PROCESS FOR THE PRODUCTION OF NONWOVEN WEBS
OF CONTINUOUS FILAMENTS

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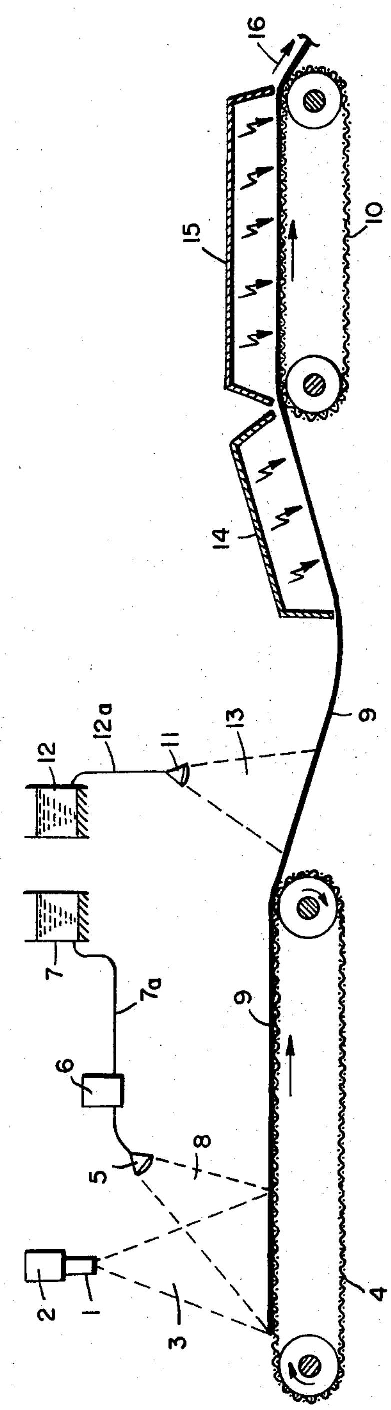

FIG. 1

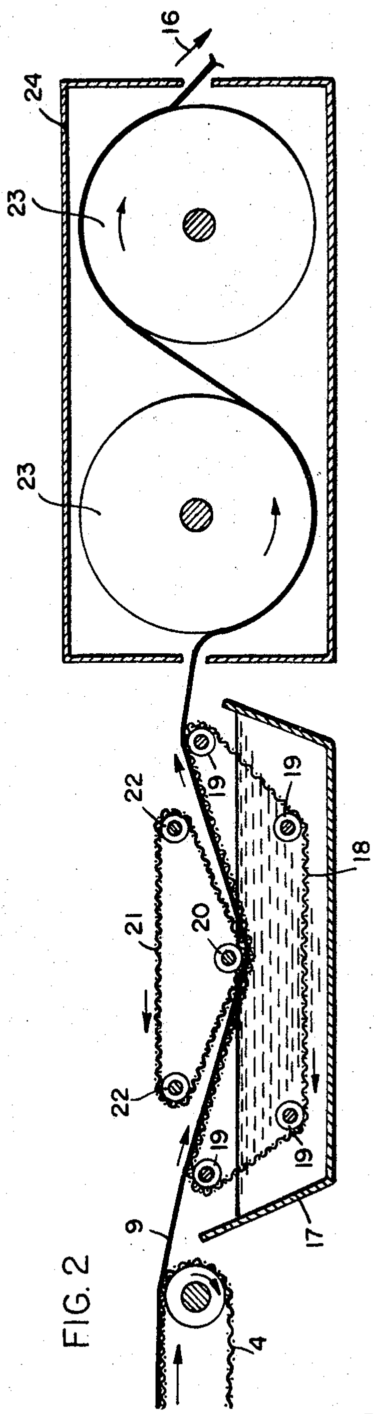

FIG. 2

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PROCESS FOR THE PRODUCTION OF NONWOVEN WEBS OF CONTINUOUS FILAMENTS

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ABSTRACT OF THE DISCLOSURE

A process for producing a nonwoven web or fabric of substantially continuous synthetic polymer filaments in which the initially formed web of randomly deposited filaments carried on an endless band or screen is sprayed with very small droplets of water in limited amounts sufficient to enhance the coherent strength of the web, after which the web is removed from the band or screen and only then treated with a binder to provide an adhesive bonding of the filaments.

