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Remarks:
Amended claims in accordance with Rule 86 (2) EPC.

(54) Weft inserted warp knit fabric for reinforcement of cementitious materials

(57) The invention relates to a fabric (200) comprising (a) at least one layer of a weft inserted warp knit fabric including in-lay warp yarns (212), stitching yarns (211), which each form a wale around a corresponding in-lay warp yarn, and weft inserted yarns (213) inserted in a parallel repetitive construction in every third or more stitch of the stitching yarns; and (b) an alkali resistant coating (220), which is useful as a reinforcement fabric for cementitious materials, such as concrete mixtures and cement mortars. Also, the invention concerns a reinforced cementitious material comprising (i) a cementitious material; such as concrete mixtures and cement mortars, and (ii) the above fabric.

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Description

Background

[0001] The present invention generally relates to concrete or cementitious materials reinforced with a fabric, especially a weft insertion warp knit fabric, and to a fabric for such reinforcement. Such reinforced concrete or cementitious materials can be formed as plates or panels, undulated or not, used in applications such as the flooring or covering of constructions intended for agriculture, industry, such plates or panels can also be used for the domestic dwellings in both the covering and as cementitious boards.

[0002] US 5,763,043 discloses an open grid fabric for reinforcing wall segments having high strength, alkali resistance, and impact resistance. The fabric has warp, weft, and tie yarns and comprises certain knits and leno weaves, including a warp knit weft inserted fabric, and bears an alkali resistant resin coating. However, this document does not teach that the warp and weft yarns may be monofilaments or twisted multifilaments, or that the tie yarns may be knitted with a tight tension.

[0003] There is a need for a knitted reinforcement fabric that can withstand the alkaline environment of concrete and has a precise construction with evenly spaced and parallel wales.

Brief Description of the Drawings

[0004] In the following, preferred embodiments of the invention will be exemplified with reference to the accompanying drawings.

FIG. 1 is a cross sectional drawing of one embodiment of the reinforced concrete;

FIG. 2 is a cross sectional drawing of one embodiment of the reinforcing fabric;

FIG. 3 is a drawing of an in-lay warp cord in weft insertion warp knitted fabric on the front face;

FIG. 4 is a drawing of in-lay warp cord in weft insertion warp knitted fabric on the back face;

FIG. 5a is a drawing of the pattern chains for one embodiment of the inlay warp cord in weft insertion warp knitted fabric shown in FIGS. 3 and 4.

FIG. 5b is a drawing of the lapping movement for ore embodiment of the in-lay warp cord in weft insertion warp knitted fabric shown in FIGS. 3 and 4.

FIG. 6 is a photograph of an embodiment of the weft inserted warp knit fabric according to the present invention.

Detailed Description

[0005] Fig. 1 shows reinforced concrete (10) containing a cementitious material (100) and a reinforcing fabric (200). The fabric is shown embedded in the concrete material towards the surface of the concrete, but is not limited to this construction and may be on an outer side of the concrete or more towards the middle. Additionally, more than the one shown layer of reinforcing fabric (200) may be used.

[0006] Concrete is made up principally of cementitious material, fine aggregate, coarse aggregate, water, air, chemical admixtures, and fiber. The cementitious material is the glue that holds concrete together. Typical cementitious materials used in concrete are Portland cement, fly ash, blast furnace slag, and silica fume. Portland cement is the dominant cementitious material used, andthe other cementitious materials will typically be added to the Portland material to adjust its performance and cost.

[0007] Portland cement is a mixture of many compounds, and the four major constituents are tricalcium silicate, dicalcium silicate, tricalcium aluminate and tetracalcium aluminoferrite. Each Portland cement contains different amounts of these major components. The calcium silicates (representing ~75 wt.-% of the Portland cement) react with water to form calcium hydroxide and calcium silicate hydrate. The calcium silicate hydrates provide the principal performance benefits of cement. The highly alkaline environment of cement is due to the hydroxides such as calcium hydroxide and the lime (CaO) present in the cement.

[0008] Fine aggregate consists of natural or manmade sand with a particle size distribution whose maximum size is typically 9.5 mm. Coarse aggregate consists of natural or manufactured particles (typically rocks) with a size of approximately 1.2-152 mm (0.3-6 inches). Aggregates typically make up 6075% of the final concrete.

