

PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Method and apparatus for Producing Tobacco Smoke Filters

We, EASTMAN KODAK COMPANY, a Company organized under the Laws of the State of New Jersey, United States of America, 343 State Street, Rochester, New York, United States of America (Assignees of RICHARD FAIRBANKS DYER and PAUL GALLAGHER) hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to the manufacture of tobacco smoke filter elements.

In accordance with the present invention there is provided a method of making tobacco smoke filter elements from continuous crimped filament tow comprising passing the tow through a slot jet in which the tow and high pressure gas, e.g., air are mixed together in the converging entrance to a venturi nozzle, passed through the restricted throat area of the venturi and then allowed to expand rapidly in a divergent exit section of the venturi whereby the tow is spread transversely and the filaments are displaced longitudinally relatively to one another, and forming the opened flow into a filter element.

According to the present invention there is also provided an apparatus for making tobacco smoke filter elements from continuous crimped filament tow comprising a pair of tow feeding rollers, a slot jet having a converging entrance into which the tow is fed by said rollers, a venturi nozzle adapted to be connected to a gas supply for directing a broad stream of gas on to the tow and a divergent exit section from which the tow emerges, a spray booth through which the opened tow is fed, a pair of feed rollers for withdrawing the tow from the spray booth and filter element forming means to which the sprayed tow is fed by the feed rollers.

In order that the invention may readily be understood, one form thereof will now be described with reference to the accompanying drawings, in which:—

[Price 4s. 6d.]

Fig. 1 is a flow diagram of the various steps of the method in accordance with a preferred form of the invention of making tobacco smoke filter elements from continuous filament crimped tow;

Fig. 2 shows diagrammatically the apparatus for making tobacco smoke filter elements in accordance with a preferred form of the invention;

Fig. 3 is a vertical section through a slot jet constructed in accordance with the invention; and

Fig. 4 is an elevation of Fig. 3.

Referring to Fig. 1, a densely packed tow comprising a continuous filament crimped tow is conditioned by being opened in a pair of slot jets and thereafter sprayed to create an adhesive condition on the filaments. The tow is then fed into a cigaretting machine to form filter elements, after which the elements may be stiffened to form the final product.

The preferred form of the invention involves feeding the tow (tow feed No. 1) at a constant rate to a slot jet, taking up the opened tow at an equal or reduced speed (tow feed No. 2) relatively to the feed rate and then subjecting it to the action of a second slot jet, then to the adhesive spray, and finally removing it from the tow conditioning zone at a reduced rate (tow feed No. 3) relatively to the rate of the (tow feed No. 2) to the second slot jet. For example, tow feed No. 1 may be at the rate of 50 yards per minute (hereinafter referred to as YPM), tow feed No. 2 at the rate of 49 YPM and tow feed No. 3 at the rate of 48 YPM. Thus during each opening process the tow is under conditions which promote its relaxation.

As shown in Fig. 2 the crimped and compacted tow 1 is withdrawn from a bale 2 over guides 3 and 3a by a first pair of tow feed rollers 4. The tow then passes through a slot jet 5 which is supplied with gas at a pressure of 10 to 50 p.s.i. gauge (pounds per square inch above atmospheric pressure). The design of the jet is such that a high



tow



L tow fed

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 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 rollers 4 and the slot jet 5. The tow then passes to a second pair of rollers 6 which are driven at such a speed relatively to the rollers 4 as to allow the tow to be in a relaxed state between the slot jet 5 and the rollers 6. In this area and particularly in the exit zone of the slot jet, the filaments are violently agitated and vibrated such that each filament is separated from the others and the crimps assume completely random positions relative to each other.

This cycle of opening is then repeated between rollers 6 and a third pair of rollers 9 by means of a second slot jet 7, tension again being present between the rollers 6 and slot jet 7 due to the influence of the high velocity of air impinging on the tow. The rollers 9, however, are driven at a speed relatively to the rollers 6 so that between the slot jet 7 and the rollers 9 there is substantially no tension other than that required to prevent excessive sag in the tow. Also, in the slack tension zone between the slot jet 7 and the rollers 9 there is located a spray booth 8 which applies plasticizer to the tow. Since the tow is relaxed and the filaments well separated at this point excellent distribution and even application of the plasticizer on each filament is possible.