Nonwoven webs or fabrics of synthetic fiber-forming polymers are well known in the textile art and have been produced by a wide variety of processes. It has been most common to produce these nonwovens from relatively short lengths of staple fibers, e.g. by air-laying or by various wet-laying procedures similar to the waterlaid fibers used in the papermaking industry. There has also been a development of special techniques for the random deposition of continuous polymer filaments into webs or mats to form a bonded nonwoven web or fabric. In some instances, the continuous thermoplastic filaments are melt-bonded to each other as they are deposited or else a solvent or other softening agent is added to achieve an immediate self-adherence. While the resulting web or sheet is then relatively rigid and coherent, it seldom exhibits the qualities of a fleece-like textile or a nonwoven fabric bonded in some other manner.

It is therefore especially desirable to provide a satisfactory means of depositing continuous polymer filaments in a random fashion such that the initially deposited web is made up of substantially solid and non-adherent or non-tacky filaments which are more or less entangled in a loosely supported manner. With the addition of one or more binders, highly satisfactory nonwoven webs or fabrics can be produced with especially advantageous mechanical properties and a high strength in its lateral dimensions, i.e. in width and length. The following discussion of the prior art is therefore directed to this preferred method of producing nonwoven webs from such solid or non-adherent continuous polymer filaments.

The production of webs, fleeces or similar nonwoven textile structures from non-adherent continuous filaments or threads is ordinarily carried out in such a way that the filaments are deposited in a statistically unordered or random state on an endless band or screen moving at a constant speed. Since the strength of the resulting fleece generally is not sufficient for any practical use, it is conventional to increase its cohesive strength by the addition of a binder. For example, it is possible to deposit the continuous filaments together with a certain proportion of low-melting fibers which then act as an adhesive binder by a later application of heat or solvents. Another known method of strengthening the initially formed fleece is that in which an aqueous suspension of a binder is sprayed into the fleece as it is formed or transported on the endless screen. Aqueous emulsions of polymeric binders are

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especially suitable, e.g. those containing about 25% by weight of solids. The application of a solid powdery binder to such fleeces has also been attempted but with less satisfactory results. A uniform distribution of the binder in the fleece can be achieved where an aqueous emulsion of the binder is sprayed onto the fleece while it remains on the endless screen. On the other hand, difficulties frequently arise when applying powdery solids or attempting to spray an emulsion at a later stage, due to the fact that the solid binder substance as a powder or as a component of the emulsion is preferentially retained on the surface of the fleece.

It has been almost imperative to apply the binder to the web of continuous filaments while it is retained and supported on the receiving surface of the moving band or screen, whether using an emulsion binder or other types of binders, including so-called "fibrids" or the like, which are capable of at least partly consolidating or strengthening the web before it is removed from the receiving surface. Most processes do employ an aqueous emulsion of a polymeric binder, e.g. by spraying it onto the layer or web of filaments deposited on a moving screen, sometimes referred to as a sieve band. The binder spray penetrates the web and the binder can be sufficiently hardened to provide the coherence necessary to remove the web from the screen.

A major disadvantage of this application of the polymeric binder dispersed in an aqueous medium is the fact that it tends to deposit and accumulate on the moving screen. Also, the air-operated injection nozzles used for randomly depositing the continuous filaments can draw in the spray or mist of the binder and become fouled. Since these injection nozzles are generally mounted to provide a traversing motion of the supplied filaments and must provide a continuous and carefully controlled deposition of the filaments on the screen, any interference with their operation can be extremely troublesome.

Attempts to transfer or remove the initially formed fleece or web from the endless screen after merely spraying with the aqueous emulsion of a binder have failed because the moistened or impregnated web is easily pulled apart and destroyed. For this reason, it is necessary to at least partly dry the web containing the emulsified binder while it is still supported on the moving screen or endless band, e.g. in a suitable heating zone. During this heating or drying process, the binder is sufficiently precondensed or hardened so as to achieve a cohesive strength of the web of about two-thirds of its final strength.

