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CA 2357868 C 2005/02/22

(11)(21) 2 357 868

(12) BREVET CANADIEN
CANADIAN PATENT

(13) C

(86) Date de dépôt PCT/PCT Filing Date: 1999/10/29
(87) Date publication PCT/PCT Publication Date: 2000/07/13
(45) Date de délivrance/Issue Date: 2005/02/22
(85) Entrée phase nationale/National Entry: 2000/01/19
(86) N° demande PCT/PCT Application No.: EP 1999/008225
(87) N° publication PCT/PCT Publication No.: 2000/040793
(30) Priorité/Priority: 1999/01/08 (199 00 424.2) DE

(51) Cl.Int.^{7}/Int.Cl.^{7} D04H 13/00, B32B 5/26

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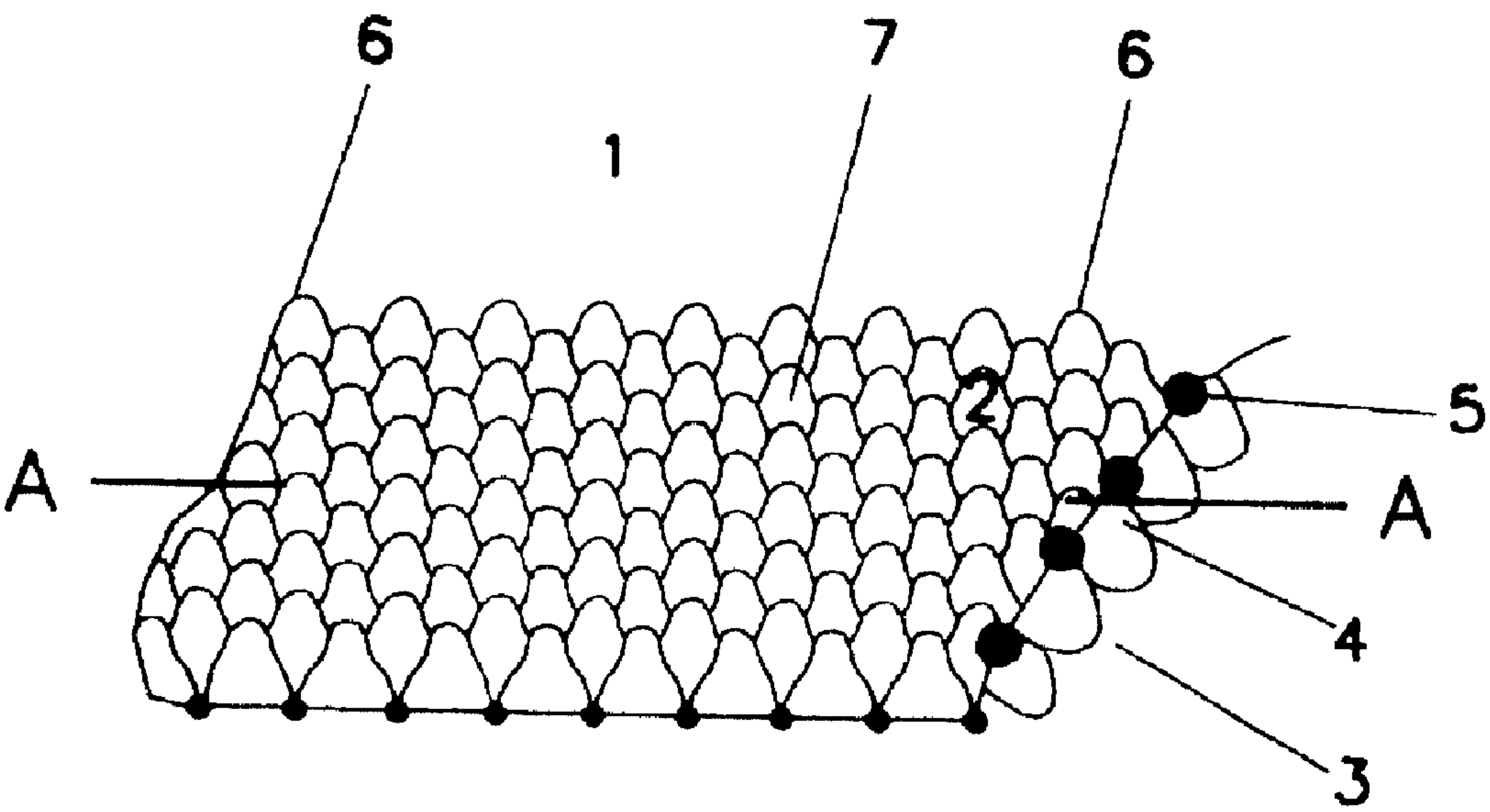
(54) Titre : SURFACE TEXTILE STRUCTUREE EN TROIS DIMENSIONS ET PROCEDE PERMETTANT DE LA PRODUIRE

