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(54) **THREE-DIMENSIONALLY REINFORCED CELLULAR MATRIX COMPOSITE AND METHOD OF MAKING SAME**

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(56) **References Cited**

U.S. PATENT DOCUMENTS

4,473,665	A		9/1984	Martini-Vvedensky et al.
4,966,801	A	*	10/1990	Becker et al. 428/113
5,158,986	A		10/1992	Cha et al.
5,334,356	A		8/1994	Baldwin et al.
5,465,760	A		11/1995	Mohamed et al.
5,637,375	A	*	6/1997	Hohman 428/113
6,045,898	A	*	4/2000	Kishi et al. 428/245

* cited by examiner

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(57) **ABSTRACT**

A light-weight and impact-resistant composite material formed from a three-dimensional textile structure preform comprising at least three systems of yarns that define a plurality of interstices within the textile structure. A cellular matrix material impregnates the textile structure so as to fill the interstices of the three-dimensional textile structure and to coat at least a portion of the surface area thereof.

11 Claims, 9 Drawing Sheets