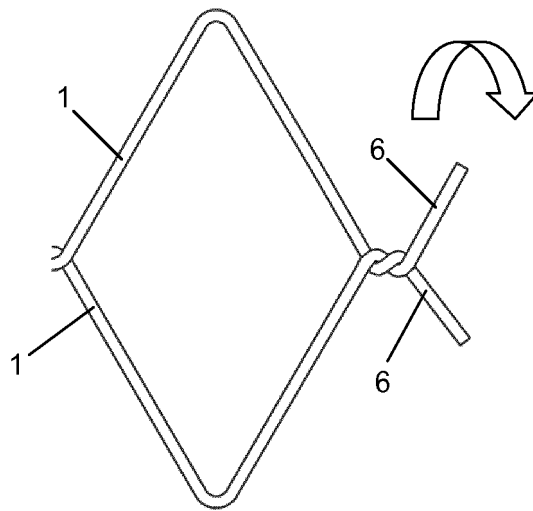


FIG. 4a

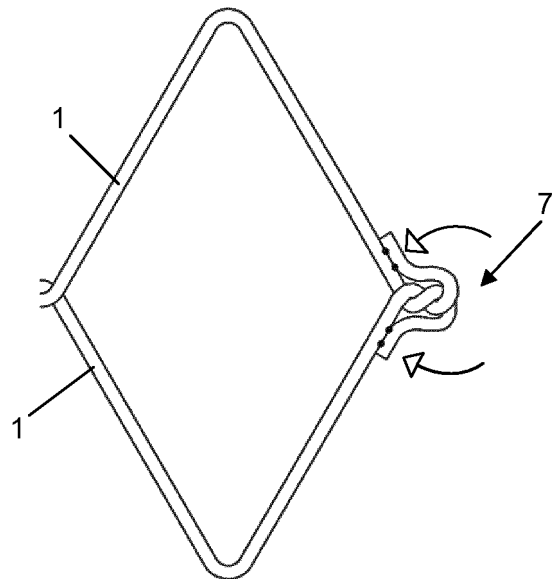
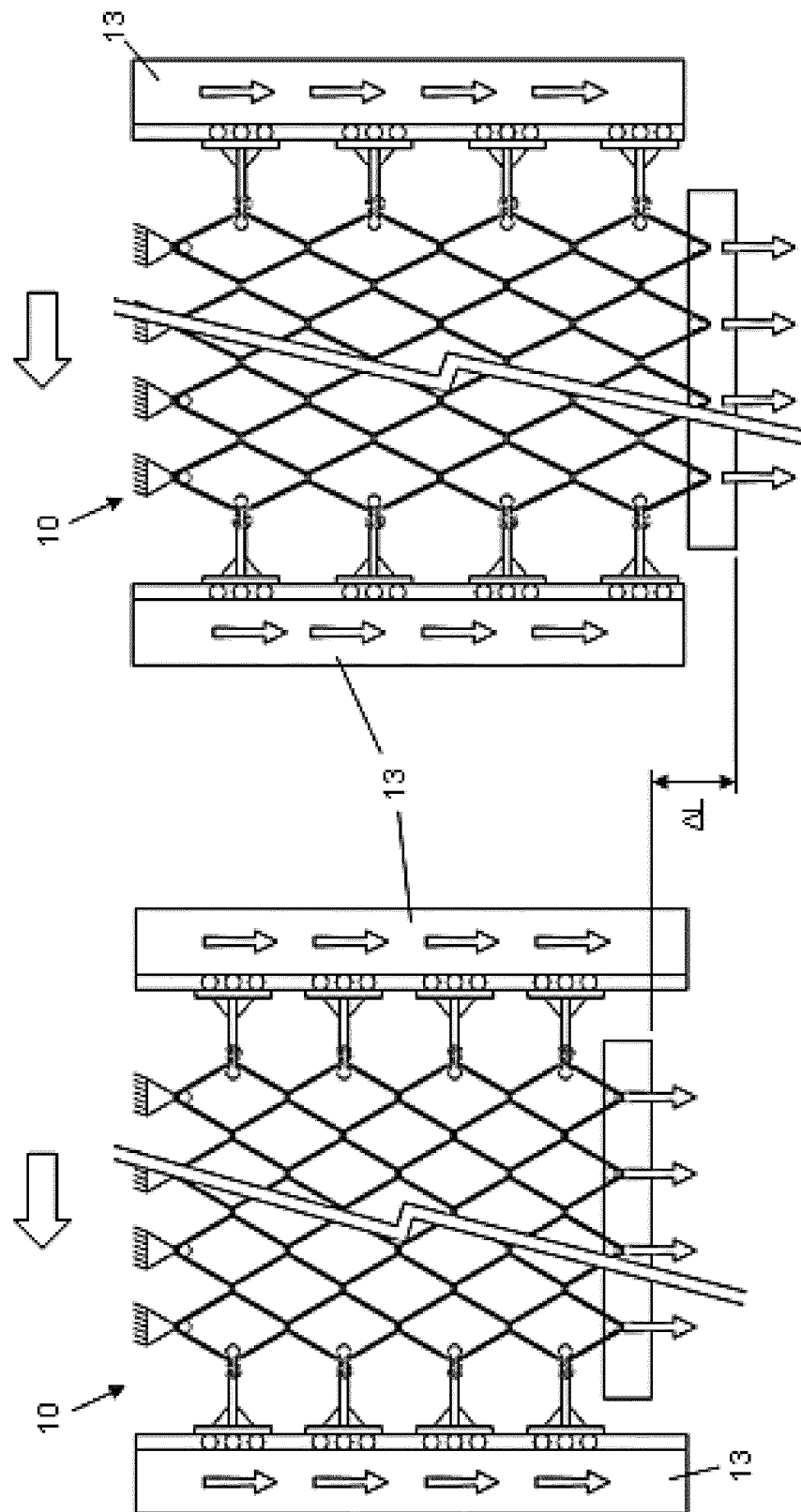


