

July 2, 1968

R. F. DYER ETAL
ENTANGLED NONWOVEN WEB PRODUCT FROM
PARALLEL LAID FILAMENTARY TOWS

3,391,048

Filed Jan. 10, 1964

3 Sheets-Sheet 1

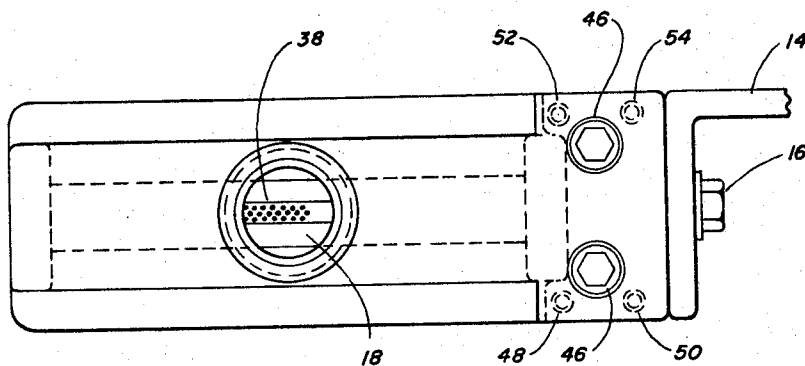


FIG. 1.

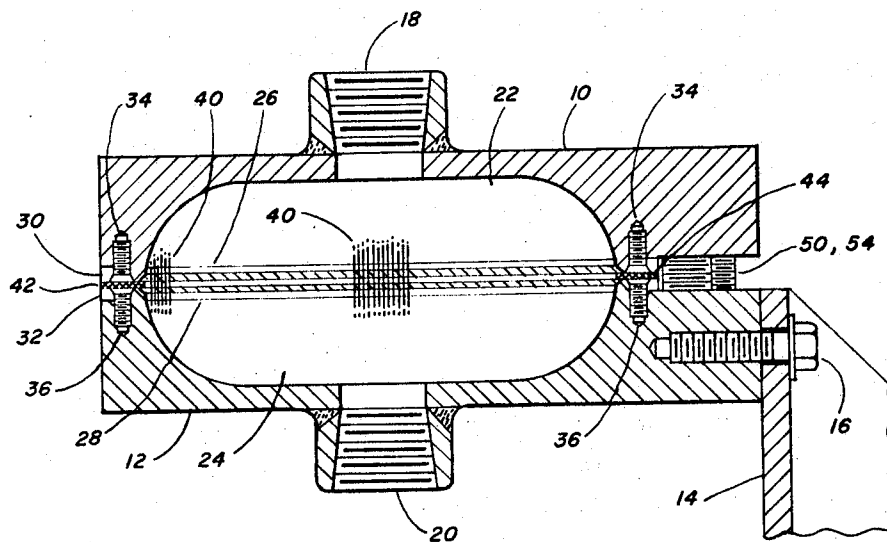


FIG. 2.

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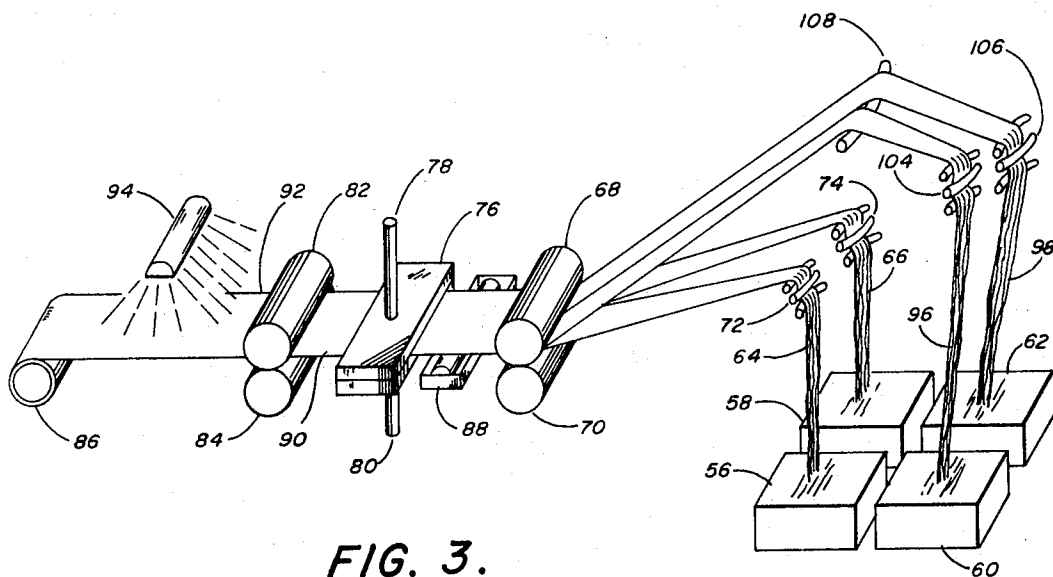


FIG. 3.

