

Sept. 19, 1967

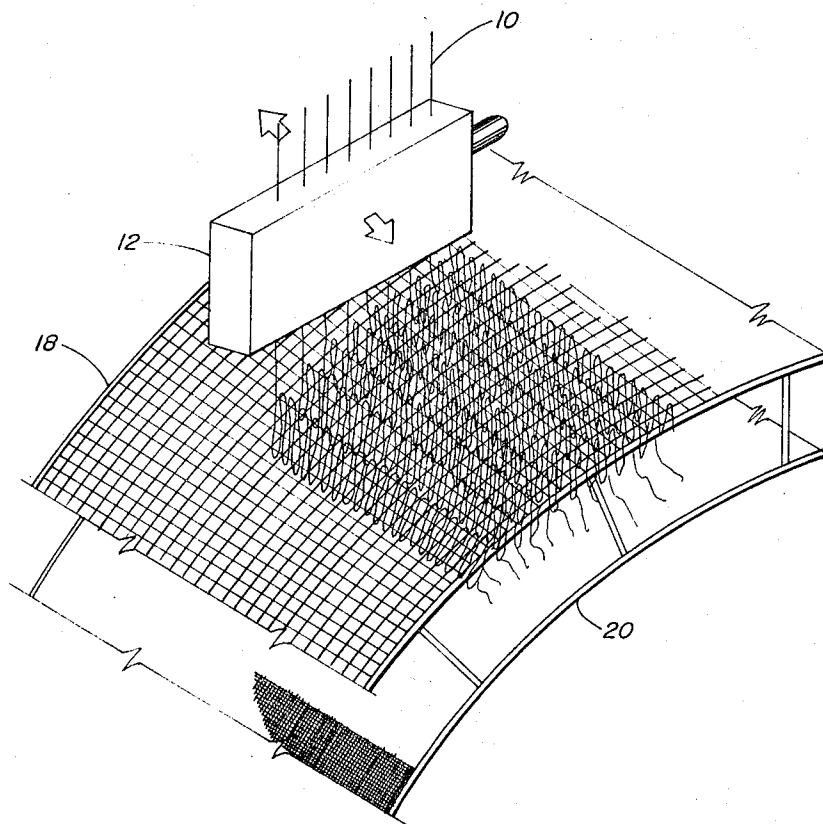
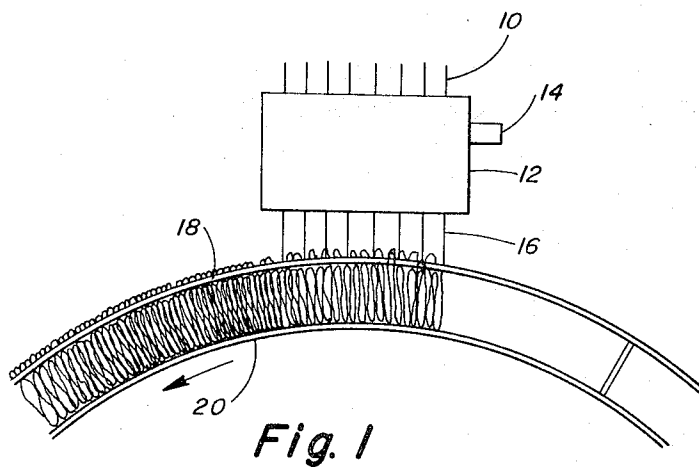
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3,341,912