[0009] The water is critical for the hydration of the cement. The water/cementitious material ratio determines many of the critical properties of concrete.

[0010] The reinforcing fabric of the invention is typically used towards the center of the cementitious material. In wall applications or backing for tile, the fabric is typically used towards the outside of the cementitious material on one or both outside surfaces.

[0011] Fig. 2 shows a cross sectional drawing of the reinforcing fabric (200) made up of the weft inserted warp knit fabric (210) and the alkali resistant coating (220). The coating completely covers the fabric yarns to protect the yarns from the cement environment.

[0012] Figs. 3 and 4 show the weft inserted warp knit fabric (210), which is made in a weft insertion warp knit machine with in-lay warp yarns (212), weft inserted yarns (213), and stitching yarns (211). The stitching yarns stitch in a specific chain stitch pattern wherein the fabric (210)

is stabilized and precisely maintained in a parallel way. The reinforcing fabric has at least one layer of a weft inserted warp knit fabric (210) including in-lay warp yarns (212), stitching yarns (211), and weft inserted yarns (213), wherein each stitching yarn (211) forms a wale around a corresponding inlay warp yarn (212), and wherein the weft insertion yarns (213) are inserted in a parallel repetitive construction in the stitches of the stitching yarns (211).

[0013] The in-lay warp yarns (212), stitching yarns (211) and weft yarns (213) may be formed with any man-made material that meets the necessary physical properties, such as polyamide, polyester, rayon, para-aramid, fiberglass, polyolefin, polyvinyl, polyvinyl alcohol (PVA), steel, carbon, meta-aramid and derivates, polyacrylic and any other known yarn material containing artificial or natural fibers. Also, hybrid yarns made of at least two fibers of different materials can be used. These different fiber materials can produce hybrid yarns with different chemical and physical properties. Hybrid yarns are able to change the physical properties of the final product they are used in. Preferred examples of hybrid yarns include an aramid fiber with any of a nylon fiber, a rayon fiber, and a polyester fiber.

[0014] In some embodiments, the warp and weft yarns are not sized before knitting.

[0015] The inlay warp yarns (212) and/or weft yarns (213) preferably may be any of single monofilament yarns, multiply twisted filament yarns, and substantially twisted multifilament yarns. "Twisted filament" here means a multifilament yarn having a twist of preferably at least Z60 or S60 (60 turns/m in the right (Z) or left (S) direction). It also includes several multifilament yarns twisted together, preferably by at least Z100 or S100 twist. Each individual multifilament yarn could be untwisted or could be pre-twisted before being assembled or cabled to get together a final additional twist of preferably at least Z100 or S100.

[0016] A concrete example useful in the present invention is a 1100 dtex f210 PVA yarn twisted Z60, then assembled at four of these yarns and twisted again with S100 (a twisted filament yarn referred to as (1100 dtex f 210 Z60) x 4 S100). The warp and weft yarns may also be formed from staple fibers. The warp yarns (212) and weft yarns (213) are not roving.

[0017] The in-lay warp yarns (212) and weft yarns (213) preferably have a weight per unit length of 100 to 23,500 dtex (90 to 21,000 deniers) made with single or multiple yarns (for example, 235 dtex (single end); or (235 dtex x 2 x 3 plies) = 1,410 dtex or (1,100 dtex x 3 x 3 plies) = 9,900 dtex (multiple ends)). In some fabric constructions, the in-lay warp yarns (212) are placed such that there are 0.1-4 ends/cm (0.25-10 ends/inch) in the weft inserted warp knit fabric (210). The number of ends is defined as the number of wales or the number of needles (or gauge) on a warp knitted fabric or the number of warp yarns per cm (inch).

[0018] The stitching yarns (211) may be made with any single monofilament or twisted multifilament, or may be made of staple fibers. In a preferred embodiment the stitching yarn (211) has a weight per unit length of 22700 dtex (20-630 deniers) and may be a single yarn or may be twisted multiply yarns.

[0019] Fig. 3 shows the front side of one embodiment of the invention where the weft yarn (213) inserted every forth stitch of the stitching yarn (211). Fig. 4 shows the backside of the embodiment of Fig. 3. Each individual stitch yarn (211) forms a wale of stitches along an associated warp yarn (212). The stitching yarns (211) join a sheet of weft yarns (213) with a sheet of warp yarns (212) when each of the weft yarns (213) are inserted in the corresponding stitch of the stitching yarns (211) along the warp yarn (212). This particular joining between the two sheets of reinforcing yarns (warp and weft yarns) maintains a parallel and equal interval between these reinforcing yarns.

