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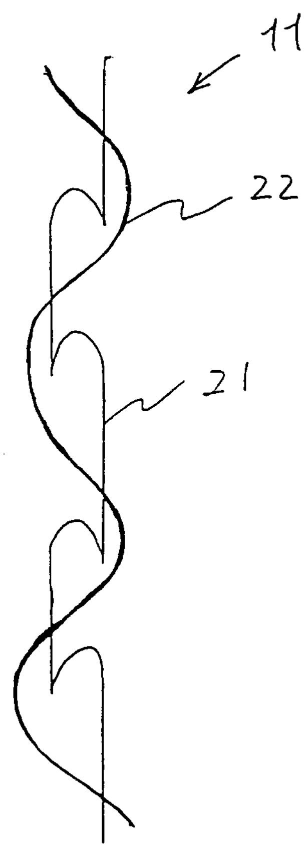
(54) Mesh sheet for use in civil engineering and construction and method for production of thereof.

(57) There are disclosed mesh sheets for use in civil engineering and construction with a warp knitted structure including a plurality of warp and weft strands which are arranged in the form of a lattice, wherein each of the warp strands is composed of a base knitting yarn and a bundle of warp yarns in a columnar shape supported by the base knitting yarn. There are also disclosed methods for the production of such mesh sheets.

Fig. 2



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The present invention relates to a mesh sheet which is used as a reinforcing and shielding material in the field of civil engineering and construction. In particular, the mesh sheet of the present invention is useful as a soil-reinforcing material for reclamation or raising the ground level in the field of civil engineering. The present invention also relates to a method for the production of the sheet.

As conventional soil-reinforcing materials used in the field of civil engineering, for example, lattice sheets, i.e., mesh sheets are well known which have been marketed under the trade name "GIOGRID", "GEOTEXTILE" or the like. They are placed between layers of soil so that soils above and below the sheets are connected each other in the form of a bridge through the mesh holes of the sheets and are integrated with the sheets to reinforce soil layers (interlocking effect). Such mesh sheets are classified into woven materials and knitted materials. These materials are optionally impregnated or coated with a resin.

In the case of woven materials, they have a structure in which warp and weft yarns become linear at each intersection, respectively, so that utilization of tenacity of fibers is increased. However, so long as the warp and weft yarns are woven into a sheet, they must take their positions above or below each other at the intersection therebetween, so that they cannot become straight. For this reason, the above-described purpose has not yet been attained.

There also is a technique, such as leno weaving, in which two of the warp yarns are twisted each other two times and returned to their original positions in the weft direction, while weft yarns are inserted into each of the loops formed by twisting the warp yarns. However, the twisted warp yarns have a lower tensile strength than that of straight warp yarns because of their flex which is caused by twisting two of the warp yarns each other (one of the weft yarns is passing through the loop formed thereby). Moreover, since each of the warp strands is formed from two warp yarns, there is a possibility that tenacity contribution may vary as compared with warp strands made of a single warp yarn. Further, such multi-yarn warp strands have a drawback that the change in elongation becomes increased even under a constant load.

On the other hand, the knitted materials which have been widely used are classified into those prepared by the weft-insertion process in which weft strands are inserted over the entire knitting width and those prepared by the warp-insertion process in which warp strands are inserted over the entire knitting length.

A typical example of the warp-insertion process is disclosed in Japanese Utility Model Publication No. 2-17030.

In this process, for example, when a warp strand is required to have a fineness of 8000 denier (d), a reed having a gauge of, for example, 2000 d/guide is provided (whether the warp strand is inserted at once or not depends on the size of a lattice to be formed), and a warp yarn of 2000 d in fineness is inserted through the spacing between needles into the loops made of each base knitting yarn (in this case, four base knitting yarns per one warp strand are used) which is being prepared from another reed. Further, another yarn is prepared from still another reed which is different from that for the base knitting yarns, and is inserted thereinto as a tightening yarn through the alternate spacings between needles so that every two warp yarns inserted into the loops of the corresponding base knitting yarns are combined with each other using one tightening yarn to form a strand. With a reduction in the delivery rate of the tightening yarns, the distance between the adjacent warp yarns of 2000 d in fineness, which have been inserted in the same distance as the gauge of the reed, is decreased, resulting in a warp strand of 8000 d.