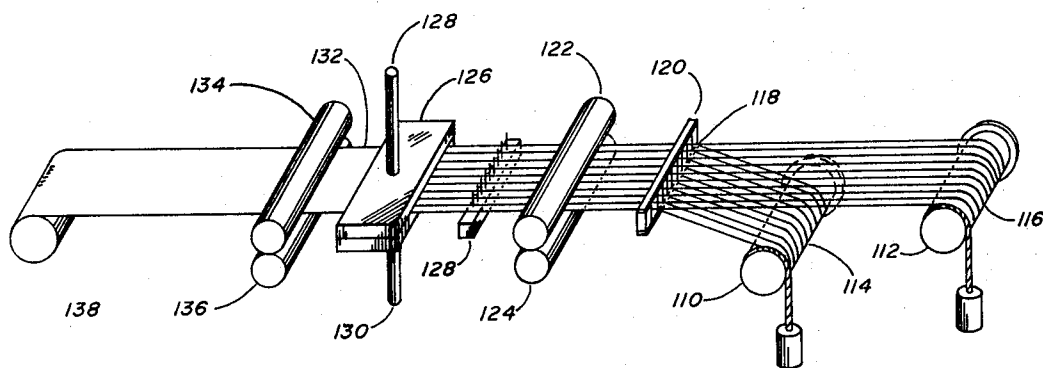


FIG. 4.

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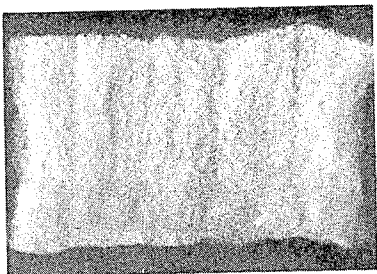


FIG. 5

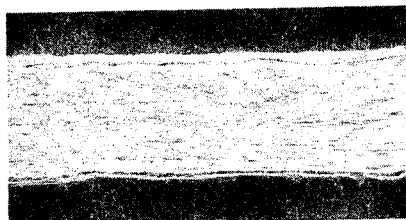


FIG. 6



FIG. 7

1

2

3,391,048 ENTANGLED NONWOVEN WEB PRODUCT FROM PARALLEL LAID FILAMENTARY TOWS

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Continuation-in-part of application Ser. No. 223,587,
Sept. 12, 1962. This application Jan. 10, 1964, Ser.
No. 336,971

10 Claims. (Cl. 161—58)

This invention relates to the production of continuous filament type nonwoven fabrics. More particularly it concerns the preparation of a new kind of nonwovens by a novel jet treatment of continuous filament tow of polymeric composition.

This application is a continuation-in-part of Ser. No. 223,587, filed Sept. 12, 1962, now abandoned, in which we described a compact intermediate yarn product characterized by a high degree of coherence and intermingling of continuous synthetic filaments and apparatus and method for the production thereof. Said yarn product is formed by passing tow, preferably banded, through a jet of special construction as detailed in said application. Although such process is highly efficient in the production of an intermingled filament intermediate tow product especially useful in making tobacco smoke filters, there has still been some room for variations as to coherence of the product, for example, for finding a way to produce a product which would be usable per se as a nonwoven useful, for example, in battings, webs, rugs, furs and the like. It has therefore been desired to alter the preparation such that a nonwoven product having such uses may be formed.

In the art prior to the instant invention various means have been used to form a wide sheet or batt-like body of desirable bulk, strength, resistance to deformation and fiber shifting from compact crimped tow but thus far without success except by lengthy processing steps. In the production of nonwoven textile webs and battings, it has been customary to go through the operations of crimping and cutting the continuous extruded fiber into short lengths, packing these short lengths in bales, and subsequently carrying out the steps of fiber opening and web formation on carding, garnetting, or the like equipment. The processing of staple fiber into a batting has thus been relatively expensive. Therefore preparation of an economical batting with desirable features with fewer complex and costly processing steps represents a highly desirable result.

