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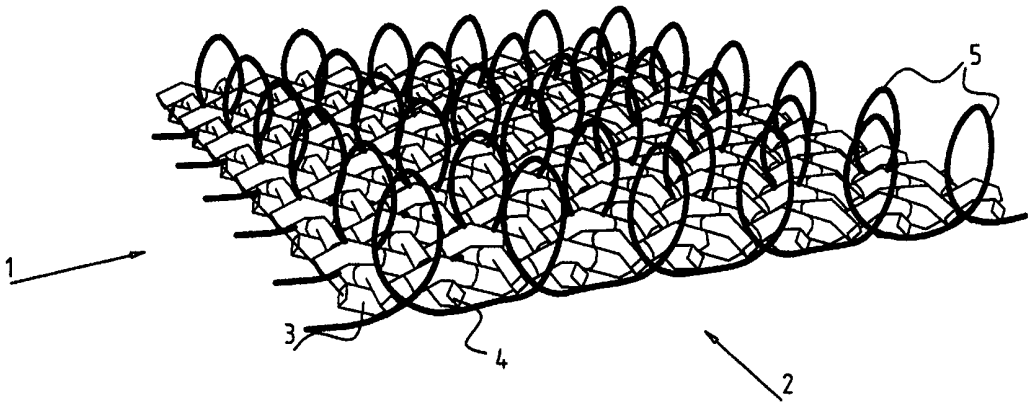

(57) Abstract

The invention relates to a three–dimensional strengthening material (1) for composites comprising a basic layer (2), consisting of a per se known textile reinforcement (3, 4) for strengthening in X–direction and Y–direction, and piles (5) tufted into the basic layer and extending substantially in Z–direction for strengthening in the Z–direction, and a composite material comprising a synthetic resin or a combination of synthetic resins having incorporated therein the strengthening material according to the invention.

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THREE-DIMENSIONAL STRENGTHENING MATERIAL

The present invention relates to a three-dimensional strengthening material for use as textile reinforcement in composites. The invention further relates to the composite materials containing such a strengthening material and a method for strengthening plastic products.

The term composites is used for plastics which are strengthened with a textile reinforcement. Such textile reinforcements can take the form of woven fabrics, mats, membranes, non-wovens, knits and the like or combinations thereof. In addition, synthetic resins can be strengthened by mixing short fibres of about 1 to 8 mm therein. Although such a mix provides strengthening in all directions, i.e. the X-, Y- and Z-direction, or in longitudinal direction, transverse direction and height direction, the mechanical properties of such composites into which fibres are mixed are however limited.

Composites which are strengthened with woven fabrics or webs consisting of endless threads have the highest strength values, because the mechanical values are greatly dependent on the length of the strengthening fibre. The great drawback however is that they provide no strengthening in the Z-direction. The result hereof is that the composite materials fail because the different layers of strengthening material delaminate from each other under continuous load.

Composites are however often also loaded in the Z-direction. In such a case a three-dimensional strengthening is necessary. In order to achieve this a double woven fabric has for instance been proposed in WO 94/01272 which consists of two woven fabrics which are mutually connected by means of pile threads. The weaving technique which has to be used for such a strengthening layer is however relatively complicated and requires expensive and complex machines. It is therefore the object of the present invention to provide a new three-

dimensional strengthening material, which can be manufactured in simple manner.

This is achieved by the invention by a three-dimensional strengthening material comprising a basic layer, consisting of a per se known textile reinforcement for strengthening in X-direction and Y-direction, and piles tufted into the basic layer and extending substantially in Z-direction for strengthening in the Z-direction.

"Pile" in this application is understood to mean a loop- or thread-like fibre or fibre bundle arranged in a basic layer by means of the tufting technique.

The advantage of such a strengthening material is that it can be manufactured in relatively simple manner and that by choosing the parameters of the tufting process a strengthening material can be obtained which has long or short piles and piles with a large or small density. For strengthening of a composite material two specimens of such a three-dimensional strengthening material will generally be used, wherein the piles will point toward each other in the end product. Because it is possible to vary the length of the piles and also the distance between the tops of the piles of two specimens of strengthening material pointing toward each other, a great variation in thickness of the final composite material is possible, wherein a high delamination resistance and impact resistance in the Z-direction can nevertheless be obtained.