After leaving the rollers 9 the tow passes to the garniture of a cigarette making machine 10. In order to ensure good control over the process, a common drive motor 11 drives all the individual rollers and the cigarette machine 10 by means of chain, cog belt or other positive drive means. Interposed between the motor 11 and the rollers 4 and 6 there are variable speed transmissions 12 and 13 to enable the relative speeds of the rollers 4, 6 and 9 to be adjusted to establish the desired degree of relaxation in each opening stage.

In some cases it may be desired to eliminate one opening stage and in this case, the rollers 4 and slot jet 5 may be omitted so that the tow passes directly from the guide 3a to the rollers 6. This arrangement may not open 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.

Another alternative is to utilize only the one slot jet 7 and to do some tension opening between the rollers 4 and 6 with or without the aid of a beater between the two sets of rollers. 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 slot jets 5 and 7 is of substantial importance to the operation of the process and will now be considered in detail with reference to Figs. 3 and 4. 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 18a (see Fig. 4). The venturi body plates 14 have attached to one side thereof a circular air chamber with air inlet nipples 20. This chamber communicates through a slot 21 with the interior of the jet to allow free passage of air or other gas. The venturi body part, when assembled to the end plates 18 and 18a, coact to form an 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 the venturi body plates 15 and 14 respectively, by means of cap screws 25 and 26. These nozzle plates coact with each other to form a slot-like tow 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 the slot 21. At the down stream side of this chamber 29 it converges at an angle of about fifteen degrees so that air passing therethrough 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.

The tow enters the jet through the 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. In the throat 23 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 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



jet



parts

of an electric fan. This action further assists in separating the filaments. Recalling that between the jet and the downstream feed rollers the tow is allowed to relax and contract, the filaments also move longitudinally relatively to each other so that crimps in adjacent filaments are thrown out of phase in a completely random manner.

As shown in Fig. 4 the jet is not the usual 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 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.

A uniform flow of air is generated in the venturi throat from side to side of the jet. This is because air will very quickly 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 the circular chamber 20, and in the converging chamber 29 is large relatively 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 levelling of air velocities and pressures tends to expand the tow width not only in the jet entrance but also in the venturi throat 23 and exit 24.

In order 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 22 should be about 0.10 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 of 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 opening. 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 nip of the pairs of rollers 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 plugs were made by the air opening 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 plugs 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 products are shown in the following table.

	Present Invention	Prior Art
	Air Opened	Tension Opened
Total Denier	54,000	72,000
Denier per Filament	2.6	2.6
Crimps per Inch	18	16
Weight of 90 MM Plug, gm.	0.74	0.82
Pressure Drop 90 MM Plug, 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, %	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 plug deformation under a specified load and a low number indicates greater firmness. It will be seen that the air opening process requires less material, makes a firmer plug, and results in more effective filtration.

EXAMPLE II

Filter plugs were made by the air opening process of the present invention using 5 D/F—70,000 denier tow. Filter plugs 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.

	Air Opened	Tension Opened	Tension Opened
Total Denier	70,000	70,000	80,000
Denier per Filament	5	5	5
Crimps per Inch	7.5	7.5	8.0
Weight of 90 MM Plug, gm.	0.87	0.80	0.92
Pressure Drop of 90 MM Plug, in H ₂ O	6.5	5.1	6.6
Hardness of Plug	6.7	5.1	5.5
Pressure Drop of 15 MM Tip, in H ₂ O	1.16	0.9	1.2
Tar Removal, %	20	12	17

The improvement obtained by the air opening process of the present invention is again clearly evident. The present invention gives improved crimp retention and a more intertwined 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 air jet open-

ing process of the present invention and filter plugs made by prior art processes. In general it will be noted that where plug weights are equal the percentage tar removal of the jet opened yarn of the present invention is higher; or if the percentage tar removal and pressure drops are equal then the weight of the jet opened filter plug is less.

