(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
11 November 2004 (11.11.2004)

PCT

(10) International Publication Number
WO 2004/097091 A1

(51) International Patent Classification[7]: D03D 9/00, 15/00, 19/00, 13/00, B32B 13/02, 13/14, 27/04, 27/12, 05/02, 11/02, 11/10, 5/08, 17/02

(21) International Application Number: PCT/US2004/002876

(22) International Filing Date: 2 February 2004 (02.02.2004)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
10/425,905 29 April 2003 (29.04.2003) US

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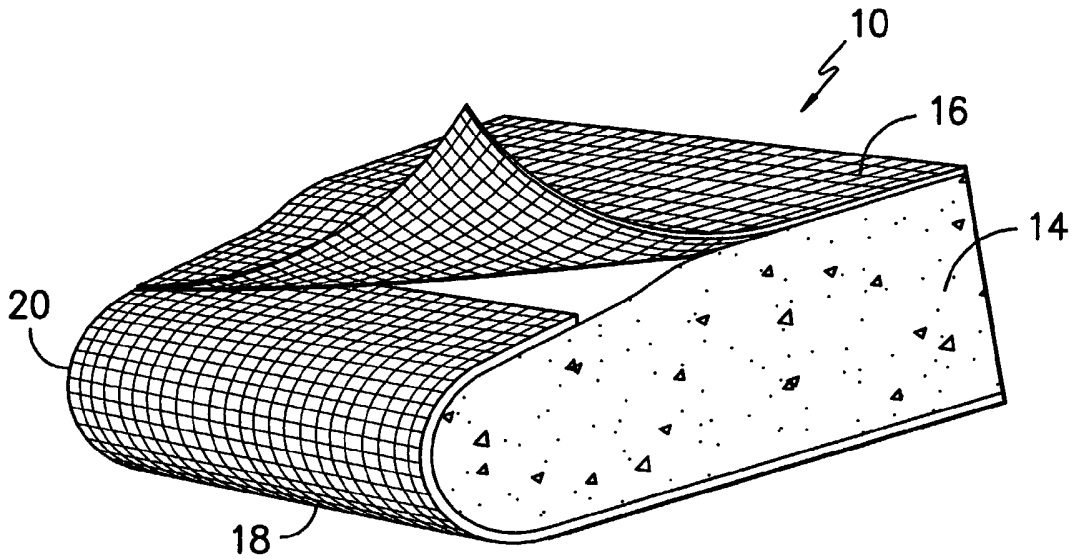
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

[Continued on next page]

(54) Title: FABRIC REINFORCED CEMENT



(57) Abstract: A cement panel that is reinforced with a fabric made of carbon fibers. The cement panel includes a core layer that is made of a lightweight cement composition. This core layer is covered with a layer of reinforcing carbon fabric on the top and on the bottom, each bonded to the core with a coating of cementitious material on the top and on the bottom of the core layer. On the edges of the cement panels, the fabric layers are overlapped so as to augment the strength of these edges.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

FABRIC REINFORCED CEMENT

BACKGROUND OF THE INVENTION:

The present invention relates generally to reinforced cementitious panels or boards, and, in particular, cementitious panels or boards that are reinforced with an adhesive bonded fabric that is unaffected by alkali attack.

The use of reinforced cement panels is well known in such industries as the ceramic tile industry. Generally, cement panels or boards contain a core formed of a cementitious material that is interposed between two layers of facing material. The facing materials employed typically share the features of high strength, high modulus of elasticity, and light weight so as to contribute flexural and impact strength to the high compressive strength but brittle material forming the cementitious core. Typically, the facing material employed with cement panels is fiberglass. Fiberglass performs particularly well in this application. Fiberglass provides greater physical and mechanical properties to the cement board. Fiberglass is also an efficient material to reinforce the cement panels because of its relatively low cost when compared with other high modulus materials.

Fiberglass, however, has a major disadvantage, which is its lack of resistance to chemical attack from the ingredients of the cements. Common cements, such as Portland cement, provide an alkaline environment when in contact with water, and the fiberglass yarn that is used in reinforcement fabrics is degraded in these highly alkaline conditions. To overcome this problem, protective polymeric coatings, such as PVC (polyvinyl chloride) plastisol coatings, are applied to the fiberglass. Although these coatings minimize fiberglass degradation, the protective coating on the fiberglass yarns is very critical to the success of the concrete panel. Furthermore, the fiberglass experiences rapid degradation with heat, which typically occurs during the curing phase of the cementitious boards. Therefore, excess fiberglass must be included to ensure a minimum amount of strength over the life of the cement boards.