(54) Title: THREE DIMENSIONALLY STRUCTURED NON-WOVEN FIBER AGGREGATE AND PROCESS FOR ITS MANUFACTURE



(57) Abrégé/Abstract:
The invention relates to a flat nonwoven fiber aggregate with three-dimensional structure which consists of filament layers which alternate perpendicularly to the plane of the surface and layers of denser short fibers which are thermally bound to said filament layers in a flat or dotwise manner. Said wide-meshed filament layers represent a loose structure, a grid or a web. Said layer of short fibers are characterized by repetitive crease- or wave-shaped elevations. According to the inventive method, all layers of the laminate are subjected to a common shrinkage process at a temperature that lies between the softening and the melting temperature of the material of the loose structure.

ABSTRACT

The invention relates to a flat nonwoven fiber aggregate with three-dimensional structure which consists of filament layers which alternate perpendicularly to the plane of the surface and layers of denser short fibers which are thermally bound to said filament layers in a flat or dotwise manner. Said wide-meshed filament layers represent a loose structure, a grid or a web. Said layer of short fibers are characterized by repetitive crease- or wave-shaped elevations. According to the inventive method, all layers of the laminate are subjected to a common shrinkage process at a temperature that lies between the softening and the melting temperature of the material of the loose structure.

THREE DIMENSIONALLY STRUCTURED NON-WOVEN FIBER AGGREGATE AND PROCESS FOR ITS MANUFACTURE

DESCRIPTION

TECHNICAL FIELD

The invention relates to planar, three-dimensionally structured non-wovens.

"Three-dimensionally structured" refers to non-wovens wherein the orientation and three-dimensional correlation of the individual fibers relative to one another is different in the respectively observed plane from the one in the next closest plane.

The invention especially relates to non-woven fabrics wherein at least one layer made of an aggregate, a scrim or netting is connected on both sides to a fleece layer.

A process of manufacture is disclosed.

PRIOR ART

Generic non-woven fabrics are known from US-A 4,302,495.

One or more layers of discontinuous, thermoplastic polymeric fibers and one or more layers of an open-meshed network of coarse, thermoplastic, continuous melt-blown fibers, which cross one another at a preselected angle are laminated to a non-woven fabric of even thickness by continuous or point form thermal bonding. The randomly oriented short fibers have a diameter of between 0.5 and 30 μm at a surface weight of 10-15 g/m^2. Further described are combinations of netting/microfiber layer/netting as well as microfiber layer/netting/microfiber layer. A preferred material for both the microfibers and the filaments of the netting is polypropylene. Such a non-woven fabric has a very high tension strength, coupled with a precisely adjusted porosity. The melt-blown microfiber layers determine the outer appearance and, for example, the filter properties, while the thermoplastic net(s) provide reinforcement, control of porosity and, if desired, simulation of the appearance of a woven textile. The material is therefore not only suitable as a filter, but also as a sterile packaging material for surgery. Further applications are chemically inert filter media or non-wettable, lightweight, thermally insulating layers for clothing, gloves or boots.

The thermal bonding of the layers with one another takes place under pressure, for example between heated rollers, whereby one of which has appropriate engravings when a spot-welding is desired. In addition, heat radiation can be applied before the heating between the rollers. The degree of heat exposure is adjusted so that the fiber materials soften but are not heated up to their crystalin melting point.

It has been found that such non-woven fabrics do not withstand pressure points or other strong mechanical forces over a longer period of time without significant compaction when they are exposed 0to high pressures and temperatures up to 60°C during packaging, extended storage and transport which, for example, is absolutely possible during shipping in hot countries. Non-wovens consisting of an aggregate, scrim or netting laminated on both sides with fleece layers are known from the documents US-A 4,522,863; GB 1,431,817; US-A 5,525,397 and WO 98/52458.

OBJECT

It is an object of the invention to provide a planar three-dimensionally structured non-woven which withstands pressure loads up to 1 psi acting perpendicular to the surface plane without destruction, even at temperatures of up to 60°C.

Furthermore, the invention is to provide a method of manufacture for such a planar non-woven.

DESCRIPTION OF THE INVENTION

The solution to this object consists in a planar three-dimensionally structured, multiple-layer non-woven with the characteristics of the first claim as well as in a process according to the first process claim. Advantageous embodiments are mentioned in the respectively dependent claims.

At least two fleece layers are respectively connected with a loose aggregate layer. The fleece layers consist of mechanically and/or thermally mutually connected fibers and in surface direction have a folded shape in the form of geometric, repeating protrusions or undulations.

At least one thermoplastic aggregate, scrim, or netting layer with mutually crossing endless filaments connected at their cross-over points by melting and with a thickness of 150-2000 μm between their crossover points and thickened portions at their crossover points up to seven times these values, is present in this structure in accordance with this invention. For simplicity, this layer is in the following always referred to as aggregate even when it is another structure with mutually crossing individual filaments.

The mesh size of the aggregate which is a distance of respectively two adjacent filament crossover points in longitudinal direction, multiplied with a corresponding distance in transverse direction, is 0.01-9 cm^2, provided that the filament crossover points are spaced from one another not less than 0.1 cm in longitudinal as well as transverse direction.

The respective bonding between the fiber layers and the aggregate layers is point form.

The endless filaments of the aggregate consist, for example, of polyethylene, polypropylene, polyamide-6, polyamide-6.6, polybutylene terephthalate, polyethylene terephthalate, polyester elastomers, copolyesters, copolymers of ethylene and vinylacetate, or polyurethane.

In a preferred embodiment of the invention, the non-woven consists of a bi-axially stretched netting. The stretching in direction of both filament directions is carried out according to known processes in longitudinal action by passing through a gap between a slower and a faster rotating roller, whereby the difference in speed between the slower and faster rotating roller determines the degree of stretching. The stretching in transverse direction is carried out by way of an expanding racking frame.

This known process causes a thickness reduction of the filaments between the mutual crossover points and thereby a reduction of the surface weight by up to 95%.

Within the framework of this invention, it is possible to structure the lamination of the aggregate with fleece on both sides in such a way that each fleece has different inherent properties with respect to the form of their folding or with respect to their inherent properties such as, for example, surface weight, fiber type, fiber bonding.

In general, a person skilled in the art is guided in the selection of the parameters for the fleeces with respect to their composition, fiber type, fiber bonding and fiber orientation by the known properties which these layers should have. In the interest of a high inherent stiffness of the protrusions and undulations, an intimate bonding of the fleece fibers with one another is necessary.

In the case of a fixation of the fibers by bonding agents, one with a strong grip is preferred, since thereby the inherent stiffness and mechanical strength of the planar non-woven as a whole is increased.

Preferably, the distance from one filament crossover point to the next within the aggregate as well as the degree of stretching and the filament strength in longitudinal and transverse direction are approximately equal, since thereby protrusions with a circular base cross-section are created after the shrinking process. Those have proven most resistant against loads perpendicular to the surface plane.

Depending on the selection of the starting materials, multi-layered planar non-wovens with weights of 20-3000 g/m^2 can be produced. Products with lower surface weights are suitable, for example, for liquid absorbing and distributing layers in diapers, those with up to a 3000 g/m^2 for high volume filter aggregates with high storage capacity for the filtrate.

The invention is described in more detail by way of the figures:

Figure 1 shows the product of the invention in top view.

Turning first to Figure 1: one of the possible embodiments of the invention is shown here in top view. The composite 1 consists of the shrunken aggregate 4 and the two fleece layers 2 and 3. Those are connected with the shrunken aggregate, but not with one another, in such a way that protrusions 6 and depressions 7 are formed on the fleeces to both sides of the aggregate. Cavities 12 and 13 (see Figures 2 and 3) are found between and below the protrusions, which are permeable for fluid media and take up particles and dust therefrom. The aggregate consists of monofilaments 5 which cross one another.

The process for the manufacture of the planar three-dimensionally structured non-woven is carried out in that an unshrunk aggregate, netting or scrim of thermoplastic endless filaments of 3-300 g/m^2 is evenly covered on both sides with a fleece and laminated into a flat non-woven using principally known lamination techniques. The fleece can be produced by all known measures, ie. dry by crimping, carting or air laying, by wet laying, or from fibers or endless filaments spun from a melt. The laminate is subsequently subjected to a thermal treatment which is sufficient for the aggregate to undergo a surface shrinking. The fleece layers which themselves are not subject to surface shrinking or to a significantly lower surface shrinking than the aggregate, give way, thereby forming protrusions perpendicular to the surface. The fleece can be internally bound over the whole surface or a part of the surface. Perforated fleeces can also be used for the process of the invention.

The aggregate in the non-woven is caused to shrink by a further increase in temperature. The shrinking temperature depends on the softening and melting range of the thermoplastic forming the aggregate. In order to initiate a shrinking, the temperature must be between those two temperatures, whereby the degree of shrinking is the higher the closer the temperatures stream actually acting on the aggregate is to the melting temperature of the thermoplastic. The person skilled in the art of course also knows that the duration of the preselected shrinking temperature has an influence on the degree of surface shrinking. The achievable rates of shrinking in longitudinal and transverse direction or the ratio of both rates to one another can be predetermined to a large degree through the selection of the aggregate. Assuming a contact free and unimpeded shrinking, the ratio of longitudinal to transverse shrinkage is then 1:1 when the monofilaments of the aggregate have the same titre and degree of stretch in longitudinal and transverse direction. If a different shrinkage in longitudinal and transverse direction is desired, aggregates are selected the monofilaments of which have been stretched differently in longitudinal and transverse direction or the titre of which is highly different at the same degree of stretch. Aggregates can also be used which have monofilaments in longitudinal and transverse direction made of different thermoplastic materials. In that case, the amount of shrinking and the direction of shrinking is determined by the earlier softening component of the aggregate, whereby a shrinking temperature is selected which lies between the softening and melting temperature of the earlier melting component of the aggregate.

The fleece bonding and the lamination onto the aggregate can also be carried out in a single step. Economics favor this process.

Aqueous plastic dispersions are used as non-fibrous binder agents, which are printed onto the laminate from either one or both sides, or a complete impregnation is carried out with a foamed mixture in a foam impregnation installation or with an unfoamed mixture by way of a submersion full-bath impregnation with the aqueous plastics dispersion. A drying is subsequently carried out and the binder agent crosslinked under heat.

An additional internal solidification can be produced by thermoplastic activation of adhesive fibers within the fleece materials.

The ratio between the longitudinal and transverse shrinking determines the shape of the protrusions in the fleece materials. Dome shaped protrusions with an idealized circular base are created with a longitudinal/transverse ratio of 1:1. At a longitudinal/transverse ratio other than one, protrusions are created with an idealized oval cross-section parallel to the base. If shrinkage, for example, in longitudinal direction is completely prevented, longitudinally continuous, groove shaped protrusions are formed on the fleece material which idealized have the same amplitude for their whole length.

It was surprising that aggregates with weights under 10 g/m^2 could be shrunken to 80% of the initial length despite a fleece material cover on both sides at weights of at least 7 g/m^2. One would have rather expected that the fleece materials would prevent the shrinkage of the aggregate, especially in view of the low starting surface weights of the aggregate. However, this is not the case.

The following process variant has proven especially advantageous because of its simplicity:

the aggregate is covered on both sides with an unbonded fiber pile and subjected to a thermal embossment calendering or an ultrasound calendering. The flat, three ply fabric resulting therefrom has sufficient bonding strength. Subsequently, the shrinking is carried out thermally or with steam without using binder agents. For this process variant, bi-component fibers with side by side eccentric or concentric core/sheet structure are used. The fleece material cover(s) can consist to 100% of these bi-component fibers or can be used in admixture with thermoplastic and/or non-thermoplastic homophylic fibers. No restrictions are necessary with respect to the selection of the homophylic fibers.