On the other hand, this precondensation or hardening of the binder contained in the web is also exhibited by the binder sprayed or deposited onto the moving screen itself. Since the moving screen serving as a support for the web is usually in the form of a porous endless band, i.e. a so-called sieve band with meshes of suitable width, the precondensed binder tends to completely clog the meshes as it accumulates on the band in a continuous operation. In order to reduce this danger as well as providing a reasonably clean supporting surface, it has previously been necessary to conduct the endless screen or band through a physical and/or chemical cleaning operation for removal of adherent binder. Depending upon the chemical composition of the binder, this cleaning operation provides more or less satisfactory results. However, a relatively complex and expensive cleaning system is required to achieve continuous operation or else the entire web-forming process must be interrupted in order to thoroughly clean the endless screen and remove the adherent and hardened binder.

One object of the present invention is to provide a continuous process for the production of a nonwoven web of continuous filaments bonded with a water-emulsifiable or water-dispersible polymeric binder wherein it is possible to deposit the filaments on an endless screen or band which remains perfectly clean, i.e. substantially completely free of the binder. Another object of the invention is to provide a means of developing sufficient strength in the freshly laid or deposited web of continuous filaments so that it can be transported or removed from the endless screen without using a precondensed or partially hardened binder. In other words, it is a primary object of the invention to impart sufficient strength to the web initially deposited and formed on the supporting surface of the endless screen so that it can be drawn off and only subsequently treated with the binder to provide the maximum strength of the finished product.

These and other objects and advantages of the invention will become more apparent upon consideration of the following detailed disclosure.

It has now been found, in accordance with the invention, that it is possible to temporarily strengthen or consolidate the fleece or web of randomly deposited continuous filaments on the surface of the receiving screen or band provided that fine droplets of water are sprayed into the initially deposited web while it is still retained on the receiving surface of the supporting band, the amount of water being sufficient to form a large number of liquid lamellae connecting adjacent intersecting filaments. Thereafter, the "water-bonded" or temporarily strengthened web is removed from the band and only then permeated or treated with a binder for the adhesive bonding of the filaments at their points of intersection. After the application of the binder, preferably by spraying it onto the web while in a freely hanging state, the web is heated for drying and for hardening or setting of the binder.

In the heating step of the invention where the web is dried and the binder is hardened or solidified, it is preferable to initially precondense or preharden the binder until the web achieves about two thirds of its final strength, i.e. corresponding to the fully hardened state of the binder. Conventional aqueous emulsions of polymeric binders are most conveniently used. During this initial heating, the bulk of the water escapes from the web while the binder assumes the function of consolidating and strengthening the web. A final consolidation of the web can be accomplished in an additional heating step, for example by conducting the web through or over heated calender rollers wherein the final hardening of the binder occurs and also a smoothing or even a deformation of the surface of the web. These heating and drying steps can be carried out with conventional equipment as can all other steps of the process.

The present invention essentially depends upon the surface tension of a liquid such as water in order to temporarily strengthen the freshly formed web or fleece of randomly deposited continuous filaments. Any liquid lamella, e.g. as a fluid skin or membrane, when spread out in a wire bow provided with a movable transverse member, is capable of withstanding a certain degree of force or tension exerted by the transverse member. This phenomenon represents one method of measuring surface tension, i.e. by measuring the force required to form the liquid lamella. At the same time, an essential step of the invention requires the formation of liquid lamellae throughout the initially deposited web of filaments by the introduction of water or an equivalent liquid in limited amounts and in such a manner that the resulting forces of surface tension are fully sufficient to temporarily consolidate or strengthen the filamentary web.

In general, the random deposition of continuous filaments on a supporting screen or band is carried out in conventional processes so as to provide a web having a thickness of approximately 0.05 to 4 mm., preferably about 0.1 to 2 mm. This loosely entangled web consists as a rule of several intermingled layers in which the filaments intersect one another with the formation or irregular n-sided polygons having straight and/or curved sides (n=2, 3, 4 . . . etc.). In other words, when viewed in a direction perpendicular to the plane of the web, adjacent filaments cross each other to form a large number of such polygons in each layer and also from layer to layer.

The distances or intervals of the points of intersection from one another usually lie between values of approximately 10 microns and 1 mm. Therefore, adjacent intersecting filaments enclose an area or substantially planar space of the polygon of approximately $100\mu^2$ to 1 mm.^{2}. The planar spaces or open areas enclosed by adjacent intersecting filaments are of course subject to wide variation, and the values set forth herein are directed to those webs or fleece-like structures most commonly developed from the deposition of continuous filaments.