A per se known textile reinforcement is used as basic layer. Such textile reinforcements are for instance woven fabrics, webs, mats, membranes, knits or combinations thereof in suitable materials such as glass fibre, aramid fibre, carbon fibre, synthetic fibres such as polyester, polypropylene, polyethylene, polyamide, vegetable fibres such as flax, cotton, jute, hemp, animal fibres such as wool, and the like. The basic layers thereby also provide strength in X-direction and Y-direction.

The piles of the strengthening material can be manufactured from the same or a different material from the basic layer. The piles can therefore be manufactured

from glass fibre, aramid fibre, carbon fibre, synthetic fibres such as polyester, polypropylene, polyethylene, polyamide, vegetable fibres such as flax, cotton, jute, hemp, animal fibres such as wool, and the like.

Loop-like piles are in principle created during tufting. However, thread-like piles can likewise be formed by clipping or cutting the piles at the top.

The three-dimensional strengthening material according to the invention is particularly suitable for use as textile reinforcement in a composite material. Such a composite material comprises a synthetic resin or a combination of synthetic resins having incorporated therein a strengthening material according to the invention. Such a composite material is preferably a sandwich material consisting of two outer layers which are formed by the basic layer of the three-dimensional strengthening material, which is impregnated with synthetic resin or incorporated in synthetic resin, and which have therebetween an intermediate layer of a foamed synthetic resin, in which are arranged the piles of the three-dimensional strengthening material extending inward from the outer layer. The piles are as it were anchored in the foamed synthetic resin which can for instance be a polyurethane or a polystyrene foam. The advantage of foam is that the final sandwich thereby becomes less solid and less heavy than when a solid intermediate layer is used.

The invention also relates however to a sandwich material consisting of two outer layers which are each formed by the basic layer of the three-dimensional strengthening material, which is impregnated with synthetic resin or incorporated in synthetic resin, and which have therebetween and connected thereto an intermediate layer which is formed by the piles of the three-dimensional strengthening material which are impregnated with a synthetic resin or are incorporated therein and extend inward from the outer layer. Such a composite material is of course much more solid than when the intermediate layer is foamed. There are however applications wherein such a solid sandwich is preferred.

The composite materials according to the invention can be manufactured by means of per se known techniques, such as hand lay-up, vacuum technique, RIM, RTM, moulding, pultrusion and so on.

The invention further relates to a method for strengthening plastic products, comprising of manufacturing a plastic product with the use of a three-dimensional strengthening material according to the invention. The plastic product can also be manufactured directly from a composite material according to the invention. The composite material according to the invention can be applied particularly advantageously in plastic products requiring a high impact resistance, such as car bumpers, boats and the like.

The three-dimensional strengthening material according to the invention is manufactured by providing a basic layer, consisting of a per se known textile reinforcement, and tufting piles into the basic layer in Z-direction.

The present invention will be further elucidated on the basis of the accompanying drawings, in which corresponding reference numerals refer to corresponding components and in which:

Figure 1 shows a perspective view of a three-dimensional strengthening material according to the invention;

Figure 2 shows a perspective view of an alternative embodiment of the material of Figure 1;

Figure 3 shows a partly broken-away perspective view of a sandwich panel in which the strengthening material according to the invention is used;

Figure 4 shows a partly broken-away perspective view of an alternative embodiment of the sandwich of Figure 3.

Figure 1 shows a view of a tufted three-dimensional strengthening material 1 according to the invention. In the shown case basic layer 2 is a woven fabric consisting of warp threads in X-direction 3 and weft threads in Y-direction 4. Loops 5 extending in Z-direction are tufted therein at a relatively low density.

Figure 2 shows a similar type of three-dimensional strengthening material according to the invention with a higher density of loops.

Figure 3 shows a sandwich structure in which the strengthening material according to the invention is applied. The material consists of two three-dimensional strengthening materials 1 according to the invention with the loops 5 directed toward each other. Loops 5 extend into a foam layer 6, which is arranged between two outer layers 7, each consisting of the basic layer 2 of strengthening material 1 according to the invention which is impregnated in a resin.

Finally, figure 4 shows an embodiment wherein the tops of the tufted loops 5 make mutual contact and wherein the direction of the loops is displaced 90° relative to each other.

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CLAIMS

1. Three-dimensional strengthening material for composites comprising a basic layer, consisting of a per se known textile reinforcement for strengthening in X-direction and Y-direction, and piles tufted into the basic layer and extending substantially in Z-direction for strengthening in the Z-direction.

