March 5, 1963 R. F. DYER ET AL 3,079,663

METHOD AND APPARATUS FOR PRODUCING TOBACCO SMOKE FILTERS

Filed May 21, 1958 2 Sheets-Sheet 1

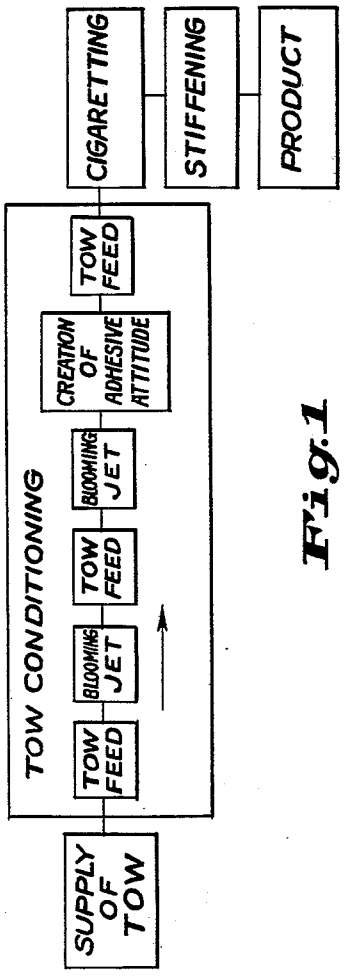

Fig. 1

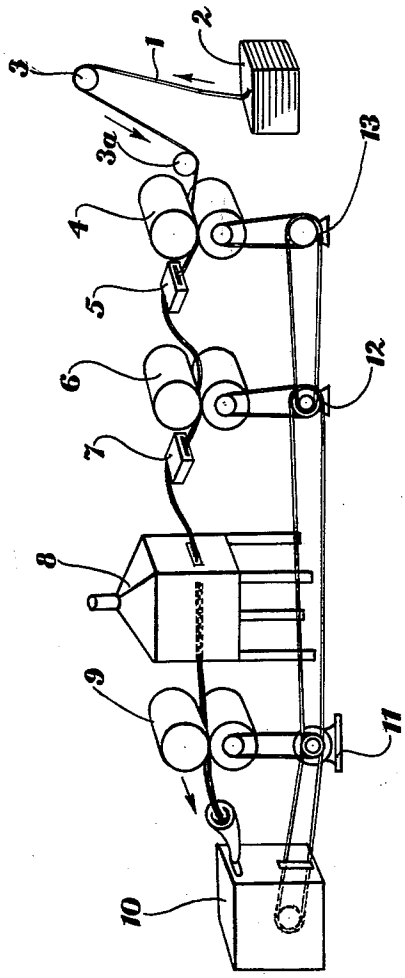

Fig. 2

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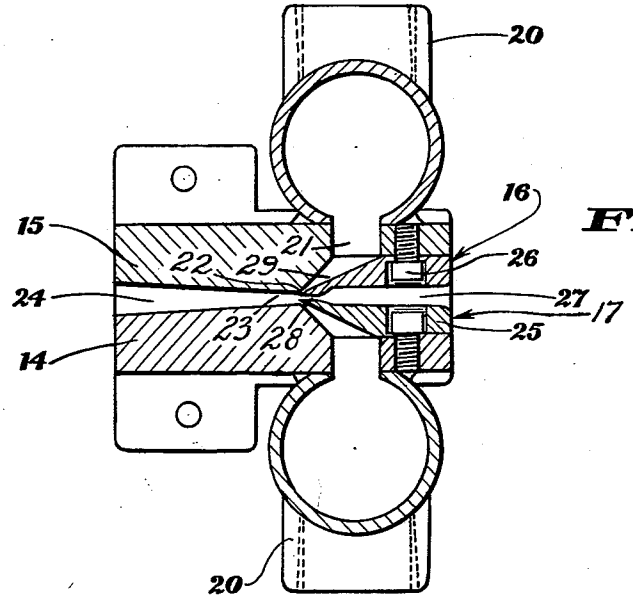

