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NEEDLED NONWOVEN PILE FABRICS AND METHOD OF MAKING SAME

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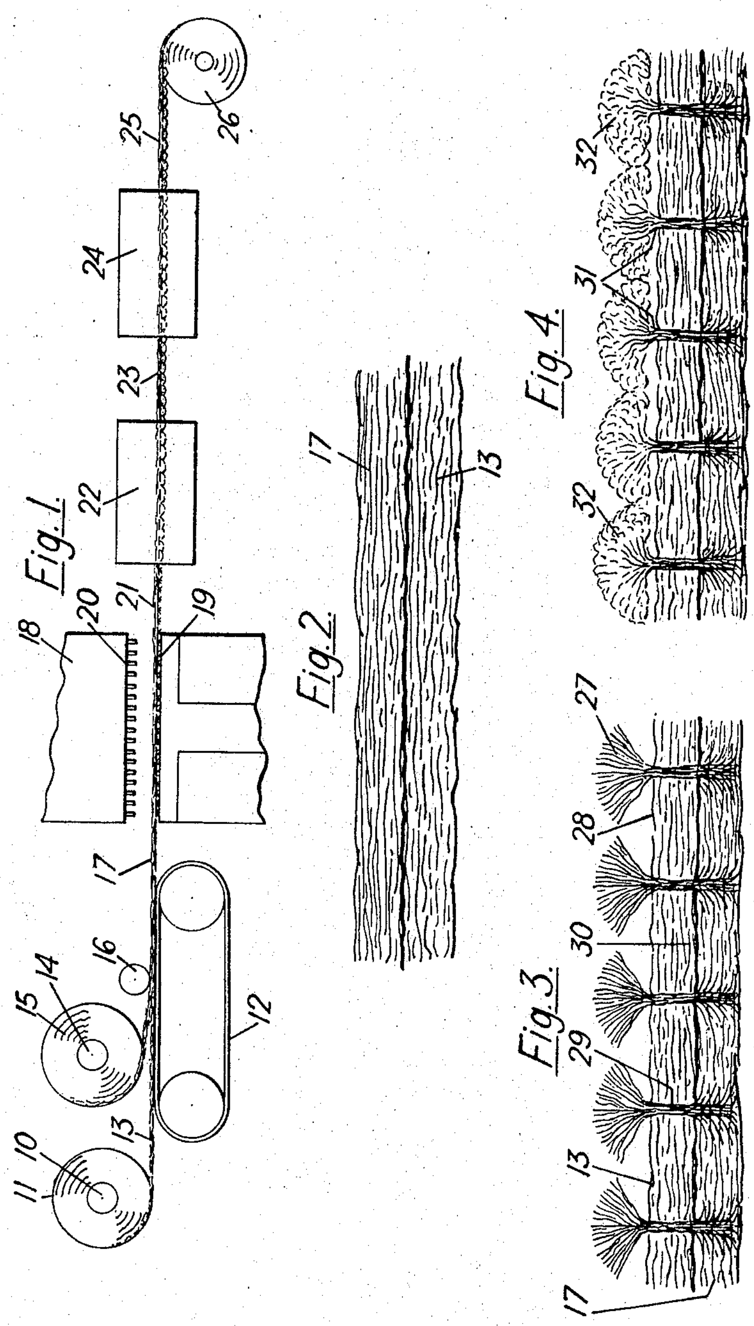

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NEEDLED NONWOVEN PILE FABRICS AND METHOD OF MAKING SAME

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ABSTRACT OF THE DISCLOSURE

Nonwoven pile fabric is made by needle-punching a laminate of first and second layers of fibres so that the fibres of one of the layers are carried through the other layer and project from the surface of the latter as fibre tufts. The tufts are subsequently locked in position by physical or chemical treatment, depending on the nature of the fibres employed, which causes some of the fibres to crimp or become adhesive. Composite synthetic fibres which contain at least one component which is potentially adhesive are particularly suitable for locking in the tufts.

This invention relates to nonwoven fabrics and is particularly concerned with nonwoven fabrics resembling pile fabrics, and to methods for making them.

Nonwoven fabrics in various forms have been known for many years. Within the last decade or so a considerable volume of literature, including many patent specifications, has been published in connection with the making of nonwoven fabrics by a technique involving the needling of a fibrous web. Much of the endeavour in this particular field of non-woven fabrics, as evinced by publications known to us, would appear to have been directed to the making of fabrics resembling felts. Felts are fabrics possessing a dense, compact structure of high density and consequently, they are restricted in the end uses to which they can be applied.