2. Three-dimensional strengthening material as claimed in claim 1, **characterized in that** the basic layer is a woven fabric, web, mat, membrane, knit or a combination thereof.

3. Three-dimensional strengthening material as claimed in claim 1 or 2, **characterized in that** the basic layer is manufactured from glass fibre, aramid fibre, carbon fibre, synthetic fibres such as polyester, polypropylene, polyethylene, polyamide, vegetable fibres such as flax, cotton, jute, hemp, animal fibres such as wool, and the like.

4. Three-dimensional strengthening material as claimed in claim 1 or 2, **characterized in that** the piles are manufactured from glass fibre, aramid fibre, carbon fibre, synthetic fibres such as polyester, polypropylene, polyethylene, polyamide, vegetable fibres such as flax, cotton, jute, hemp, animal fibres such as wool, and the like.

5. Three-dimensional strengthening material as claimed in claims 1-4, **characterized in that** the piles are loop-like or thread-like.

6. Three-dimensional strengthening material as claimed in claims 1-5 for use as textile reinforcement in a composite material.

7. Composite material comprising a synthetic resin or a combination of synthetic resins having incorporated therein a strengthening material as claimed in claims 1-5.

8. Composite material as claimed in claim 7, **characterized in that** the material is a sandwich material consisting of two outer layers which are each formed by

the basic layer of the three-dimensional strengthening material, which is impregnated with synthetic resin or incorporated in synthetic resin, and which have therebetween an intermediate layer of a foamed synthetic resin, in which are arranged the piles of the three-dimensional strengthening material extending inward from the outer layer.

9. Composite material as claimed in claim 7 or 8, **characterized in that** the material is a sandwich material consisting of two outer layers which are each formed by the basic layer of the three-dimensional strengthening material, which is impregnated with synthetic resin or incorporated in synthetic resin, and which have therebetween and connected thereto an intermediate layer which is formed by the piles of the three-dimensional strengthening material which are impregnated with a synthetic resin or are incorporated therein and extend inward from the outer layer.

10. Composite material as claimed in claims 7-9, **characterized in that** the tops of the piles of two three-dimensional strengthening materials located mutually opposite do not make mutual contact.

11. Composite material as claimed in claims 7-9, **characterized in that** the tops of the piles of two three-dimensional strengthening materials located mutually opposite make mutual contact.

12. Composite material as claimed in claims 7-11, **characterized in that** the synthetic resin is chosen from thermo-setting synthetic resins and thermoplastic synthetic resins and particularly from polyester resin, epoxy resin, vinyl ester resin, phenol resin etc.

13. Composite material as claimed in claims 7-12, **characterized in that** the foamed synthetic resin is chosen from polyurethane, polystyrene etc.

14. Method for strengthening plastic products, comprising of manufacturing a plastic product with the use of a three-dimensional strengthening material as claimed in any of the claims 1-5.

15. Composite material as claimed in claim 14, **characterized in that** the plastic product is manufactured from a composite material as claimed in claims 7-13.

16. Method of manufacturing a three-dimensional strengthening material as claimed in claims 1-5, comprising of providing a basic layer, consisting of a per se known textile reinforcement, and tufting piles into the basic layer in Z-direction.