If water or an equivalent liquid is sprayed into this fleece as very fine droplets, it is possible to develop liquid lamellae between the adjacent intersecting filaments, i.e. in the plane of the enclosed polygon. The resulting polygonal lamellae hold the filaments in place under the influence of the resulting surface tension.

The step of developing such liquid lamellae requires that the water or other liquid be "sprayed in" or "sprayed into" the initially deposited and supported web, i.e. supplying the liquid in the form of extremely fine droplets capable of penetrating the loosely entangled web and building up the polygonal lamellae. For example, it is especially desirable to provide a spray with an average droplet size of between approximately 50 and 150 microns. However, depending upon the density of the fleece, the liquid spray can be supplied as a mist with particle sizes of less than 50 microns. The density of the fleece depends upon a number of factors but is generally related to the closeness at which points of intersection are spaced from one another, i.e. the relative size of the polygons enclosed by adjacent intersecting filaments. With denser structures, i.e. smaller polygons, it is desirable to employ correspondingly finer sprays in order to fully penetrate the web and form a maximum number of lamellae. The liquid spray can be produced in a conventional manner, e.g. under pressure with the use of so-called spray guns or atomizers.

Due to the presence of several vertically stratified and intermingled layers of continuous filaments, the liquid lamellae form not only in a horizontal plane but also in various inclined or vertical planes so that the lamellae tend to spread out between different layers. The polygons formed by adjacent intersecting filaments thus are not limited to a horizontal plane but extend in various directions throughout the web. This results in a considerable increase in the tensile strength or cohesive forces exerted by the lamellae on the individual filaments after these lamellae have been developed by spraying the deposited web with a suitable liquid.

It is essential, of course, to form a specific lamellae surface area which is as large as possible, i.e. a relatively large lamellae surface per unit volume of the deposited web. The relationship between the amount of water sprayed into and taken up by the web must be maintained within certain limits according to the denier of the individual filaments, the weight per square meter of the web and the degree of looseness or density of the entangled filaments. For example, it is not desirable to add water during the spraying operation to such an extent that it completely fills the hollow volume of the web since the lamellae initially formed during spraying would eventually run together and lose their laminar or skin-like characteristic which produces the desired surface tension. Thus, it has generally been found that the amount of water should be less than 90% of the total hollow volume of the web, e.g. from about 10 to 90%.

Immersing the web in a water bath does not normally yield the desired result, as shown below in a comparative test, because there is a strong tendency for the water to immediately fill all of the hollow spaces both vertically and horizontally as the web is drawn through and out of the bath. As a result, this technique of applying water to the web does not generate a sufficiently high specific lamellae surface within the web and the desired effect is not achieved. Likewise, a high specific lamellae surface will not result if too much water is sprayed into the fleece and/or the size of the droplets is so large that individual lamellae do not properly develop.

It is especially preferred to use natural water for the spraying step, i.e. as the term "water" is defined in the "BROCKHAUS ABC Der Naturwissenschaft und Technik," Leipzig (1962), page 940, left-hand column. Thus, the term "water" broadly includes not only chemically pure or distilled water of the formula H_2O but also any naturally occurring water which may contain a wide variety of organic and inorganic substances, especially dissolved or suspended minerals. Such ordinary or natural water may contain up to 0.2% of solids, usually calcium or magnesium compounds. For purposes of the present invention, the only important factor is to employ a liquid in the spraying step which has a coefficient of surface tension which is approximately the same as that of pure water, i.e. where this coefficient $\sigma=72$ dynes/cm., measured at 20° C.

It is preferable to employ water at about room temperature although somewhat higher or lower temperatures are also permissible. As is known, the coefficient of surface tension increases as the temperature is lowered and decreases as the temperature is raised. In general, then, the surface tension of the water or any equivalent liquid must amount to at least about 60 dynes/cm. and preferably about 68 to 75 dynes/cm.

The amount of water sprayed into the initially deposited web or fleece in order to achieve a sufficiently high strength or cohesiveness can be readily determined by a routine preliminary experiment. The ratio by weight of water to the filaments must be maintained within certain limits but can vary within these limits depending upon the strength required for a given web. For example, one can readily determine a minimum amount of water at which sufficient lamellae are formed to show a definite increase in the cohesive strength of the web. As the number of lamellae increases, the strength of the web likewise increases up to a maximum which can be characterized as the "saturation point." Thereafter, the strength of the web falls off rapidly with greater amounts of water because too much water interferes with the desired formation of lamellae.