[0020] The fabric (210) of the invention can be produced on a weft insertion warp knit machine, which is wider and faster than a traditional weaving machine makingthe process economical. For the fabric (210), the chain stitch pattern is worked on one needle for each individual warp yarn (212) and weft yarns (213) are inserted in a repetitive construction. Fig. 5a shows the chain pattern of the embodiment of the present invention shown in Figures 3 and 4. Fig. 5b shows the lapping movement for the embodiment of the present invention shown in Figs. 3 and 4. An image of the weft inserted warp knit fabric (210) is shown in Fig. 6.

[0021] The stitch used for the stitching yarn (211), as shown in Figs. 3, 4, 5a and 5b, is a chain stitch working always on the same needle. The chain stitch may be made with opened stitches (0.1/1.0 or 1.0/0.1) as represented in all figures. The chain stitch may also be made with closed stitches (0.1/0.1 or 1.0/1.0) or a combination or mixture of both open and closed stitches (as example only: 0.1/0.1/1.0/1.0). In one embodiment, the pattern for the chain stitching yarn used for the in-lay cord warp (212) is a 0.0/1.1 movement around the same needle, alternatively changing at each stitch, one stitch on the right side of the needle and next stitch on the other left side of the same needle, or in opposite way, first stitch on the left side then second stitch on the right side of the same needle (1.1/0.0). If closed stitch and opened stitch are mixed, the in-lay movement of in-lay bar would be adapted following the result needed, it is possible to also mix the movement of inlay bar versus the stitching bar (as example: 0.0/1.1/1.1/1.1/0.0/0.0), without any limitation.

[0022] In one embodiment, the stitching yarn (211) stitches with high tension creating a secure connection between the in-lay warp (212) and weft-inserted yarns (213). Prior art teaches that loose tension is preferred because it permits a polymer coating to penetrate the warp yarn strands more uniformly and deeply. It has been found that using a high or tight tension on the stitching yarn (211) creates a fabric with a precise construction of the warp yarns (212) and weft yarns (213) in terms of

geometry, spacing, and stability, while at the same time having an even coating on the yarns (211), (212), and (213). In a preferred embodiment of the invention, the ratio of the length of stitching yarn (211) to the length of in-lay warp yarn (212) is 3.1 or less, and more preferably the ratio is within the range of 2.63.0.

[0023] The denier of the stitching yarn (211) may be approximately the same or different than the denier of the inlay warp yarn (212).

[0024] The weft insertion warp knit machine gives the possibility to stabilize the inlay warp yarn (212) on a flat plane with the insertion of a weft yarn (213) in the chosen stitches of the stitching yarn (211). The weft yarn (213) may be inserted in each stitch or in a repetitive construction (repetitive construction including each stitch or any multiplicity of stitches), for example one weft in each four stitches. The terminology used to describe this weft insertion is one stitch with a weft inserted in (called "1 in") with three consecutive stitches without a weft inserted in (called "3 out").

[0025] There is no limitation in the construction and in the repeat of the pattern, for example: 1 in 1 out, 1 in 2 out, 1 in 3 out (Figs. 3-5b), 1 in 4 out, 1 in 5 out, etc. In a preferred embodiment, the weft inserted yarns(213) are inserted every 4 stitches of the stitching yarn (211). In this embodiment one can increase the size of the open scrim without losing any stability and geometry of the scrim. To obtain an open scrim, having less weft yarns inserted per cm (inch) is preferred over increasing the size of each individual stitch having a weft inserted in each stitch.

[0026] For example, with one weft each four stitches, the fabric has 6.3 stitches/cm (16 per inch) and 1.6 weft yarns/cm inserted (4 per inch), which means that each of the stitches has a small size. On the other hand, with one weft per stitch, the fabric will have only 1.6 stitches/cm (4 per inch) and 1.6 weft yarns/cm inserted (4 per inch), which means that each stitch is much larger. Having one weft insertedevery 4 stitches enables the stability and geometry of the fabric.

[0027] The fabric is desired to be open allowing the cementitious material to pass through the fabric. More closed fabrics, such as when a weft yarn (213) is inserted at each stitch of the stitching yarn (211), produce a fabric that will not allow for as much penetration as a more open fabric.