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FIG. 2

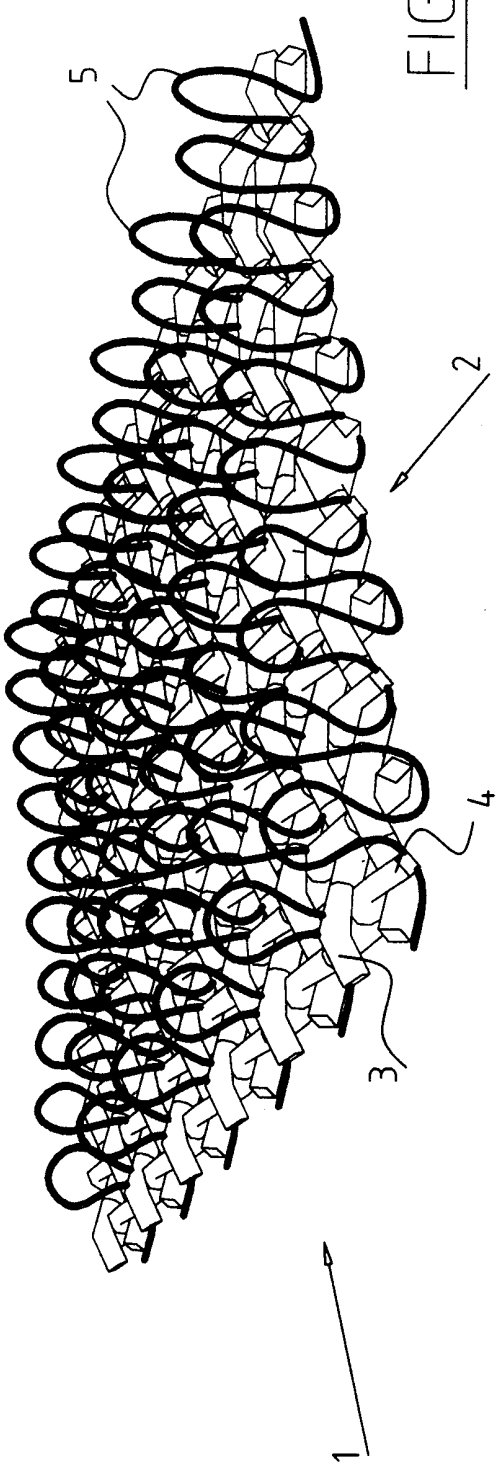
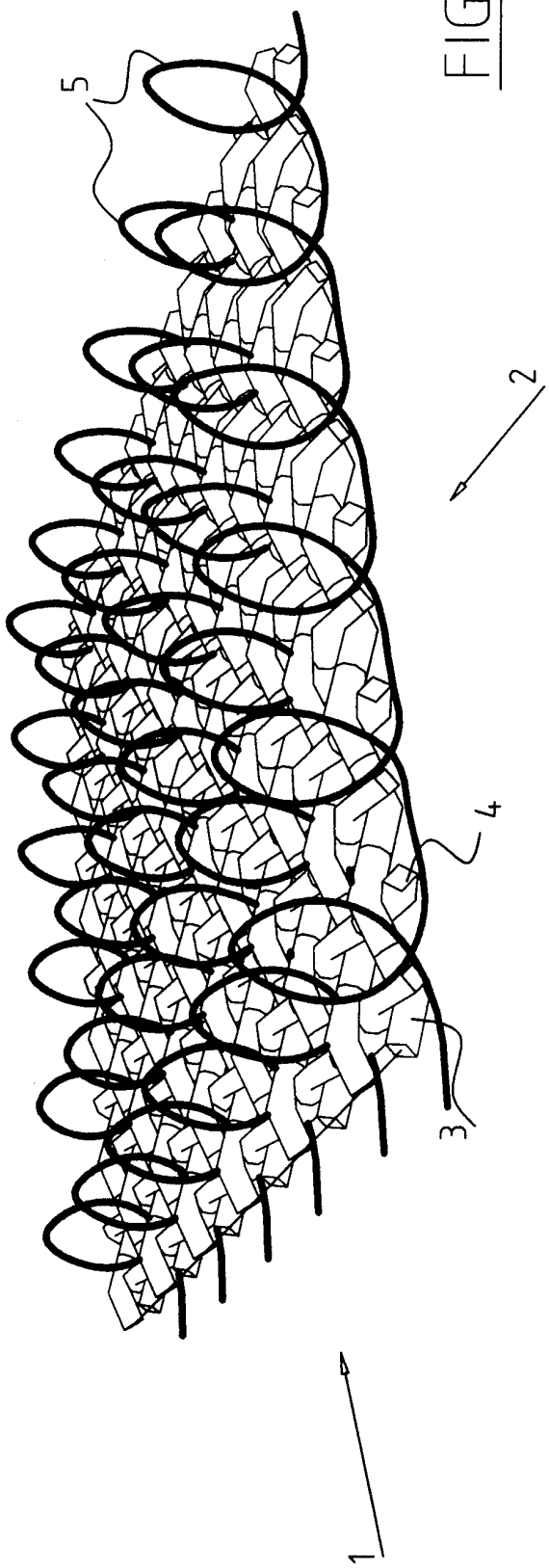