It has been found that satisfactory results are generally obtained by spraying in about 65 to 970 parts by weight of water per 100 parts by weight of the filaments. Especially good results have been achieved where the amount of water is about 400 to 500 parts by weight per 100 parts by weight of filaments. In all cases, of course, it is usually desired to achieve the maximum strength of the web required for removing it from the receiving surface of an endless band or screen without any severe disturbance of the random filament orientation.

Once the web or fleece has been strengthened by spraying in the fine droplets of water, it can be withdrawn from the supporting band and further treated in a conventional manner, i.e. to add a binder and to heat and dry the web for hardening or setting of the binder which tends to accumulate at the intersection points of the continuous filaments. For example, it is possible to remove the temporarily strengthened and moist web from the initial supporting band and conduct it to a second supporting band, e.g. another endless or continuously moving band or screen. The binder can then be applied while the web is on this second band, thereafter running the web through a heating or drying zone. This procedure does require a means of cleaning the second band or screen since the binder tends to accumulate on the supporting surface. However, this second band can be much shorter in length so that its maintenance is not so expensive. Furthermore, the surface quality of this second band in a heating or drying zone is not so critical as the surface

quality of the screen or band employed in the web-forming zone.

An especially preferred procedure of the invention is to remove the sprayed and temporarily strengthened web from the initial supporting surface and conduct it in a freely sagging state over a relatively short distance wherein the binder can be sprayed into the web while it has no supporting substrate. It is preferable to heat the web to achieve at least a partial hardening or setting of the binder while the web is still in this freely hanging or unsupported state. Thereafter, the web can be conducted by a second endless belt or band through a heating and/or drying zone to complete its consolidation. Again, there may be some deposition of the binder on the second band surfaces, but any excess binder tends to drip off from the fleece at the point of application, i.e. where it need not come in contact with any supporting element. Also, by partially drying the web while it is unsupported, the binder is sufficiently prehardened so that very little if any is deposited on subsequent supporting surfaces.

In another procedure according to the invention, it is also possible to partially immerse the temporarily strengthened web in a bath containing the binder, i.e. a so-called immersion tub, by transporting it therethrough on a second endless band. Subsequently, the web permeated with the binder is dried, preferably on a perforated drum drier.

The continuous filaments employed for purposes of the present invention are those commonly employed in the formation of bonded nonwoven webs or fabrics, i.e. any conventional synthetic, thermoplastic, fiber-forming polymer, all of which are normally melt-spun and stretched to produce a continuous filament or yarn. Especially suitable as fiber-forming polymers are polyamides such as polycaprolactam and polyhexamethylene adipamide, polyesters such as polyethylene terephthalate, polyurethanes, and similar linear polymers. Polyolefins, including polypropylene, may also be used. All of these polymer filaments are well known in this art although the polyesters are especially mentioned for the production of nonwoven fabrics directly from the continuously spun filaments. The continuous filaments being deposited to form the web should be reasonably clean, even though a washing is not required. Finishing agents or other preparations may be present provided that they do not overly reduce the wettability of the filaments so as to prevent the formation of the required lamellae.

The term "spunbonded" has been generically applied to the particular type of nonwoven textiles wherein continuous filaments are formed directly into a loosely entangled web as in the present invention. The continuous filaments can be those which are freshly spun and immediately solidified and deposited on the web-forming surface of an endless band, or else one may also use previously formed and stored reels of a continuous filament yarn. A wide variety of means have been suggested for properly laying or depositing these continuous filaments to form the initial nonwoven web or fleece, and the present invention is not restricted to any particular apparatus required for this purpose.

This production of spunbonded textiles in the form of webs, fleeces or fabrics is best accomplished with individual filaments having a relatively fine denier rather than with coarse filaments. For purposes of the present invention, it is especially desirable to use individual filaments having a size within the range of approximately 1 to 12.5 denier.