[0028] It is desirable to keep the length of each stitch as small as possible and having several stitches without weft inserted, compared to maintaining the rafe of one weft/one stitch and increasing the length of stitch to open the space between weft yarns. Increasing the length of the stitch may cause the fabric to become loose and not stabilize the fabric as much. Hence, the present fabric has a structure, which is sufficiently open to allow a good flow of the cementitious material through the fabric, thus allowing easy processing, and at the same time good stabilizing and reinforcing properties are achieved.

[0029] In one preferred embodiment, the weft yarns are inserted at a rate of 0.8-16 stitches/cm (2-40 stitches/inch). As an example, with one weft in each four stitches (1 in 3 out), the fabric will contain 0.2-4 wefts/cm (0.5-10 wefts/inch). Another embodiment of the invention may have 0.1-4 wales/cm (0.25-10 wales/inch). As an example, with 2.36 needles/cm (6 needles/inch) and one inlay yarn and one stitching yarn per needle, the number of wales could be 2,36 wales/cm (6 per inch). The space needed between wefts will determine the construction per cm (inch).

[0030] After the weft inserted warp knit fabric (210) is formed, it is then coated with the alkali resistant coating (220) (See Fig. 2). Such coatings include, but are not limited to composite plate, rubber material, styrene butadiene rubber (SBR), and polyvinyl alcohol (PVA) coatings. The coating (220) must be resistant to bases such as NaOH, KOH, and $Ca(OH)_2$. The coating may be applied by any known means such that all of the yarns of the fabric (210) are coated in the alkali resistant material. Preferably, the weight of the coating (220) should be within the range of 1560 g/m^2, more preferably 20-50 g/m^2, even more preferably 25-40 g/m^2 to protect the fabric (210) against the alkaline of the cementitous material (100). A preferred specific example may be a coating weight of about 30 g/m^2.

[0031] The fabric (210) coated with the alkali resistant coating (220) should pass at least one of the Austria norm test B 61 22, the FR norm tests (Building Norm M1) and the test according to German DIN 4102. These tests are related to concrete products, which are used in the internal portion of buildings. The geometric shape, or stability of the fabric, needs to be held stable. Stability of the fabric (210) is to the thickness of the fabric and stiffness is related to the Tg (glasstransition temperature) of the alkali resistant coating.

[0032] In one embodiment, the alkali resistant chemical of the coating (220) is Penformax® 18034 F, which is a formulated compound, based on a blend of a soft and stiff carboxylated SBR latex, in order to modify the Tgof the coating. The soft SBR has a styrene content of 50 wt.-%, a butadiene content of 50 wt.-%, and a Tg of -2°C. The stiff SBR has a styrene content of 75 wt.-%, a butadiene content of 25 wt.-%, and a Tg of +54°C. The styrene and butadiene content of the soft and stiff SBR may be varied to obtain the desired physical characteristics. In Performax® 18034 F the weight ratio of soft SBR to stiff SBR is 60:40. In other SBR mixtures, the soft and stiff SBR polymers may be present in a weight ratio of 90:10 to 10:90, more preferably 60:40 to 40:60, depending on the stiffness desired to achieve. The SBR mixture imparts excellent alkali resistance to the fabric (210) and good adhesion to the cementitious material (100). Optionally, melamine resin may be added to the polymer of the coating (220) in order to modify the stiffness.

[0033] In another embodiment, PVA is used as the coating (220) because of its compatibility with concrete (tensile strength, temperature stability, elongation at break, and temperature stability) as well as its excellent

alkali resistance. PVA is available as, for example, as Vibatex KN® (Ciba Geigy). PVA may also be modified with a fluororesin, such as Flovan CGN®, other fluororesin chemicals, or other chemicals.

[0034] The fabric (210) or the yarns, (211), (212), (213) making up the fabric may also be subjected to chemicals that improve the adhesion of the reinforcing fabric (200) to the cementitious material (100) or to give other advantages such as nonwicking and/or fire proofing. In certain embodiments, a blue or other coloration may be added for identification of the fabric.

Claims

1. A fabric comprising (a) at least one layer of a weft inserted warp knit fabric including in-lay warp yarns, stitching yarns, which each form a wale around a corresponding in-lay warp yarn, and weft inserted yarns inserted in a parallel repetitive construction in every third or more stitch of the stitching yarns; and (b) an alkali resistant coating.