FIG. 1



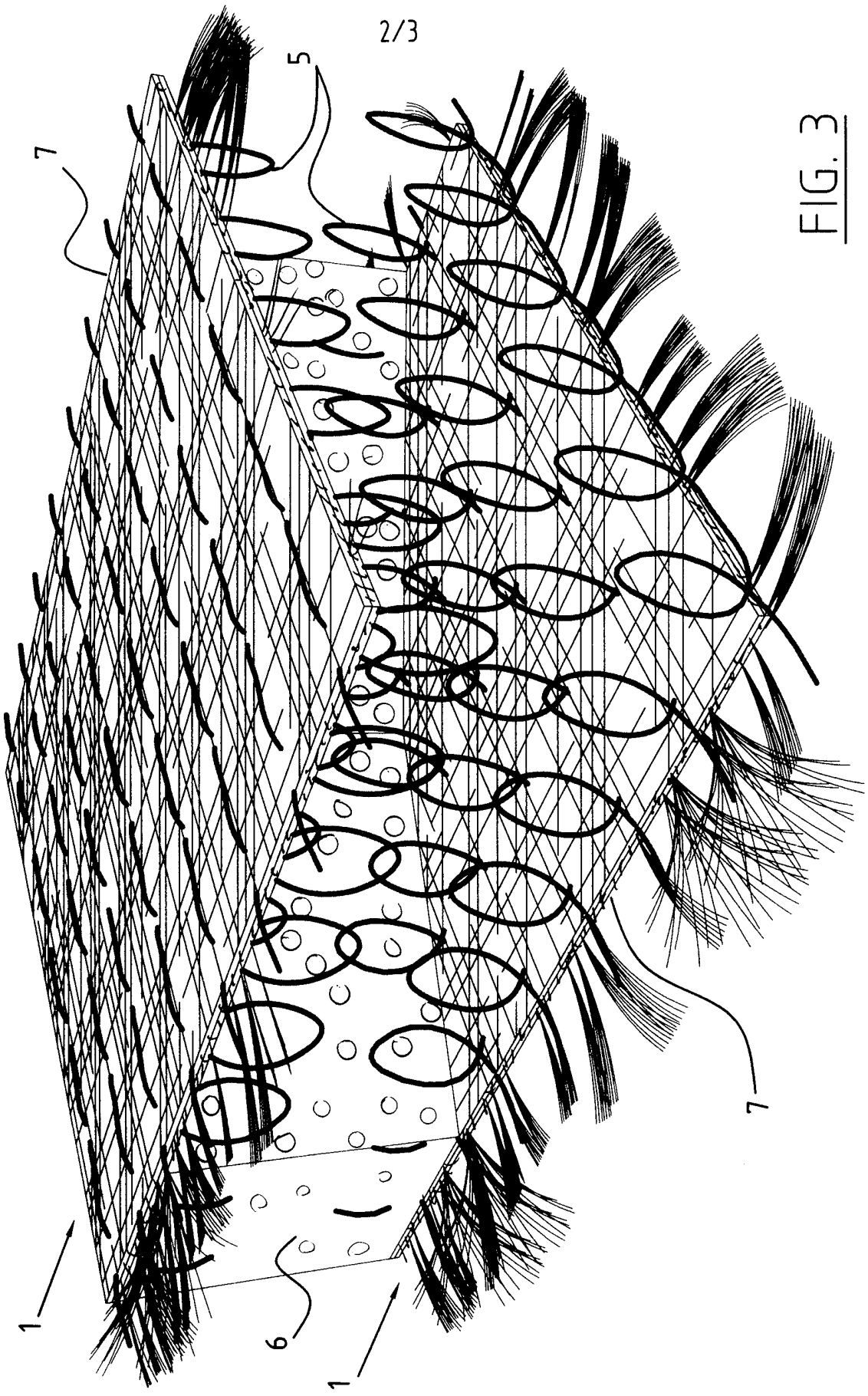


FIG. 3

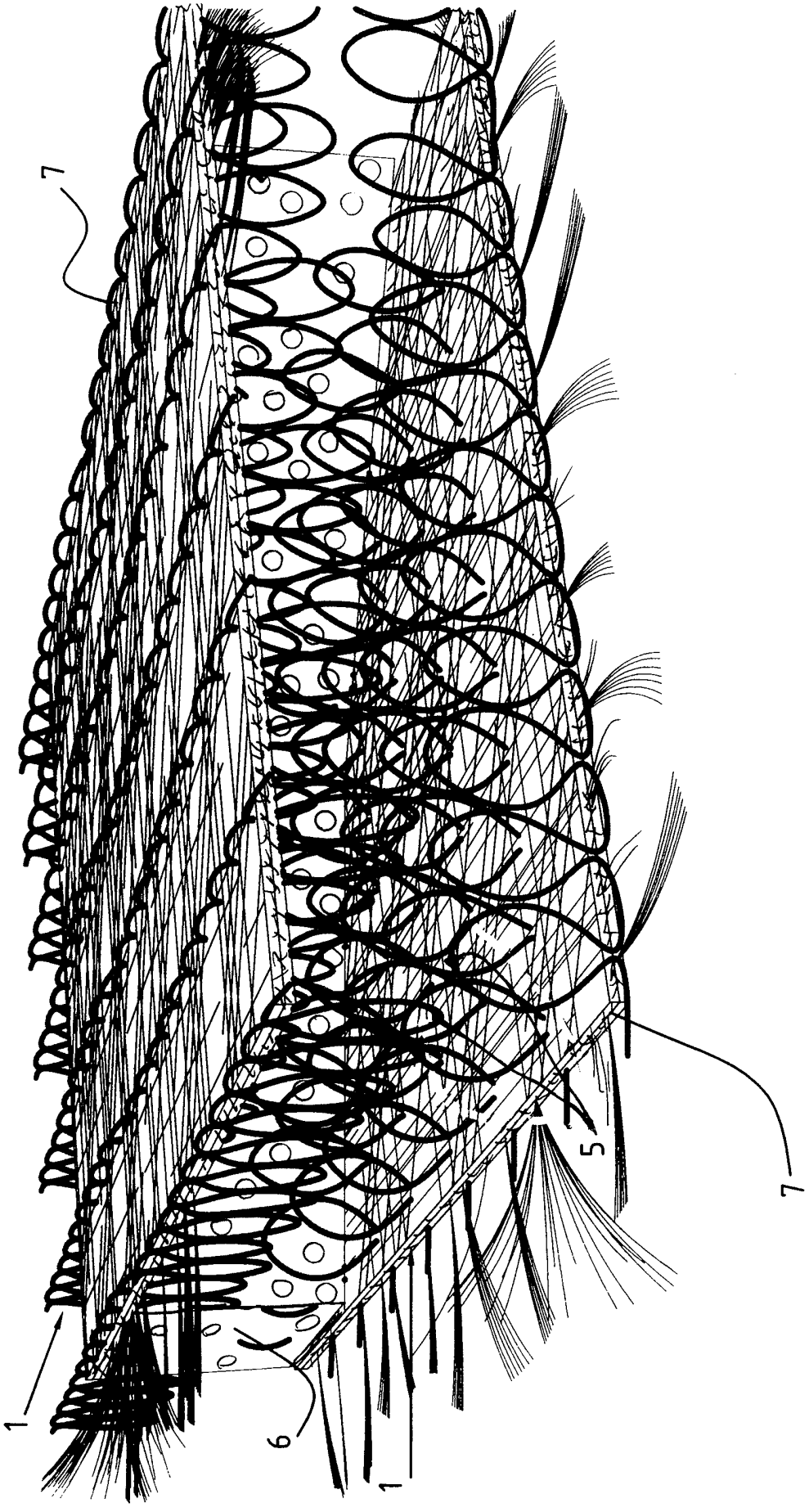


FIG. 4

INTERNATIONAL SEARCH REPORT

Int ational Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B29C70/24 //B29L9:00

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)
IPC 6 B29C

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 practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	FR 1 362 018 A (MÖLNLYCKE AKTIEBOLAG) 9 September 1964 see the whole document	1-7,9, 11,12, 14-16
X	DE 38 35 046 A (HOECHST AG) 19 April 1990 see column 2, line 67 - column 3, line 2; figure 1	1-7, 9-12, 14-16
X	EP 0 356 930 A (GOODRICH CO B F) 7 March 1990 see the whole document	1-7,9, 11,12, 14-16

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[X] Further documents are listed in the continuation of box C.

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X	EP 0 174 886 A (AEROSPATIALE) 19 March 1986 see page 7, line 29 - page 8, line 13; figures 2-6 see page 2, line 33 - page 3, line 14	1-7,12, 14-16
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