The binder used in the present invention may be any conventional material capable of being applied as a liquid to the web temporarily strengthened with water. Suitable binders are disclosed in detail, for example, in "Nonwoven Fabrics" by Buresh, Rheinhold Publ. Corp. (1962), chapter 4, pp. 55–69. The binders which are water-based emulsions of thermally settable or cross-linkable polymers are especially advantageous as liquids which can be sprayed onto the web. For example, there can be mentioned the aqueous emulsions of polyacrylic acid esters and various synthetic latex emulsions. The aqueous emulsion may also contain other well known agents such as catalysts, accelerators and the like to ensure the proper setting or curing of the binder. The amount of binder added to the web will vary in known manner depending upon the final strength to be developed in the bonded product. Such variations in the selection of polymeric binders can be made by one skilled in this art and do not constitute a critical feature of the invention.

The present invention does offer an additional advantage in that relatively concentrated emulsions or dispersions of the binder can be applied to the web or fleece after its removal from the initial receiving surface without destroying the cohesive forces of the lamellae. Since the web does contain a substantial amount of water, the binder rapidly permeates the web and subsequently coalesces at the points of filament intersection as the web is heated or dried.

The invention is further illustrated by the following examples in conjunction with the accompanying drawing in which:

FIG. 1 is a largely schematic side elevational view of a preferred apparatus for the production of the bonded nonwoven web; and

FIG. 2 is a similar schematic side elevational view of that portion of the apparatus in which the binder is applied with a subsequent drying stage, illustrating a different embodiment of these subsequent operations.

As indicated in FIG. 1, the continuous filaments are initially deposited by means of a suitable feed member **1** attached to a beam **2** permitting a traversing motion or other variation in the direction in which the filaments are discharged and directed through a downwardly diverging zone **3** onto the endless screen or porous band **4**. For example, the filaments can be freshly spun from a spinneret or nozzle plate and drawn off and passed through an injector nozzle or pneumatic jet so as to be spread apart and directed downwardly onto the receiving surface of the endless screen. The injector nozzle or jet then serves as the feed member **1**, and many variations of such feed members are known in this art. (See, for example, U.S. 3,338,992 which issued on Aug. 29, 1967.)

As the continuous filaments are deposited and form a loosely entangled web or fleece, a fine spray of water is applied to the web from a spray nozzle or atomizer **5** which is likewise preferably attached to a beam **6** to provide a traversing motion of the spray or at least an adjustable position of the nozzle itself. Water is supplied to the spray nozzle **5** from a storage tank **7** through a flexible conduit **7*a***. As the spray nozzle or atomizer **5**, there may be employed any conventional device such as "spray guns" or "shower heads" which are designed to atomize the water into very fine droplets of the requisite particle size and which direct these droplets through the downwardly diverging zone **8** into the deposited web. As shown in FIG. 1, this zone **8** of the sprayed water can overlap the zone **3** of the downwardly directed and opened bundle of continuous filaments. On the other hand, the spray of water droplets may also be applied onto the completely deposited web **9** as it is transferred in the direction of the arrow on the supporting surface of endless screen **4**.

The temporarily strengthened web **9** containing a large number of polygonal lamellae throughout its layered and wetted structure is withdrawn from the band **4** and taken up by a second endless transporting band **10** spaced at a distance from the first band **4**. Between these two endless bands, the web is unsupported and hangs or sags somewhat in a path which can be controlled by adjusting the rate of withdrawal. If desired, the web can also drop to a lower level as it is transported from the first to the second endless band.

In this free space where the web is no longer supported, another spray device **11** is arranged in fluid connection with a supply tank or storage vessel **12** through the fluid conduit **12*a***. The binder, preferably in the form of an aqueous emulsion, is thereby supplied and sprayed through the zone **13** onto the web **9** while it remains out of contact with any supporting surface.

Thereafter, the web is passed through one or more heating or drying zone, preferably through or under a preliminary heating means **14** such as a radiation heating system, e.g. infrared radiation, where the still unsupported web can be rapidly heated to preharden or partially set the binder before it is taken up on the second endless band **10**. A second heating means **15** can then be positioned over the web **9** as it is transported on the band **10**, again using an infrared heater or other suitable means to complete the drying and final hardening of the binder.

Finally, the web can be conducted from the band **10** in the direction of the arrow at **16** in order to provide a supplemental hardening or further consolidation of the web, for example by calendering, embossing or the like. All of these subsequent treatments are well known and do not require further illustration.