2. The fabric of claim 1, wherein the alkali resistant coating comprises at least one of polyvinyl alcohol and styrene butadiene rubber (SBR).

3. The fabric of claim 1 or 2, wherein the weft inserted yarns are inserted in every third, fourth, fifth or sixth stitch of the stitching yarns.

4. The fabric of any of the preceding claims, wherein the in-lay warp yarns comprise at least one of monofilaments, twisted multifilaments and staple fibers.

5. The fabric any of the preceding claims, wherein the weft inserted yarns comprise at least one of monofilaments, twisted multifilaments and staple fibers.

6. The fabric any of the preceding claims, wherein the in-lay warp yarns have a weight per unit length of 100 to 23,500 dtex (90 to 21,000 deniers).

7. The fabric any of the preceding claims, wherein the weft inserted yarns have a weight per unit length of 100 to 23,500 dtex (90 to 21,000 deniers).

8. The fabric any of the preceding claims, wherein the stitching yarns have a weight per unit length of 22 to 470 dtex (20 to 420 deniers).

9. The fabric any of the preceding claims, wherein the stitching yarns comprise at least one material selected from polyamide, polyester, rayon, para aramide, fiberglass, polyolefin, polyvinyl alcohol, steel and carbon.

10. The fabric any of the preceding claims, which comprises two or more layers of the weft inserted warp knit fabric.

11. The fabric any of the preceding claims, wherein the in-lay warp yarns and weft inserted yarns are not sized.

12. The fabric any of the preceding claims, wherein the ratio of the stitching yarn length to the in-lay warp yarn length is less than 3.1.

13. The fabric of claim 13, wherein the ratio is 2.6-3.0.

14. A reinforced cementitious material comprising (i) a cementitious material; and (ii) a fabric of any of the claims 1-13.

15. The reinforced concrete of claim 14, wherein the cementitious material is selected from concrete mixtures and cement mortars.

16. Use of a fabric of any of claims 1-13 as a reinforcement fabric for cementitious materials.

17. Use of claim 16, wherein the cementitious material is selected from concrete mixtures and cement mortars.

Amended claims in accordance with Rule 86(2) EPC.

1. A fabric comprising (a) at least one layer of a weft inserted warp knit fabric (210) including in-lay warp yarns (212), stitching yarns (211), which each form a wale around a corresponding in-lay warp yarn (212), and weft inserted yarns (213) inserted in a parallel repetitive construction in every third or more stitch of the stitching yarns (211); and (b) an alkali resistant coating (220).

2. The fabric of claim 1, wherein the alkali resistant coating (220) comprises at least one of polyvinyl alcohol and styrene butadiene rubber (SBR).

3. The fabric of claim 1 or 2, wherein the weft inserted yarns (213) are inserted in every third, fourth, fifth or sixth stitch of the stitching yarns (211).

4. The fabric of any of the preceding claims, wherein the in-lay warp yarns (212) comprise at least one of monofilaments, twisted multifilaments and staple fibers.

5. The fabric any of the preceding claims, wherein the weft inserted yarns (213) comprise at least one of monofilaments, twisted multifilaments and staple fibers.

6. The fabric any of the preceding claims, wherein the in-lay warp yarns (212) have a weight per unit length of 100 to 23,500 dtex (90 to 21,000 deniers).

7. The fabric any of the preceding claims, wherein the weft inserted yarns (213) have a weight per unit length of 100 to 23,500 dtex (90 to 21,000 deniers).

8. The fabric any of the preceding claims, wherein the stitching yarns (211) have a weight per unit length of 22 to 470 dtex (20 to 420 deniers).

9. The fabric any of the preceding claims, wherein the stitching yarns (211) comprise at least one material selected from polyamide, polyester, rayon, para-aramide, fiberglass, polyolefin, polyvinyl alcohol, steel and carbon.

10. The fabric any of the preceding claims, which comprises two or more layers of the weft inserted warp knit fabric (210).

11. The fabric any of the preceding claims, wherein the in-lay warp yarns (212) and weft inserted yarns (213) are not sized.

12. The fabric any of the preceding claims, wherein the ratio of the length of the stitching yarn (211) to the length of the in-lay warp yarn (212) is less than 3.1.