One object of this invention is to provide a process and apparatus for converting densely packaged compact, continuous-filament crimped tow into bulky, wide batting characterized by a substantially parallel filament arrangement, said filaments retaining a high degree of crimp and being distributed in a substantially uniform manner throughout the batting. Another object is to provide a fluffy voluminous nonwoven product suitable for use as pile members when several layers forming a batting are sliced transverse to the longitudinal fiber axes and bonded to a backing vertical to the plane of the fabric, as garment insulating material, as furniture cushion material, as sleeping bags and comforter filling material, and as air filter material. Still another object is to provide a spread-out fluffy voluminous nonwoven material having a high degree of uniformity in the random distribution of the crimped filaments therein, which material may be readily impregnated or surface treated with chemical binders or compacted by a mechanical manipulation such as needle punching and compressed and cured into a resilient material suitable for use in such applications as garment interfacing. A further object is to provide a simple effective

apparatus combination for converting a dense highly crimped tow into a wide web or batting comprising uniformly distributed intermingled continuous filamentary material. A still further object is to provide a method whereby fibers having a higher crimp than those which can ordinarily be processed on cards, garnetts, and air laying web formers may be converted into nonwovens. Another object is to provide a method of producing nonwoven materials utilizing continuous textile filaments which have been treated with fiber finishes of high electric resistivity or with potentially adhesive materials which would ordinarily preclude the processing into webs of such fibers in staple form. Other objects will appear hereinafter.

In its broadest aspects our invention involves impinging needle-like streams of a high-velocity gaseous medium such as air from above and below on a plurality of strands of continuous-filament tow each strand or end of which may contain 10,000 filaments or more to produce a nonwoven web product the filaments of which are randomly distributed in a highly coherent form, being interlaced and in a substantially uniform distribution. The tow used may be from one or more synthetic organic fiber-forming materials, for example, cellulose acetate, cellulose triacetate, regenerated cellulose, polyamides, copolyamides, polyesters, copolyesters, acrylics, modacrylics, polycarbonates, polyurethanes, polyethylenes, polypropylenes and the like. The tow is preferably subjected to a certain amount of filament separation by banding or opening out prior to subjection to the impinging streams of gas. Banding promotes uniformity of distribution and exposure. One way in which this may be accomplished is by the process of our coworker Jackson, as described in U. S. Patent 2,737,688. A series of curved guide bars may be used to further spread the tow prior to our multi-jet treatment. Either crimped or uncrimped tow may be used. Crimped tow is used when batting for such end uses as comforters, insulated underwear, garment interliners, rugs or carpets, and the like is contemplated. Uncrimped tow may be used when it is planned to produce, for example, mens' tie interliners, shirt and suit lapel interliners, drapery liners, drapery fabrics, and the like. The density of the nonwoven product may be varied from 0.002 oz./cu. in. to 0.06 oz./cu. in. Higher densities may be obtained by heat treatment, calendaring and the like.

According to our invention the streams of gas used in treating the tow are provided by an impingement or needling jet in which are used one or more substantially straight rows of orifices in opposing or mating body members arranged substantially perpendicular to the direction of movement of a plurality of yarn ends or strands. These orifices or holes may be directly opposite each other or out of alignment. The angle of the hole axes may be perpendicular to the moving tow or at an angle of less than 90°.

For a more complete understanding of our invention reference will be made to the attached drawings forming a part of the present application.

In the drawing, FIG. 1 is a top view of the impingement jet of the present invention.

FIG. 2 is a transverse cross-section of the impingement jet of the present invention.

FIG. 3 is a schematic representation showing the treatment of a plurality of strands of crimped tow taken from bales or boxes to produce a nonwoven product in accordance with our invention.

FIG. 4 is a schematic drawing showing the production of a nonwoven product according to our invention by impingement jet treatment of a plurality of yarns from separate beams brought together as a single warp sheet of uncrimped tow.

FIG. 5 is a photographic reproduction of the nonwoven product of this invention formed from crimped tow as it looks after emerging from the impingement jet according to our invention by a procedure such as depicted in FIG. 3.

FIG. 6 is a photographic reproduction of a sheet like nonwoven product of this invention produced by jet treatment such as that of FIG. 4.

FIG. 7 is a photographic reproduction of a thick batting nonwoven product of this invention produced by jet treatment such as that of FIG. 4.

Referring now to FIGS. 1 and 2, our impingement jet consists of two mating body members 10 and 12. Body member 12 is adapted to be fastened to a support member 14 by bolt 16. Each body member is provided with one or more gaseous supply inlets 18 and 20. Each body member is hollowed out at 22 and 24 to provide a large gas chamber or plenum adjacent the inlets 18 and 20 respectively. These gas chambers are open on the abutting surfaces 26 and 28 of the body members 10 and 12. These openings are covered by flat thin plates 30 and 32 held in place by flat head screws 34 and 36 respectively. Each of the plates 30 and 32 has a plurality of tiny holes closely spaced in a staggered relationship as shown at 38 in FIG. 1. The hole arrangement in plates 30 and 32 may be such that the holes are directly opposite as indicated by the hole axis lines 40 or they may be displaced so that the axis of any given hole in plate 32 is centered between the axis of the two approximately opposed equivalent holes in any given row of holes in plate 30. The particular hole pattern which gives optimum results for a given treating process may vary. In some cases 3 closely adjacent rows of holes may be best as shown in FIG. 1. In other cases 2 closely spaced rows of holes may be used with a third row displaced say $\frac{1}{2}$ " from the first 2 rows. The frequency of the holes may be varied according to the type material being used and the end product desired. Closely spaced holes may be required for tows in which the filaments are more highly resistant to separation or where a heavy inter-filament reaction or movement is desired. Fewer holes may sometimes be used for easy-to-separate filaments or where the degree of inter-filament movement desired is small. One spacing found to give good results is where the holes are of .011" diameter and spaced .094" apart in each row and the rows are spaced .062" apart.