TABLE A

Example No.	D/F	Tow Denier	Crimps per Inch	Weight of 20 Plugs	Hardness	Pressure Drop	% Tar Removal	Air Jet		Control Plug 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	—
	2.0	54,000	17	13.3	8.1	8.6	24	—	—	Yes
	2.0	72,000	17	17.5	8.9	13.3	34	—	—	Yes
IV	2.5	54,000	17	14.9	5.7	11.2	34	17	17	—
	2.5	54,000	17	13.1	11.7	7.0	22	—	—	Yes
	2.5	72,000	17	16.4	7.8	11.0	30	—	—	Yes
V	3.0	70,000	11	16.9	5.8	10.8	29	15	36	—
	3.0	84,600	11	19.4	6.8	11.3	29	—	—	Yes
VI	5.0	70,000	7.5	17.4	6.7	6.5	20	15	35	—
	5.0	80,000	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:



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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 Roller Set (4)	—	54.4 YPM
Air Pressure to Jet (5)	—	25 p.s.i. Gauge
Speed of Roller Set (6)	—	54.5 YPM
Air Pressure to Jet (7)	—	25 p.s.i. Gauge
Speed of Roller Set (9)	—	53.4 YPM

5 The tow was under no tension between the jet 5 and rollers 6 and between the jet 7 and rollers 9. The speeds of the rollers 4 and 6 in this case were equal and the jet 5 was 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 crimps. Between the rollers 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 rollers driven at equal speeds but still have the tow relaxed slightly between the jet and the output rollers since this slack or relaxed condition represents recovery of the stretching effected between the input rollers and the jet input due to the tension generated by the jet air flow.

10 In the above examples the air pressures, roller speeds, etc., are preferred values, but other values may be used. For example, air pressures within the range of 5 to 100 p.s.i.g. may be used. The speeds of the various rollers may be as follows: Input feed rollers 4, 30—200 YPM; rollers 4 to 6 speed ratio, 1.20/1 to 0.7/1; rollers 6 to 9 speed ratio, 1.20/1 to 0.8/1.0. 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 0.1 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 the spray booth 8 for cellulose ester filaments we used the plasticizer glycerol triacetate to the extent of 8—12% on the filaments, other plasticizers, such as dimethoxyethyl phthalate or triethyl citrate, may be used, or other materials such as dextrin or gum arabic in aqueous solution may be applied.

45 Although the examples given relate particularly to cellulose acetate filaments, other

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

WHAT WE CLAIM IS:—

1. Method of making tobacco smoke filter elements from continuous crimped filament tow comprising passing the tow through a slot jet in which the tow and high pressure gas, e.g., air, are mixed together in the converging entrance to a venturi nozzle, passed through the restricted throat area of the venturi and then allowed to expand rapidly in a divergent exit section of the venturi whereby the tow is spread transversely and the filaments are displaced longitudinally relatively to one another, and forming the opened tow into a filter element.

2. Method according to claim 1 wherein the tow passes from the slot jet into a zone of relative relaxation from which it is withdrawn at a rate such that it is not subjected to any material tension.

3. Method according to claim 2, comprising the additional steps of passing the tow from the zone of relative relaxation through a second slot jet in which the tow is subjected to further opening and displacement of the crimps by a stream of gas, passing the tow while in a relaxed condition from the second slot jet through a spray booth to produce an adhesive condition in the filaments and conducting the tow to a filter element forming device.

4. Method according to any of the preceding claims, wherein the tow is fed to, and withdrawn from, the jet or jets at an angle.

5. Method according to any of the pre-



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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 Roller Set (4)	—	54.4 YPM
Air Pressure to Jet (5)	—	25 p.s.i. Gauge
Speed of Roller Set (6)	—	54.5 YPM
Air Pressure to Jet (7)	—	25 p.s.i. Gauge
Speed of Roller Set (9)	—	53.4 YPM

5 The tow was under no tension between the jet 5 and rollers 6 and between the jet 7 and rollers 9. The speeds of the rollers 4 and 6 in this case were equal and the jet 5 was used to flex the tow much in the manner of a spring, but this flexing opened up the
10 tow, randomized the filament arrangement and the locations of the crimps. Between the rollers 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
15 have two pairs of rollers driven at equal speeds but still have the tow relaxed slightly between the jet and the output rollers since this slack or relaxed condition represents recovery of the stretching effected between
20 the input rollers and the jet input due to the tension generated by the jet air flow.

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40 for cellulose ester filaments we used the plasticizer glycerol triacetate to the extent of 8—12% on the filaments, other plasticizers, such as dimethoxyethyl phthalate or triethyl citrate, may be used, or other materials such
45 as dextrin or gum arabic in aqueous solution may be applied.

Although the examples given relate particularly to cellulose acetate filaments, other

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

WHAT WE CLAIM IS:—

1. Method of making tobacco smoke filter elements from continuous crimped filament tow comprising passing the tow through a slot jet in which the tow and high pressure gas, e.g., air, are mixed together in the converging entrance to a venturi nozzle, passed through the restricted throat area of the venturi and then allowed to expand rapidly in a divergent exit section of the venturi whereby the tow is spread transversely and the filaments are displaced longitudinally relatively to one another, and forming the opened tow into a filter element.

2. Method according to claim 1 wherein the tow passes from the slot jet into a zone of relative relaxation from which it is withdrawn at a rate such that it is not subjected to any material tension.

3. Method according to claim 2, comprising the additional steps of passing the tow from the zone of relative relaxation through a second slot jet in which the tow is subjected to further opening and displacement of the crimps by a stream of gas, passing the tow while in a relaxed condition from the second slot jet through a spray booth to produce an adhesive condition in the filaments and conducting the tow to a filter element forming device.

4. Method according to any of the preceding claims, wherein the tow is fed to, and withdrawn from, the jet or jets at an angle.

5. Method according to any of the pre-



ceding claims, wherein the tow comprises continuous cellulose acetate filaments.

5 6. Method according to claim 5, wherein the filaments have a denier 0.1—8 per filament and a total denier of 15,000—100,000.

7. Method according to any of the preceding claims, wherein the tow has at least 7.0 crimps per inch.

10 8. An apparatus for making tobacco smoke filter elements from continuous crimped filament tow comprising a pair of tow feeding rollers, a slot jet having a converging entrance into which the tow is fed by said rollers, a venturi nozzle adapted to be connected to a
15 gas supply for directing a broad stream of gas on to the tow and a divergent exit section from which the tow emerges, a spray booth through which the opened tow is fed, a pair of feed rollers for withdrawing the tow from
20 the spray booth and filter element forming means to which the spray tow is fed by the feed rollers.

25 9. Apparatus according to claim 8, in which an additional pair of feed rollers is disposed between the slot jet and spray booth for feeding the opened tow to the spray booth.

30 10. An apparatus according to claim 8 or 9, wherein the slot jet comprises two body portions which form therebetween the venturi exit slot, two nozzle sections which form therebetween the entrance passageway within the body portions, end plates for securing
35 the body portions and nozzle sections together, and a conduit connected to the body

portions for supplying gas to the interior thereof.

11. An apparatus according to claim 10, wherein the angle of divergence of the venturi portion is from 4 to 10 degrees. 40

12. An apparatus according to claim 10 or 11, wherein the diverging portion of the venturi is 4 to 10 times the length of the throat section of the venturi.

13. An apparatus according to claim 10, 11 or 12, wherein the included angle formed between the body section and the nozzle section is from 45 to 135 degrees. 45

14. A tobacco smoke filter element when made by the method according to any of the preceding claims 1 to 7. 50

15. A tobacco smoke filter element according to claim 14, wherein the filaments have a denier per filament of less than 3, a total denier of between 30,000 and 50,000
55 and more than 12 crimps per inch.

16. A tobacco smoke filter element according to claim 15, wherein the filaments have a denier per filament of 2 to 3, a total denier of 43,000 to 46,000 and at least 17 crimps
60 per inch.

17. Method of making tobacco smoke filters substantially as hereinbefore described.

18. Apparatus for making tobacco smoke filters substantially as hereinbefore described
65 with reference to, and as shown in, the accompanying drawings.

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Patent Agent. 16

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