An object of this invention is to provide a needled fabric which resembles a pile fabric and which finds application in end uses for which pile fabrics of a conventional nature are generally suitable. Such a fabric is distinguished from a felt by the presence therein of a multitude of fibres extending outwardly from a surface of a base structure in the form of fibre tufts which provide the fabric with its pile surface.

Another object of this invention is to provide a pile fabric of novel structure and exhibiting advantageous properties.

A further and more specific object of this invention is to provide a nonwoven pile fabric wherein the pile surface is formed of fibre tufts exhibiting a good permanence of form.

These and still other objects and advantages will be apparent from the following description and appended claims.

Thus, according to one aspect of this invention there is provided a nonwoven fabric which simulates in appearance a conventional pile fabric and which comprises a foundation layer, and a fibre tuft precursor layer with fibres from the precursor layer oriented through the foundation layer and projecting beyond a planar surface thereof as fibre tufts, said fibre tufts being set in the foundation layer.

In a preferred form of the nonwoven fabric in accordance with this invention fibres in at least the foundation layer are crimped.

The pile fabrics of this invention may be made by a method which involves forming a composite structure

comprising a first layer of fibres as the fibre tuft precursor layer, a second layer of fibres as the foundation layer, needle-punching the composite structure in a needle loom whereby fibres are carried from the precursor layer through the foundation layer beyond the planar surface of which they project as fibre tufts, and thereafter subjecting the needled product to at least one treatment to set the fibre tufts.

A particularly convenient method of setting the fibre tufts in position is to provide in either or both of the foundation layer or the fibre tuft precursor layer fibres having a latent crimp which is developed after the needle-punching operation. In the event that the foundation layer is provided with fibres having a latent crimp, the setting of the fibre tufts which occurs on development of the crimp in the fibres of the foundation layer is attributable to the fibre interlocking, entanglement and interlooping resulting from the distortion of the fibres on crimping. The fibre entanglement in addition to setting the fibre tufts in position also reinforces the mechanical strength and dimensional stability of the fabric. Furthermore, the presence in the foundation layer of crimped fibres endows the fabric with a good bulk or loft which is particularly valuable when the fabric is to be used as a floor covering material.

When the fibre tuft precursor layer is provided with fibres having a latent crimp then the setting of the fibre tufts which originate from that layer is owed to their transformation from straight "spiky" structures to mushroom-shaped structures on the development of the crimp. The retraction in length which is associated with the development of crimp enhances the keying effect of the fibre tufts and thereby sets them more securely in position. Moreover, the collapse of the fibre tuft into a mushroom-shaped structure with each tuft terminated by a dome-shaped cap spreads the fibre tufts over the surface and thereby provides for a more effective concealment of the underlying fibrous foundation layer.

Although the fibre tufts, in the nonwoven fabrics, wherein fibres have been crimped subsequently to the needle-punching operation, are reasonably well held in position it is frequently advantageous to further set the fibre tufts therein. In a preferred embodiment of this invention the fibre tufts are further set by a treatment which results in the direct or indirect backing of fibres in the foundation layer. As a result of this bonding, the "roots" of the fibre tufts, that is, the vertically disposed fibres embedded in the foundation layer, are fixed in position, and consequently, the fibre tufts are backed in their needled configurations thereby endowing the resulting nonwoven fabric with an enhanced tuft retention.

Each of the foundation layer and the fibre tuft precursor layer may be composed of one fibrous web or a plurality of fibrous webs superimposed one on the other. The internal fibrous web may be made of any kind of fibre, natural or synthetic, which is suitable for use in the making of nonwoven fabrics. However, in these instances where the fibre tufts are set by the development of crimp which is latent in fibres in either or both of the foundation layer or fibre tuft precursor layer, then it is necessary to provide the layer or layers with a proportion of such fibres. Generally when such fibres are present in any or both of the layers they should constitute at least 10 percent by weight based on the total weight of fibres present in the layer. While a variety of synthetic filaments can be manufactured to have the ability to crimp when suitably heated, they range in desirability in the practice of the present invention. Composite fibres, that is, fibres containing two or more components arranged in a contiguous relationship along the length and which possess a latent crimp because of their structure are particularly suitable for use in this invention. Conveniently the composite fibres contain at least one component which can be rendered adhesive under conditions which do not sensibly affect the other component or components, this potentially adhesive component occupying at least a portion of the peripheral surface of the fibre. Such composite fibres possess not only a latent crimp which on development contributes toward the setting of the fibre tufts, but the presence therein of a potentially adhesive component permits the further setting of the fibre tufts by the fibre bonding which is a consequence of its activation.