The mesh sheet using such a warp strand has the following advantages: first, both of the warp and weft strands become straight at the intersection therebetween and there is no flex of the warp and weft strands, so that they have an excellent tenacity utilization; and secondly, it is possible to prepare such a mesh sheet so long as the warp yarns prior to insertion (in this case, they has a fineness of 2000 d) themselves can pass through the guide holes of the yarn reed. However, with an increase in the fineness of warp strands to be required, a number of warp yarns delivered from many guides must be combined with each other to form a warp strand. This causes a drawback that such a warp strand has a tendency to become flattened.

Although the flattening of warp strands can be prevented to a certain extent by increasing a guide hole size of the reed, there is a limit in the range of a guide hole size to be increased, so that when a mesh sheet having a high tensile strength is required, the degree of warp strand flattening is inevitably increased to become a wide belt-like warp strand, resulting in a decrease in the mesh density, i.e., number of mesh holes per unit area in meshes/m^2, as well as a decrease in the size of mesh holes. For this reason, such a mesh sheet has a drawback that it has only a decreased interlocking effect as compared with that which would be given if the mesh holes have a reasonable size. It is, therefore, impossible to attain a satisfactory reinforcing effect.

Under these circumstances, in order to solve the above problems in the warp-insertion process, the present inventor has intensively studied mesh sheets to improve their reinforcing effect. As a result, it has been found that when at least warp strand is composed of a bundle of yarns in a columnar shape, such a warp strand can prevent a decrease in the size of mesh holes, i.e., interlocking effect, even in the case of larger fineness, which therefore presents an improvement in the reinforcing effect.

That is, the main object of the present invention is to provide mesh sheets which can prevent decrease in their mesh hole size, even when thicker warp strands are used therein, because each warp strand is composed of a bundle of warp yarns to have a columnar shape, and which is, therefore, excellent in the reinforcing effect arising from the interlocking effect.

Another object of the present invention is to provide methods for the production of the above mesh sheets.

These objects are solved with the features of the claims.

In a preferred embodiment, one base knitting yarn forms a chain stitch and the warp strand composed of a bundle of warp yarns is inserted together into the loops of the chain stitch; or two base knitting yarns supports each warp strand and the warp strand composed of a bundle of warp yarns is positioned between the base knitting yarns and bound up together with the base knitting yarns by use of a binding yarn.

The mesh sheet of the present invention is characterized in that a bundle of warp yarns are used for the formation of a warp strand, and therefore, the resulting warp strand can be formed in a columnar shape. Accordingly, the blinding of mesh holes, i.e., the action of decrease in mesh holes size, which arises from the flattening of warp strands, can be reduced, and it is, therefore, possible to prevent a decrease in the interlocking effect when the mesh sheet is buried in the soil as a reinforcing material in the field of civil engineering.

In the present invention, a plurality of filament yarns or spun yarns are gathered together to pass through a pipe guide, which are then used as a warp strand, so that the resulting warp strand can be formed into a columnar shape. That is, a plurality of warp yarns are allowed to pass through only one pipe guide, so that substantially uniform stress is applied to each warp yarn, thereby making it possible to prevent the flattening of a warp strand.

The mesh sheet of the present invention has a warp-insertion knitted structure including a plurality of warp and weft strands which are arranged in the form of a lattice. Each of the warp strands is composed of a bundle of warp yarns supported by at least one base knitting yarn. For example, the warp strand has a plurality of warp yarns which are inserted into the loops of a chain stitch formed by a base knitting yarn to form a columnar bundle of warp yarns. Alternatively, the warp strand has a plurality of warp yarns which are positioned between two base knitting yarns and are bound up together with the supporting yarns by use of a binding yarn to form a columnar bundle of warp yarns.

In the present invention, the weft strands may be conventional weft strands. However, preferably, each of the weft strands is composed of a bundle of weft yarns as in the warp strands because a larger mesh size can be obtained.

The yarn of the base knitting yarn may be filament yarn or spun yarn of 3000 d or less in fineness, preferably 2000 d or less, more preferably 1500 d or less, and particularly preferred fineness is 800 d or less. The fineness of warp and weft yarns is not particularly limited, but it is preferred that the warp strand has a fineness of 5000 to 150,000 d and the weft strand has a fineness of 3000 to 150,000 d. Too much finer strands cannot have a satisfactorily tenacity, whereas too much thicker strands have an increased stiffness which makes it difficult to handle them.