The melting point of the bi-component fibers with respect to the earlier melting component must be lower or equal to the melting point of the individual filaments of the aggregate initiating the shrinkage. Advantageously, the melting point difference should not be more than 40°C in order to prevent a brittling of the fleece layers.

Even when the use of the thermoplastic polymer contributing to the melt bonding is not critical, it has proven practical with a one-sided fleece covering to use a melt component which has a chemical connection to the thermoplastic polymer of the aggregate. Otherwise the danger exists of a bad lamination strength after lamination. In this connection, for example, for an aggregate of polyethylene terephthalate filaments, it is practical to use in the fleece, polyester bi-component fibers with a copolyester or polyethylene terephthalate mantle component melting above 200°C.

Especially when the aggregate and fleece material are to be connected by thermal embossment calendering or ultrasound calendering, it is advantageous to cover the aggregate on both sides with fiber piles. After the calendering, both piles above and below the aggregate are welded together in a pattern at the open regions of the aggregate. The aggregate is thereby permanently embedded into the composite. The number of thermal welding points between fleece material and aggregate in this unshrunken semifinished material is very low and negligible. The engraved surface of the embossment roller includes 4-30% of the total contact surface.

Especially for the case of a smaller difference in melting temperature between the aggregate and the mantle component of the bi-component fibers, engraved rollers are preferably used with a melt bonding surface of only 4-14% of the total surface.

The shrinkage is initiated already by only a single thermal treatment. It is not possible to again achieve a shrinkage of an already shrunken and cooled laminate by way of a second thermal treatment.

The multilayer, three dimensionally structured planar material of the invention can be made of alternating fleece and aggregate. The fleece materials on both sides of the aggregate can be the same or different in structure and weight. In special cases, it is also possible to provide internal layers of two successive fleece materials.

The structured fibrous planar material can be used in such fields wherein a large specific surface, a high fluid throughput with a high particle storage capacity or a high compression resistance under mechanical load, especially at elevated temperatures, are present. Examples are filter, hygiene or medical products. The products in accordance with the invention can also be used for decorative purposes in the household, for example, as wall coverings.

Example1

A biaxially stretched plastic netting of polypropylene endless filaments with a weight of 7.8 g/m^2 and a mesh size of 7.6 mm by 7.6 mm is positioned between two transversely laid, loose staple fiber piles with a weight of 10 g/m^2 respectively and fed to a spot melt bonding by calendering between a smooth and an engraved steel roller. The melt boding surface of the engraved surface is 9.6% at an engraving depth of 0.73mm. Calendering is carried out at a temperature of 140°C and a line pressure of 30 kPa/cm at a throughput speed of 6 m/min. The stock width is 50 cm.

The fleece consists of 90% sheath/core fibers with a core of polyethylene terephthalate and a sheath of copolyester, which melt at 120°C. The remainder is rayon staple. The titre of the sheath core fiber is 4.8 dtex, its cut length 55 mm. The titre of the rayon staple is 3.3 dtex at a cut length of 60mm.

The three ply, smooth non-woven sheet product with a total weight of 27.8 g/m^2 is subsequently subjected to a thermal shrinkage treatment in a belt dryer at 170°C and at a residence time of 2 minutes and 20 seconds. The half finished material of originally 50 cm width after the shrinkage and cooling has a width of only 16 cm and a surface weight of 20 g/m^2. This calculates into a linear shrinkage in transverse direction of 68%, a surface shrinkage of 76.8% and a linear shrinkage in longitudinal direction of 27.6%.

The mathematical formulas for calculation of the shrinkage are:

$$S\Diamond = \left(\frac{Gv}{Gn}\right) \bullet 100[\%]$$

$$Sq = \left(\frac{bn}{bv}\right) \bullet 100[\%]$$

$$SL = \left(\frac{Gv \bullet bv}{Gn \bullet bn}\right)[\%]$$

G_v surface weight before the shrinkage in g/m^2

G_n surface weight after the shrinkage in g/m^2

b_v stock width before the shrinkage in m

b_n stock width after the shrinkage in m

$S_\Diamond$ surface shrinkage in %

S_q linear shrinkage in transverse direction in %

S_L linear shrinkage in longitudinal direction in %

The following table shows the thicknesses measured under different loads at room temperature and after a storage period of 48 hours at a load of 1 psi. The compression resistance K, the repetition W and the resistance to creep KB, respectively expressed in percent can be calculated from the formulas presented below. The thickness measurement for the calculation of the resistance to creep is carried out at 0.2 psi contact pressure.