Suitable components for producing the composite fibres can be found in all groups of synthetic fibre-forming materials. Because of their commercial availability, ease of processing and excellent properties, the condensation polymers, for example, polyamide, and polyesters, and particularly those which can be melt spun are very suitable for use in the present invention. Other composite fibres which may be used include, for example, those based on or containing polyesteramides, polysulphonamides, polyesters, polyolefines, polyurethanes or any combination of these polymers, the only substantial limitation being that the components of the composite fibres should be sufficiently compatible to resist undue fibrillation.

Examples of suitable composite fibres include those listed in the following table:

	Potentially adhesive component
Polyhexamethylene adipamide	Poly (omega-aminoundecanoic acid).
Polyhexamethylene adipamide	Polyhexamethylene adipamide and poly-epsilon-caprolactam copolymer (various proportions of the two components by weight).
Polyhexamethylene adipamide	Polyhexamethylene adipamide and polyhexamethylene sebacamide copolymer (various proportions of the two components by weight).
Polyethyleneterephthalate	A copolymer (various proportions by weight) of polyethylene-terephthalate and polypropylene-terephthalate.
Polypropylene	Polyethylene.
Polyhexamethylene adipamide	A suitable polyurethane.
Polyethyleneterephthalate	A suitable polyether-polyurethane copolymer.

Such composite fibres hold their shape and retain their identity as filaments during activation of the potentially adhesive component by virtue of the fact that the other component of the heterofilament is relatively unaffected by the activation treatment.

A number of methods are available by which the composite fibres may be prepared. Thus, for example, they may be prepared by the methods described in British Patents Nos. 579,081, 580,764, and 580,941, which involve co-spinning by a process of melt, plasticised melt, or wet or dry spinning, the polymer materials so that they form a unitary filament. Suitable processes and apparatuses for use in the production of composite fibres in which the components are in a side-by-side relationship by melt spinning, are, for example, described in the specification of our copending application for Letters Patent No. 27,350/61 and 29,295/62. Prior to or during the

spinning operation there may be added pigments, plasticisers, dyes, moth-proofing agents, fire-proofing agents, fillers, abrasives and/or light stabilisers. In particular when the potentially adhesive component is heat-activatable it may be desired to add to the spinning solution or otherwise incorporate into the potentially adhesive component of the composite fibre suitable substances for lowering the softening point of that component, such for example, as plasticisers, soft resins and the like. Among suitable plasticisers for this purpose are dibutyl tartrate, ethyl phthalate, and ethyl glycollate. Examples of suitable soft resins are polyvinyl acetate, ester gum, coumarone resin and the lower molecular weight alkyd resins.

For the purposes of this invention the components of the composite fibre may, for example, be arranged in a side-by-side relationship, or one component may be completely surrounded by another component, i.e. a form of the so-called sheath and core relationship with the component forming the sheath being the potentially adhesive component, or the heterofilament may be of noncircular form, for example, trilobal with one or two of the lobes being formed by the potentially adhesive component. The relative proportions of the components constituting the composite fibre may be varied in accordance with the type of bonded textile material required, having regard to the physical properties desired for the fabric and the end use for which it is intended.

The composite fibres may be blended with up to 90 percent of fibres which do not possess a latent crimp.

The fibrous webs may be made by the air deposition of fibres, by garnetting processes, by carding fibres followed by the cross-laying of the carded webs, by fluid paper-making techniques and indeed by any method whereby a web of loosely associated fibres may be formed.

To a certain extent the method employed is dependent upon the length of fibre being processed.

The foundation layer which consists of one or more of such fibrous webs, generally has a weight in excess of 0.4 ounce per square yard and preferably not less than 1 ounce per square yard, so that the weight of the initial fibrous web is adjusted in relation to the desired weight for the foundation layer and the number of such webs utilised in the making thereof.

The weight of the fibre tuft precursor layer depends primarily upon the fibre tuft density and the greater the density desired the heavier the layer must be and vice versa. Generally, the fibre tuft precursor layer has a weight of between 0.4 and 5 ounces per square yard.

The needle-punching operation is carried out in a conventional needle loom, well known for use in textile operations generally. The penetration density, that is, the extent of the needle penetration, may vary considerably and since the fibre tuft density is dependent upon this parameter, variations therein are reflected in the appearance of the nonwoven fabric. In the practice of this invention penetration densities in the range of between 50 punches per square inch up to several, say, ten thousand punches per square inch have been found to be generally convenient while around 200 punches per square inch are the most usual. The depth of needle-punching depends upon the thickness of the composite structure being needled bearing in mind that it is essential that the fibres reoriented by the needle-punching project beyond a surface of the foundation layer as fibre tufts.