TOW INTERLACING APPARATUS

Original Filed March 7, 1963

4 Sheets-Sheet 1



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Fig. 3

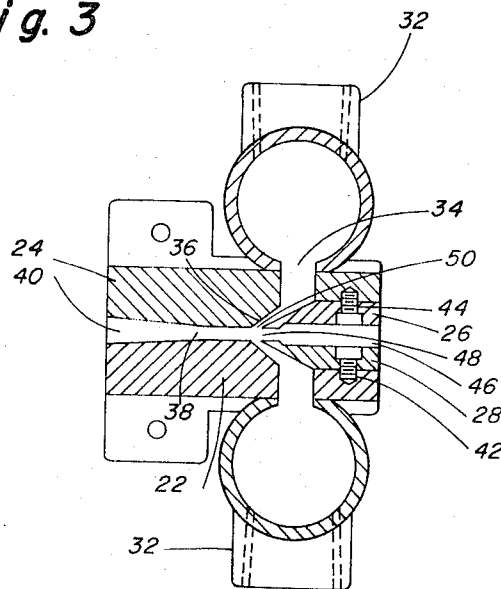
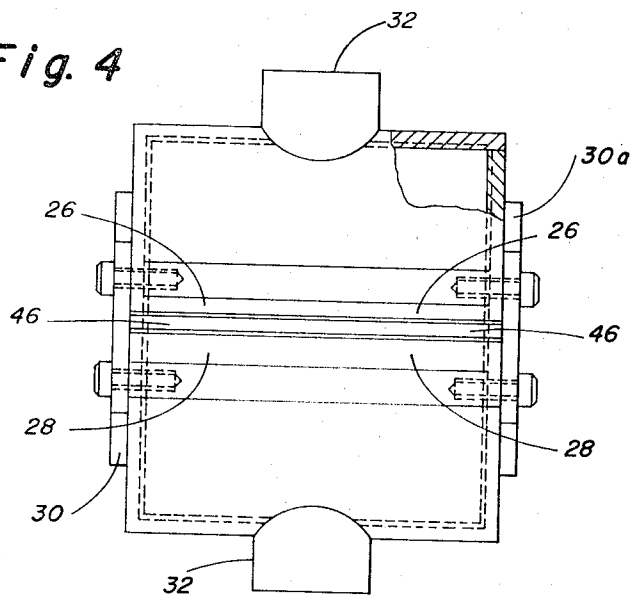


Fig. 4



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Fig. 5

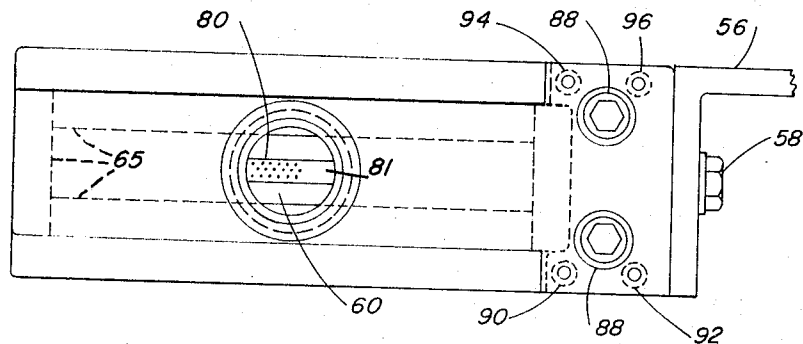
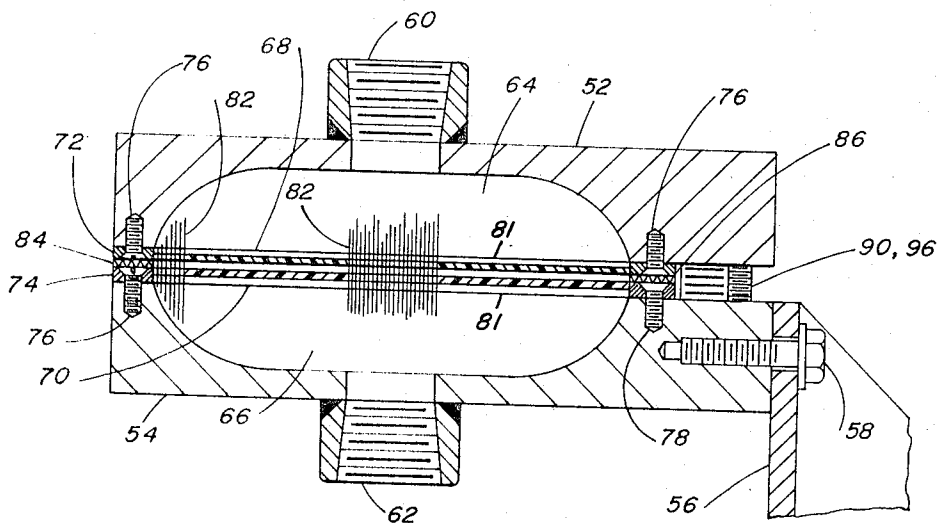


Fig. 6



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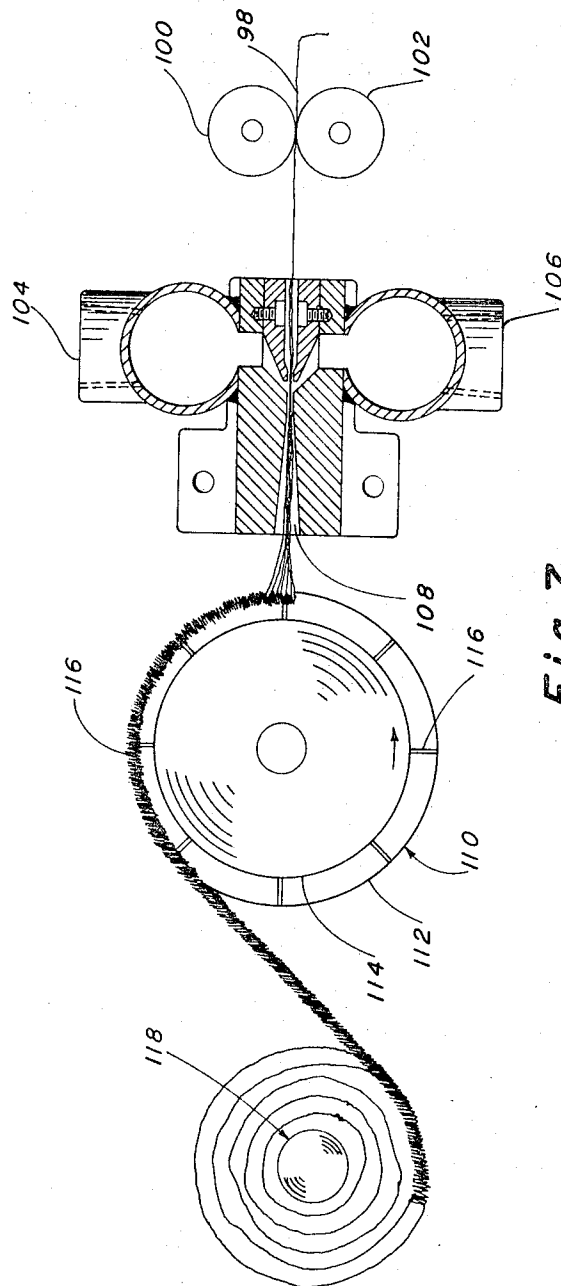


Fig. 7

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3,341,912

TOW INTERLACING APPARATUS

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Original application Mar. 7, 1963, Ser. No. 263,641.
Divided and this application Nov. 26, 1965, Ser.
No. 528,002

9 Claims. (Cl. 28—1)

This application is a division of United States patent application Ser. No. 263,641, which was filed on Mar. 7, 1963, and is now abandoned.

This invention relates to the production of an interlaced continuous-filament textile product. In particular this invention is concerned with an apparatus and process for treating and collecting a continuous-filament crimped tow in the form of an interlaced-filament product useful in tobacco smoke filters, battings and webs, wicks, cable stuffers, upholstery filler or edging, catemenial products and the like.

In the art prior to the instant invention various means have been used to try to alter the filament parallelism to randomize the location of the knees of the crimp to some extent and to intermesh or interlace the filaments in a compact manner. Such means have included mechanical vibrators or strikers, pinch rolls and the like. However, such procedures as including a high static electrical charge on the tow by means of rubber rollers or the alternate application of high and low tension by passing the tow from slow speed to high speed and then to low speed rolls or the beating of the tow by mechanical beaters have certain disadvantages. The generation of a high charge of static electricity on the tow may present a hazard if any volatile matter is present or if at a later step in the process it is desired to treat the tow with certain liquids or powdered additives. The application of high tensions or the beating of the tow with vibrators may weaken the filaments slightly and may cause filament breaks. Also such prior art type of treatment has reduced to some extent the effectiveness of the crimp. In other words, in the prior art one has to some extent been placed in the position of choosing between a good crimp that remains in the treated tow or a deficiency of crimp that is randomized and, therefore, in each instance does not obtain a compact interlaced-filament textile product which has both crimps out of registry and high coherence, as indicated by a high coherency factor.

In prior attempts to make such an interlaced-filament product, difficulty has sometimes been experienced in obtaining the desired batt thickness and the desired amount of interlaced-filament entanglement. Oftentimes it has been desirable after banding and fluffing to the tow to employ further processing to obtain a thick batt-type product. Furthermore, in further treatment such as in heating and tensioning the tow, the stresses involved are sufficiently great to permanently remove a substantial amount of the crimp and to prevent the formation of a compact interlaced-filament batt-like web with a desired degree of intertwining or entangling of filaments.

It is therefore believed apparent that the development of a method and apparatus for the production of a highly coherent textile product containing compactly interlaced filaments, preferably crimped, by which method and ap-

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paratus the filaments may be neatly and efficiently intermingled and compacted, thereby forming a product with filaments interlaced in such a manner as to comprise a highly efficient tobacco-smoke filter or other non-woven structure, represents a highly desirable result.

One object of this invention is to provide an apparatus and process for converting continuous-filament crimped tow into a textile product having a randomized filament arrangement, said filaments retaining a high degree of their original crimp. Another object is to provide a simple and effective apparatus arrangement for processing a dense continuous-filament crimped tow into a compacted and coherent interlaced-filament product. A particular object is to provide an apparatus and process for treating continuous-filament crimped tow and collecting it in the form of an entangled-filament batt-like textile product. Other objects will appear hereinafter.

In its broader aspects our invention involves method and apparatus adapted for treating continuous-filament tow with a jet-applied fluid and then collecting the tow on a moving surface as a coherent interlaced-filament textile product. In a preferred embodiment the tow moves directly through jet-treatment apparatus to a movable receiving item whereon it is collected as the entangled-filament product. The receiving item may be a moving roll, a moving belt-like object or the like. The preferred form is a perforated-surface pickup device, preferably moving substantially perpendicularly or at a right angle to the direction of exit of tow from the jet treatment.

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

FIG. 1 is a schematic diagram in perspective view from the tow-collection end of an over-all apparatus arrangement of the invention.

FIG. 2 is a perspective view of the over-all apparatus arrangement shown in FIG. 1.

FIG. 3 is a detailed cross-section view of one embodiment of a jet which may be used in association with collecting means according to the present invention.

FIG. 4 is a part semi-diagrammatic front end view of the jet shown in FIG. 3.

FIG. 5 is a top elevation view of another embodiment of a jet which may be used in juxtaposition with collection means according to our invention.

FIG. 6 is a transverse cross section of the jet of FIG. 5.

FIG. 7 depicts an apparatus arrangement including a drum or roll collecting device in association with the jet of FIG. 3, said device being followed by wind-up mandrel.

Referring now to FIG. 1, as indicated above the general over-all arrangement for jet treating continuous filament tow and collecting same as a coherent interlaced product in accordance with the present invention is shown. Banded continuous filament tow 10 is passed through jet 12, to which air or other appropriate fluid is introduced through line 14. After leaving jet 12 the jet-treated tow 16 falls on perforated surface 18, through which some of the filaments fall to a lower perforated surface 20. The upper perforated surface may be, for example, a coarse $\frac{1}{2}$ "-mesh wire screen as opposed to a wide $\frac{1}{16}$ "-mesh wire screen for the lower perforated surface 20. Both of these surfaces 18 and 20 move at the same rate at about a right angle to the original direction of movement of the tow prior to falling thereon. Thus, the

individual filaments form a batting of entangled filaments the width of the distance between the two collecting surfaces as a result of entanglement by treatment by jet 12 and some of the filaments moving to the lower surface.

Referring next to FIG. 2, which is a perspective showing of the tow treatment and collection of FIG. 1, the banded tow 10 after passing through jet 12 falls on upper porous surface 18, some of the filaments falling to lower finer-mesh surface 20, thereby forming an intertwined batt-like product.

The design of the jet 12 is of substantial importance to the operation of the process and will now be considered in detail with relation to FIG. 3. The preferred jet is composed of the parts as follows: Venturi body plates 22 and 24, nozzle plates 26 and 28, and end plates 30 and 30a (see FIG. 4). The venturi body plates have attached to one side a circular air chamber with air inlet nipples 32. This chamber communicates through slot 34 with the interior of the jet to allow free passage of air or the like fluid. The venturi body parts when assembled to the end plates coact to form elongated slot venturi entrance 36, a venturi throat 38 and a diverging venturi exit 40. The two nozzle plates 26 and 28 are assembled to venturi body plates 24 and 22 respectively by cap screws as indicated at 42 and 44. These nozzle plates coact with each other to form a slot-like yarn entrance passage 46 which converges at 48. The nozzle plate 26 also coacts with venturi plate 24 to form a wedge-shaped chamber 50 which is in communication with the circular air chamber 32 via slot passage 34. At the downstream side of this chamber 50 it converges at an angle of about fifteen degrees so that air passing through is accelerated to a high velocity at the transition between the venturi entrance 36 and the venturi throat 38. Nozzle plate 28 and venturi plate 22 coact in a similar manner. As apparent from FIG. 3, although only slot 36, air chamber 32, etc. have been referred to specifically, on the other side of part 28 there are comparable slots, chambers and the like. Hence, further description thereof appears to be unnecessary.

The tow enters the jet through passageway 46 and at the tip of the nozzle 48 it is subjected to the impingement of the high velocity "sheets" of air emerging from the venturi entrance 36. In the throat 38 air and tow are intermixed and the velocity effect of the air generates a tension in the tow and a suction in the nozzle entrance 46. This suction is strong enough to make the jet self threading, i.e. it will suck the tow into the jet. As the high velocity gas and tow mixture leaves the venturi throat 38 and enters the diverging throat 40, the air begins to lose velocity and expand. This action has the effect of "exploding" the tow and causing the filaments of the tow to diverge also, thus separating the filaments one from another. Also the filaments tend to vibrate much in the manner of ribbons attached to the front of an electric fan. This action further assists in separating the filaments. Recalling that between the jet and the downstream feed roll the tow is allowed to relax and contract, the filaments also move longitudinally relative to each other so that knees of crimp in adjacent filament are thrown out of phase in a completely random manner. Thus as the tow emerges from the jet the filaments are completely rearranged relative to each other as compared with their relative positions on entering the area of high velocity gas flow.

So far we have considered only the cross section of the jet. We will now consider FIG. 4. The principal purpose of FIG. 4 is to illustrate that the jet shown in FIG. 3 is not a round or cylindrical type of jet but is an elongated slot type of jet. In FIG. 4 the jet has been shown broken away on one corner to show the air chamber. The width of the jet may be, for example, 4-20 inches.

Referring in more detail to FIG. 4, it will be observed that the air inlet pipe is shown at 32 as are the nozzle plate parts 26 and 28. The opening indicated at 46 is the entrance passageway for the tow being fed to the jet. FIG. 4 also shows parts 30 and 30a which are the end plates. An end plate is merely a metal plate bolted onto the side of the parts discussed in the description of FIG. 3 to provide an end closure for the jet. Also, the construction of the end plate is such that the spacing of the parts may be accomplished to the desired degree.

If we look in the transverse plane i.e., along the width of the jet, it will be seen that an even sheet of air flow is generated in the venturi throat from side to side of the jet. This is because air very quickly will equalize any variations in pressure or velocity in a given zone or enclosure. Thus if high pressure was present in the middle of the jet it would quickly level out by transfer of air from the high pressure spot to the adjacent low pressure spot. Furthermore, the jet is so proportioned that the supply of air in circular chamber 32, and in the converging chamber 50 is large relative to the amount that can pass into and through the venturi. The tow enters the jet with a width of from 2" to 5" compared to a jet width of 10", for example. However, the continued leveling of air velocities and pressures tends to expand the tow width not only in the jet entrance but also in the venturi throat 38 and exit 40.

To obtain the most efficient use of air compatible with the most effective blooming of the tow certain proportions have been found to be desirable. The angle of divergence of the venturi should be from four to ten degrees with eight degrees being preferred. The length of the diverging portion 40 should be about four to ten times the length of the throat 38 and preferably about seven times the length. The nozzle throat length 38 should be about three times its width. The total area of the entrance slots as 36 should be about .10 times the area of the venturi throat. This latter ratio, however, is adjustable depending on the amount of suction or back pressure desired in the entrance nozzle 46. A low ratio tends to increase the suction while too high a ratio causes back pressure or blow back in the nozzle entrance 46. The width of the jet is largely determined by the width to which it is desired to spread the tow. The proportion of the area of the venturi throat to the denier of the tow is not unduly critical but values in the order of one square inch per 50,000 denier are desirable. The included angle of the venturi throat entrance formed by plates 22 and 24 is preferably 90° but may vary from 45 to 135°.

The manner in which the tow enters and leaves the jet can be arranged to improve the blooming. In general a straight line pass is less desirable. Bringing the tow in parallel to the jet axis and removing it at about a right angle produces improved results. Also about a right angle bend in the tow as it enters the jet and a second approximate right angle bend as it leaves with the tow either reversing its general direction of flow or ending up proceeding in the same direction are also beneficial in improving opening. This can be accomplished by positioning the jet somewhat above or below the bite plane of feed or collecting rolls. There should be no twist or false twist in the tow for best results. Judicious placement of guides will largely eliminate any false twist in the tow.

Referring now to FIGS. 5 and 6 according to another embodiment our jet consists of two mating body members 52 and 54. Body member 54 is adapted to be fastened to a support member 56 by bolt 58. Each body member is provided with one or more gaseous supply inlets 60 and 62. Each body member is hollowed out at 64 and 66, as indicated by dash line 65 in FIGURE 5, to provide a large gas chamber or plenum adjacent the inlets 60 and 62 respectively. These gas chambers are open on the abutting surfaces 68 and 70 of the body members 52 and 54. These openings are covered by flat thin plates

72 and 74 held in place by flat head screws 76 and 78 respectively. Each of the plates 72 and 74 has a recessed groove 81 with a plurality of tiny holes closely spaced in a staggered relationship as shown at 80 in FIG. 5. The hole arrangement in plates 72 and 74 may be such that the holes are directly opposite as indicated by the hole axis lines 82 or they may be displaced so that the axis of any given hole in plate 74 is centered between the axis of the two approximately opposed equivalent holes in any given row of holes in plate 72. 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. 5. 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 72 and 74 highly compressible gasket strips 84 and 86 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 88. The spacing of the two body members may be varied by set screws 90, 92, 94 and 96. Thus, the jet opening may be narrow on the up-stream side, i.e., at the tow entrance, and caused to diverge in the vertical plan by extending set screws 90 and 92 and retracting set screws 94 and 96. Also by extending set screws 90 and 94 and retracting set screws 92 and 96 the jet tow opening can be made wider or one side of the tow than at the other. Thus the angles formed by the planes in the surfaces of plates 72 and 74 may be varied as desired and due to the flexible gaskets 84 and 86 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 60 and 62, 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 60 and 62 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 80. This effect may be achieved by maintaining the area of the inlet pipe 60 at a value of at least 10 times the total area of the holes 80 in plate 72.

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. 5 and 6 is used to treat a highly crimped tow, it has been found that a high degree of filament separation or debundlization can be obtained

while at the same time retaining or achieving a moderate to high degree of interfilament migration 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 garnet 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.

Moving now to FIG. 7 wherein jet treating and interlaced filament product collecting means are shown in another embodiment, banded continuous filament tow 98 is introduced after moving between guide rolls 100 and 102 to a jet such as that of FIG. 3 through a narrow slit-like orifice for entrance. After treatment by impinging fluid introduced through ports 104 and 106, the tow in jet-treated entangled or interlaced-filament form moves from venturi shaped nozzle 108 onto moving drum 110, the perforated outer shell 112 of which is separated from an inner perforated shell 114 by substantially evenly spaced braces 116. The interlaced filament textile product is then collected as batting in wound up form on mandrel 118.

The method and apparatus of the present invention have several advantages over those of prior art arrangement as will be evident by the following examples.

Example I

Filter rods were made by the jet treatment in an apparatus arrangement such as that of FIG. 2 using a 54,000 denier tow containing approximately 20,800 filaments having an average size of 2.6 denier. For comparison, filter rods were made by the prior art procedures using a 72,000 denier tow containing approximately 27,700 filaments having an average size of 2.6 denier. The physical characteristics and filtering efficiency of both rods are shown in the following table.

	Present Invention Air Treated	Prior Art, Tension Treated
Total Denier.....	54,000	72,000
Denier per Filament.....	2.6	2.6
Crimps per Inch.....	18	16
Weight of 90 mm. Rod, gm.....	.74	.82
Pressure Drop 90 mm. Rod, in H ₂ O.....	11.2	11.3
Hardness of Rod.....	5.7	7.8
Pressure Drop 15 mm. Tip, in H ₂ O.....	2.1	2.1
Tar Removed, Percent.....	34	30

Tests of pressure drop, hardness, removal and weight were conducted under standard conditions using procedures and apparatus which are accepted in the cigarette industry. The hardness value is a measure of rod deformation under a specified load and a low number indicates greater firmness or compactness. It will be seen that the air treatment process requires less material, makes a firmer rod, and results in more effective filtration.

In Table A which follows are summarized the results of tests made on a range of denier/filament sizes and tow sizes, comparing filter plugs made by the jet treatment process described hereinabove and filter plugs made by prior art processes. In general it will be noted that where rod weights are equal, the percent tar removal of the jet blown yarn of the present invention is higher; or if the percent tar removal and pressure drops are equal, then the weight of the jet prepared filter plug is less.

TABLE A

Example No.	D/F	Tow Denier	Crimps per Inch	Weight of 20 Rods	Hardness	Pressure Drop	Percent Tar Removal	Air Jet		Control Rod Made by Tension Blooming
								No. 5 Pressure	No. 7 Pressure	
III-----	2.0	54,000	17	14.5	6.3	11.9	33	15	20	Yes. Yes.
	2.0	54,000	17	13.3	8.1	8.6	24	-----	-----	
	2.0	72,000	17	17.5	8.9	13.3	34	-----	-----	
IV-----	2.5	54,000	17	14.9	5.7	11.2	34	17	17	Yes. Yes.
	2.5	54,000	17	13.1	11.7	7.0	22	-----	-----	
	2.5	72,000	17	16.4	7.8	11.0	30	-----	-----	
V-----	3.0	70,000	11	16.9	5.8	10.8	29	15	35	Yes.
	3.0	84,600	11	19.4	6.8	11.3	29	-----	-----	

In treating the tow used in these plugs of Table A the jet device of Fig. 3 was used.

Examples VI-X

A 15,800 denier tow was passed through an impingement jet such as shown in FIGS. 5 and 6 in a manner similar to the arrangement depicted in FIGS. 1, 2 and 7. The properties of the tow, the feed and take-up speeds, the jet width and jet air pressure, product appearance, and the like of 5 individual samples are given in Table B which follows.

TABLE B

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)	-----	-----	-----	-----
Jet Air (p.s.i.g.)-----	do-----	50-----	10-----	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	Few clusters of	Intermingled	Some clusters of
Binder-----	None	None	unopened fiber.	None	unopened fiber.
			None		None.

Example XI

Tow in denier from 1.5 to 50 denier per filament (D/F) and from 2,000 to 200,000 total denier (TD) was treated in an apparatus arrangement such as that of FIG. 7, being passed first through an entangling jet and then collected on a turning drum of outer and inner perforated external surfaces before being wound as batting.

Example XII

Tow within the denier range of preceding Example XI was converted into a web or batting of about 0.25 inch in thickness by passage through an apparatus arrangement such as shown in FIGS. 1 and 2, that is, by passage first through a fluid treatment jet from which it was withdrawn at substantially a right angle on a moving perforated surface.

By the foregoing description and examples it is apparent that we have provided a novel process and apparatus arrangement whereby continuous-filament tow is first treated by a filament-entangling jet and is then collected on movable receiving means in the form of a compact and coherent interlaced-filament textile product such as batting.

The invention has been described in detail with particular reference to preferred embodiments thereof, but it will be understood that variations and modifications can be effected within the spirit and scope of the invention as described hereinabove and as defined in the appended claims.

We claim:

1. Tow-treating apparatus comprising movable tow-receiving means in close association with a slot-venturi jet comprising two body sections which when placed adjacent to one another are adapted to form a venturi exit slot, two nozzle sections which when placed adjacent are adapted to form an entrance passageway within said body sections, end plates for positioning and holding the afore-

said parts in the relationship indicated and conduit means associated with the body sections and adapted to supply air to the slot-venturi jet, said jet being adapted to entangle tow filaments prior to deposit upon said receiving means.

2. Apparatus according to claim 1 wherein the tow-receiving means comprise a roll having a perforated surface.

3. Apparatus according to claim 1 wherein the tow-collecting means comprise a roll having a perforated surface, said surface containing two separate layers, the perforations of the inner of which are a smaller size than the outer.

4. Apparatus according to claim 1 wherein the tow-receiving means comprise a perforated surface adapted to move at a right angle to the direction of movement of tow as it leaves the slot-venturi jet.

5. Tow-treatment apparatus comprising a slot-venturi jet having two body sections which when placed adjacent to one another are adapted to form a venturi exit slot, two nozzle sections which when placed adjacent are adapted to form a passageway within said body sections, end plates for positioning and holding the aforesaid parts in the relationship indicated and conduit means in association with the body sections and adapted to supply air to the slot venturi jet, and, in juxtaposition with said slot-venturi jet, a double-layered movable perforated surface, the perforations of a lower layer thereof being smaller than that of an upper layer.

6. Apparatus according to claim 5 wherein the moving perforated surface is adapted to move substantially at right angles to the direction of the venturi exit slot.

7. Tow-treatment apparatus comprising a jet having mating body members hollowed out centrally to provide a large plenum chamber therebetween, said plenum chamber being connected with abutting surfaces by openings above and below, said openings being covered by thin plates, one for each of said body members, dividing said plenum chamber into mating portions, a plurality of small orifices in said plates connecting said plenum chamber halves with a combined central passageway located by the said plates adapted for passage of web product-forming material therethrough for impingement of a plurality of fluid streams along the length thereof, and, adjacent exit means for said jet, means for collecting a web prod-

uct, said means having a surface containing two perforated layers, the perforations of the lower of which are smaller than those of the upper.

8. Apparatus according to claim 7 wherein the surface of the means for collecting the web product is adapted to move substantially at a right angle to the direction of passage of web product through the jet.

9. Apparatus for fluid treatment of continuous-filament tow which comprises a jet housing, a nozzle orifice, a filament entry member in the form of a slot-shaped filament passageway, generally rectangular cross sections mounted in the opposite end of the housing and projecting into the inlet end of said nozzle for feeding a band of continuous-filament tow to the slot-shaped orifice for treatment, fluid supply means to the nozzle including slot-shaped fluid openings between the filament entry member and the inlet end of the nozzle member for introducing streams of treating fluid to interlace the filaments and pass with the filaments through the slot-shaped orifice, filament receiving means positioned closely adjacent to the outlet of the slot-shaped orifice so that the portion

of the receiving surface nearest forms an angle of substantially 90 degrees with the axis plane of the orifice slot, said receiving means having a perforated surface for receiving the filaments in the form of a compact interlaced-filament product, and means for removing the treated filaments from the receiving surface as a continuous sheet.

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