To provide clearance for the tow to pass between the plates 30 and 32 highly compressible gasket strips 42 and 44 are placed parallel to the direction of tow movement at either side of the jet assembly. These gaskets serve also to guide and maintain the tow band in the active area of the jet and prevent treatment gas or tow filaments from escaping from the sides of the jet.

The two body members are fastened together by means of screws 46. The spacing of the two body members may be varied by set screws 48, 50, 52, and 54. Thus, the jet opening may be narrow on the upstream side, i.e., at the tow entrance, and caused to diverge on the downstream side by extending set screws 48 and 50 and retracting set screws 52 and 54. Also by extending set screws 48 and 52 and retracting set screws 50 and 54 the jet tow opening can be made wider on one side of the tow than at the other. Thus the angles formed by the planes in the surfaces of plates 30 and 32 may be varied as desired and due to the flexible gaskets 42 and 44 the sides of the jet remain sealed. Other types of adjusting means may be used. For example, the jet may be hinged at one end to facilitate threading the tow through the jet.

The impingement jet just described has a wide range of utility in the treatment of tow or warp sheets. In processing tow for use in cigarette filters, for example, it has been found to produce an unusually high degree of filament separation, blooming and deorientation of the crimps in the individual filaments.

If an aerosol of tow treating liquid is injected into the

air lines 18 and 20, it has been found that an unusually high degree of uniformity of liquid application to a tow may be obtained. The aerosol is readily conveyed by the slow velocity air stream in pipes 18 and 20 and accelerated and impinged with violence onto the filaments of the tow due to the high velocity of the air stream and the inertia of the aerosol droplets emerging from the tiny holes 38. This effect may be achieved by maintaining the area of the inlet pipe 18 at a value of at least 10 times the total area of the holes 38 in plate 30.

Another advantage is that by using somewhat higher air pressure the jet has been found to be particularly effective in stripping water or other liquids from a wet tow so that the amount of surface moisture is reduced to a level of only a few percent even though the tow enters the jet with fifty to several hundred percent moisture content on the surface of the fibers. The foregoing, however, serves mainly to illustrate the wide utility of the jet.

When the jet of FIGS. 1 and 2 is used to treat a highly crimped tow, it has been found that a high degree of filament separation or debundlization can be obtained so that a batting may be formed which has good uniformity and as much, generally even greater, resistance to transverse forces than a card or garnett web and in many instances more coherence. In addition such a batt has a much higher degree of crimp retained in the filaments than is possible with carded fibers since the mere act of carding a fiber strains the fibers and tends to remove the crimp. Moreover, two or more parallel-fed tow bands are readily interlocked at their edges to form a uniform wide web without thin or heavy joints where the tows are joined together.

Referring next to FIG. 3, crimped continuous filament tow of from 10,000 to 200,000 total denier is supplied in bales or boxes 56, 58, 60, and 62 or in the form of ball warps if desired. The tow may be comprised of filaments of from 1 d./f. to 50 d./f. in size. The filaments may be of round Y, C, X, or other like crosssections. Tows 64 and 66 are withdrawn from the bales 56 and 58 by rolls 68 and 70 and pulled over the curved tow spreading bars 72 and 74 respectively. If desired, banding or tow spreading jets such as those of Jackson U.S. Patent 2,737,688 may be used also. This spreads the tow, removes any false twist in the tow and places the tows under a moderate tension to even out any irregularities or distortions of the tow bands. These tow bands then pass between the nip of withdrawal rolls 68 and 70 to the impingement jet 76. The impingement jet is supplied with a gaseous fluid such as air or steam by fluid conduits 78 and 80. While not shown it will be understood that the flow of gas may be controlled by suitable valves, pressure regulators and may be pretreated to heat the gas, dry it or inject an aerosol of liquid particles into it if desired. The tows 64 and 66 after treatment and combining into a wide web by the jet 76 then pass through the nip of the output rolls 82 and 84. These rolls may be driven slightly faster, say up to 10 percent, or up to 100 percent slower than the rolls 68 and 70 so that the tow may be slightly stressed to straighten out the crimp or conversely allowed to relax so that the filaments migrate in the tow to a high degree and the tow is increased in thickness.