Accordingly, there remains a need for an improved cement panel that is reinforced by a fabric that both minimizes or eliminates the need to include a

protective fabric coating and that retains the beneficial features of other facing materials.

SUMMARY OF THE INVENTION:

According to its major aspects and briefly recited, the present invention is a new and improved cement panel that is reinforced with a fabric made of carbon fibers. The cement panel includes a core layer that is made of a cement composition. This core layer is covered with a layer of reinforcing carbon fabric on the top and on the bottom, each bonded to the core with a coating of cementitious material on the top and on the bottom of the core layer. On the border edge regions of the cement panels, the fabric layers are overlapped so as to augment the strength of these regions.

In a first embodiment, the reinforcement fabric is a bi-directional, adhesive bonded fabric substrate including a plurality of lateral weft yarns that intersect a plurality of warp yarns at right angles and that are bonded at the intersections by an adhesive composition. In a second embodiment, the reinforcement fabric is a tri-directional, also commonly referred to as triaxial, adhesive bonded scrim fabric that is held together by an adhesive composition. As used herein, the term "scrim" shall mean a fabric having an open construction used as a base fabric or a reinforcing fabric. In a triaxial scrim, plural weft yarns having both an upward diagonal slope and a downward diagonal slope are located between plural longitudinal warp yarns that are located on top of the weft yarns and below the weft yarns. In yet another embodiment, a non-woven mat made of carbon fibers may be used in place of the bi-directional or triaxial fabric to reinforce the cement panel.

A feature of the present invention is the use of reinforcement fabric made of carbon fibers in combination with the cement panels. Not only does the use of carbon fibers minimize or altogether eliminate the need for a protective fabric coating, but also carbon possesses the same if not more beneficial features of other facing materials, such as fiberglass. As compared to the typically used fiberglass, carbon has 3 to 6 times the tenacity of fiberglass. Further, carbon breaks at lower elongations than fiberglass. Because the modulus of elasticity of carbon is similar to

that cement, the carbon fibers break at elongations in the same range as the cement. Therefore, the cement board or panel is less likely to fail for being too brittle, or too flexible. Carbon is also more resistant to alkali attack than fiberglass. Accordingly, the degradation of the reinforcement fabric due to alkali attack is reduced and the strength of the cement panel throughout its use is increased. Finally, carbon does not experience the same rapid degradation as fiberglass during the curing phase of the cement panels. Therefore, less carbon fiber needs to be employed in the reinforcement of the panels.

Other features and advantages of the present invention will be apparent to those skilled in the art from a careful reading of the Detailed Description of the Preferred Embodiments presented below and accompanied by the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS:

In the drawings,

FIG. 1 is a perspective view of a reinforced cement panel according to a preferred embodiment of the present invention;

FIG. 2 is a top view of a reinforcement fabric for use in combination with cement panels according to a preferred embodiment of the present invention;

FIG. 3 is a top view of a reinforcement fabric for use in combination with cement panels according to an alternative embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS:

The present invention is a new and improved cement panel **10** that is reinforced with an adhesive bonded fabric **20**. As shown if FIG. 1, cement panel includes a core layer **14** that is made of a concrete composition. Core layer **14** is covered by a top layer **16** and a bottom layer **18** of reinforcement fabric **20**. Preferably, top layer **16** and bottom layer **18** of fabric **20** overlap on the edge region of the cement panel **10**. Because of its cementitious nature, a cement board or panel may have a tendency to be relatively brittle at its edges, which often serve as points of attachment for the boards. Accordingly, by overlaying the fabric **20** at these

regions the strength of the cement board edges is augmented and the boards retain sufficient structural integrity such that they remain attached.

In FIG. 2, there is shown in detail reinforcement fabric **20** according to a first embodiment of the present invention. As illustrated, reinforcement fabric **20** is a bi-directional, adhesive bonded scrim, and includes a layer of parallel weft yarns **26** that are disposed between two convergent layers of parallel warp yarns **28**, **29**. These yarns are held together by an adhesive, such as polyvinyl alcohol (PVOH), acrylic, polyvinyl acetate, polyvinyl chloride, polyvinylidiene chloride, polyacrylate, acrylic latex or styrene butadiene rubber (SBR), plastisol, or any other suitable adhesive. This adhesive coating is dried upon application so as to stabilize reinforcement fabric **20**, thus reducing the shrinkage that can occur after the reinforcement fabric **20** is applied to cement panel **10**.