In FIG. 2, an alternative method of applying and setting the binder is illustrated, the random deposition of the filaments to form web **9** on the endless screen or band **4** being identical to the arrangement shown in FIG. 1. In this case, the temporarily strenghtened web **9** is transferred from endless band **4** and conducted to an aqueous bath **17** containing an emulsified or suspended binder by means of an endless screen **18** continuously passing above and then through the bath on a system of rollers **19** positioned near the ends of the bath. One centrally located roller **20** is positioned so that the band **18** dips just below the surface of the bath and permits only a partial imresion of the supported web **9**, i.e. so that the top layer or surface of the web is not completely covered by the liquid level in the bath. Another endless band **21** directed around rollers **22** as well as roller **20** can be used as a means of carefully holding the web **9** in place as it is immersed in the bath while also placing a slight pressure on the web to prevent an excessive saturation thereof by the bath liquid. Care must be exercised in this embodiment to avoid a disintegration or substantial alteration of the web structure by the bath liquid. Finally, the web is transported around a pair of drum driers **23**, preferably perforated or so-called sieve drums in a heated chamber **24**. The dried web which has been bonded is then removed at **16** and wound up on a suitable spooling device or otherwise treated in a conventional manner.

The following examples were carried out using the apparatus of FIG. 1 and serve to further illustrate the invention while also establishing the necessity of spraying certain amounts of water into the initially deposited web.

EXAMPLE 1

A sample web is produced from continuous filaments of nylon 6 (polycaprolactam) having a size of 4.4 tex (40 denier), 10 individual filaments. These filaments are a prespun, stretched, washed and subsequently dried yarn bundle which are easily deposited on the moving surface of the endless screen by means of a pneumatic jet as shown in FIG. 1.

The web is initially formed in this conventional manner, but at first no water is sprayed into the web so that the crude or dry weight of the web can be determined. With a thickness fluctuating between about 0.2 and 0.25 mm., the dry web (without water and without any binder) has a weight of 24 grams per square meter. The hollow volume of this web or fleece therefore amounts to about 91%. The continuous filaments have a random orientation in vertically stratified and loosely entangled layers with a large number of polygons enclosed by adjacent intersecting filaments. The surface area enclosed by these polygons varies from approximately 100 $\mu m.^2$ to 50 $mm.^2$, most of the polygons having 2, 3 or 4 sides.

After these preliminary observations are made as to the dry weight and appearance of the web, it is then sprayed with fine droplets of water in gradually increasing amounts. The spray gun or atomizer provides droplets having an average size of about 100 microns, and the spraying operation is carried out at room temperature.

The resulting wetted web acquires a sufficiently high cohesive strength to be lifted off or transported from the endless supporting screen only after water has been sprayed into it in an amount of 65 parts by weight to 100 parts by weight of the filaments. The strength then continues to increase as the proportion of water taken up by the web is increased. The web does not tend to lose the desired cohesiveness until the amount of water added is 940 parts by weight per 100 parts by weight of filaments. Therefore, it is possible to temporarily strengthen the web as its hollow volume is filled with water to an extent of about 7% to 88%.

EXAMPLE 2

A sample web is prepared in the same manner as in Example 1 from continuous filaments of polyethylene terephthalate having a size of 4.4 tex (40 denier), 10 individual filaments. In gradually increasing the amount of water sprayed into the web, an optimum strength of the wetted web is achieved when the web has taken up about 450 parts by weight of water per 100 parts by weight of filaments.

EXAMPLE 3

A sample web is again prepared as in Example 1, using continuous filaments of nylon 6,6 (polyhexamethylene adipamide) having a size of 4.4 tex (40 denier), 10 individual filaments. The web achieves its greatest cohesive strength and is best removed from the supporting screen when it has taken up about 430 parts by weight of water per 100 parts by weight of filaments.

EXAMPLE 4

In order to determine the strength of the sample web sprayed with water as obtained in Example 1, a number of strips of 14 cm. in width are cut off from the temporarily strengthened web and these are carefully loaded in the longitudinal direction. With a weight ratio of water:filaments of 2:1, the web gradually breaks up or disintegrates at a load of 200 grams (force). At a higher weight ratio of water:filaments of 5:1, the sample strip can be loaded with 600 grams before it is torn apart or destroyed.