Fig. 3

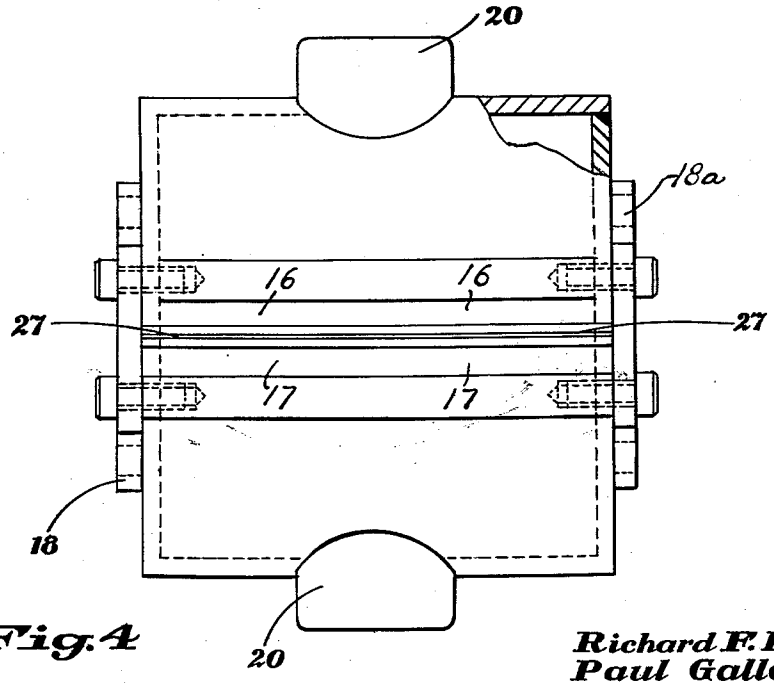

Fig. 4

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METHOD AND APPARATUS FOR PRODUCING TOBACCO SMOKE FILTERS

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11 Claims. (Cl. 28—1)

This invention relates to the production of tobacco smoke filters suitable for cigarettes, pipes, and cigarette and cigar holders. In particular this invention is concerned with an apparatus and process for treating a continuous filament crimped tow to substantially increase the filtration efficiency thereof for the removal of nicotine, tars and aerosol particles from the tobacco smoke while at the same time effecting a reduction in weight of filter material required and materially improving the processing of the tow into filter plugs.

In the industry at the present time a large number of tobacco smoke filters are made from continuous crimped filament tow. Such tow material is very useful for making such filter element constructions for a number of reasons. The continuous filament tow works well in automatic filter making machinery. The filaments due to their longitudinal arrangement contain elongated aligned parallel type passageways for the smoke. However, while in making filters from such tow although it has been desired to preserve to some extent the longitudinal alignment, it has also been desired to alter the crimp arrangement in a manner that the crimps are out of registry, thereby producing shoulders in the filter upon which the smoke may impinge. Also the putting of the crimps out of registry enables the obtaining of a firmer filter with lower quantities of material.

In the art prior to the instant invention, various means have been used to try and alter the filament parallelism and to randomize the location of the knees of the crimp to some extent. Such means have included mechanical vibrators or strikers, pinch rolls and the like. However, such procedures as inducing a high static electrical charge on the tow by means of rubber rollers or the alternate application of high and then 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 not only weakens the tow and may cause breaks therein but such prior art type of treatment has destroyed to a substantial extent the effectiveness of the crimp. In other words, in the prior art one must choose between a good crimp that remains in the treated tow or a deficiency of crimp that is randomized and, therefore, in each instance the most efficient and economical filter plug is not obtained.

Another and perhaps more serious problem encountered in the prior art type of operation is that it has not been possible to utilize tow having a particularly high degree of crimp. That is, highly crimped tow may have certain weak points at the point of crimp. Consequently, when it has been attempted to process highly crimped

tow in accordance with prior art procedures with rolls or vibrators, such attempts have not been too satisfactory because of the breaking of the highly crimped tow. Furthermore, as already briefly mentioned, the prior art processes of beating and tensioning the tow in an effort to break up the registry of the knees of the crimp often causes the filaments to be strained beyond the yield point. Thus the sharp angular crimp originally in the filaments is often removed because the stresses of blooming the tow are great enough to permanently remove a substantial amount of the crimp.

It is, theerfore, believed apparent that the development of a simpler more effective method for treating continuous filament crimped tow for use in the manufacture of tobacco smoke filters whereby the tow may be opened up, the crimps placed out of registry and yet the crimp not removed from the tow as well as filament breakage avoided represents a highly desirable result. After extended investigation we have found an improved apparatus and method whereby prior art difficulties as above discussed may be eliminated or materially reduced.

One object of this invention is to provide an apparatus and means for processing a continuous filament crimped tow into a filter plug having a randomized filament arrangement, said filaments retaining a high degree of their original crimp so that a filter may be obtained which has an efficiency that is relatively high to the weight of the filter material. Another object is to obtain a well opened up tow suitable for filters without substantially impairing the strength or the degree of crimp in the individual filaments. A particular object is to provide a simple and effective apparatus arrangement for converting a dense continuous filament crimped tow into a well opened up filter tow readily susceptible to treatment with plasticizer and the like. Still another object is to make a filter from continuous filament crimped tow, which filter for a specific filament size and resistance to air flow, is more efficient in removing tars and nicotine than prior art filament filters. A still further object is to utilize tows which have a higher crimp than heretofore tolerated with the prior art processes used in making filters from such tow. Other objects will appear hereinafter.

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

In these drawings FIG. 1 is a schematic flow diagram of the processing of the continuous filament tow into a filter plug for tobacco smoke filters.

FIG. 2 is a schematic diagram of the overall apparatus arrangement of apparatus which would be used in carrying out the process of the present invention.

FIG. 3 is a detailed cross-sectional view of the fluffing jet of the present invention.

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

Referring now to FIG. 1, as indicated above the general overall arrangement for making filters in accordance with the present invention is shown. As mentioned above, one object of the tow conditioning of filter tow is to convert the densely packed crimped tow from the supply package into a relatively fluffy resilient flat sheet of filaments which are in a randomized state, then to establish an adhesive condition on the filaments by suit-

able procedure. In the present invention we prefer to apply a plasticizer to the filaments. The opened, banded flat sheet of adhesive filaments are then fed into the cigarette or plug making machine after which the plugs may be stiffened to form the final product. It is thought that the various legends on FIG. 1 render this figure understandable without further description herein.

Considering in more detail the tow conditioning means and apparatus in accordance with this invention, it will be seen that where opening and banding and fluffing were formerly separate steps, these steps are combined in our new process. The preferred system now involves feeding the tow at a constant rate to a blooming jet, taking up the bloomed tow at an equal or reduced speed relative to the feed rate and then subjecting it to the action of a second blooming jet, then to the adhesive spray, and finally removing it from the tow conditioning zone at a reduced rate relative to the rate of the initial tow feed. For example, tow feed No. 1 may be at the rate of 50 y.p.m., tow feed No. 2 at the rate of 49 y.p.m. and tow feed No 3 at the rate of 48 y.p.m. Thus during each blooming process the tow is under conditions which promote its relaxation

In FIG. 2 the overall apparatus arrangement is shown in more detail. Crimped and compacted tow **1** is withdrawn from bale **2** over guides **3** and **3***a* by the first pair of tow feed rolls **4**. The tow then passes through blooming jet **5** which is supplied with gas at a pressure of 10 to 50 p.s.i. gauge. The design of the jet is such that a high velocity gas flow is produced which is evenly distributed over the width of the rectangular-shaped jet. The action of this high velocity gas separates the individual filaments from each other and spreads the tow out into a band or sheet of filaments. At the same time the filaments are given a strong thrust by the air flow such that tension is generated in the tow between the rolls **4** and the jet **5**. The tow then passes to roll pair **6** which is driven at such a speed relative to roll pair **4** as to allow the tow to be in a relaxed state between the jet **5** and the rolls **6**. In this area and particularly in the exit zone of the jet the filaments can thus be violently agitated and vibrated such that each filament is separated from the other and the crimp knees assume completely random position relative to each other.

This cycle of blooming or debundlizing is then repeated with roll pairs **6** and **9** and jet **7**. Here tension is again present between rolls **6** and jet **7** due to the influence of the high velocity jet air on the tow. Roll pair **9** however is driven at a speed relative to roll pair **6** so that between jet **7** and rolls **9** there is substantially no tension other than that required to prevent excessive sag in the tow. Also in the slack tension zone between jet **7** and rolls **9** there is located spray booth **8** which applies plasticizer or other material to the tow. Since the tow is relaxed and the filaments well separated at this point excellent distribution and even application of the plasticizer or the like on each filament is possible.

After leaving roll pair **9** the tow passes to the garniture of the cigarette making machine shown overall at **10**. To insure good control over the process a common drive motor **11** drives all the individual rolls and the cigarette machine **10** by chain, cog belt or other positive drive means. Interposed between the motor **11** and roll pairs **4** and **6** there are variable speed transmissions **12** and **13** such that the relative speeds of roll pairs **4**, **6** and **9** can be adjusted to establish the desired degree of relaxation in each blooming stage.

In some cases it may be desired to eliminate one blooming stage and in this case, roll pair **4** and blooming jet **5** may be omitted with the tow passing directly from guide **3***a* to roll pair **6**. This arrangement may not bloom the tow as effectively as the two-jet assembly described above. However, the one jet assembly of the present invention will process the tow better than prior art procedures. There are other alternatives. One is to retain maximum crimp in the bloomed tow which may leave a few groups of unopened filaments in the tow. The other is to use somewhat higher air pressure than is required with two jets. This will bloom the tow well but may remove some slight amount of crimp from the opened filaments.

Another alternative is to utilize one fluffing jet **7** and do some tension blooming between rolls **4** and **6** with or without the aid of a beater between the two sets of rolls. This method requires a larger tow to provide a specified filter efficiency and firmness.

These several alternatives illustrate the flexibility of the new method. The arrangement shown in FIG. 2 will give the most efficient filter, will require the lowest total denier, and will make the firmest rod using fine filaments. However, other considerations, such as the type of filter making equipment the manufacturer already has on hand, may make it desirable to utilize one of the above alternatives and these are included in the invention.

The design of the blooming jets **5** and **7** 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 **14** and **15**, nozzle plates **16** and **17**, and end plates **18** and **18***a*. (See FIG. 4.) The venturi body plates have attached to one side a circular air chamber with air inlet nipples **20**. This chamber communicates through slot **21** 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 **18** and **18***a* coact to form elongated slot venturi entrance **22**, a venturi throat **23** and a diverging venturi exit **24**. The two nozzle plates **16** and **17** are assembled to venturi body plates **15** and **14** respectively by cap screws as indicated at **25** and **26**. These nozzle plates coact with each other to form a slot-like yarn entrance passage **27** which converges at **28**. The nozzle plate **16** also coacts with venturi plate **15** to form a wedge-shaped chamber **29** which is in communication with the circular air chamber **20** via slot passage **21**. At the down stream side of this chamber **29** 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 **22** and the venturi throat **23**. Nozzle plate **17** and venturi plate **14** coact in a similar manner. As apparent from FIG. 3 that although only slot **22**, air chamber **20**, etc. have been referred to specifically, that on the other side of part **17** there are comparable slots, chambers and the like. Hence, further description thereof appears to be unnecessary.

The tow enters the jet through passageway **27** and at the tip of the nozzle **28**, it is subjected to the impingement of the high velocity "sheets" of air emerging from the venturi entrances. It may be observed from inspection of the sectional view shown in FIGURE 3 of the drawings that there is a low included angle of incidence. Also the tow is subjected to the impingement of two thin intersecting flat sheets of air emerging from the passages formed by the mating plates **15**, **16** and **14**, **17** so that there are two high velocity sheets of air emerging from the entrances. In the throat **23** air and tow are intermixed and parallelized in their direction of flow and the velocity effect of the air generates a tension in the tow and a suction in the nozzle entrance **27**. 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 **23** and enters the diverging throat **24**, 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 filaments 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 the usual round or cylindrical type of jet known in the prior art 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 20 as are the nozzle plate parts 16 and 17. The opening indicated at 27 is the entrance passageway for the tow being fed to the jet. FIG. 4 also shows parts 18 and 18a 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 29, and in the converging chamber 29 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 continual leveling of air velocities and pressures tend to expand the tow width not only in the jet entrance but also in the venturi throat 23 and exit 24.

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 24 should be about four to ten times the length of the throat 23 and preferably about seven times the length. The nozzle throat length 23 should be about three times its width. The total area of the entrance slots as 22 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 27. A low ratio tends to increase the suction while too high a ratio causes back pressure or blow back in the nozzle entrance 27. 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 14 and 15 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 jets 5 and 7 somewhat above or below the bite plane of roll pairs 4 and 6 of FIG. 2. There should be no twist or false twist in the tow for best results. Judicious placement of the guide 3 will largely eliminate any false twist in the tow.

The method and apparatus of the present invention produces filters which have several advantages over those produced by prior art arrangements as will be evident from the following examples:

EXAMPLE I

Filter rods were made by the air blooming process of this invention 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.

Total Denier	Present invention—air bloomed, 54,000	Prior art—tension bloomed, 72,000
Denier per Filament	2.6	2.6
Crimps per Inch	18	18
Weight of 90 mm. Rod, gm	.74	.82
Pressure Drop 90 mm. Rod, inches H_2O	11.2	11.3
Hardness of Rod	5.7	7.8
Pressure Drop 15 mm. Tip, inches H_2O	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. It will be seen that the air blooming process requires less material, makes a firmer rod, and results in more effective filtration.

EXAMPLE II

Filter rods were made by the air blooming process of the present invention using 5 d./f.—70,000 denier tow. Filter rods were made by the prior art tensioning process using 5 d./f.—70,000 denier tow and also 5 d./f.—80,000 denier tow. The comparative tests are tabulated below.

Total Denier	Air bloomed, 70,000	Tension bloomed, 70,000	Tension bloomed, 80,000
Denier per Filament	5	5	5
Crimps per Inch	7.5	7.5	8.0
Weight of 90 mm. Rod, gm	.87	.80	.92
Pressure Drop of 90 mm. Rod, inches H^2O	6.5	5.1	6.6
Hardness of Rod	6.7	5.1	5.5
Pressure Drop of 15 mm. Tip, inches H^2O	1.16	.9	1.2
Tar Removal, percent	20	12	17

The improvement obtained by the air blooming process of the present invention is again clearly evident. The present invention gives improved crimp retention and a more inter-twined condition of the tow.

In Table A which follows there is summarized the results of tests made on a range of denier/filament sizes and tow sizes, comparing filter plugs made by the jet-blooming process of the present invention 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 bloomed yarn of the present invention is higher; or if the percent tar removal and pressure drops are equal then the weight of the jet bloomed filter plug is less.

Table A

Example No.	D./f.	Tow denier	Plug code	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	40B	17	14.5	6.3	11.9	33	15	20	
	2.0	54,000	1AXP	17	13.3	8.1	8.6	24			Yes.
	2.0	72,000	1AXM	17	17.5	8.9	13.3	34			Yes.
IV	2.5	54,000	40E	17	14.9	5.7	11.2	34	17	17	
	2.5	54,000	1AWX	17	13.1	11.7	7.0	22			Yes.
	2.5	72,000	1AWT	17	16.4	7.8	11.0	30			Yes.
V	3.0	70,000	40K	11	16.9	5.8	10.8	29	15	35	
	3.0	84,600	1AXU	11	19.4	6.8	11.3	29			Yes.
VI	5.0	70,000	40J	7.5	17.4	6.7	6.5	20	15	35	
	5.0	80,000	1BAE	8.0	18.5	5.5	6.9	17			Yes.

In making these plugs of Table A the filter plug making apparatus of FIG. 2 was operated typically in a manner as will be described in the example which follows:

EXAMPLE VII

In this example the following pressures, speeds and the like conditions were used.

Tow denier	57,000
Denier/filament	3
Crimps/Inch	18
Speed of roll set 4 y.p.m.	54.4
Air pressure to jet 5 p.s.i. gauge	25
Speed of roll set 6 y.p.m.	54.5
Air pressure to jet 7 p.s.i. gauge	25
Speed of roll set 9 y.p.m.	53.4

The tow was under no tension between jet 5 and roll set 6 and between jet 7 and roll set 9. The speed of the roll sets 4 and 6 in this case were equal with the jet 5 being used to flex the tow much in the manner of a spring, but this flexing opened up the tow, randomized the filament arrangement and the locations of the crimp knees. Between roll set 6 and 9, an actual slight contraction of the tow was allowed to take place. Since crimped tow is highly elastic it is possible to have two pairs of rolls at equal speeds but still have the tow relaxed slightly between the jet and the output rolls since this slack or relaxed condition represents recovery of the stretching done between the input rolls and the jet input due to tension generated by the jet air flow.

While the exact mechanism by which the air jets of the present invention bloom the tow is not fully known, we think some of the following factors may be involved. It may be that the aspirating action of the jet applies tension without, however, applying excessive tension to many of the filaments as results from mechanical tensioning. Probably the air flow in the exit funnel of the jet is largely responsible for the debundlizing and filament separation.

While in the above examples we have described certain air pressures, roll speeds, etc. and we prefer such values, other values may be used. For example, air pressures within the range of 5 to 100 p.s.i.g. may be used. The roll speeds of the various rolls may be as follows: Input feed roll set 4, 30–200 y.p.m.; rolls 4 to 6 speed ratio, 1.20/1 to .7/1; rolls 6 to 9 speed ratio, 1.20/1 to .8/1.0. The total denier (T.D.) of the tow may vary between 15,000 to 100,000 and the denier per filament (D.F.) may be .1 to 8. As pointed out above, this invention works well on highly crimped filaments. Hence, the crimp in the tow would generally not be less than 7 crimps per inch, and may be 17 or 18 per inch. In certain filaments the crimp may be higher, say up to 35 per inch. Whereas, in spray booth 8 for cellulose ester filaments we used the plasticizer glycerol triacetate to the extent of 8–12% on the filaments, other plasticizers as dimethoxyethyl phthalate or triethyl citrate may be used. Or other materials such as dextrin or gum arabic in aqueous solution may be applied.

In the above description y.p.m. means yards per minute and is the measured roll surface speed. The term p.s.i. gauge means pounds per square inch above atmospheric pressure as measured by any standard pressure recording instrument.

Although the examples given relate particulary to cellulose acetate fiber, other textile fiber tows may also be successfully bloomed by the method of this invention. Such materials as cellulose acetate butyrate, cellulose acetate propionate, cellulose triacetate, acrylamide polymers and copolymers, polyolefins and polyester fibers could also be used although the method of producing an adhesive state in the tow may be varied to use other plasticizers, adhesives, solvents or the like which are compatible with the particular filaments being treated.

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. The method of manufacturing tobacco smoke filters from continuous filament crimped tow in a compacted packaged form, which comprises withdrawing said tow from said package through the nip of a pair of feed rolls, passing the tow from the rolls through a blooming jet having a rectangular divergent exit section whereby the individual filaments of the tow are violently agitated, vibrated, and separated by the expansion of the air in the rectangular divergent exit section of a blooming jet so that the tow is opened up and the crimp put out of registry; said air flow being distinctly in the direction of movement of the tow thereby advancing the tow, withdrawing the tow from the jet by further rolls at a speed such that the tow is not put under tension, passing this withdrawn tow through a further jet where the tow is subjected to further air treatment, then passing the processed tow through a spray booth and further rolls, said last-mentioned rolls also operating at a speed so that the tow is not put under tension and conducting the processed tow from the last-mentioned rolls to filter formation, and throughout the process avoiding tensions in the tow greater than those required to support and transport the tow.