In the preferred fabric construction, warp yarns **28**, **29** are disposed at approximately 4 to 18 ends per inch, and the weft yarns **26** are disposed at approximately 4 to 18 ends per inch. Further, warp yarns **28**, **29** and weft yarns **26** are preferred in the denier range of 150 to 2000. It is contemplated that the denier of warp yarn **28**, **29** and/or weft yarn **26**, as well as the number of warp yarns **28**, **29** and/or weft yarns **26** per inch can be increased or decreased, as preferred in meeting the strength requirement of the finished cement panel **10**.

As previously discussed, the use of carbon fibers to make reinforcement fabric **10** is a particular feature of the present invention. Preferably, both warp yarns **28**, **29** and weft yarns **26** are made of carbon fibers. The use of carbon fibers minimizes or eliminates the need for a protective coating over reinforcement fabric **20**. Further, carbon includes the same if not more beneficial features of other typically used cement reinforcement materials including high strength, high modulus of elasticity, and lightweight. Finally, carbon does not experience the same rapid degradation as fiberglass during the curing phase of the cement panels. Therefore, less carbon fiber needs to be employed in the reinforcement of the panels

Alternatively, only warp yarns **28**, **29** or weft yarns **26** of reinforcement fabric **20** are made of carbon fibers and the corresponding weft yarns **26** or warp yarns **28**, **29** are made of fibers such as polyester, polyamides, polyolefin, ceramic, nylon, fiberglass, basalt, and aramid. In another alternative embodiment, the yarns in both the warp and weft direction could include alternating yarns made of carbon fiber and a second fiber such as those listed above. As used herein, the term "alternating" includes any combination of carbon fibers with a second fiber, including both multiple carbon fibers next to multiple second fibers, as well as a single carbon fiber next to a single second fiber. Because the cost of carbon fibers can be relatively high, the use of more inexpensive yarns in combination with carbon yarns can help to decrease the overall cost of manufacture of the reinforcement fabric **20**.

FIG. 3 illustrates reinforcement fabric **20** according to a second embodiment. As shown, reinforcement fabric **20** is a tri-directional, or triaxial adhesive bonded scrim fabric that is held together by an adhesive composition, such as polyvinyl alcohol (PVOH), acrylic, polyvinyl acetate, polyvinyl chloride, polyvinylidiene chloride, polyacrylate, acrylic latex or styrenebutadiene rubber (SBR), plastisol, or any other suitable adhesive. In a triaxial construction, plural weft yarns **26** having both an upward diagonal slope and a downward diagonal slope are located between plural longitudinal warp yarns **28** that are located on top of the weft yarns **26** and below the weft yarns **26**. The preferred range of the fabric construction of reinforcement fabric **20** is between approximately 4 x 2 x 2 (4 ends/inch in the warp direction, and 2 ends per inch on the upward diagonal slope in the weft direction, and 2 ends/inch on the downward diagonal slope in the weft direaction) and 18 x 9 x 9, and is most preferably 8 x 3 x 3. Further, warp yarns **28** and weft yarns **26** are preferred in a denier range of 150 to 2000.

Similar to the first embodiment, this adhesive coating of reinforcement fabric **20** is dried upon application so as to stabilize reinforcement fabric **20**. Preferably, both warp yarns **28** and weft yarns **26** are made of carbon fibers. Alternatively, only warp yarns **28** or weft yarns **26** of reinforcement fabric **20** are made of carbon fibers and the corresponding weft yarns **26** or warp yarns **28** are made of fibers such as polyester, polyamides, polyolefin, ceramic, nylon, fiberglass, basalt, and aramid. In

another alternative embodiment, the yarns in both the warp and weft direction could be made of could include yarns made of materials such as those listed between each carbon yarn.

Alternatively, it is contemplated that a non-woven web of carbon fiber may be used as the reinforcement fabric for a cement panel. Such a non-woven web, in a preferred embodiment, is sufficiently open to permit a cementitious core material to penetrate the fabric when the fabric is embedded in one or both major surfaces of the cementitious panel before the cementitious core material hardens. The non-woven carbon fiber web may be made from aligned (carded) or randomly oriented fibers.