The material of the warp and weft yarns is not particularly limited, but examples of the material include synthetic fibers, regenerated fibers, natural fibers, and those containing metallic fibers, carbon fibers, aramide fibers or the like. Particularly preferred are polyester fibers.

The mesh sheet of the present invention can be produced by the per se known method as described in Examples hereinafter.

If necessary, a selvage can be formed at each end of the mesh sheet according to a conventional manner. The formation of a selvage is useful for the subsequent resin impregnating step, particularly in that the mesh sheet can be treated in a state of tension by fixing it at the selvage with a pin tenter, and for sewing two mesh sheets together without difficulty. It is preferred that the width of the selvage is 30% or less of the entire knitting width of the mesh sheet.

The mesh sheet of the present invention may be further treated with an appropriate resin according to a conventional manner to increase its toughness. Usually, the mesh sheet is impregnated with an emulsion of the resin and dried to harden the resin. Examples of the resin include thermosetting resins such as epoxy resins, and thermoplastic resins such as acrylic resins.

The invention and its advantages will become apparent from the following description and examples with reference to the accompanying drawings.

Fig. 1 is a schematic diagram showing the warp-insertion knitted lattice structure of a mesh sheet of the present invention.

Fig. 2 is a schematic enlarged view showing a warp strand of the mesh sheet of Fig. 1.

Fig. 3 is a schematic enlarged view showing a warp strand of another mesh sheet of the present invention.

Fig. 4 is a schematic diagram showing the warp-insertion knitted lattice structure of a conventional mesh sheet.

Fig. 5 is a schematic enlarged view showing a warp strand of the mesh sheet of Fig. 4.

Example 1

Fig. 1 shows a mesh sheet 10 of the present invention with a warp-insertion knitted structure in which a plurality of columnar warp strands 11 and a plurality of non-columnar weft strands 12 are arranged in the form of a lattice. Fig. 2 shows an enlarged view showing that the warp strand 11 is inserted into the loops of a chain stitch formed by a base knitting yarn 21. Each warp strand 22 has a fineness of 30,000 d and is composed of a plurality of polyester filament yarns of 1500 d in fineness.

The mesh sheet of this example was produced by use of a 9-gauge raschel machine of the warp-and-weft insertion type as follows:

A plurality of polyester filament yarns of 1500 d in fineness were subjected to warping, and every twenty filament yarns were introduced as a warp strand (in this case, it had a fineness of 30,000 d) through a leading guide into the corresponding pipe of the pipe guide which had been prepared in the same size as the prescribed mesh size.

At this time, the warping of multi-filament yarns so as to have a prescribed fineness in d/strand makes it possible to prevent the flattening of warp strands. The multi-filament yarns may also be twisted in advance before the warping, to form a strand having the prescribed fineness or having one half to one third thereof.

On the other hand, a doubling and twisting yarn having a twist of 80 times/m, made of twenty polyester multi-filament yarns of 1500 d in fineness, was supplied as a weft strand through a creel to a weft-inserting machine which had been adjusted to fit the prescribed mesh size, and inserted into the stitch at a fixed pitch.

At this time, the weft strand may be inserted into the stitch as a single strand having the prescribed fineness per course, or as a composite strand (the weft strand is beforehand divided into equal parts, and each part is separately inserted per course and then combined together to form a composite strand; for example, when a weft strand of 30,000 d in fineness is required, ten weft yarns of 1500 d in fineness are twisted into a strand of 15,000 d in fineness (i.e., 1500 d $\times$ 10 yarns = 15,000 d), and two of these strands are combined together to form a composite strand of 30,000 d in fineness (i.e., 15,000 d/course $\times$ 2 courses)), in which case the resulting weft strand has a more flattened shape than the former but the excellent advantage of the mesh sheet of the present invention can never be degraded thereby.

In this example, as the base knitting yarn, a polyester multi-filament of 250 d in fineness was used to form a chain stitch. With the warp-insertion process, the above warp strand of 30,000 d in fineness was inserted through a pipe guide into the loops of this chain stitch. At this time, the delivery rate of the chain stitch was set to a great value, because if this rate was decreased, the warp strand had a tendency to meander. The weft strand was inserted into the stitch at the fixed pitch, as described above.

The mesh sheet thus obtained was impregnated with an emulsion of acrylic resin and then dried to set the acrylic resin, resulting in a resin-impregnated mesh sheet with increased toughness, as shown in Fig. 1.

In addition, for the purpose of preventing stitch distortion, another polyester multi-filament yarn of 250 d in fineness may be used as a distortion-preventing yarn and knitted in the mesh sheet in the same number as that of the warp strands. For example, such a distortion-preventing yarn is inserted into the chain stitch together with the warp strand until it meets the weft strand, and then allowed to move along the weft strand to the position of the adjacent warp strand, after which the distortion-preventing yarn is inserted into the adjacent chain stitch together with the adjacent warp strand until it meets the next weft strand, and then returned along the next weft strand to the position of the original chain stitch, followed by further insertion in the warp direction and repeating these steps.

Example 2

The mesh sheet of this example has the same external appearance as that of Example 1 but has a different structure of warp strands from that of Example 1. That is, as shown in Fig. 3, a plurality of warp yarns 31 in the warp strand 11 are supported in a different way from that of Example 1, i.e., by two base knitting yarns 32 and two binding yarns 33. Such a mesh sheet was produced as follows:

In the same manner as that of Example 1, polyester multi-filament yarns of 1500 d in fineness were subjected to warping, and every twenty multi-filament yarns were introduced as a warp strand (in this case, it had a fineness of 30,000 d) through a leading guide into the corresponding pipe of the pipe guide. Also, two polyester multi-filament yarns each of 250 d in fineness were used to support the warp strand therebetween, and the warp strand was combined by inserting it into the central one of three needles in such a manner that the warp strand was enclosed from its front and back faces between the two base knitting yarns which had been formed from the polyester multi-filament yarns each of 250 d in fineness. That is, the warp strand was inserted between the two yarns which were also inserted respectively into the central one of other three needles.

On the other hand, a doubling and twisting yarn having a twist of 80 times/m, made of twenty polyester multi-filament yarns of 1500 d in fineness, was supplied as a weft strand through a creel to a warp-inserting machine which had been adjusted to fit the prescribed mesh size, and inserted into the stitch loops at a fixed pitch by the weft-insertion process.

In this example, a selvage was formed at both ends in the weft direction of the mesh sheet to have a width of 10 cm, which was less than 30% of the entire knitting width of the mesh sheet. For a selvage at one end of the mesh sheet, thirty-six polyester multi-filament yarns of 1500 d in fineness were used to form a full-closed chain stitch, and thirty-six polyester multi-filament yarns of 250 d in fineness were closely inserted into the stitch as strands of 1500 d in fineness. Further, different thirty-six polyester multi-filament yarns of 250 d in fineness were used to connect the adjacent stitches closely with each other, resulting in a selvage. The selvage at the other end of the mesh sheet was formed in the same way as described above. Of course, the weft strands had also been allowed to pass through the selvages.

The mesh sheet thus formed to have the warp strands in a columnar shape was further treated on the warp-knitting machine to cut the end of the selvages with heat for the purpose of preventing the selvages from being unknitted.

The mesh sheet thus obtained was impregnated with an emulsion of acrylic resin and then dried to set the acrylic resin, resulting in a resin-impregnated mesh sheet with increased toughness, as shown in Fig. 1.

Comparative Example

In this comparative example, a mesh sheet having the same fineness of warp strands and the same mesh density in meshes/m^2 as those of a mesh sheet of the present invention was produced by a conventional process as described in Japanese Utility Model Publication No. 2-17030.

Fig. 4 shows a mesh sheet 40 produced by this conventional process. The sheet has a plurality of warp strands 41 and weft strands 42. They are in a non-columnar, flattened shape. Fig. 5 shows an enlarged view of the warp strand of this mesh sheet. In this warp strand, each warp yarn 51 is supported by one base knitting yarn 52 and warp yarns are combined by a tightening yarn 53.

For example, taking into consideration the hole size and distance of leading guides of a 9-gauge warp-knitting machine, the maximum fineness of warp strands which can be used in this warp-knitting machine is in the range of 7500 to 9000 d. If warp strands of 7500 d in fineness are used from the view point of stable operation, a warp strand of 30,000 d in fineness to be desired corresponds to four warp strands of 7500 d in fineness (i.e., 7500 d $\times$ 4 strands), which also means that it is necessary to use twenty multi-filament yarns of 1500 d in fineness (i.e., 1500 d $\times$ 20 yarns).

Such four warp strands of 7500 d in fineness per guide were inserted in the warp direction, and a tightening yarn of 250 d in fineness was used to combine these warp strands with each other by inserting thereinto through the alternate spacings between needles. The delivery rate of the tightening yarn was decreased, so that four warp strands were drawn near to run parallel with each other, resulting in a flattened composite warp strand. The flattened composite warp strand had a width of about 5.2 to 5.5 mm. The mesh sheet was designed to have a mesh size of 20 mm $\times$ 20 mm in inner dimension, so that the mesh density became to be 39 meshes/m^2.

On the other hand, a mesh sheet having the same mesh size as described above was produced by the process of the present invention. In this case, the warp strand of 30,000 d in fineness had a width of 2.55 mm, so that the mesh density became to be 44 meshes/m^2, which indicated a 12.8% increase in the mesh density, although the designed tenacity (i.e., the fineness of warp strands was the same; however, columnar strands had a greater tenacity contribution than that of flattened composite strands) and mesh size of the sheet were the same in both cases.

Further, when the conventional process was repeated in the same manner as described above, except that an 18-gauge warp-knitting machine was used together with an one-needle omission technique, warp strands were expected to have an increased width of around 10 mm, so that the mesh density became 33 meshes/m^2, which indicated a 33.3% increase.

As described hereinabove, when buried in the soil as a reinforcing material in the field of civil engineering, the mesh sheet of the present invention can attain an improved interlocking effect on the soil as compared with the conventional mesh sheet.

Claims

1. A mesh sheet for use in civil engineering and construction with a warp-insertion knitted structure comprising a plurality of warp and weft strands arranged in the form of a lattice, wherein each of the warp strands is 5000 to 150,000 d in fineness and is a bundle of warp yarns in a columnar shape supported by at least one base knitting yarn composed of a filament yarn or spun yarn of not more than 3000 d in fineness in warp-insertion manner; each of the weft strands is 3000 to 150,000 d in fineness; and the weft strands are inserted over the entire width.

2. A mesh sheet according to claim 1, wherein the weft strand is composed of a bundle of weft yarns and has a columnar shape.

3. A mesh sheet according to claim 1 or 2, wherein the warp strand is supported by one base knitting yarn by inserting the warp strand into loops of a chain stitch formed by the base knitting yarn.

4. A mesh sheet according to claim 1, 2, or 3, wherein the warp strand is supported from both sides by two base knitting yarns, said base knitting yarns being bound by two binding yarns.

5. A method for the production of a mesh sheet with a lattice warp-insertion knitted structure including a plurality of warp and weft strands, which comprises the steps of:

   forming a chain stitch by a base knitting yarn; and

   inserting a bundle of warp yarns into the loops of the chain stitch to form a columnar warp strand, while inserting a weft strand into the stitch loops at a fixed pitch over the entire knitting width, resulting in a lattice warp-insertion knitted structure.

6. A method for the production of a mesh sheet with a lattice warp-insertion knitted structure including a plurality of warp and weft strands, which comprises the steps of:

   forming a structure from two base knitting yarns to support the warp strand therebetween;

   inserting a bundle of warp yarns between the two base knitting yarns of this structure to support the bundle of warp yarns from both sides;

   inserting two binding yarns into the loops between the two base knitting yarns so as to hold the front and back faces of the bundle of warp yarns, and tightening the bundle of warp yarns with the binding yarns to form a columnar shape; and

   forming a lattice warp-insertion knitted structure with the columnar-shaped bundle of warp yarns and weft-insertion yarns which are inserted and fixed into the loops of the base knitting yarns at a fixed pitch over the entire knitting width.

Fig. 1

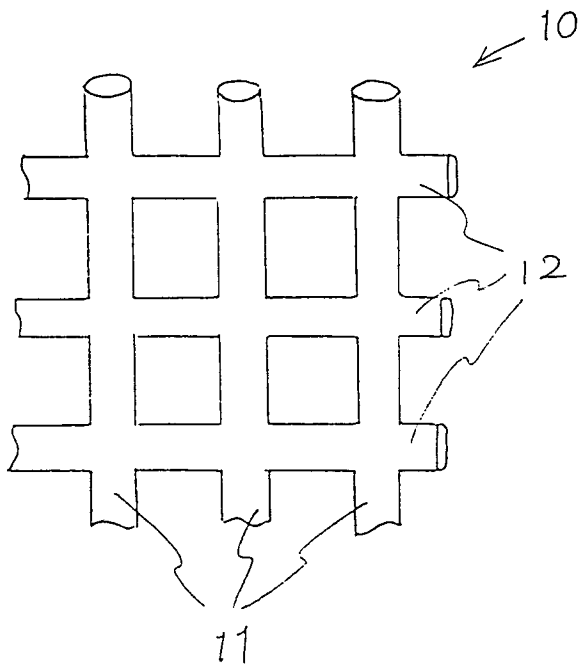


Fig. 2

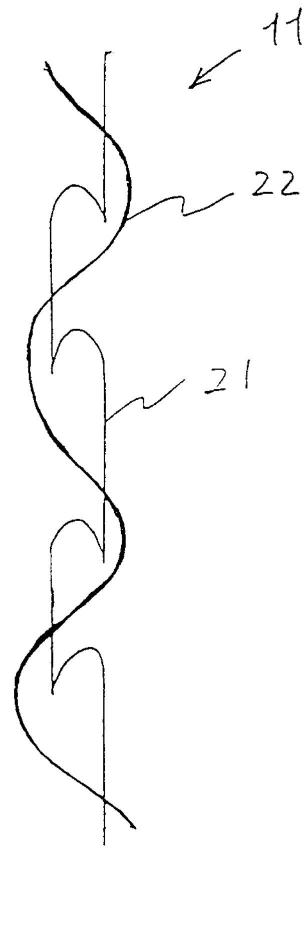


Fig. 3

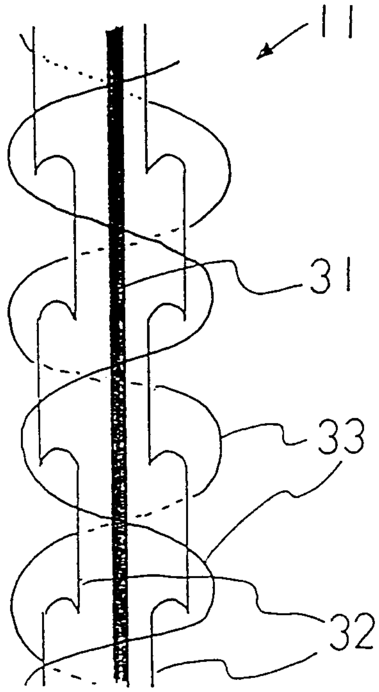


Fig. 4

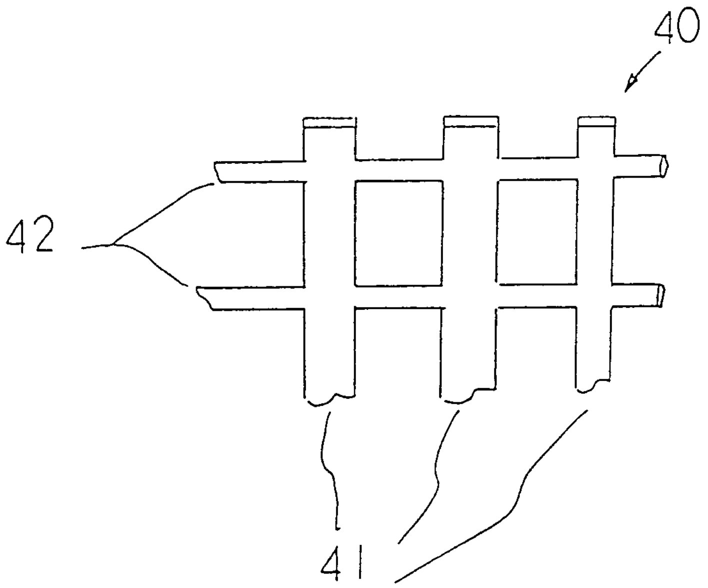
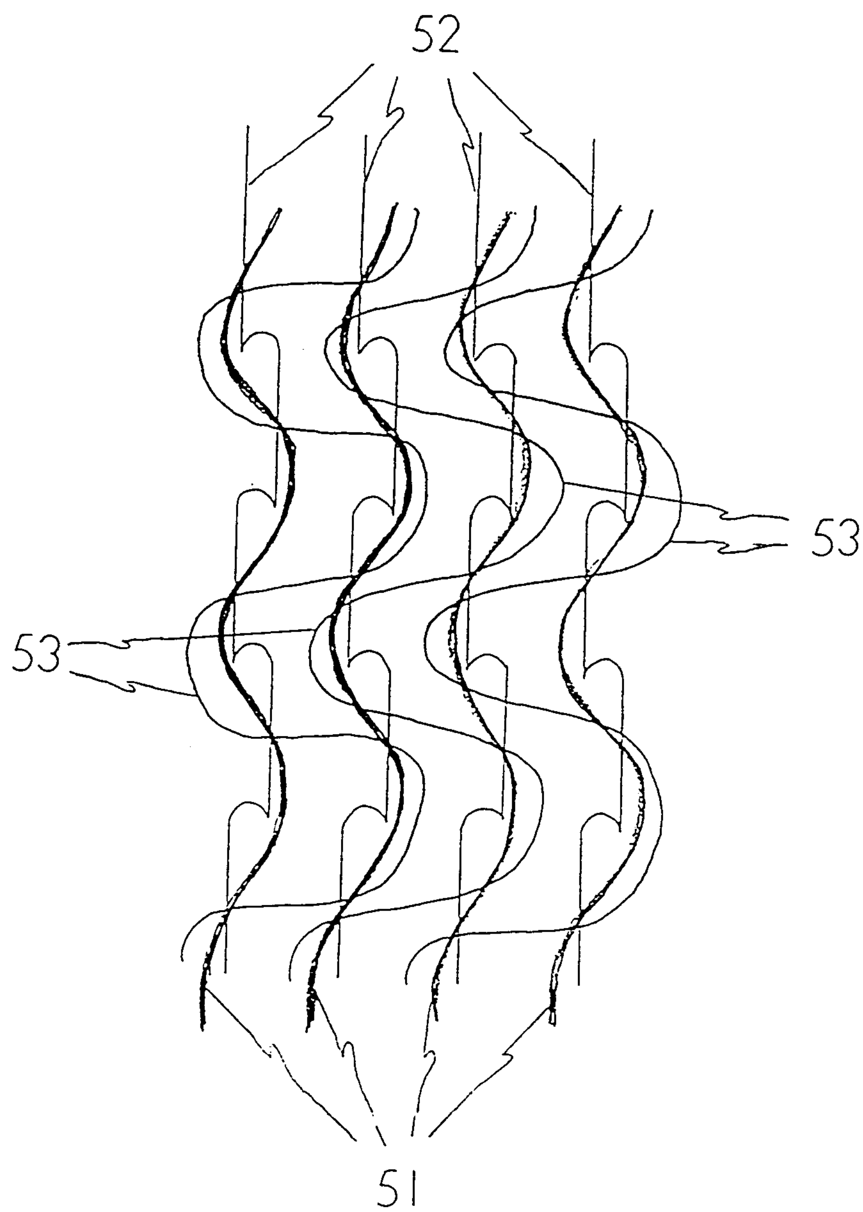


Fig. 5



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EUROPEAN SEARCH REPORT

Application Number

EP 92 10 7048

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	WO-A-8 703 250 (PEABODY ABC CORP.) * page 4, line 25 - page 5, line 29; figures 1,2 *	1-4	D03D15/00
X	FR-A-2 572 426 (UNION TEXTILE DU NORD SA) * page 2, line 5 - page 5, line 15; figures 1-5 *	1,2	
X	DE-A-2 707 001 (VYZKUMNY USTAV PLETARSKY (TSCHECHOSLOWAKEI)) * page 12, line 14 - page 13, line 26; figures 1-14 *	5	
A		1-4,6	
D,A	JP-U-2 017 030 (....) * figures 1-3 *	1-6	
A	DE-A-3 728 255 (HUESKER SYNTHETIC GMBH) * column 5, line 20 - line 58; figures 1-12 *	1-4	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

D03D
E02D
D04B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	31 JULY 1992	HENNINGSEN O.

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