The thickness measurements were carried out as follows:

the sample was loaded for 30 seconds at a contact pressure of 0.6205 kPa and a thickness value after the expiry of 30 seconds was determined. Immediately subsequent the contact pressure was increased by changing the weight at the thickness measurement apparatus to 1.3789 kPa and again after a further 30 seconds the thickness was determined at exactly the same measurement location.

The same procedure was again repeated with the contact pressure series of 3.4473, 6.8947 and again 0.6205 kPa for 30 seconds respectively.

For determination of the resistance to creep KB the sample was loaded for 48 hours at a pressure of 1psi at 60°C and subsequently the thickness at 1.3789 kPa contact pressure was determined.

KW, W and KB are calculated as follows:

One obtains the value for KW by dividing the thickness at 6.8947 kPa with the thickness at 0.6205 kPa and multiplying by 100 (result in percent).

One obtains the value for W by dividing the thickness obtained at 6.8947 kPa after completion of the measurement cycle with the first measured value at 6.8947 kPa and multiplying by 100 (result in percent).

One obtains the value for KB by dividing the thickness of the sample low-pressed at 60°C for 48 hours at 6.8947 kPa by the thickness of the non-compressed sample, respectively measured at 1.3789 kPa and multiplying by 100 (result in percent)

Non-Compressed Laminate Structure	
Thickness at	
0,6205 kPa	4,996 mm
1,3789 kPa	4,560 mm
3,4473 kPa	4,168 mm
6,8947 kPa	3,547 mm
0,6205 kPa	4,318 mm
KW (%)	71,00
W (%)	86,40

Compressed Fibrous Sheet Aggregateerial at 60°C over 48 hours	
Thickness at	
1,3789 kPa	2,485 mm
KB(%)	53

CLAIMS

1. A planar, three-dimensionally structured fibrous non-woven consisting of an aggregate, netting or scrim of thermoplastic endless filaments with a mesh size of 0.01 to $9cm^2$, which is on both sides covered with a fleece, whereby the endless filaments have a thickness of 250 to 2000 μm and are thermally bonded at the respective cross-over points and the filament cross-over points are spaced apart at least 0.1cm, characterized in that the fleece layer includes repeating protrusions in the form of at least one of a crease and a wave, whereby the non-woven was subjected to a calendaring selected from the group of thermal embossment calendaring , and ultrasound calendaring, and shrunk by the action of one of heat and steam.

2. The planar fibrous non-woven according to claim 1, wherein the filaments of the aggregate layer at the cross-over points have an increased thickness of up to seven times that between the cross-over points.

3. The planar fibrous non-woven according to claim 1 or 2, wherein the individual fibers of the fleece are bonded with one another by a binder with strong grip.