FIG. 4b

FIG. 5



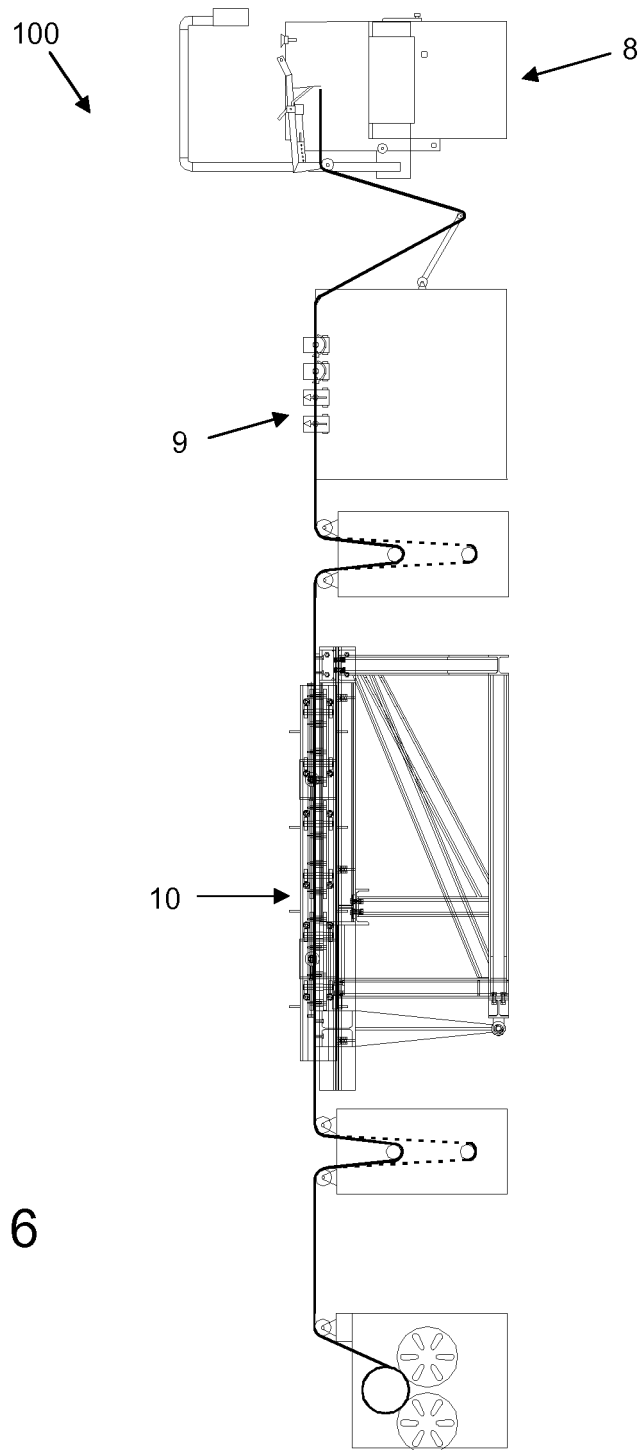


FIG. 6

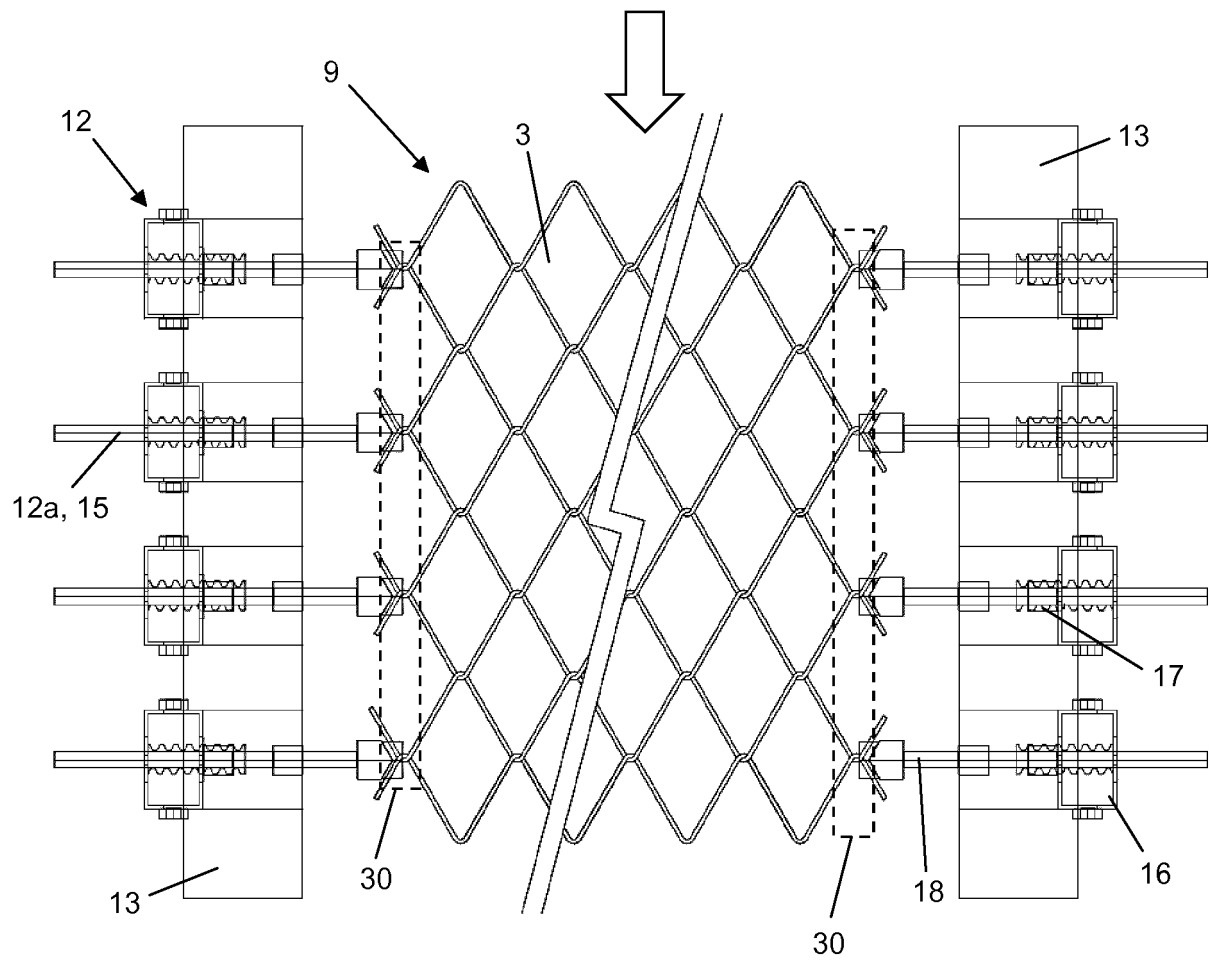


FIG. 7a

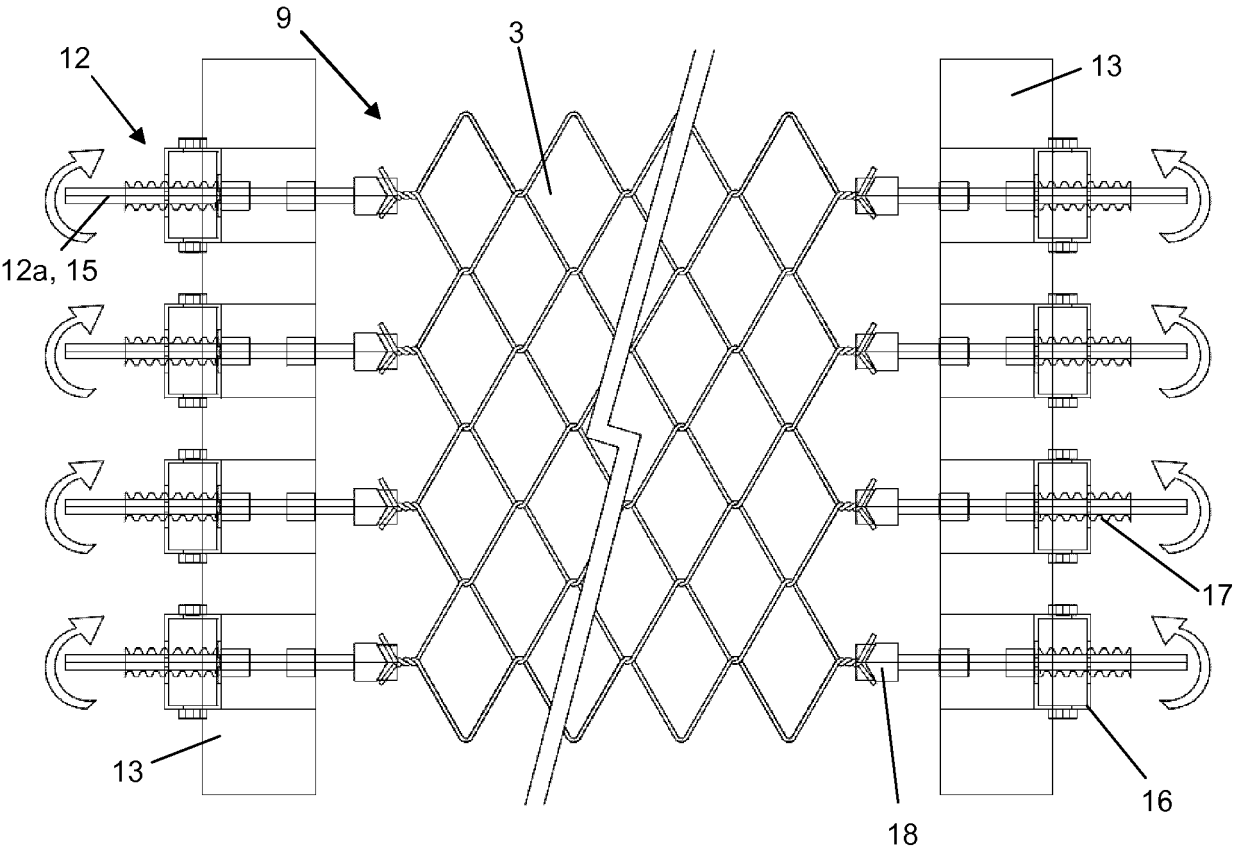


FIG. 7b

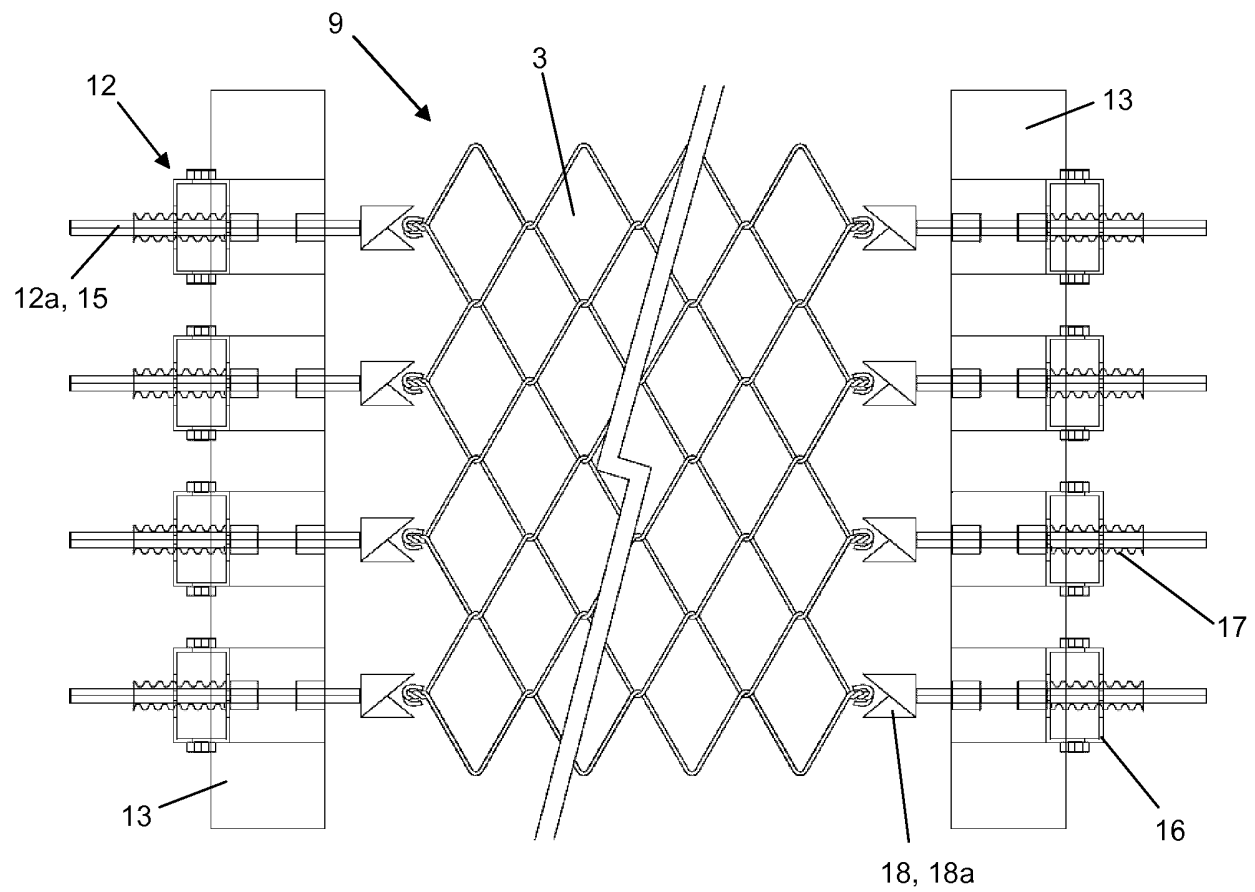


FIG. 7c

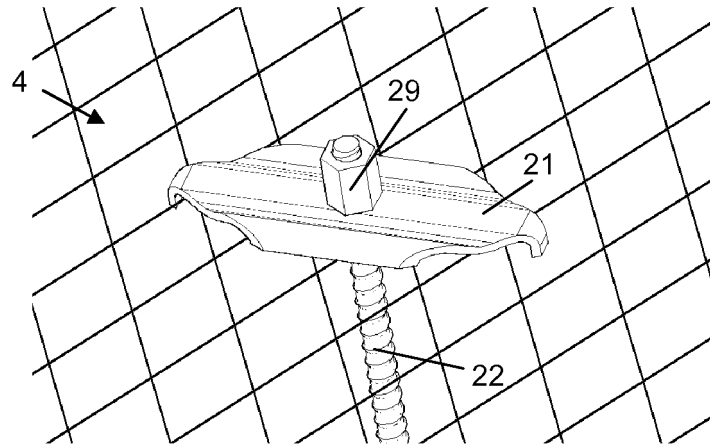


FIG. 8

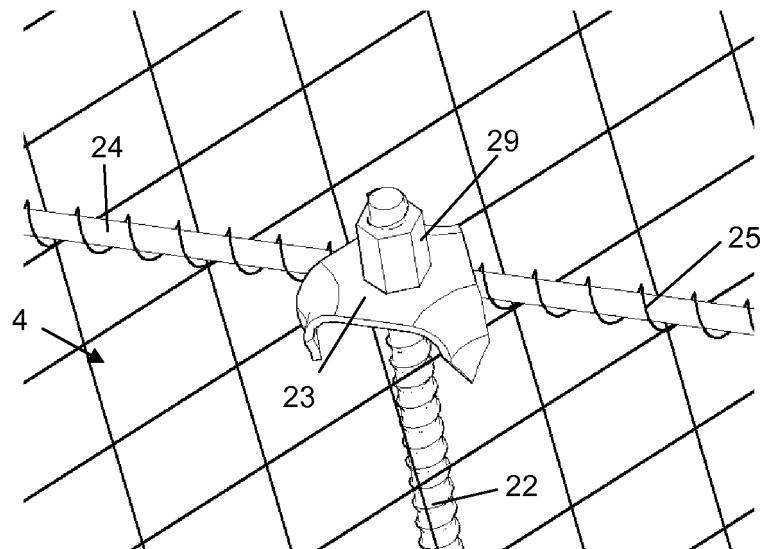


FIG. 9

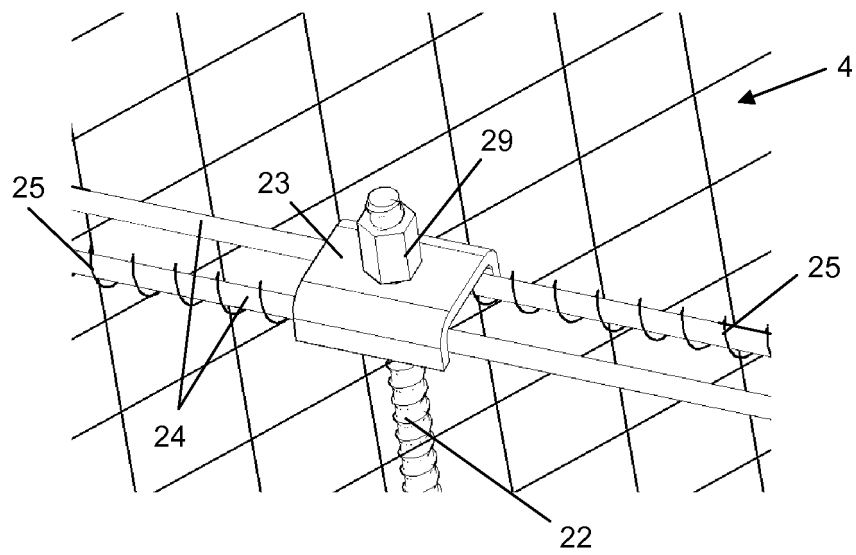


FIG. 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/ES2014/070073

A. CLASSIFICATION OF SUBJECT MATTER

E02D17/20 (2006.01)

B21F27/14 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
E02D, B21F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPODOC, INVENES

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	ES 2374127 A1 (3S GEOTECNIA Y TECNOLOGIA S L) 14/02/2012, page 3, lines 50 - 66; page 5, lines 36 - 64; page 7, line 6 - page 8, line 28; figures 1 - 14.	1-12
Y	FR 2247300 A1 (TOURNIER ETS) 09/05/1975, page 4, line 30 - page 6, line 20; figures 8 - 16.	1-12
A	JP 2001137990 A (RAILWAY TECHNICAL RES INST ET AL.) 22/05/2001, abstract; figures 1-4	1-12
A	ES 2197601T T3 (FATZER AG) 01/01/2004, the whole the document.	1-12
A	US 5908052 A (GARCIA JOSE G) 01/06/1999, the whole the document.	1-12

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance.

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure use, exhibition, or other means.

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
20/10/2014Date of mailing of the international search report
(20/10/2014)

Name and mailing address of the ISA/

OFICINA ESPAÑOLA DE PATENTES Y MARCAS
Paseo de la Castellana, 75 - 28071 Madrid (España)
Facsimile No.: 91 349 53 04

Authorized officer
A. Andreu Cordero

Telephone No. 91 3493055

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/ES2014/070073

5

10

15

20

25

30

35

40

45

50

55

C (continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of documents, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 585873 C (WAFIOS A G MASCHF) 12/10/1933, the whole document.	1-9

INTERNATIONAL SEARCH REPORT

International application No.

PCT/ES2014/070073

Information on patent family members

Patent document cited in the search report	Publication date	Patent family member(s)	Publication date
ES2374127 A1	14.02.2012	NONE	
FR2247300 A1	09.05.1975	NONE	
JP2001137990 A	22.05.2001	NONE	
ES2197601T T3	01.01.2004	KR100434892B B1	07.06.2004
		JP2002088765 A	27.03.2002
		JP4052423B B2	27.02.2008
		US6279858 B1	28.08.2001
		NO995177 A	22.10.1999
		NO320628B B1	02.01.2006
		UA63948 C2	15.08.2000
		TR9902651T T1	22.05.2000
		RU2229561 C2	27.05.2004
		PT979329E E	30.09.2003
		PL336411 A1	19.06.2000
		PL212319B B1	28.09.2012
		NZ500062 A	31.05.2002
		JP2001522422 A	13.11.2001
		JP3630693B B2	16.03.2005
		IL132182 A	01.12.2002
		HU0002864 A2	29.01.2001
		HU0002864 A3	28.01.2002
		EP0979329 A1	16.02.2000
		EP0979329 B1	16.04.2003
		CZ9903752 A3	14.02.2001
		CZ298951 B6	19.03.2008
		CN1256734 A	14.06.2000
		CN1152991C C	09.06.2004
		WO9943894 A1	02.09.1999
		CA2286196 A1	02.09.1999
		CA2286196 C	15.07.2008
		BR9904872 A	19.09.2000
		AU2044299 A	15.09.1999
		AU751554B B2	22.08.2002
		AT237717T T	15.05.2003
		CH692921 A5	13.12.2002
US5908052 A	01.06.1999	NONE	
DE585873 C	12.10.1933	NONE	

Form PCT/ISA/210 (patent family annex) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- ES 2374127 A1 [0028]