The treatment whereby fibres in either or both of the layers are crimped and the fibre tufts set may invlove heating by various means, as by the application of water, oil, steam, air or other fluid which is relatively inert with respect to the particular fibrous material employed. Alternatively, or in addition, the treatment may involve subjecting the needled product to a suitable chemical treatment. Mild acid and alkali baths are examples of what may often be acceptable chemical treatment.

The bonding together of fibres in the foundation layer to one another and to the vertically disposed fibres passing therethrough, if it is desired to reinforce the effect of the fibre crimp in setting the fibre tufts, may be achieved in a number of ways and the particular method used is to a large extent dependent on the fibres present in the structure.

Thus, when the fibres present in the foundation layer are simple one component fibres i.e. homofilaments, it is often convenient to bond fibres therein and in the fibre tuft precursor layer by the application to the composite needled structure, on the side of the precursor layer, an adhesive. The adhesive diffuses through the fibrous structure and bonds together fibres thereby setting the fibre tufts.

Many different adhesives may be used in this invention. It may be an aqueous or nonaqueous solution, emulsion or dispersion of an adhesive or of a potentially adhesive material which, upon curing, forms adhesive bonds. As examples of suitable adhesives there may be mentioned rubber (natural or synthetic), polyurethanes, polyvinyl resins such as polyvinyl acetate, polyvinyl alcohol and polyvinyl chloride, and polyamide resins.

The adhesive is conveniently applied in a liquid form to the appropriate surface of the composite needle structure by spraying, for example, through conventional spray nozzles, or by means of licker-roll. Alternatively the adhesive may be spread over the surface of fibre tuft precursor layer in the form of a foam.

The adhesive may take the form of a bonding agent incorporated in the foundation layer, the bonding agent being potentialy adhesive under conditions which do not effect fibres therein. For example, the bonding agent may have a softening point below that of fibres present therein and hence can be rendered adhesive i.e. activated, by heat. In such instances the treatment may conveniently involve heating to a temperature above the softening point of the extraneous bonding agent but below that of the fibres. The heating may conveniently be carried out by passing the composite needled structure over a hot drum in such a manner, that only the surface of the structure on the side opposite the side carrying the fibre tufts is brought into contact with the drum. The bonding agent may be capable of being activated by some suitable chemical means, when the treatment may conveniently comprise application of a suitable chemical medium to the fibre tuft precursor layer of the composite needled structure.

The bonding agents which may be activated by heat or chemical means are frequently in the form of powders, flock fibres or staple fibres.

When the foundation layer and/or the fibre tuft precursor layer contains composite fibres of the type comprising at least two synthetic polymer components, it is often convenient to have present in the composite fibre at least one component which can be rendered adhesive under conditions which leave the other component or components non-adhesive, the potentially adhesive component being arranged to form at least a portion of the periphery of the filament, for then the treatment to bond fibres in the fibrous web base stratum, and thereby set the fibre tufts need involve merely activation of the potentially adhesive component. Activation of the potentially adhesive component may be accomplished in the same treatment as that used to develop crimp in the heterofilaments or a subsequent treatment.

Particularly suitable composite fibres for use in the method of this invention are those in which the potentially adhesive component has a lower softening point than the other component or components and can thus be activated, and the fibre tufts thereby secured by a treatment involving heating. As examples of such composite fibres we may mention polyhexamethylene adipamide-polyepsilon-caprolactam (nylon 66/6) filaments in which polyepsilon-caprolactam is the lower melting component, and polyhexamethylene adipamide - polyomega-aminoundecanoic acid (nylon 66/11) filaments in which the polyomega-aminoundecanoic acid component has the lower melting point, and polyhexamethylene adipamide/polyhexamethylene adipamide - polyepsilon caprolactam copolymer filaments in which the copolymer component has the lower melting point.

The potentially adhesive component of the composite fibre may be such, that it can be activated, and the fibre may be such, that it can be activated, and the fibre tufts thereby set, by treatment using suitable chemical media, for example, by treatment with an essentially non-aqueous formaldehyde solution. An example of such a heterofilament is one consisting of polyhexamethylene adipamide as one component and an 80/20 random copolymer of polyhexamethylene adipamide and polyepsilon caprolactam as the other component, in which the copolymer component can be activated by means of a hot ethylene glycol solution of formaldehyde, which leaves the polyhexamethylene adipamide component substantially non-adhesive.