2. A process in accordance with claim 1 wherein the speed of feed to the first jet is between 30–250 y.p.m.

3. The process in accordance with claim 1 wherein the tow enters the jets at an angle and exits at an angle.

4. The process in accordance with claim 1 wherein the tow fed through the process is made up of continuous cellulose acetate filaments of .1–8 denier per filament and 15,000–100,000 total denier crimped to at least 17 crimps per inch.

5. A process in accordance with claim 1 wherein the tow fed to the process is 2–5 inches wide and in the process is spread out to at least 10 inches in width.

6. In a process for the manufacture of tobacco smoke filter elements from continuous crimped compacted tow the improvement step which comprises opening up the tow and putting the crimp out of registry by a substantially tensionless process comprising the passage of the

tow through a high velocity slot venturi jet having a rectangular divergent exit section supplied with air including contacting the compact ribbon-like crimped tow with two intersecting flat thin streams of high velocity air at a low angle of incidence, passing both the tow and air stream through a venturi throat to further accelerate the air velocity, then causing the air to expand and lose velocity in the divergent exit portion of the venturi such that the compact crimped tow is caused to expand and bloom in width and thickness and the filaments are longitudinally displaced relative to each other whereby the crimp is put out of registry without breaking the filaments.

7. In a method of manufacturing tobacco smoke filters from crimped tow in a package form, the steps which comprise withdrawing said tow from said package through the nip of a pair of feed rolls, passing the tow from said rolls through a high velocity rectangular cross section venturi jet supplied with a gas, said jet being positioned in close proximity to said rolls and the jet being of a construction whereby the gas flows from the jet in two sheets of gas in a direction relatively parallel to the direction of movement of the tow so that the tow is advanced by the gas, and conducting said tow after it passes through such slot jet to further steps for forming a filter therefrom and throughout the process avoiding tensions in the tow greater than those required to support and transport the tow.

8. An apparatus arrangement for carrying out processes for advancing and opening tow in the manufacture of filters which comprises three pairs of feed rolls in series, said feed rolls being adapted to receive and pass through the nip of the rolls a continuous filament crimped tow, a high velocity rectangular cross section venturi jet positioned between the first and second roll pair, said jet when supplied with gas being adapted to advance and open said tow, a further jet and spray booth positioned between the second and third roll pair, and means for forming in series with the third roll pair for forming tow processed in said jets into filter elements.

9. In an apparatus for opening tow in the manufacture of filters two pairs of rolls in series, said rolls being adapted to receive and pass through the nip of the rolls a crimped tow, a high velocity rectangular cross section venturi jet having a divergent exit section adapted to be supplied with a gas positioned between the two pairs of rolls and in close proximity to the first pair of rolls, said jet being of a construction having an inlet for tow as it is received from the first pair of rolls and an exit from the jet, the internal construction of the jet being such that the gas supplied to the jet is caused to contact the tow and then is accelerated in the same direction as the movement of the tow to a high velocity, and is then caused to expand as it is discharged from the jet in the divergent exit section so as to exert both a longitudinal and divergent transverse thrusting force on the individual crimped filament of the tow.

10. An apparatus construction in accordance with claim 9 wherein the high velocity rectangular cross section venturi jet is positioned above and at an angle to the path of the tow between the two pairs of rolls.

11. An apparatus in accordance with claim 9 wherein the high velocity rectangular cross section venturi jet is 4–20 inches wide.

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2,908,045	Stevens	Oct. 13, 1959
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2,966,198	Wylde	Dec. 27, 1960