Those skilled in the art of cement panels will recognize that many substitutions and modifications can be made in the foregoing preferred embodiments without departing from the spirit and scope of the present invention.

CLAIMS

1. A reinforced cement panel, comprising:

a core layer of cementitious material ; and

a first layer and a second layer of a reinforcement fabric with said core layer therebetween, wherein said first and said second layers each include plural weft yarns that cross plural warp yarns, and wherein at least some of said weft yarns and said warp yarns are at least partially made of carbon fibers.

2. The reinforced cement panel as recited in claim **1**, wherein said weft yarns and said warp yarns are made of 100% carbon fiber.

3. The reinforced cement panel as recited in claim **1**, wherein said reinforcement fabric is bi-directional.

4. The reinforced cement panel as recited in claim **3**, wherein said weft yarns and said warp yarns are disposed at 4 to 18 ends per inch.

5. The reinforced cement panel as recited in claim **1**, wherein said weft yarns and said warp yarns are in a denier range from approximately 150 to 2000 denier.

6. The cement panel as recited in claim **1**, wherein said reinforcement fabric is tri-directional.

7. The cement panel as recited in claim **6**, wherein said reinforcement fabric has a fabric construction of 4 to 18 ends per inch in the warp direction and between 2 x 2 and 9 x 9 ends per inch in the weft direction.

8. The cement panel as recited in claim **1**, wherein said weft yarns and said warp yarns are made of a combination of said carbon fiber and a fiber that is selected from a group consisting of polyester, polyamides, polyolefin, ceramic, nylon, fiberglass, basalt, aramid, and combinations thereof.

9. The cement panel as recited in claim **1**, wherein said weft yarns and said warp yarns are bonded by an adhesive.

10. The cement panel as recited in claim 9, wherein said adhesive is selected from a group consisting of polyvinyl alcohol, acrylic, polyvinyl acetate, polyvinyl chloride, polyvinylidiene chloride, polyacrylate, acrylic latex, styrene butadiene rubber, and plastisol.

11. The cement panel as recited in claim 1, wherein said first layer and said second layer of said reinforcement fabric are overlapped at the edges of said core layer.

12. A reinforced cement panel, comprising:

a core layer of cementitious material; and

a first layer and a second layer of a reinforcement fabric with said core layer therebetween, wherein said first and said second layers each include plural weft yarns that cross plural warp yarns, and wherein at lease some of said plural weft yarns are made of carbon fibers and said plural warp yarns made of a second fiber.

13. The reinforced cement panel as recited in claim **12**, wherein said second fiber is selected from a group consisting of polyester, polyamides, polyolefin, ceramic, nylon, fiberglass, basalt, aramid, and combinations thereof.

14. The reinforced cement panel as recited in claim **12**, wherein said reinforcement fabric is bi-directional.

15. The reinforced cement panel as recited in claim **12**, wherein said reinforcement fabric is tri-directional.

16. A reinforced cement panel, comprising:

a core layer of cementitious material;

a first layer and a second layer of a reinforcement fabric with said core layer therebetween, wherein said first and said second layers each include plural weft

yarns that cross plural warp yarns, and wherein at least one of said weft yarns or said warp yarns includes alternating yarns of carbon fiber and a second fiber.

17. The reinforced cement panel as recited in claim **16**, wherein said second fiber is selected from a group consisting of polyester, polyamides, polyolefin, ceramic, nylon, fiberglass, basalt, aramid, and combinations thereof.

18. The reinforced cement panel as recited in claim **16**, wherein said reinforcement fabric is bi-directional.

19. The reinforcement cement panel as recited in claim **17**, wherein said reinforcement fabric is tri-directional.

20. A fabric comprising:

a plurality weft yarns that cross plural warp yarns, wherein at least some of said weft yarns and said warp yarns are at least partially made of carbon fibers.

21. The fabric as recited in claim 20, wherein said weft yarns and said warp yarns are made of 100% carbon fiber.

22. The fabric as recited in claim 20, wherein said reinforcement fabric is bi-directional.

23. The fabric as recited in claim 22, wherein said weft yarns and said warp yarns are disposed at 4 to 18 ends per inch.

24. The fabric as recited in claim 20, wherein said weft yarns and said warp yarns are in a denier range from approximately 150 to 2000 denier.

25. The fabric as recited in claim 20, wherein said fabric is tri-directional.

26. The fabric as recited in claim 25, wherein said fabric has a fabric construction of 4 to 18 ends per inch in the warp direction and between 2 x 2 and 9 x 9 ends per inch in the weft direction.

27. The fabric as recited in claim 20, wherein said weft yarns and said warp yarns are made of a combination of said carbon fiber and a fiber that is selected from a group consisting of polyester, polyamides, polyolefin, ceramic, nylon, fiberglass, basalt, aramid, and combinations thereof.

28. The fabric as recited in claim 20, wherein said weft yarns and said warp yarns are bonded by an adhesive.

29. The fabric as recited in claim 28, wherein said adhesive is selected from a group consisting of polyvinyl alcohol, acrylic, polyvinyl acetate, polyvinyl chloride, polyvinylidiene chloride, polyacrylate, acrylic latex, styrene butadiene rubber, and plastisol.

30. A reinforced cement panel, comprising:

a core layer of cementitious material; and

a first layer and a second layer of a reinforcement fabric with said core layer therebetween, wherein said first and said second layers each include a non-woven mat made at least partially of carbon fibers.

31. The reinforced cement panel as recited in claim 30, wherein said non-woven mat includes randomly oriented fibers.

32. The reinforced cement panel as recited in claim 30, wherein said non-woven mat includes aligned fibers.

33. The reinforced cement panel as recited in claim 30, wherein said non-woven mat is made from 100% carbon fibers.

34. A reinforcement fabric for cement panels, said reinforcement fabric comprising a non-woven mat made from 100% carbon fibers.