The incorporation in either or both of the foundation layer or the fibre tuft precursor layer of at least a certain proportion of composite fibre of the type previously described, permits the tufts to be set in a convenient and efficient manner, as a result of what is in essence an in situ development of a bonding agent through the activation of a potentially adhesive component of the heterofilaments. The activation of the potentially adhesive component is normally accomplished, without destruction of the fibrous character of the heterofilament, for the activated component is maintained in contiguous association with the other component, and this retention of fibrous character and the absence of adhesive from the bulk of the structure is believed to be of importance in properties such as tuft definition and retention, properties which contribute toward determining the permanence of the pile surface, and also the dyeability of the resulting pile fabric. In addition, the use of composite fibres allows precise control of the quantity of binder and uniform disposition throughout the fibrous web to be readily attained.

The nonwoven pile fabrics of this invention find particular application as floor-covering materials, but they are diversified in regard to the end uses in which they can be employed, for example, they are useful, for furniture, for instance, upholstery, fabrics.

In their use as a floor-covering material the novel fabrics may with advantage be provided with a backing material.

The invention is further described by reference to the following illustrative examples and the accompanying drawings wherein:

FIGURE 1 is a diagrammatic view sequentially illustrating a simplified embodiment of a method of making a pile fabric according to this invention;

FIGURE 2 is a diagrammatic cross-sectional view of the layered assembly of FIGURE 1 prior to needling;

FIGURE 3 is a diagrammatic cross-sectional view of the composite needled structure of FIGURE 1; and

FIGURE 4 is a diagrammatic cross-sectional view of the composite needled structure of FIGURE 1 after fibres therein have been crimped.

In referring to the figures; In FIGURE 1 there is shown a supply roll **10** for fibrous web **11**, which is unwound from the supply roll and horizontally moved from left to right on the surface of an endless belt **12**. Layer **13** so formed is intended to be used as the foundation layer in the formation of the nonwoven pile fabric product. Reference numeral **14** designates a supply roll of a fibrous web **15** which is being continuously superimposed, with the aid of a roller **16**, as a layer **17** upon the foundation layer **13** and moved at the same rate and in the same direction as the latter. The composite structure which is shown in FIGURE 2, and which comprises fibrous web **17** as the fibre tuft precursor layer on the foundation layer **13**, is then fed to a needle loom, indicated generally by reference numeral **18**, of conventional design.

Needle loom **18** comprises a horizontal surface **19** and a needle board **20**. The needle loom **18** reciprocates needles into, and out of, the fibrous web, and reorients some of the fibres of the web into planes normal, or substantially so, to the planar surfaces thereof, the vertically disposed fibre projecting beyond a planar surface, into, and through, the foundation layer as fibre tufts.

The composite needled structure **21** so formed is shown in FIGURE 3. It consists of three superimposed strata; a tuft precursor layer **17**, the foundation layer **13** and a stratum of fibre tufts **27** which provide the pile surface of the resulting fabric, and which represent the projections beyond a planar surface **28** of the foundation layer of vertically disposed fibres **29** embedded within the foundation layer. The foundation layer contains not only fibres **29** but also other fibres **30** arranged in planes predominantly normal to the plane of the vertically disposed fibres **29**. The foundation layer in addition to its role in reinforcing the non-woven pile fabric, and supporting the fibre tuft precursor layer **17** in the needling operation, also serves to shape and hold the fibre tufts needled into it.

The composite needled structure **21** is then subjected to a treatment, for example, immersion in boiling water to crimp fibres therein, and the means employed for this purpose is indicated by reference numeral **22** in FIGURE 1. The development of crimp in the fibre tufts **27**, as can be seen in FIGURE 4, results in an efflorescence thereof, with a consequent diffusion or spreading out of the tufts over the surface, and in doing this, they adopt a more rounded configuration. Indeed, individual crimped tufts, with a short vertical stem portion **31** standing proud above the foundation layer **13**, terminating in a rounded cap **32**, have the general appearance of mushrooms.

The non-woven pile fabric **23** emerging from the crimping treatment is then carried through a zone, indicated by reference numeral **24** in FIGURE 1, wherein means, for example, an oven, are employed to further set the fibre tufts **27** in the foundation layer. The pile fabric **25** so formed is wound up on a product reel **26**.

EXAMPLE 1

A quantity of 15 denier, two inch staple fibres formed from composite fibres consisting of polyhexamethylene adipamide as one component and polyhexamethylene adipamide/polyepsilon caprolactam copolymer as the other (nylon 66//66/6), the two components existing in a side-by-side relationship, was carded as in conventional textile operations. A web having a weight of approximately 4 ounces per square yard was then formed from the carded layers using a cross-lapping machine which laid the laps on top of one another with successive laps disposed at an angle of 90° with respect to the previous lap. The web which consisted of loosely associated fibres was dimensionally stabilised by a single passage through a conventional needle-loom and thereafter passed into a dye-bath (Solway Blue B.N.) in which the disperse medium was boiling water.