13. The fabric of claim 13, wherein the ratio is 2.6-3.0.

14. A reinforced cementitious material comprising (i) a cementitious material; and (ii) a fabric of any of the claims 1-13.

15. The reinforced concrete of claim 14, wherein the cementitious material is selected from concrete mixtures and cement mortars.

16. Use of a fabric of any of claims 1-13 as a reinforcement fabric for cementitious materials.

17. Use of claim 16, wherein the cementitious material is selected from concrete mixtures and cement mortars.

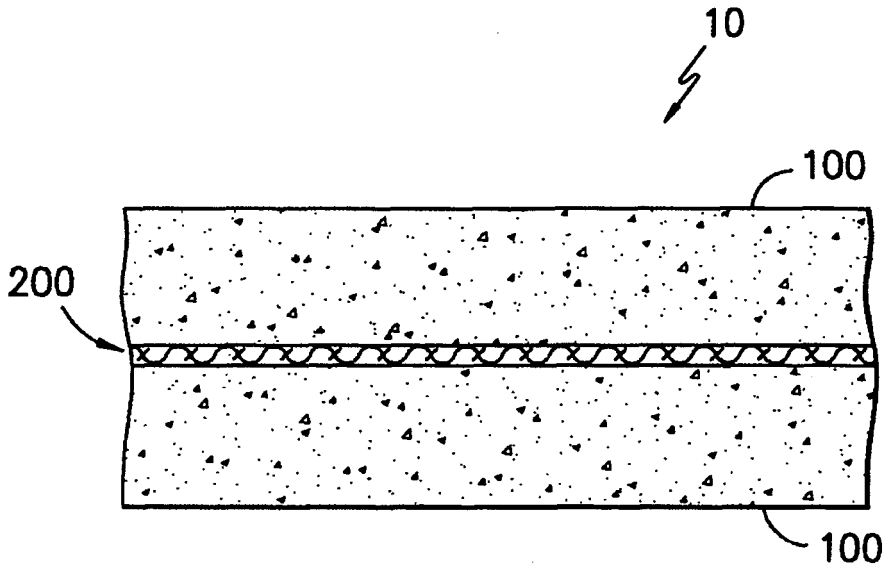

FIG. –1–

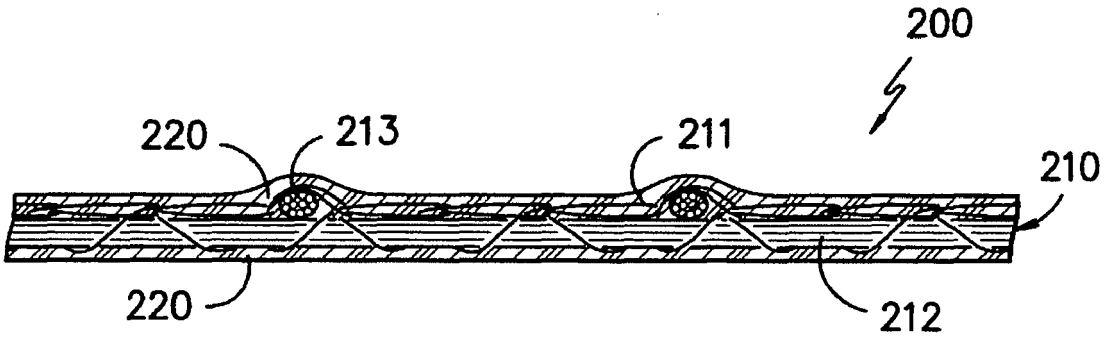

FIG. –2–

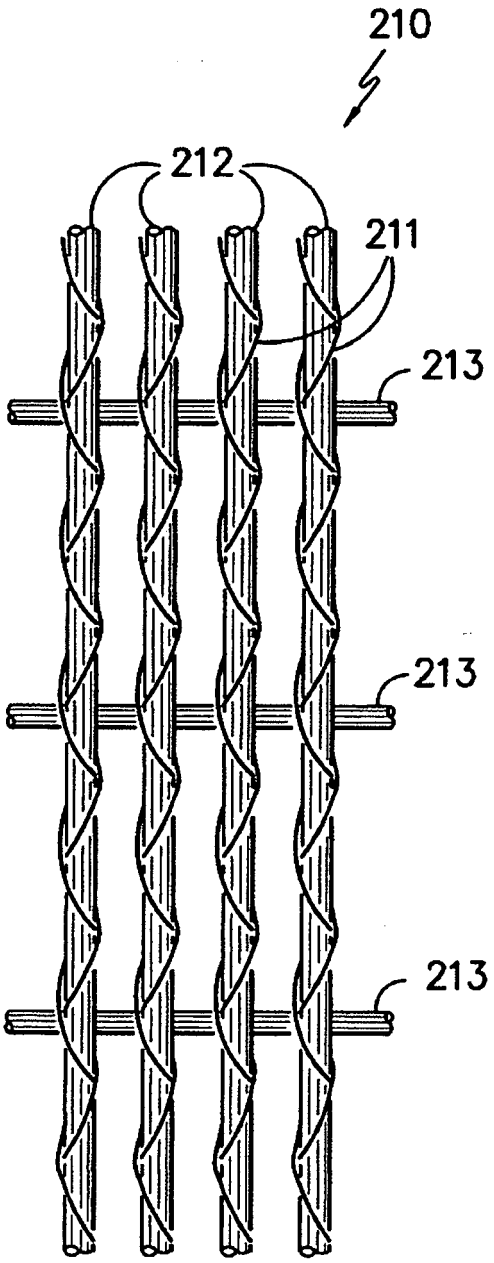

FIG. -3-

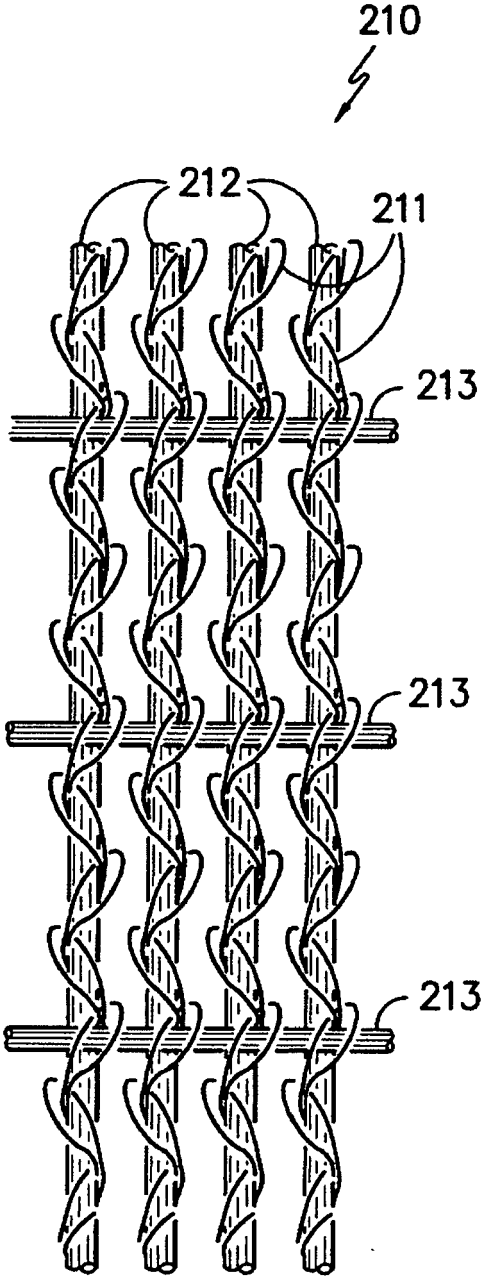

FIG. -4-

①	②
1	0
0	0
0	1
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1	0
0	0
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FIG. –5A–

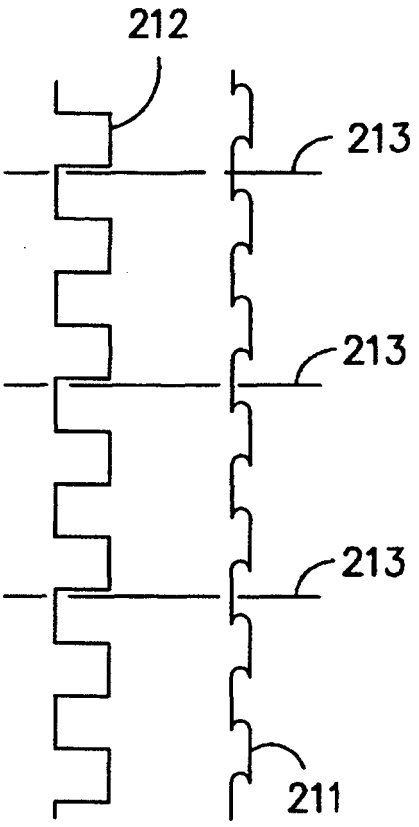

FIG. –5B–

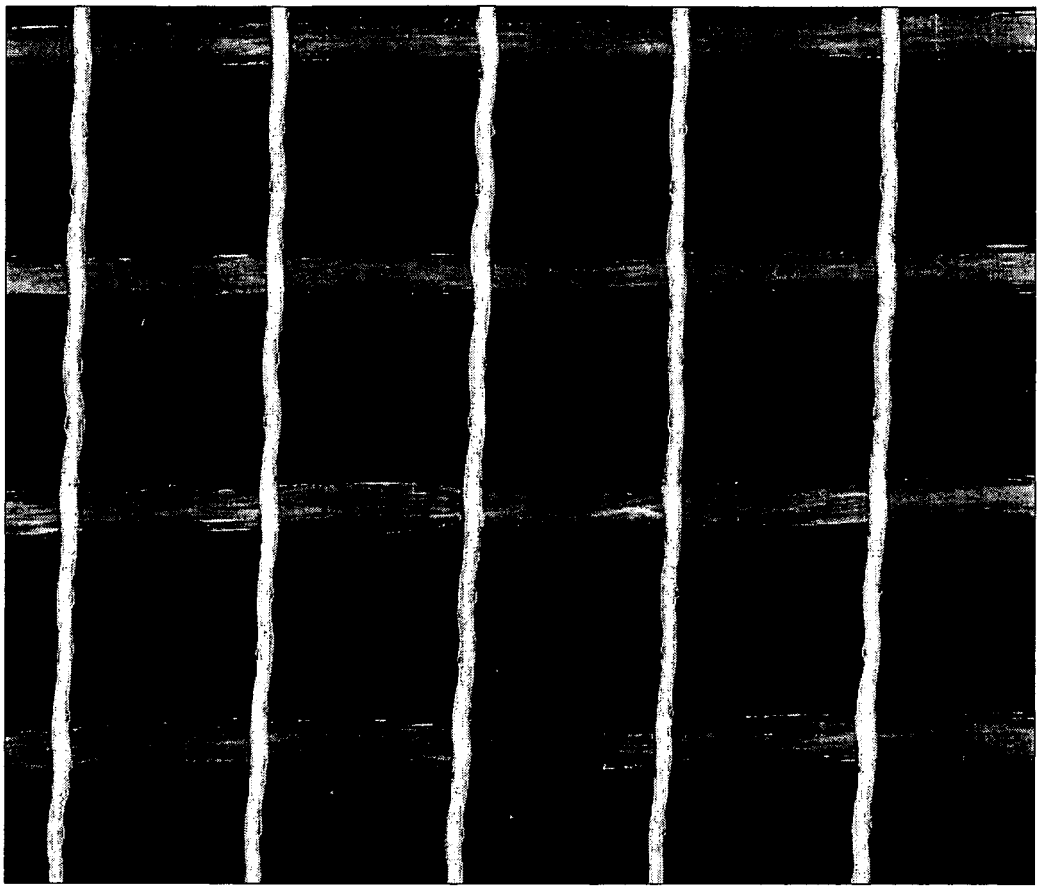

FIG 6

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 06 00 2869

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 0 464 803 A (BAY MILLS LIMITED) 8 January 1992 (1992-01-08) * page 3, line 53 - page 4, line 35; figure 1 *	1-17	D04B21/16 E04F13/04
X	US 5 763 043 A (PORTER ET AL) 9 June 1998 (1998-06-09) * column 5, line 42 - column 6, line 62; figure 4a *	1-17	
A	US 2005/233656 A1 (ROYER JOSEPH R ET AL) 20 October 2005 (2005-10-20) * paragraphs [0003] - [0011]; claims 1-17; figures 3-5 *	1,14-17	
A	US 2001/002971 A1 (KITTSON MARK) 7 June 2001 (2001-06-07) * paragraphs [0003] - [0011]; claims 1-6; figure 5 *	1,3-5	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	22 March 2006	Dreyer, C

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
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E : earlier patent document, but published on, or after the filing date
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L : document cited for other reasons

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 06 00 2869

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 5763043 A **[0002]**