35. The reinforcement fabric as recited in claim 34, wherein said non-woven mat includes randomly oriented fibers.

36. The reinforcement fabric as recited in claim 34, wherein said non-woven mat includes aligned fibers.

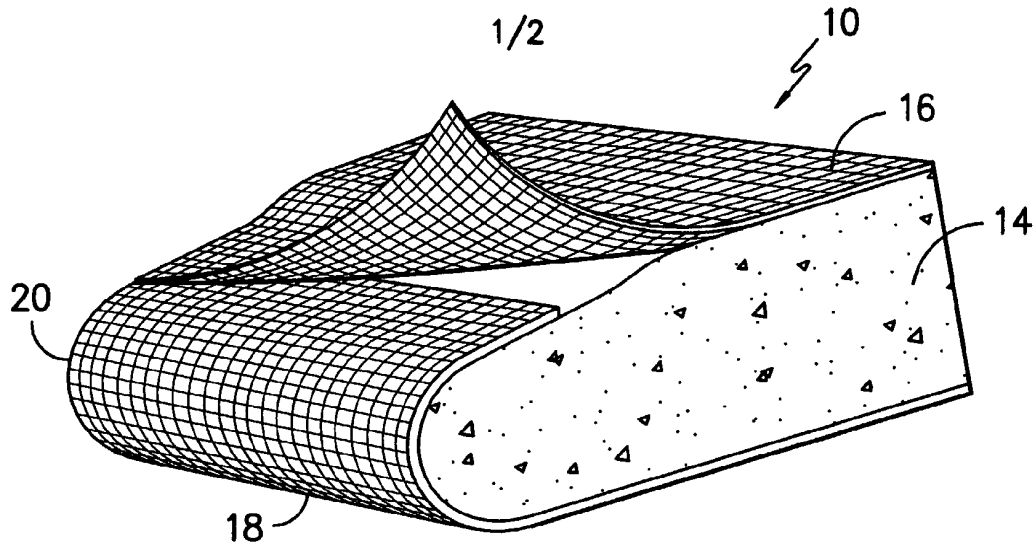

FIG. -1-

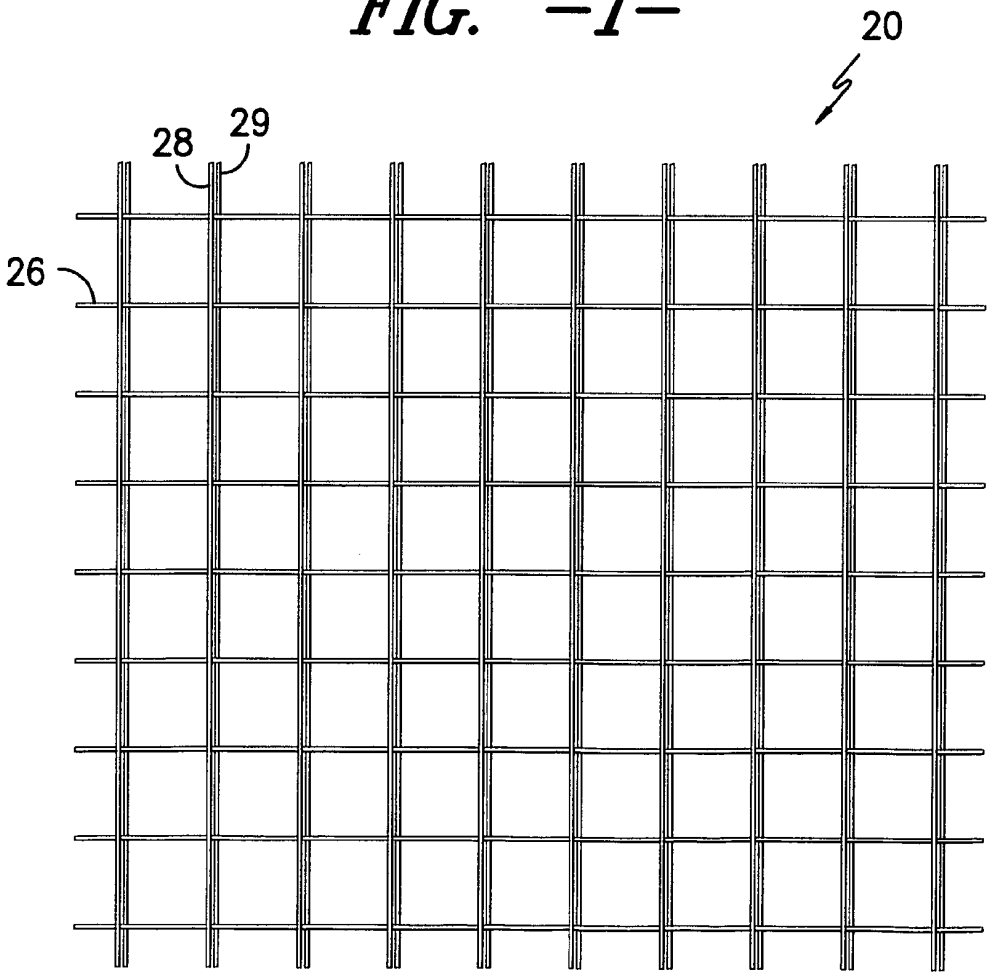

FIG. -2-

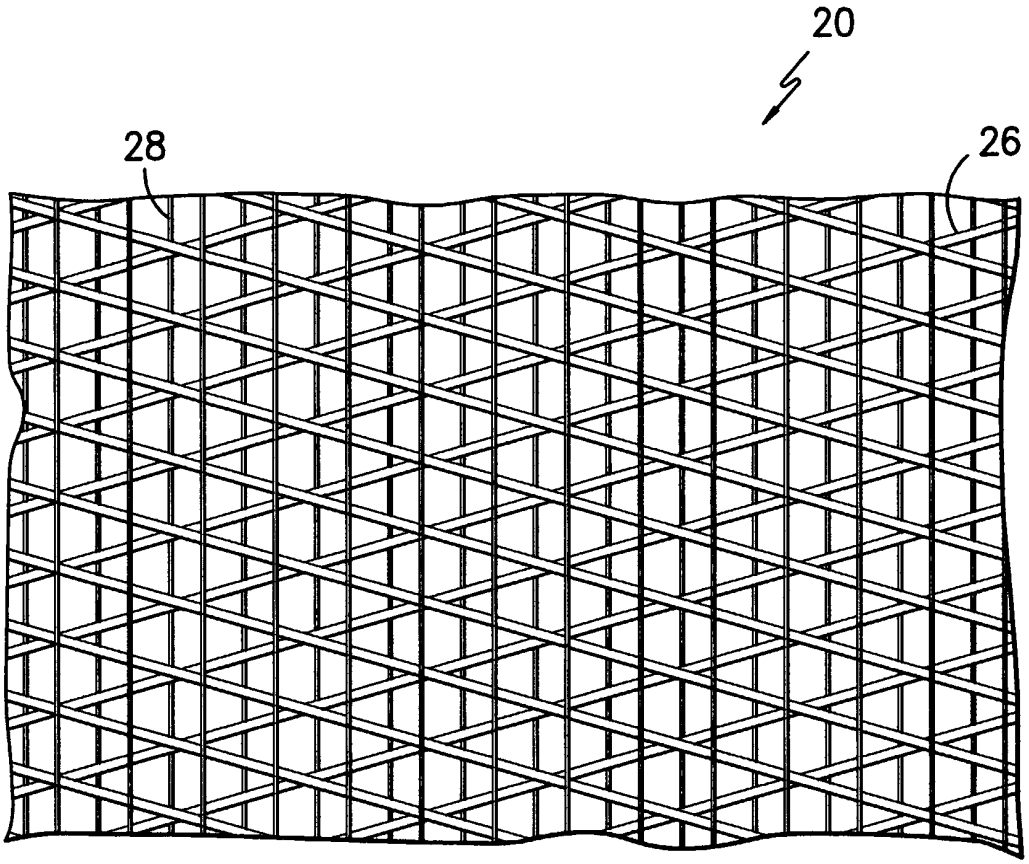

FIG. -3-

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US04/02876

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : D03D 9/00, 15/00, 19/00, 13/00; B32B 13/02, 13/14, 27/04, 27/12, 5/02, 11/02, 11/10, 5/08, 17/02
US CL : 442/20, 21, 42, 43, 48, 149, 203, 208, 209, 210, 212, 213, 215, 216, 217, 218, 219, 220, 415

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)
U.S. : 442/20, 21, 42, 43, 48, 149, 203, 208, 209, 210, 212, 213, 215, 216, 217, 218, 219, 220, 415

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
PGPB, USPT, USOC, EPAB, JPAB, DWPI

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2002/0151240 A1 (SMITH et al.) 17 October 2002 (17.10.2002). Entire document.	1, 2, 5-7, 9, 10, 11, 30, 31, 33, 34, and 35
X	US 4,617,219 A (SCHUPACK) 14 October 1986 (14.10.1986), col 4, lines 1-5; col 4, lines 14-16).	30, 31 and 33-35
X --- Y	US 2004/0025465 A1 (ALDEA et al) 12 February 2004 (12.02.2004), see entire document.	3 and 4 --- 3 and 4
X --- Y	US 2001/0049919 A1 (FYFE) 13 December 2001 (13.12.2001), col 3, lines 49-67 to col 4, lines 1-10; col 4, lines 48-53; col 8, lines 60-68; col 5, lines 7-27; col 1, lines 5-7; col 2, lines 36-41; col 2, lines 57-59.	8, 12, 13, 15-17 --- 8, 12, 13, 15-17
X --- Y	US 6,263,629 B1 (BROWN, JR) 24 July 2001 (24.07.2001) see entire document	14 and 18 --- 14 and 18