In consequence of their immersion in the dye-bath, fibres of the web were not only dyed but crimped; the latter effect caused the composite fibres to assume a curled, coiled, looped or convoluted configuration with a considerable interlocking and interlacing of adjacent fibres, and an overall retraction of the web into a smaller volume (approximately 60 percent shrinkage in area), the resulting dense web having a weight of approximately 9 ounces per square yard. This web is hereinafter in this example referred to as Web. A.

A second web (referred to hereinafter as Web B) having a weight of approximately 2 ounces per square yard was prepared by carding and cross-lapping a quantity of 15 denier, six inch staple formed from heterofilaments similar to those used in the preparation of Web A.

Web B as the fibre tuft precursor layer was then placed on top of Web A as the foundation layer which had previously been dried at a temperature of well below 200° C. and the composite structure passed through a single-bed needle-loom with 25 gauge regular barbed needles. Needling in this fashion orients fibres of Web B through Web A, acting as the foundation layer, so as to project beyond the under surface of said web. The resulting non-woven fabric had a pleasant textile-like handle, a good flexibility or drape, and an adequate tensile strength. To improve the tensile strength which, at this stage, was attributable solely to fibre interlocking, and entanglement due to crimp, the tufted structure was then heated in an air oven for a period of 3–4 minutes at a temperature of 230–240° C. During this heating period, the composite fibres of Web B, the majority of which had been tufted through Web A, crimped thereby imparting an increased stability to the structure in both the thickness direction and in the plane of the fabric.

The development of crimp lead to an efflorescence of the fibre tufts, which spread out and formed mushroom-shaped structures. The spreading out of the fibre tufts in this manner, was reflected in the denser pile surface so obtained, with a corresponding enhanced coverage of the foundation layer which was completely hidden from visual discernment. Furthermore, the conversion of the tufts from predominantly vertically disposed structures into more diffuse and rounded "mushroom-shaped" structures imparted to the nonwoven pile fabric better wearing qualities, for instance, the resilience, that is to say, the ability of the pile surface to return to its original conformation after deformation (for example, by placing weight thereon), was much improved.

As the needled product attained the ambient oven temperature, by which time all fibres therein were substantially fully crimped, the lower melting point component of the composite fibres, i.e. the polyhexamethylene adipamide/polyepsilon caprolactam copolymer which melts at a temperature of around 220° C. became adhesive, developed its coalescent or adhesive characteristics and caused fibres in contact with one another to stick or fuse together.

As a result of this coalescence, that part of each of the tufted fibres which was actually in the foundation layer formed by fibres of Web A, coalesced with adjacent fibres in that web, thereby providing a tufted fabric possessing an adequate tensile strength, good abrasion resistance and a reasonable flexibility or drape. The tufted fabric was then placed in a dyebath to colour the fibres of Web B (tufted fibres) and thereafter dried.

A differential dyeing effect could be obtained by first dyeing the fibres of Web A a dark colour, then the tufts of Web B a lighter colour in a second dyebath.

This tufted fabric was eminently suitable for use as a floor covering or for upholstery purposes; structurally it consisted of a dense mat of interlocked and entangled fibres.

In the utilisation of the tufted fabric as a floor-covering it is frequently advantageous from the standpoint of creep prevention and dimensional stability to provide a hessian backing to which the untufted surface of the fabric is secured by the application of a suitable adhesive.

EXAMPLE 2

A quantity of 12 denier, two inch staple fibres formed from heterofilaments similar to those used in the preparation of the webs of Example 1 was carded and cross-lapped to form a web (hereinafter referred to as Web C) having a weight of approximately 8 ounces per square yard. A second web (hereinafter referred to as Web D) identical to Web B described above in connection with Example 1 was prepared by a carding and cross-lapping technique and then laid as the fibre tuft precursor layer on

Web C as the foundation layer. Fibres of the precursor layer were then needled through fibres of Web C as the foundation layer by passage of the layered structure through a needle-loom with 32 gauge regular barbed needles. The tufted structure was then heated in an air oven for a period of 3 to 4 minutes at a temperature of 230°–240° C. During this heating treatment the heterofilament fibres crimped, the needled product retracted into a smaller area (approximately 45 percent shrinkage in area) and ultimately, as the fibres attained the ambient oven temperature, the lower melting point component of the heterofilament fibres, i.e. the polyhexamethylene adipamide-polyepsilon caprolactam copolymer, which melts at a temperature of around 220° C. became adhesive, developed its coalescent or adhesive characteristics and caused fibres in contact with one another to stick or fuse together. This fusion of adjacent fibres reinforced the contribution made by fibre entanglement due to crimp to the tensile strength of the nonwoven fabric.

The fabric was dyed by immersion in a dyebath and then dried.

The tufted fabric provided a very useful floor-covering material when it was preferred to attach it to a suitable backing material, such, for example, as hessian with or without foam rubber or a polyurethane foam.

Instead of a mono-colour dyeing effect, differential dyeing of the tufted fabric could be achieved by fabricating Web C of spun-dyed heterofilament staple and dyeing only the tufted fibres derived from Web D, or by fabricating the webs C and D of different heterofilaments, the heterofilaments of Web C having different dyeing characteristics to the heterofilaments of Web D.

EXAMPLE 3

The procedure of Example 1 was repeated except that, Web A consisted of 12 denier, one and a half inch super-crimped polyhexamethylene adipamide fibres and had a weight of approximately 6 ounces per square yard.

The tufted fabric resulting from the crimping and fusion (by heat) of fibres of the needled structure had a softer and better developed textile-like handle than the fabric of Example 1 and the tuft anchorage was excellent and endowed the fabric with a good abrasion resistance.

EXAMPLE 4

The procedure of Example 1 was repeated except that, Web A consisted of a blend of equal proportions by weight of 20 denier, two inch heterofilament staple and 6 denier, one and a half inch polyhexamethylene adipamide staple.

Once again, the tufted fabric possessed a softer handle than that of Example 1; its tensile strength, attributable to the combined effects of fibre crimping and fibre fusion, was adequate.

EXAMPLE 5

In this example the proceduce of Example 1 was followed except that, Web B, i.e. the web which provides the tufts of the resulting fabric, consisted of a blend of equal proportions by weight of 15 denier, two inch heterofilament staple and 12 denier, one and a half inch polyhexamethylene adipamide staple.

EXAMPLE 6

The procedure of Example 1 was repeated except that, a loosely woven hessian scrim fabric was interposed between Webs A and B immediately prior to the needling operation.

Incorporation of the hessian scrim in this manner provided a tufted fabric wherein anchorage of the tufts in the foundation layer, formed by the fibres of Web B, was superior to that of the tufts in the product of Example 1. Furthermore, the tufted fabric could be utilized as a floor-covering without any hessian backing material, which was often necessary when the tufted fabric of Example 1 was employed for this purpose.

EXAMPLE 7

In this example, the procedure of Example 1 was followed except that, both a loosely woven scrim fabric and a foam rubber sheet were interposed between Webs A and B immediately prior to the needling operation.

The effect of the foam rubber was to enhance the resilience of the resulting tufted fabric.

EXAMPLE 8

A quantity of 12 denier two and a half inch staple fibres formed from a composite fibre consisting of equal proportions by weight of polyhexamethylene adipamide as one component and an 80/20 random copolymer of polyhexamethyleneadipamide/polyepsilon caprolactam as the other, the two components being arranged in a side-by-side relationship was air-laid by means of a Proctor and Schwartz "Duo-Form" air-laying machine, to produce a fibrous web having a weight of approximately 2 ounces per square yard.

A second fibrous web having a weight of 9 ounces per square yard was also air-laid by means of the same air-laying machine from a blend comprising equal quantities by weight of the composite fibre present in the first web and 15 denier two and a half inch black dyed trilobal shaped polyhexamethylene adipamide. This web was then dimensionally stabilised by lightly needle-punching (225 penetrations per square inch) in a single pass through a conventional needle loom. The needle-punching was found to facilitate further processing, to stabilise the fibre tuft precursor layer during the needle-punching operation, and also to enhance the abrasion resistance of the final fabric.

The first web was then laid as the fibre tuft precursor layer on the second as the foundation layer and the composite structure passed through a single bed needle loom supplied by William Bywater Ltd., Leeds, and equipped with 25 gauge regular barb needles. The composite structure was passed twice through the needle loom; in the first pass the penetration density was 75 penetrations per square inch and in the second it was 150 penetrations per square inch. In both passes the depth of needling was adjusted so that the needles penetrated a distance of ⅝" beyond the under surface of the foundation layer and the first few barbs passed completely therethrough.

The needled structure, which was 43" wide, was passed through an Efco conveyorised oven operating at a temperature of 245° C. and with a throughput of 10 feet per minute. On account of the heat treatment the composite fibres within the structure crimped and bonded together giving a stable structure approximately 40 inches wide.