Following the rolls 82 and 84 the bloomed and entangled tow product, for example, as shown in FIG. 5, may be wound up on roll 86.

In some cases it may be desirable to apply a chemical binder to the tow. This may be done with a roll applicator shown at 88 before the jet 76 treatment. As previously noted, the binder treatment in some cases may be advantageously applied by means of an aerosol in the jet air. In other cases it may be desired to immerse the bloomed tow product emerging from rolls 82 and 84 in a latex emulsion. Alternatively a powdered binder such as phenolic resin may be dusted on the tow batt before 90 or after 92 passage through the rolls 82 and 84. In any case the binder is cured by a heating or other activat-

ing means such as the infrared heater shown schematically at 94. In other cases hot calender rolls may be used if a compacted sheet-like product is desired. For example, if a plasticizer for a cellulose acetate tow is applied at 88 then rolls 82 and 84 may be heated to hot calender and cure the tow band into a sheet-like product.

If desired, the tow banded batt product emerging from the rolls 82 and 84 may be needle punched to increase the coherence thereof. Further methods of treating the tow product as known to those skilled in the art may be used. It is also possible by using our impingement jet to laminate a second or even third or more tow banded batt product to form almost any desired thickness. For example, in FIG. 3 tows 64 and 66 may be laid side by side and tows 96 and 98 superimposed thereupon to make a thicker product. Between bales 56 and 58 and rolls 68 and 70 tows 64 and 66 pass over guides 72 and 74, and between bales 60 and 62 and rolls 68 and 70 tows 96 and 98 pass over guides 104, 106, and 108. The surprising degree of poining of the superimposed webs prevents delamination such as often encountered in prior art laminates. It is likewise possible to make only a single narrow width ribbon-like product such as a felt-like strip from a single tow supply.

The foregoing discussions have related only to crimped filaments. Our impingement jet has also been found to be useful for converting a parallel laid warp sheet of continuous filament yarns having no transverse strength or coherence into sheet, fabric or batting-like products having a remarkable degree of transverse strength. For example, it has been found possible to convert a warp sheet of a plurality of uncrimped multifilament zero or low twist yarns directly into a fabric without the need to go through the expensive operations of weaving or knitting the yarn ends on conventional looms or knitters. The product produced by the entanglement jet from a warp sheet has in itself sufficient transverse strength to be adequate for many end uses now requiring a woven fabric. For example, it may be sliced into strips transverse to the longitudinal fiber axes and bonded to a backing such that the substantially parallel fibers are approximately vertical to the main fabric direction. Other uses include men's tie interliners, shirt and suit lapel interliners, and possibly drapery liners and even drapery fabrics. If higher transverse strengths are required, cross-laid fabric sheets or chemical binders may be used.

To produce these products an apparatus setup such as shown in FIG. 4 is used. One or more warp beams 110 and 112 wound with a plurality of ends 114 and 116 of continuous multifilament are provided. The width of the beams depends on the number of ends, which may vary from 5 ends/per beam to 10,000 or more, and the width of the end product desired. The number and size of the multifilament yarns may be varied over a wide range. For example, they may be composed of 55 to 5,000 total yarn denier with filament counts dependent on the filament size, which may be varied from about 1 d./f. to about 50 d./f. The warp sheets composed of 5 to 10,000 or more yarns from each beam in the case of a plural supply of beams are combined into a single warp sheet 118. The ends are threaded through a suitable comb or reed 120 to maintain and control a uniform density of ends or yarn strands per inch of width. The warp sheet is then passed between the bite of a pair of feed rolls 122 and 124. The warp sheet of ends may then be passed directly into the impingement jet 126 or may be passed through a second comb or reed 128. This may be desirable when very good control over the spacing of the yarns is required or when they are excessively disarranged by passage through the feed rolls 122 and 124. In passage through the impingement jet 126 each yarn is broken down into its individual filaments. That is, the individual filaments of the yarns are separated from each other. They are then whipped about by the eddy current actions of the plurality of gas jet streams issuing from the holes of the

jet 126. Air or other suitable fluid either hot or cold is fed to the jet by pipes 128 and 130 under the desired pressure and temperature conditions. In some cases differentially shrinking filaments that tend to curl and crimp when exposed to heat may be used as the yarn supply. In this case in addition to some tangling and interweaving of filaments a crimp is developed in the fibers when they are exposed to hot air or steam. In some cases this effect is enhanced by supplying the heated gas to only one side of the jet through pipe 128. The bottom plate of the jet in this case is not drilled with the holes and acts as an impingement baffle or obstruction against which the hot gas and heated filaments impinge. The surface of this plate may be flat or tilted at a suitable angle to the yarn and gas streams. This has been found in some cases to increase and enhance the degree of crimp and interfilament entanglement desired in the filaments. The plate may be heated or chilled to further enhance the crimp effect obtained in the filaments. In its passage through the jet, the warp sheet of individual yarn ends is converted into a coherent fabric or sheet-like material as shown in FIG. 6. Removal of this sheet 132 from the jet 126 is accomplished by rolls 134 and 136. This pair of rolls is driven at a constant speed ratio relative to rolls 122 and 124. Usually the feed-in rolls are driven faster than the takeup rolls 134 and 136. This overfeed may, however, be varied from substantially zero to 100 percent or even more, say 1,000 percent, depending on the end product desired, the degree of crimp developed in the filaments if hot gas is used, and the degree of filament takeup or shortening in product length due to the interweaving action of the individual filaments. The end product is then wound up on a takeup spool or roll 138. In some cases rolls 134 and 136 may be omitted and in this case the wind up roll 138 acts as the means of withdrawing the product from the jet. The product wound up on roll 138 may then be treated in any manner common in the finishing of woven or knitted fabrics. It may be treated with a binder to improve its transverse strength. It may be dyed, printed, calendered, napped, embossed, laminated with other layers of a similar product or with plastic or conventional woven fabrics. Several obvious advantages are inherent in producing a fabric in the foregoing manner. Many fibers that are difficult to weave or knit into fabrics due to the various limitations of twist, filament size, shape, pilling, electrostatic, and frictional properties may now be made into fabric.

The product may be compact or bulky as desired. The fabric produced in general has the surface characteristics of fabrics woven or knit from staple fiber yarns without the need of the costly cutting, crimping, and the cotton, worsted or woolen system yarn spinning processes and weaving or knitting required to produce this type fabric from man-made fibers. It opens up a wide range of possibilities which will be recognized by those skilled in the textile arts. For example, a latex or other suitable binder may be applied to one side of the product and the other side napped and sheared to produce furlike fabrics or carpet fabrics. The sheet-like product may, if desired, be rolled transversely on itself to produce yarns, ropes, cords, cable, stuffers and wicks. It may also, if desired, be rolled on itself to produce tobacco smoke filters or liquid and gas filters.

FIG. 5 clearly shows the intermingling, interweaving and intermigration or crosslaying of the filaments between the adjacent edges of the individual ends of a crimped filamentary tow brought together as a filament-banded cohesive nonwoven web product.

FIG. 6 shows a similar coherent intermingled-filament web product wherein a plurality of yarn ends in the warp sheets are united by entwining of filaments to form a single uniform sheet.

Prior to the present invention difficulty has sometimes been experienced in air treating a yarn of large denier filaments. For instance, a 1,000-denier yarn composed of

1,000 filaments of 1 d./f. at times does not respond satisfactorily when treated with lofting jets known to the art.

air pressure, product appearance, and the like of 5 individual samples are given in the Table I, which follows.

TABLE I

Sample No.	1	2	3	4	5
Tow Denier	15,800	15,800	15,800	15,800	15,800
D/F	2.1	2.1	2.1	2.1	2.1
Crimps per inch	16	16	16	16	16
Jet Width (in.)	Control (no jet)	1	1	1	1
Jet Air (p.s.i.g.)	do.	50	40	50	30
Feed (ft./min.)	do.	10	10	10	10
Take-up (ft./min.)	do.	10	10	10	10
Product	Control	Excellent	Good	Excellent	Fair
Appearance	(Unmingled strands)	Intermingled Fig. 5	Few Clusters of Unopened Fiber	Intermingled	Some Clusters of Unopened Fiber
Binder	None	None	None	None	None

This difficulty may be overcome according to our invention by introducing a plurality of ends, for example, 100 denier, 1 d./f. (about 100 filaments) in a total of about 10 ends of yarn in the form of a warp sheet or flat ribbon, to our impingement jet. Thus, we may obtain the desired degree of interfilament entanglement with or without humped loops, crunodal loops or other species of loop shapes or filament curling, as desired depending on the net overfeed to the jet. The sheet-like narrow ribbon product merging from the jet can be twisted into a round

EXAMPLES VI-XVIII

Filament yarn warp samples were converted by passage through an impingement jet such as that depicted in FIGS. 1 and 2 according to the procedure of FIG. 4 into a sheet-like narrow ribbon nonwoven textile product under the conditions illustrated in Table II, which follows. The appearance and filament entanglement of the impingement jet-treated product is indicated. The yarn used in these samples was cellulose acetate yarn.

TABLE II.—IMPINGEMENT JET CONVERSION OF FILAMENT YARN WARP INTO NONWOVEN FABRIC

Sample No.	1	2	3	4	5	6	7
Denier	150	150	150	150	150	150	150
D/F	4	4	4	4	4	4	4
Ends/inch	90	180	100	100	100	100	140
Jet Width (in.)	1	1	1	1	1	1	1
Hole Size (in. diam.)	.040	.040	.040	.040	.040	.040	.040
Rows	1	1	3	3	3	3	3
Hole Space (in.)	.094	.094	.094	.094	.094	.094	.094
Row Space (in.)			.062	.062	.062	.062	.062
Plate Spact at:							
Entrance (in.)	.020	.020	.020	.020	.020	.020	.020
Exit (in.)	.020	.020	.030	.030	.030	.030	.030
Air Pressure (p.s.i.g.)	34	34	40	50	60	60	60
Feed Speed (yd./min.)	10	10	10	10	10	30	60
Over Feed Product	Slight	Slight	Slight	Slight	Slight	Low	5.
Entanglement	Slight	Slight	Good	Good	Very good	Good	Very good.
Appearance	Stringy	Smooth	Good	do.	Good	do.	Do.
Uniformity	Poor	Fair	do.	do.	do.	do.	Do.
Type	Sheet	Sheet	Sheet	Sheet	Sheet	Sheet	Sheet.
Thickness	1/32"	1/32"	1/32"	1/32"	1/32"	Sheet	Sheet.
						1/32"	1/32"
	8	9	10	11	12	13	
Denier	150	150	150	150	150	150	
D/F	4	4	4	4	4	4	
Ends/inch	220	280	350	160	280	160	
Jet Width (in.)	1/8" in.	1/8" in.	3/8" in.	1/8"	1/2"	1/8"	
	1" out	1" out	3/4" out				
Hole Size	.040	.040	.040	.040	.040	.040	
Hole Size (in. diam.)	.040	.040	.040	.040	.040	.040	
Rows	3	3	3	3	3	3	
Hole Space (in.)	.094	.094	.094	.094	.094	.094	
Row Space (in.)	.062	.062	.062	.062	.062	.062	
Plate Spact at:							
Entrance (in.)	.020	.040	.040	.040	.040	.040	
Exit (in.)	.030	.060	.060	.060	.060	.060	
Air Pressure (p.s.i.g.)	50	55	45	45	45	45	
Feed Speed (yd./min.)	10	5	5	10	45	45	
Over Feed Product	Low	Heavy	Heavy	Low	Heavy	Heavy	
Entanglement	Good	Very high	High	Very high	Very high	Very high	
Appearance	do.	Very good	Good	Very good	Bulky ²	Bulky.	
Uniformity	do.	do.	do.	do.	Good	Good.	
Type	Sheet	Batting	Batting	Batting	Batting	Batting	
Thickness	3/64"	1/8"	1/8"	1/16"	1/8"	1/16"	

¹ Fig. 6. ² Fig. 7.

yarn of 1,000 denier or more depending on the degree of bulk or overfeed imparted by the jet treatment. This yarn has a remarkably improved internal cohesiveness and as a result is characterized by a generally higher bulkiness than the prior art heavy denier bulked or entangled yarns.

A further understanding of our invention may be had by reference to the following examples which are intended to be illustrative only.

EXAMPLES I-V

A 15,800 denier tow was passed through an impingement jet such as shown in FIGS. 1 and 2 in a manner similar to that depicted in FIG. 3. The properties of the tow, the feed and take-up speeds, the jet width and jet

EXAMPLE XIX

A nonwoven batting was made by carding 3 d./f. 2" high crimp cellulose acetate staple fiber and spraying the card web with a plasticizer, di-(methoxyethyl)phthalate. Several layers of the card web were then plied together to form a batting weighing 12 ounces per square yard. The batting was then cured in an oven for one minute at 275° F. The batting was then sliced into 1/2 inch wide strips transverse to the longitudinal fiber axes. A piece of backing fabric was then prepared by coating it on one side with an adhesive. The strips of cut batting were then placed on end in close proximity to each other on the adhesive coated fabric so that the fibers were vertical to the plane of the fabric. The adhesive was allowed to cure. The resulting product was an attractive

fur-like pile fabric suitable for floor covering or apparel use.

EXAMPLE XX

The experiment of Example XIX was repeated except continuous filament lightly crimped cellulose acetate tow was used with the process of FIGURE 3 to produce a thick coherent batting as shown in FIGURE 5. No plying, plasticizing or curing steps were required before the batting was cut into strips and adhered to the backing material. The resultant product with an unbonded pile contained intermingled filaments standing substantially perpendicular to the backing fabric. Advantageous to this product was the fact it could be more readily treated by brushing and polishing by conventional means to produce an attractive fur fabric.

EXAMPLES XXI AND XXII

The procedure of Example XIX was used except that modacrylic and polyester tows were used to make a durable and attractive fur fabric with filaments substantially perpendicular to backing.

The process of Examples XIX-XXII readily lends itself to the use of tows having very low or no crimp so that the amount of polishing and finishing required to produce a fur-like fabric is greatly reduced. Thus, fur pile fabrics having improved sheen and luster are more readily produced. In the prior art of making fur fabric from crimped staple, the removal of the crimp from the pile fibers in the polishing operation has always been difficult with the more temperature resistant polyester fibers. The use of zero crimp or very low crimp tow, as in Example XX, overcomes this difficulty as the staple carding operation which requires the crimp to make a stable silver is eliminated. A further advantage of this tow process is that, if desired, a tow of low shrinking filaments can be blended with a tow of high shrinking filaments to produce a two-level pile height guard hair fur fabric by exposing the filaments to heat after they have been adhered to the backing material.

Several types of apparatus are available in the art and are readily adapted for cutting, stacking and adhering or embedding the entangled tow in a backing material. See, for example, C. Jacquet U.S. Patent No. 2,940,504. Another suitable apparatus which may be modified to use on entangled tow intermediate product is disclosed in C. Pearse U.S. Patent 2,931,418. Both these machines are commercially available and it is thought accordingly need no further description herein.

It will be apparent from the foregoing description that we have provided a continuous-filament nonwoven product which has a particularly high degree of association and intermingling of filaments between the edges of the plurality of multifilament strands or ends which are joined together cohesively to make up said product thereof. We have provided for the first time by the use of our novel impingement jet process a highly uniform batting of multi-strand entangled-filament structure adapted for ready use as pile fabrics, in comforters, insulated underwear, garment innerliners and the like. Use of the unbonded continuous filament tow batt product of our invention containing a plurality of united yarn ends substantially eliminates leakage of fibers such as that sometimes encountered with prior art batts, thus reducing any degrading of the garments which might result from such leakage and preventing any disagreeability to the wearer which might result from protruding fibers, for example, itching and irritation of the skin. In addition, the tow product of this invention may be further treated by bonding or otherwise to produce fiber tapes, felts, paper-like sheets, tobacco smoke filters and the like. Our novel nonwoven product has both increased longitudinal and transverse strength caused by the interweaving and intermingling of the continuous filaments between the several strands thereof. Two or more layers of our fiber web product may be cross laminated with their axis at an angle of up to 90°. The

intermingling of filaments between the plurality of ends of tow of the web product permits an even greater transverse strength than that of bonded staple batts, the strength of which is dependent on the necessarily weakened short-fiber properties.

Although the invention has been described in considerable detail with particular reference to certain preferred embodiments thereof, variations and modifications can be effected within the spirit and scope of the invention as described herein, and as defined in the appended claims.

We claim:

1. A porous, bulky, flexible, highly uniform, self-supporting, nonwoven product comprising substantially parallel laid continuous filamentary tow materials of synthetic organic polymer; the continuous individual fibers of said filamentary tow materials being randomly entangled at a plurality of points throughout the three dimensions of the nonwoven product; said continuous individual fibers being substantially separated from and in parallelism with one another along the longitudinal axes of the nonwoven product in the area between said entangled points; the surfaces of the nonwoven product being composed essentially of said continuous individual fibers; the nonwoven product being further characterized in that it has a high transverse strength and uniform density per inch of width.

2. The nonwoven product of claim 1 wherein the continuous individual fibers are crimped.

3. The nonwoven product of claim 1 wherein at least two of the filamentary tow materials are laid side-by-side with the edges thereof being randomly entangled to produce a single continuous nonwoven product.

4. The nonwoven product of claim 1 wherein the filamentary tow materials consists of differentially shrinking continuous filaments which will curl and crimp when exposed to heat thereby producing a bulky nonwoven product.

5. The nonwoven product of claim 1 wherein the density of the product is between .002 and .06 oz. per cubic inch.

6. The nonwoven product of claim 1 wherein the filamentary tow materials have a total denier between from about 10,000 to 200,000 and the individual fibers thereof have a denier per filament of from about 1 to 50.

7. The nonwoven product of claim 1 wherein the sole bonding effect existing between the continuous individual fibers results from the random entanglement of the fibers.

8. The nonwoven product of claim 1 wherein the filamentary tow materials are laminated upon one another so that the fiber axis of one tow material is at an angle to the fiber axis of the other tow material with the continuous individual fibers of each tow material being substantially separated from and in parallelism with one another.

9. The nonwoven product of claim 1 wherein the product is twisted to produce a heavy bulky yarn-like material.

10. The nonwoven product of claim 1 wherein the product is secured at a plurality of points to a backing material.

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