☒ 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

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"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 such 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	Date of mailing of the international search report
04 August 2004 (04.08.2004)	19 OCT 2004
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450 Alexandria, Virginia 22313-1450 Facsimile No. (703) 305-3230	Authorized officer Marian Knode Telephone No. 571-272-1700

Jean Proctor
Paralegal Specialist

Form PCT/ISA/210 (second sheet) (July 1998)

PCT/US04/02876

INTERNATIONAL SEARCH REPORT

C. (Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 5,607,527 A (ISLEY, JR) 4 March 1997 (04.03.1997) see entire document	14 and 18 ---------- 14 and 18
X --- Y	US 5,244,693 A (INABA et al) 14 September 1993 (14.09.1993) see entire document	14 and 18 ---------- 14 and 18
X --- Y	US 4,581,275 A (ENDO et al) 8 April 1986 (08.04.1986) see entire document	14 and 18 ---------- 14 and 18
X --- Y	EP 0 572 243 A1 (TONEN) 26 May 1993 (26.05.1993) see entire document.	32 and 36 ---------- 32 and 36

INTERNATIONAL SEARCH REPORT

PCT/US04/02876

Continuation of B. FIELDS SEARCHED Item 3:
warp, weft, bi-directional, tri-directional, non-woven, nonwoven, unwoven, scrim, mesh, net, netting, lattice, grid, screen, cement$6 or gypsum, fiber, filament, fibre, yarn, carbon, polyester, pet, polyethylene, terephthalate, polyamide, kevlar, polyolefin, ceramic, nylon, glass, bassalt, aramid, adhesive, resin, binder, polyvinyl alcohol, pva, acrylic, polyvinyl acetate, polyvinyl chloride, PVC, polyvinylidien chloride, polacrylate, acrylic laten styrene butadiene rubber.