The product was dyed to give a two-tone effect due to the presence of the black fibres in the foundation layer. After drying, abrasion resistance tests were performed on a sample of the needled structure prior to the development of crimp and inter-fibre adhesion, and after them. The measurements were made on a Taber abraser under a load of 1000 gms. and H10 abrasive wheels, following 500 revolutions of the wheel.

It was found that the product before the heat treatment lost 0.171 gm. of fibre, which compares well with conventional floor covering materials, but the product after the heat treatment lost only 0.120 gm. of fibres which was excellent, and its appearance was unchanged.

EXAMPLE 9

A quantity of 6 denier, one and a half inch staple fibres formed from a composite fibre consisting of equal proportions by weight of polyethylene and polypropylene with the two components arranged in a side-by-side relationship was air-laid by means of a Proctor and Schwartz "Duo-Form" air-laying machine, to produce a fibrous web having a weight of approximately 2½ ounces per square yard.

A second fibrous web having a weight of 8 ounces per square yard was also air-laid by means of the same air-laying machine from a blend comprising equal quantities by weight of the composite fibres present in the first web and 15 denier two and a half inch black dyed trilobal shaped polyhexamethylene adipamide fibres. This web was then dimensionally stabilised by lightly needle-punching to an extent of 225 penetrations per square inch in a single pass through a conventional needle loom. The needle-punching was found to facilitate further processing, to stabilise the fibre tuft precursor layer during the needle-punching operation, and also to enhance the abrasion resistance of the final fabric.

The first web was then laid as the fibre tuft precursor layer on the second as the foundation layer, and the composite structure passed through a single bed needle loom supplied by William Bywater Ltd., Leeds, and equipped with 25 gauge regular barb needles. The composite structure was passed twice through the needle loom, in the first pass the penetration density was 75 penetrations per square inch and in the second it was 150 penetrations per square inch.

In both passes the depth of needling was adjusted to penetrate a distance of ⅝″ beyond the outer surface of the foundation layer and the first few barbs passed completely therethrough.

The needle structure was passed through an Efco conveyorised oven operating at a temperature of 165° C. and with a throughput of about 10 feet per minute. On account of the heat treatment, the composite fibres within the structure crimped and bonded together to give a stable structure having a pile surface composed of mushroom-shaped fibre tufts. The fabric made a very suitable floor covering material, for which application it could, with advantage, be provided with a hessian backing.

What I claim is:

1. A nonwoven pile fabric comprising: a fibrous nonwoven foundation layer and a nonwoven fibre precursor layer oriented through the foundation layer and projecting beyond a planar surface thereof as fibre tufts, at least said foundation layer containing crimped heterofilaments of the type comprising at least two synthetic polymer components arranged in contiguous relationship along the length of the filament, said tufts being fixed in position in said foundation layer and said fabric having enhanced strength due to fibre entanglement resulting from the crimp in said heterofilaments.

2. A nonwoven pile fabric as in claim **1** wherein one of said components of said heterofilaments occupies at least a portion of the peripheral surface of the filament and is potentially adhesive and wherein the other component is relatively nonadhesive, said one component being bonded to adjacent fibres by virtue of the adhesive nature of said component thereby further enhancing the strength of said fabric.

3. A nonwoven fabric according to claim **1** wherein the fibre tufts are crimped.

4. A method of making a nonwoven pile fabric comprising: forming a composite structure which includes a first nonwoven fibrous layer and a second nonwoven fibrous layer, at least said second layer containing potentially crimpable heterofilaments of the type comprising at least two synthetic polymer components arranged in contiguous relationship along the length of the filament; needle-punching said composite structure to carry fibres from said first layer through the other layer beyond the planar surface so as to project as fibre tufts; and thereafter effecting crimp in said heterofilaments so as to fix said tufts in position in said other layer and so as to enhance the strength of said fabric by fibre entanglement resulting from said crimp.

5. A method according to claim **4** wherein crimp is effected in the fibres in both the foundation layer and the fibre tuft precursor layer.

6. A method of making a nonwoven fabric as in claim **4** wherein one of said components of said heterofilaments occupies at least a portion of the peripheral surface of the filament and is potentially adhesive and wherein the other component is relatively nonadhesive, said method including the step of rendering adhesive said potentially adhesive component after needle-punching to thereby bond said component to adjacent fibres and further enhance the strength of said fabric.

7. A method according to claim **6** wherein the potentially adhesive component of the heterofilaments is rendered adhesive in the same treatment as that used to crimp them.

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