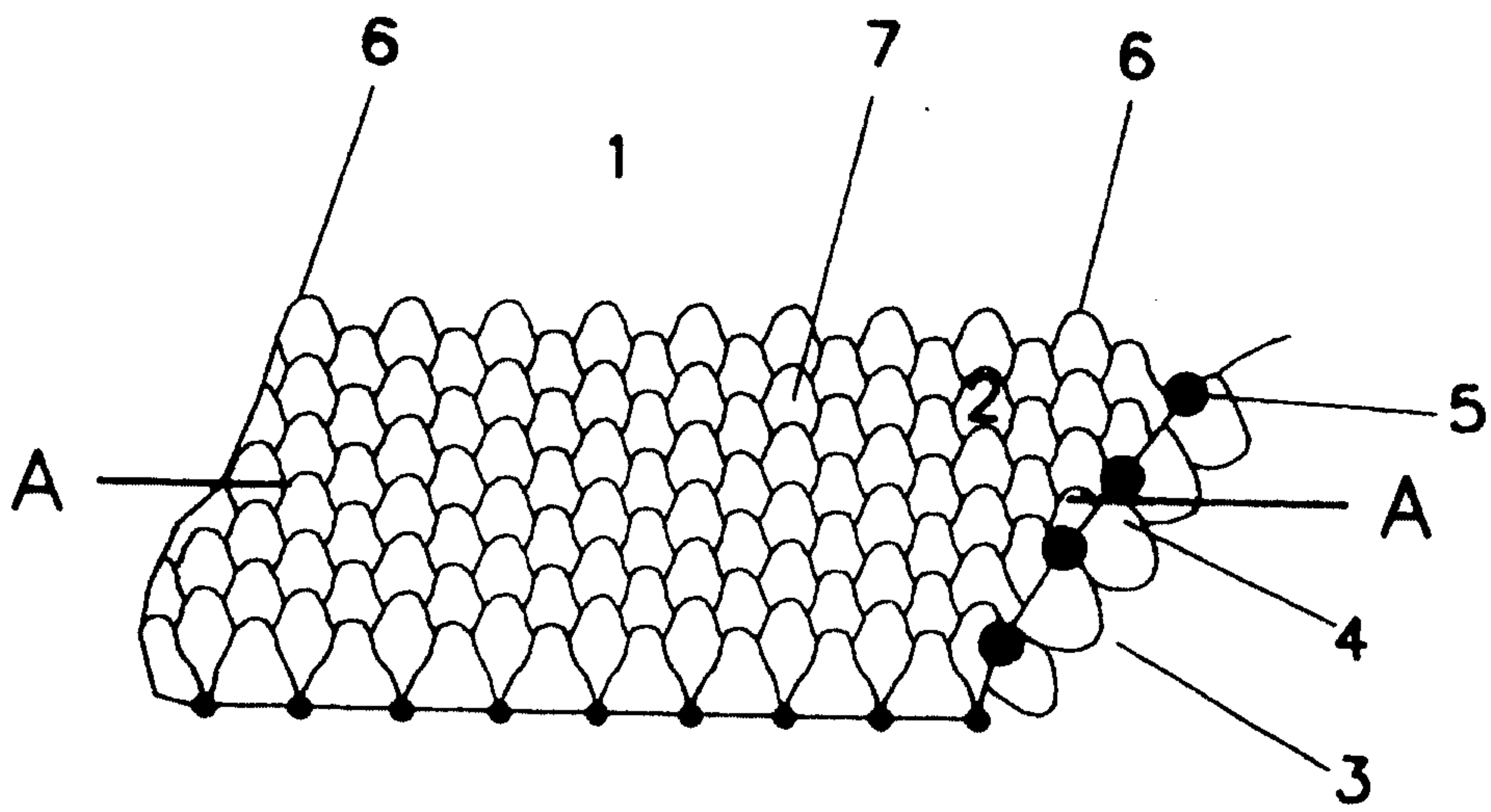
4. The planar fibrous non-woven according to one of claims 1 to 3, wherein the fleece layers consist of fibers selected from the group of core/sheath fibers, side-by-side bi-component fibers and combinations thereof, whereby the components of each fiber differ from one another with respect to their softening point.

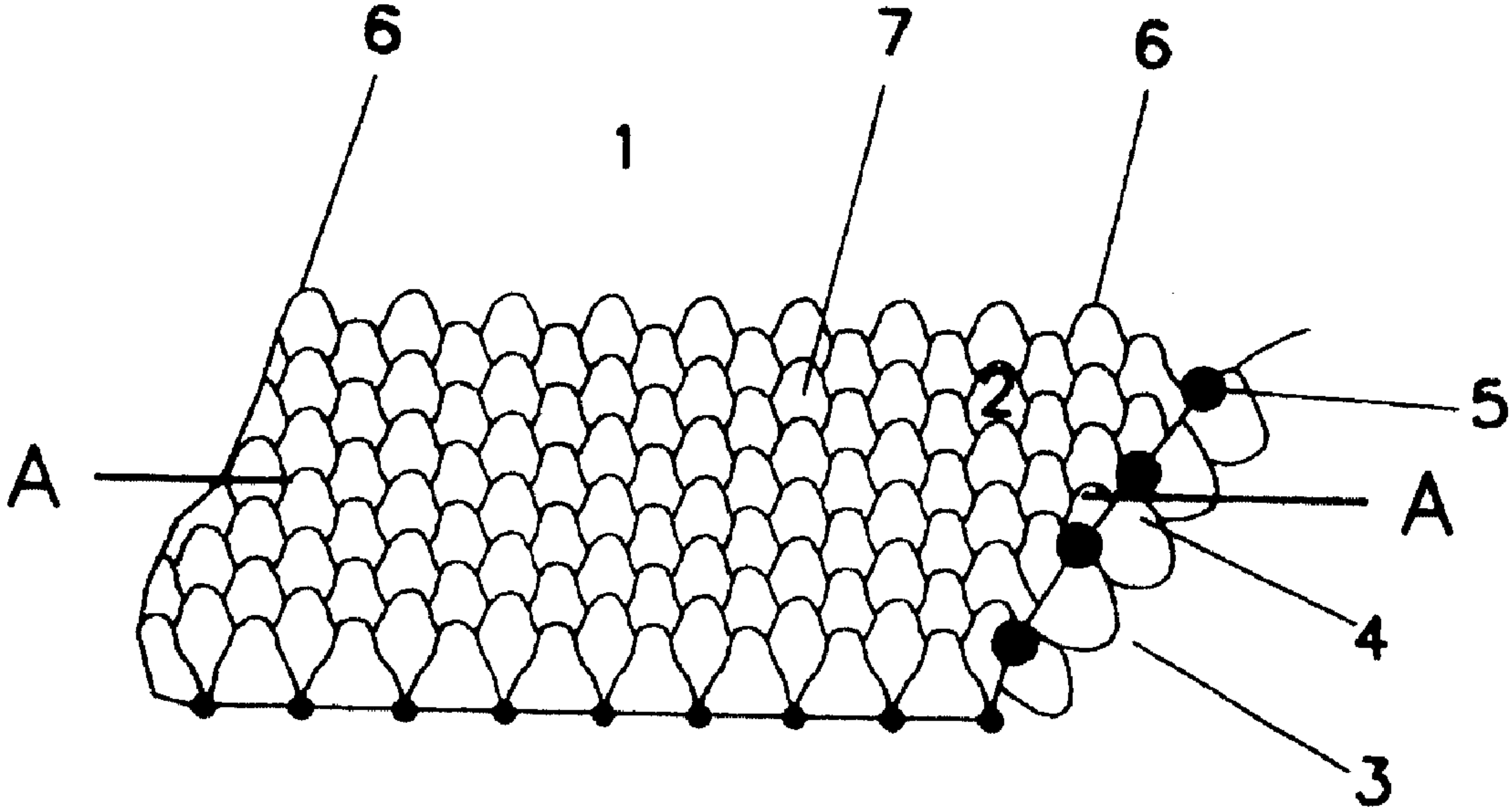
5. A process for the manufacture of a planar three-dimensionally structured fibrous non-woven constructed according to claim 1, wherein a biaxially stretched netting of thermoplastic endless filaments is used with a mesh size of 0.01 to $9cm^2$ and a weight of $3\text{-}300g/m^2$, the distance between adjacent filament cross-over points being at least 0.1cm, is on both sides covered with a fleece, and all layers are bonded over their surface by known lamination techniques, wherein the whole laminate is subjected to a calendaring selected form the group of thermal embossment calendaring and ultrasound calendaring, and subsequently all layers of the laminate are together subjected to a shrinking process at a temperature which is between the softening and the melting range of the aggregate material.

6. The process according to claim 5, wherein at least one aggregate is covered on at least one side with an unbonded fiber pile, which consists at least in part of bi-component fibers with a higher and a lower melting component, whereby the latter component has a melting point which is at most equal to that of the shrinkable component of the aggregate, the whole laminate is subjected to a calendaring selected from the group of thermal embossment calendaring and ultrasound calendaring, and subsequently the shrinking is carried out by heat by way of steam.

7. The process according to claim 5 or 6, wherein that the aggregate prior to being processed into the multi-layer planar structure is racked in longitudinal direction between rollers rotating at different speeds and racked in transverse direction by an expandable racking frame.

Fig.1

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