Comparative example

In order to determine if the web or fleece can be temporarily strengthened by immersion in a water bath and then withdrawn, the dry web obtained as set forth in Example 1 is treated as follows. First, the web is deposited on the surface of the water where it floats due to the support provided by air inclusions. The web or fleece sample sinks partially into the water but its top surface remains unwetted. A few drops of water added to this top dry surface of the web then brings about an immediate sinking or complete immersion in the water. Beneath the surface of the water, the web cannot be handled or maintained in its original form. It disintegrates under the slightest load and loses its random orientation so as to be completely useless as a nonwoven product. After removal from the water bath, the resulting deformed web is permitted to stand until excess water completely drips off. At this point, a moist web composed of polyethylene terephthalate still contains 470 parts by weight of water per 100 parts by weight of filaments while a moist web of polycaprolactam still contains 600 parts by weight of water per 100 parts by weight of filaments. These comparative tests clearly establish a critical saturation point of the web at which too much water destroys or prevents the formation of polygonyl lamellae which temporarily strengthen the web.

Samples of the temporarily strengthened web as obtained in a continuous operation according to Examples 1–3 are subsequently treated with an aqueous emulsion of a binder, using the techniques illustrated in both FIG. 1 and FIG. 2. In both instances, care was exercised to maintain the optimum strength of the web while being removed or carried in a freely hanging or unsupported state from the endless supporting screen **4**. The resulting products after complete drying and hardening of the binder exhibited excellent strength and a uniform covering effect with substantially the same random orientation of the continuous filaments as in the originally deposited web.

The invention is hereby claimed as follows:

1. A process for the production of a bonded nonwoven web consisting essentially of synthetic polymer continuous filaments which comprises:

randomly depositing said continuous filaments onto the receiving surface of a supporting band to form a non-bonded web of loosely entangled filaments;

spraying fine droplets of water having an average droplet size of up to about 150 microns into the initially deposited non-bonded web while it is retained on said supporting band without substantially altering the position of the individual filaments in order to form a large number of liquid lamellae connecting adjacent intersecting filaments, thereby filling up to 88% of the hollow volume of the web and temporarily strengthening the web; and

removing the thus strengthened web from the band and only then treating said web with a binder for the adhesive bonding of filaments at their points of intersection.

2. A process as claimed in claim **1** wherein said water is sprayed into said web at about room temperature.

3. A process as claimed in claim **1** wherein from 65 to 970 parts by weight of water per 100 parts by weight of filament are sprayed into the initially deposited web to form said liquid lamellae.

4. A process as claimed in claim **1** wherein from about 400 to 500 parts by weight of water per 100 parts by weight of filament are sprayed into the initially deposited web to form said liquid lamellae.

5. A process as claimed in claim **1** wherein said temporarily strengthened web removed from the supporting band is sprayed with a binder while being transported in a freely hanging state and thereafter heated for drying and hardening of the binder.

6. A process as claimed in claim **5** wherein said binder is at least partly hardened by applying heat to said web while it is still in a freely hanging state.

7. A process as claimed in claim **1** wherein said temporarily strengthened web removed from the supporting band is carried on a second supporting band and partially immersed in a bath of a binder and thereafter dried.

8. A process as claimed in claim **7** wherein the final drying of the web and hardening of the binder is carried out on the cylindrical surface of a drum dryer.

9. A process as claimed in claim **1** wherein said continuous synthetic polymer filaments are composed of a polymer selected from the class consisting of fiber-forming polyamides, polyesters and polyurethanes.

10. A process as claimed in claim **9** wherein said polymer is polycaprolactam.

11. A process as claimed in claim **9** wherein said polymer is polyhexamethylene adipamide.

12. A process as claimed in claim **9** wherein said polymer is polyethylene terephthalate.

13. A process as claimed in claim **1** wherein said liquid lamellae are formed by adjacent intersecting filaments enclosing individual polygonal and substantially planar spaces, each of which has an area of approximately $100\mu^2$ to 1 mm.^{2}.

14. A process as claimed in claim 13 wherein said web of randomly deposited continuous filaments has a thickness of approximately 0.1 to 2 mm.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,676,245 Dated July 11, 1972

Inventor(s) Helmut Werner et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Drawings page, "W. Helmut et al" should read -- H. Werner et al

Column 1, line 4, "Werner Helmut" should read -- Helmut Werner

Column 3, line 74, "formation or" should read -- formation of --

Column 8, line 8, "zone" should read -- zones --; line 35, "resion" should read -- mersion --.

Column 10, line 1, "polygonyl" should read -- polygonal --.

Signed and sealed this 9th day of January 1973.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents