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PATENT SPECIFICATION

DRAWINGS ATTACHED

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Cl.:—A 24 c 5/50

COMPLETE SPECIFICATION

Manufacture of Tobacco Smoke Filters

We, EASTMAN KODAK COMPANY, a Company organized under the Laws of the State of New Jersey, United States of America of 343 State Street, Rochester, New York 14650, United States of America (Assignees of THEODORE CALVIN FRITZ and RICHARD FAIRBANKS DYER) do 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:—

In the manufacture of tobacco smoke filters from special tows made up of crimped filaments of cellulose acetate and related plasticizable polymeric materials it is customary to use various mechanical means for processing the filter tow. It is already widely practiced and well known in the cigarette industry as disclosed in British patent specification No. 765,963, for example, to mechanically treat the tow in a plurality of steps which involve the separation of the filaments in the crimped tow, applying thereto a spray coating of plasticizer, followed by forming and compacting the tow into the desired filter shape. In more recent disclosures, such as in British patent specification 986,391, the use of gaseous jet treatment means have been employed to obtain filament separation of the filter tow after it had been treated with an application of a plasticizer. Although the above-mentioned proposals satisfactorily fulfill the requirements of many filamentary filter manufacturing operations, especially those in which relatively large denier per filament materials can be employed, they are not capable of producing a high quality fine denier per filament tobacco smoke filter having high tar removal capability. Such a filter can be produced by use of fine denier per filament tow if the filaments are completely and uniformly separated from each other except, of course, at those points where the filaments are bonded together by the plasticizer, because the tobacco smoke stream is required to impinge on a maximum area of filamentary material. Moreover, this increase in tar removal

efficiency can be accomplished by such a filter having a minimum weight of material per filter element as measured by a desired pressure drop reading. In referring to "fine denier per filament" we have reference to tows which are composed of filaments of smaller than 3 denier per filament.

The use of such fine denier per filament tows, which have a relatively large number of filaments per given tow cross-section, requires the solution of special problems to ensure the uniform application of a plasticizer if the filters having the required degree of uniform hardness throughout the finished filter elements are to be obtained. Moreover, the emphasis on obtaining maximum tar removal efficiency with the minimum weight of material per filter element requires that each filament be separated from each other filament throughout the body of the filter, except at those points bonded together, to ensure that the tobacco smoke stream passing thereto can impinge on the maximum area of filamentary material. Suffice it to say at this point that tobacco smoke filter elements produced by the prior known methods will be shown by the examples to follow to be incapable of achieving the type of uniformity and tow separation necessary to give a more effective tobacco smoke filter for removing tar.

The present invention involves the combination of mechanical, fluid, and liquid plasticizer treatment steps of a fine denier per filament tow and the apparatus for carrying out these steps to effect substantially complete separation of the filament and an effective and uniform distribution of plasticizer throughout the filamentary mass. In the apparatus of our invention, a liquid plasticizer is applied in a highly uniform manner to the already uniformly separated filaments of the tow thereby obtaining in the ultimate product adequate filter hardness with a minimum amount of plasticizer. Furthermore, the substantial current interest in the selective removal of certain components of tobacco smoke also makes it desirable

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SEE ERRATA SLIP ATTACHED

SPECIFICATION AMENDED - SEE ATTACHED SLIP

ble that any improved process or apparatus be readily adaptable to the inclusion of a step in which particulate additive such as activated carbon, sodium bicarbonate, cellulose acetate floc and other solid particulate materials having selective removal properties may be added to the tow as it is being processed prior to the step of filter element formation. Our process and apparatus lends itself especially well to a further modification of the invention in which solid particulate additives may be added to the tow desired.

In accordance with the present invention there is provided a continuous process for the production of tobacco smoke filters from a bundle of crimped, continuous filaments, comprising forming a bundle of crimped continuous filaments into a banded tow, subjecting the banded tow to a relatively constant tension sufficient to remove secondary crimps present in the filter tow, separating the filaments of the tow by subjecting portions of the tensioned tow to longitudinal incremental pulling action which causes said portions to be displaced relative to other adjacent portions of the tow with the result that filaments are separated longitudinally with respect to each other, spreading the tow to a uniform, constant width by passing the separated filaments into a banding jet supplied with high velocity gas, applying a thin uniform coating of plasticizer to one or both surfaces of the spread filter tow, passing the tow into and through a jet treating zone supplied with high velocity gas which gas acts to separate uniformly and completely the filaments of the plasticized tow and uniformly distribute the plasticizer therein, and thereafter shaping the tow to form it into a substantially cylindrical tobacco smoke filter rod.

Filters made by the above process may have a hardness value (as hereinafter defined) of less than 8%, with a plasticizer content of less than 8% of the weight of the filaments in said filters, and a standard deviation of filter pressure drop (as hereinafter defined) of less than 5% from the average filter pressure drop.

According to the present invention there is also provided apparatus for the production of fine denier per filament filamentary tobacco smoke filters, comprising means for continuously withdrawing a crimped, plasticizable synthetic polymeric tow from a supply thereof, means for forming the tow into a relatively flat band or ribbon, means for pretensioning the tow and removing secondary crimps therefrom, means for mechanically separating the filaments of the tow one from another by filament-to-filament lengthwise displacement, a second means for further spreading the tow to a uniform constant width, means for applying a thin uniform coating of liquid plasticizer to one or both surfaces of the spread or banded tow, means for further uniformly separating the filaments and uniformly distributing plasticizer therein, and means for forming the plasti-

cized tow into a substantially cylindrical tobacco smoke filter rod.

In the accompanying drawings:—

Fig. 1 is a side elevation of an apparatus for carrying out the process of the present invention;

Fig. 2 is a section, to an enlarged scale, taken on the line 2—2 of Fig. 1;

Fig. 3 is a side elevation of an apparatus similar to that shown in Fig. 1, but modified to include an applicator for incorporating a particulate additive into the plasticizer treated tow;

Figs. 4, 5, 6 and 7 are illustrations of the filament distribution in portions of the tow treated according to the various prior art procedures;

Fig. 8 is an illustration of a filament distribution in a portion of the tow prepared by employing the process and apparatus of the present invention and illustrating the high degree of filament separation and uniformity of the filament separation attainable thereby.

Referring now to Fig. 1 which is a diagrammatic overall view illustrating the manner in which tow is processed in accordance with one embodiment of the present invention, a continuous, fine denier per filament, crimped, multifilament tow 46 is withdrawn upwardly from a supply package or bale 48 through a spreading or banding jet 50 supplied with a countercurrent of air through a pipe 52, and thence over a guide 54 which may be fixed or freely rotatable. Tow 46 then passes downwardly to a pretensioning device 56 where it passes between the nip of a pair of contacting pretension rollers 58 and 60 thereof. The bottom roller 58 is rotatably mounted in a fixed bracket 62 which is attached to the main frame 64 of the apparatus. The top roller 60 is rotatably mounted in a vertically movable bracket 66 which in turn is attached to the fixed bracket 62 by means of a leaf spring hinge 70. The top roller 60 is loaded downwardly against the bottom roller 58 by means of a pneumatic diaphragm plunger or a weighted plunger 72.

Tow 46 passes from the nip of pretension rollers 58 and 60 to the nip of a pair of filament separating feed rollers 74 and 76 which are driven from a main drive shaft (not shown) of a plug making device 99. The tension in the tow 46 entering the filament separating feed rollers 74 and 76 is determined by the sum of the drag force imposed on the tow by the countercurrent air flow in the banding jet 50, the frictional drag force of the tow in passing over the fixed guide 54 (or the frictional bearing drag of the guide if a roller guide is used) and the drag force generated by the frictional drag of the pretension rollers 58 and 60.

The frictional drag of the pretension rollers 58 and 60 may be adjusted by means of the force applied to the top roller 60 by the pneumatic or static weight loading means 72. This

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pretension on the tow entering the filament separating feed rollers 74 and 76 should preferably be kept at the minimum sufficient to remove secondary crimps or folds in the tow without substantially straightening out the primary or fine crimps in the individual filaments. This roller pair 74 and 76 is mounted in much the same way as roller pair 58 or 60, that is, the bottom roller 74 is rotatably mounted in bearings which in turn are supported in the framework 64 of machine 99 while roller 76 is freely rotatable in bearings in a bracket 76A. The bottom roller 74 is positively driven by means of a connection (not shown) to the main drive of the machine 99 and drives the roller 76 by frictional contact therewith.

The top roller 76 has a configured surface, e.g., a surface with a plurality of circumferential square-form cross-section grooves and lands. Alternatively, these grooves and lands may be interrupted at intervals around the circumference of the roller. When the top roller 76 is loaded pneumatically by means of an air diaphragm 78 it is pressed against the bottom roller 74 which preferably has a resilient, smooth surface constructed, for example, of rubber with a hardness of about 55—80 as measured by the Shore "A" Durometer.

Portions of tow which are passed between the nip of the lands on the top roller 76 and the smooth surface of the bottom roller 74 are pulled against the tension generated by the roller pair 58 and 60 and are also displaced forwardly by a small increment relative to adjacent other portions of the tow which are incompletely or not at all gripped in the nip of rollers 74 and 76 where the grooves occur in the roller 76. Thus, the filaments in portions of the tow are longitudinally incrementally displaced relative to the filaments in adjacent portions of the tow with the result that the filaments are individually separated longitudinally one from the other. Stated in another way, the pretensioned tow had been subjected to a mechanical lengthwise separating action by means of the action of rollers 74 and 76.

Figs. 5 and 6 give illustrations of tow which has been subjected solely to such mechanical separation and it will be apparent that the "density" or number of filaments per unit area is variable across the width of the tow band due to the action of the rollers 74 and 76. Thus, a roller having continuous grooves will impart a continuous lengthwise ribbed or corduroy effect to the tow as shown in Fig. 5, while a roller having interrupted lands and grooves will impart an elongated checkerboard pattern as shown in Fig. 6. Both figures are reproductions of a photomicrograph of a portion of the tow at a magnification of about 20. Thus, though both types of rollers separate and open the filaments, the action may be incomplete or non-uniform. In other words, where a tobacco smoke filter is produced from a tow in which such incomplete or non-uniform

filament separation is present smoke passing therethrough may tend to channel through zones of lesser filament density and the overall effectiveness of the filter may thus be substantially impaired for certain tobacco smoke filter applications, although such channeling may not be objectionable in others. This effectiveness would be particularly detrimental by producing lower pressure drop per unit weight of tow and, therefore, lower tar removal capabilities.

In producing filters by use of plain rollers in conjunction with air jets, such as is described in British patent specifications Nos. 986,391 and 918,598 it has been found that certain of the filaments may not separate completely one from another, especially when using fine denier filament tow, e.g., 1.0 to 3.0 denier per filament tows are being processed in accordance with such known processes. Thus, careful examination of a filter tip made from fine denier tow by use of air jets to separate the filaments may reveal the presence of occasional clusters of 2 to 5 or more filaments that have not separated from each other. Filters made from such processes tend to contain clusters of unseparated filaments as illustrated in Figs. 4 and 7. Fig. 4 shows a portion of a banded tow containing such clusters while Fig. 7 shows the presence of such clusters in a finished filter which has been broken open. It is this type of non-uniformity of filament separation which is present in the finished filter when using prior known methods for treating filter tow. The filter product made by our invention, as described below, results in a filter having the filamentary structural uniformity necessary to obtain an improved and more effective tar removal performance.

After leaving the filament separating feed rollers 74 and 76 the opened tow is passed through a pneumatic spreading or banding jet 80 which is similar in construction and operation to the banding jet 50. The action of this jet is further to increase the width of the band of tow and also to control and maintain its width just prior to application of plasticizer to the tow by its passage through a plasticizer applicator 81.

Referring to Fig. 1, tow 46, after being subjected to the differential pulling action of rollers 74 and 76 as it passes from pretension or drag rollers 58 and 60 and being further banded or spread out to a constant uniform width by passing through pneumatic banding jet 80, is advanced to plasticizer applicator rollers 82 and 84 which are in geared relation to each other and driven by positive means from the main drive (not shown) of machine 99. The function of these rollers is to transfer a film of liquid plasticizer to both surfaces of the band of tow as it passes between the rollers. The plasticizer employed in a given case will be any liquid plasticizer capable of plasticizing the material of which the filaments of

the tow are composed. For example, if the filaments are composed of cellulose acetate, triacetin would be a suitable plasticizing agent.

5 As shown in Figs. 1 and 2, rollers 82 and 84 are slidably mounted within a frame 90. Each roller is supplied with plasticizer by means of vertically disposed dual applicators 86 and 88 which are provided with internal liquid plasticizer reservoirs 86A and 88A, respectively. Applicator 86 carries a wick element 86B connected to the plasticizer reservoir thereof as shown. Likewise, applicator 88 carries a wick element 88B which is similarly connected to its own internal reservoir. Reser-
10 voir 86A and wick 86B of applicator 86 are supplied through a conduit 93 with a metered amount of plasticizer by means of a metering pump (not shown). Reservoir 88A of applicator 88 and its wick 88B are similarly supplied with plasticizer by means of a separate metering pump and a conduit 95.

As shown in Figs. 1 and 2, wick applicators 86 and 88 are attached, respectively, to positioning means 94 and 92, which may take the form of solenoids or air cylinders which may be actuated in known manner to move applicators 86 and 88 toward or away from rollers 82 and 84, as desired. The lengths of the respective roller contacting surfaces of wicks 86B and 88B are substantially equal to the width of the outlet orifice of the banding jet 80 and thus equal to the width of the banded tow passing between the rollers 82 and 84.

In operation, plasticizer deposited by the wicks 86B and 88B on the rollers 82 and 84 is picked up by the tow as it passes between the roller and a film of liquid plasticizer is thus uniformly spread over both surfaces of the tow and into contact with all of the filamentary material of the tow band.

The action of the plasticizer on the individual filaments is to soften or partially solvate the materials of which they are composed, thus rendering them capable of bonding themselves one to another at random points of contact throughout the filamentary mass by coalescence or fusing together of the contacting softened or partially solvated filament material to form a filamentary network. If solid particulate materials such as activated carbon, sodium bicarbonate, rice starch, cellulose acetate floc, or other additives are placed on the tow to increase the effectiveness of the filter in removing gaseous or solid components from tobacco smoke, in accordance with that embodiment of our invention shown in Fig. 3, these particles are effectively entrapped and firmly held within the resulting filamentary network.

In accordance with the first mentioned embodiment of the invention, the tow, after passing through the nip of applicator rollers 82 and 84, is forwarded to a venturi air jet 96 which may be of the general construction and operation described in British patent specification No. 986,391 and U.S. patent specification

No. 3,081,951. The function of this jet is further to open the tow by completely separating the filaments thereof one from another and to ensure uniformity of filament separation by evening out any irregularities in filament distribution which may have resulted from the action of rollers 74 and 76. The action of this jet also serves the important added function of more uniformly distributing the plasticizer throughout the separated filaments of the tow.

The tow will then have a filament distribution pattern similar to that shown in Fig. 8 which is a reproduction of a photomicrograph of a portion of the tow at a magnification of about 20. It can be seen that the product has achieved a complete and uniform filament separation which had not been previously possible when using prior proposed methods. For example, in comparing this product as illustrated in Fig. 8 with the product of Fig. 4, which is a photomicrograph of a portion of tow as produced by the known method, whereby a 3 denier per filament or less tow is first carried between smooth surfaced feed rolls, treated with plasticizer and then bloomed in a venturi type jet, it will be seen that there is a complete absence of clusters of unseparated filaments in the product of Fig. 8 as compared to the product of Fig. 4. A significant comparison can also be made with the product of Fig. 7 which is an illustration of a filter, the paper wrap having been broken open to expose the filaments. This product was made by a process employing jet filament separation with an "S" wrap wiping-type plasticizer applicator of the type disclosed in British patent specification No. 986,391. These clusters or accumulations of unseparated filaments clearly reduce the effectiveness of the finished filter and is one of the major disadvantages of tobacco smoke filters presently being produced by any of the known methods.

In Fig. 3 there is illustrated that embodiment of our invention which includes the step of depositing solid particulate material on the tow prior to actual filter formation. In this modification, the tow is processed by the identical steps employed in processing the tow in accordance with the first modification of the invention as described in detail above up to the point where the tow emerges from plasticizer applicator rollers 82 and 84. The tow is then passed through a banding jet 104 which serves to further separate the filaments and enhance the uniformity of their separation as well as evenly distribute the plasticizer. The tow is then carried between the pinch of freely rotating guide rollers 106 and 107 and beneath a vibratory distributor 108 which deposits on the surface of the moving tow a predetermined amount of particulate additive material such as activated carbon, sodium bicarbonate, rice starch, cellulose acetate floc, or other solid particulate material which serves to enhance the ability of the ultimate filter product to remove

tars and other solid and gaseous components from tobacco smoke. The tow bearing the particulate material then passes to a forming funnel 110 which causes it to assume a cylindrical shape, thus locking the particulate material within the filamentary mass. The tow then passes between the pinch of a pair of delivery rollers 112 and 114, thence into the garniture 102 of a filter making machine where it is wrapped in a paper wrap to form the finished filter plug. It will, of course, be understood that the action of the plasticizer deposited on the tow from rollers 82 and 84 will be as described above, that is, the material of the filaments at random points of contact will be solvated and caused to coalesce, thus bonding the filaments together at these points of contact to form an open filamentary network in which the solid particulate material is entrapped.

All of the driven rollers of the apparatus may be connected either directly or through each other to the main drive of the filter plug making machine and in this manner carefully controlled positive speed ratios may be established between the filament separating rollers 74 and 76, applicator rollers 82 and 84, delivery rollers 98 and 100 and the tap roller (not shown) of filter forming garniture 102. In some cases it may be desirable to insert positive variable speed devices in the drive trains between the various roller positions so that the tow opening and delivery roller speeds may be adjusted to suit the requirements of a given size and type of filter tow to meet certain specifications of weight of filter and pressure drop. For further convenience, all the apparatus elements may, as shown, be mounted on a common-frame 64 so that the entire unit may be quickly set in place on a cigarette making machine, thus enabling quick conversion from production of tobacco rods to filters rods and *vice versa* without excessive loss of machine time.

In the following Examples and description we have set forth by way of illustration several of the preferred embodiments of our invention.

EXAMPLE 1

A 1.6 denier/filament, 48,000 total denier cellulose acetate tow made up of round cross section filaments was used to produce filter rods by employing a process similar to that disclosed in British patent specification No. 986,391 using jet blooming with an "S" wrap wiping-type plasticizer applicator. The machine operating conditions employed and the test results obtained are given under the heading of Sample 1 in Table 1 below.

The same type of tow was then processed on the apparatus of the present invention as described above and further illustrated in Fig. 1. Details of the machine set up and test results are listed under the heading of Sample 2 in Table 1. The mechanical separation step was performed on a continuous square-grooved roller.

Comparison of the tow appearance after treatment indicated that the Sample 1 tow contained several unseparated or unbloomed filaments as shown in Figs. 4 and 7. By contrast, the same tow processed on the apparatus of Fig. 1 of the present invention was substantially free of unbloomed filaments and had the appearance of the tow shown in Fig. 8.

Moreover, although the plasticizer metering pump speed remained constant, 12.9% by weight plasticizer was measured as being applied to the tow in the process of Fig. 1, while only 9.4% by weight plasticizer was measured as being applied to the tow by the prior art process.

Thus, some 27% of the plasticizer delivered by the metering pump was lost as drippage and other losses when manufacturing the filters by the process of Sample 1. It can be stated that our process was able to achieve a filter rod which required less bonding agent for a given level of filter rod firmness or hardness.

It was further significant that the standard deviation of the pressure drop of the rods of Sample 2 as made by our process and apparatus of Fig. 1 was 0.616 as compared to 1.149 for the Sample 1 rod made by the prior art process. This is significant because it shows the reliability with which our method can produce consistently uniform filters when measured by their pressure drop. Not only are we able to produce a filter having a high pressure drop which effectively removes tar from tobacco smoke but our process produces filters with a uniformity and standardization which assures the ultimate smoker that he can expect to receive a more uniform tasting or flavoured cigarette when smoking a particular brand of cigarette.

EXAMPLE 2

The same type of tow was then processed again on the same set up in Fig. 1 except that the plasticizer metering pump speed was reduced about 40% to about 43 RPM. Sample 3 of Table 1 gives the data of this test result. The filter rods were examined for hardness and quality of bond and found to be at least equal to or slightly better than the prior art rods of Sample 1.

From the foregoing and the comparative data it may be seen that the apparatus and process of this invention makes possible a 40% to 46% reduction in the pressure drop standard variation and an improved uniform appearance of rods. Since pressure drop is directly related to tar removal, a similar improvement in tar removal uniformity can be expected resulting in more uniform taste and flavour in cigarettes.

The same type of tow used in Example 1 was processed in accordance with prior art procedure on a square-grooved roll (the mechanical filament separation process) using for Sample 4 (Table 1) an interrupted square form groove roller and for Sample 5 (Table 1) a

continuous grooved roller. Machine set-up and filter rod test data are listed in Table 1 under the appropriate sample number headings.

- 5 Visual examination of the bloomed tow of Samples 4 and 5 clearly indicated a less uniform separation and distribution of the filaments (Figs. 6 and 5 respectively) than for the tow of Fig. 8 treated by using the process and apparatus of this invention (Samples 2 and 10 3 in Table 1).

- 15 Examination of the data shows clearly that a lower pressure drop and a lower tar removal count were obtained for the Samples 4 and 5 as produced by the prior art method of mechanical filament separation when compared to Samples 2 and 3 as made by our invention. It was further noted that the tow was used

less effectively by the prior art process since Samples 4 and 5 indicate they have only 23.4 and 23.5 inches of pressure drop per gram of tow, respectively, as compared to 26.1 and 25.7 inches pressure drop per gram of tow for the filter made by our invention. It was further noted that the filter rod hardness was completely unacceptable as required by the trade and that to improve the hardness to an acceptable level considerably more plasticizer or more tow would be necessary. This is economically undesirable. 20 25

While it was noted that the uniformity of the interrupted groove roller process Sample 4 was good, this uniformity occurred at the cost of lower tar removal count, poorer tow utilization and loss of rod hardness. 30

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TABLE I					
Sample No.	1	2	3	4	6
D/F	1.6	1.6	1.6	1.6	1.6
Total Denier	48,000	48,000	48,000	48,000	48,000
Filament Cross Section	Round	Round	Round	Round	Round
Filter Length mm	102	102	102	102	102
Filter Circumference mm	24.83	24.85	24.88	24.82	24.82
Plasticized Rod Weight in Grams					
Average	.827	.875	.853	.764	.805
Standard Deviation	.019	.021	.020	.008	.016
Rod Pressure Drop*					
Inches of Water					
Average	18.1	18.0	18.2	14.8	16.1
Standard Deviation	1.149	0.616	0.725	0.332	0.617
Percent Standard Deviation	6.3	3.4	4.0	2.2	3.8
Hardness 0.1 mm					
Penetration**					
Average	7.1	6.2	6.5	13.6	9.0
Range	4.8—9.7	4.7—7.9	5.5—7.4	11.5—15.5	7.8—10.5
% by weight Plasticizer (Triacetin)	9.4	12.9	7.9	7.3	7.0
Tow weight per Rod in grams	.681	.694	.709	.634	.685
Inches Pressure Drop per gram of Tow	26.7	26.1	25.7	23.4	23.5
Tar Removal mg.	57	57	58	50	53
Speed Ratios					
Feed 74/76 to Delivery 98/100	1.39	1.55	1.62	1.70	1.31
Feed 74/76 to Tape of 102	1.22	1.33	1.33	1.64	1.24
Feed 74/76 to Tension 58/60	1.45	1.55	1.56	2.35	1.70
Feed 74/76 to Applicator 82/84	—	1.24	1.21	—	—
Plasticizer Pump RPM	72	72	43	—	—

*Pressure drop in inches of water at an air flow rate of 17.5 cc/sec through the filter rod.

**Hardness being the deformation in units of 0.1 mm. caused by a suddenly applied load of 347.5 grams across the width of the filter rod.

The percent deviation is derived by dividing rod pressure drop in inches of water (average) into the standard deviation and multiplying by 100.

5 While the process and apparatus of our invention has been compared using 1.6 denier per filament oval or substantially circular section cellulose acetate tow, similar results are obtained when non-circular cross section filament tows with larger or smaller filament sizes and tows of different compositions such as polyolefin, polyamide, polyester or the like are used.

15 By applying the plasticizer to the filamentary material of the tow by depositing the plasticizer from duplex applicator rollers, which convey it simultaneously to both surfaces of the banded tow, much more uniform distribution of plasticizer is obtained than was possible with methods which involve spraying particles of plasticizer onto the tow or wiping plasticizer onto the tow surfaces. Particulate sprays, for example, tend to form a non-uniform film of plasticizer on the filaments and this results in what may be referred to as a "spotted distribution" pattern. Such a distribution pattern is unsatisfactory because one portion of the filamentary mass may receive an excess amount of plasticizer while adjacent areas may receive none at all. When employing the prior art wiping method of applying plasticizer, one segment of the filamentary tow mass may wipe the applicator clean while a segment immediately following may receive no plasticizer at all, thus producing a lengthwise intermittent pattern of plasticizer distribution. Moreover, in employing wiping applicators it was generally necessary to snub the tow over the applicator at an angle in order to ensure good contact and this was found to result in tensioning the tow to such extent as to remove some of the crimp from the filaments and thus reduce the ability of the tow to produce a satisfactory filter product. In other words, under such circumstances a greater weight of filamentary material and a greater amount of plasticizer was required to obtain a satisfactory filter of given removal efficiency. All of these undesirable occurrences are avoided by the present invention.

50 The process and apparatus of this invention have other unique features of novelty and versatility not present in processes and tow processing machines of the prior art. For example, in some cases it may be desired to produce a filter product which increases the removal of the phenol component from cigarette smoke. In this case a high molecular weight polyethylene glycol liquid additive has been found to be quite effective and when mixed with plasticizer can be readily applied by our improved apparatus. However, when such as material is added to the triacetin plasticizer, the bonding power and hence the hardness of the filter rod may be impaired. We have found, however,

that by applying the polyethylene glycol through one of the wicks of the double roller applicator of the invention to one surface of the tow and the triacetin through the other wick to the opposite surface of the tow that the plasticizing action of the triacetin is not impaired and firm tobacco smoke filter rods with a high phenol removal characteristics can thus be readily produced.

WHAT WE CLAIM IS:—

1. A continuous process for the production of tobacco smoke filters from a bundle of crimped, continuous filaments, comprising forming a bundle of crimped continuous filaments into a banded tow, the banded tow to a relatively constant tension sufficient to remove secondary crimps present in the filter tow, separating the filaments of the tow by subjecting portions of the tensioned tow to longitudinal incremental pulling action which causes said portions to be displaced relative to other adjacent portions of the tow with the result that filaments are separated longitudinally with respect to each other, spreading the tow to a uniform, constant width by passing the separated filaments into a banding jet supplied with high velocity gas, applying a thin uniform coating of plasticizer to one or both surfaces of the spread filter tow, passing the tow into and through a jet treating zone supplied with high velocity gas which gas acts to separate uniformly and completely the filaments of the plasticized tow and uniformly distribute the plasticizer therein, and thereafter shaping the tow to form it into a substantially cylindrical tobacco smoke filter rod.

2. Process according to claim 1, in which after the tow has passed through the jet treating zone a predetermined amount of solid particulate additive is deposited on the upper surface of the moving band of tow.

3. Process according to claim 1 or 2, in which the tow is composed of continuous crimped filaments having a denier of less than 3.

4. Process according to claim 3, in which the tow is composed of crimped filaments of cellulose acetate and the liquid plasticizer is triacetin.

5. A continuous process for the production of tobacco smoke filters from a bundle of crimped, continuous filaments according to claim 1, substantially as hereinbefore described.

6. Apparatus for the production of fine denier per filament filamentary tobacco smoke filters, comprising means for continuously withdrawing a crimped, plasticizable synthetic polymeric tow from a supply thereof, means for forming the tow into a relatively flat band or ribbon, means for pretensioning the tow and removing secondary crimps therefrom, means for mechanically separating the filaments of the tow one from another by filament-to-filament lengthwise displacement, a second means

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The percent deviation is derived by dividing rod pressure drop in inches of water (average) into the standard deviation and multiplying by 100.

5 While the process and apparatus of our invention has been compared using 1.6 denier per filament oval or substantially circular section cellulose acetate tow, similar results are obtained when non-circular cross section filament tows with larger or smaller filament sizes and tows of different compositions such as polyolefin, polyamide, polyester or the like are used.

15 By applying the plasticizer to the filamentary material of the tow by depositing the plasticizer from duplex applicator rollers, which convey it simultaneously to both surfaces of the banded tow, much more uniform distribution of plasticizer is obtained than was possible with methods which involve spraying particles of plasticizer onto the tow or wiping plasticizer onto the tow surfaces. Particulate sprays, for example, tend to form a non-uniform film of plasticizer on the filaments and this results in what may be referred to as a "spotted distribution" pattern. Such a distribution pattern is unsatisfactory because one portion of the filamentary mass may receive an excess amount of plasticizer while adjacent areas may receive none at all. When employing the prior art wiping method of applying plasticizer, one segment of the filamentary tow mass may wipe the applicator clean while a segment immediately following may receive no plasticizer at all, thus producing a lengthwise intermittent pattern of plasticizer distribution. Moreover, in employing wiping applicators it was generally necessary to snub the tow over the applicator at an angle in order to ensure good contact and this was found to result in tensioning the tow to such extent as to remove some of the crimp from the filaments and thus reduce the ability of the tow to produce a satisfactory filter product. In other words, under such circumstances a greater weight of filamentary material and a greater amount of plasticizer was required to obtain a satisfactory filter of given removal efficiency. All of these undesirable occurrences are avoided by the present invention.

55 The process and apparatus of this invention have other unique features of novelty and versatility not present in processes and tow processing machines of the prior art. For example, in some cases it may be desired to produce a filter product which increases the removal of the phenol component from cigarette smoke. In this case a high molecular weight polyethylene glycol liquid additive has been found to be quite effective and when mixed with plasticizer can be readily applied by our improved apparatus. However, when such as material is added to the triacetin plasticizer, the bonding power and hence the hardness of the filter rod 65 may be impaired. We have found, however,

that by applying the polyethylene glycol through one of the wicks of the double roller applicator of the invention to one surface of the tow and the triacetin through the other wick to the opposite surface of the tow that the plasticizing action of the triacetin is not impaired and firm tobacco smoke filter rods with a high phenol removal characteristics can thus be readily produced.

WHAT WE CLAIM IS:—

1. A continuous process for the production of tobacco smoke filters from a bundle of crimped, continuous filaments, comprising forming a bundle of crimped continuous filaments into a banded tow, the banded tow to a relatively constant tension sufficient to remove secondary crimps present in the filter tow, separating the filaments of the tow by subjecting portions of the tensioned tow to longitudinal incremental pulling action which causes said portions to be displaced relative to other adjacent portions of the tow with the result that filaments are separated longitudinally with respect to each other, spreading the tow to a uniform, constant width by passing the separated filaments into a banding jet supplied with high velocity gas, applying a thin uniform coating of plasticizer to one or both surfaces of the spread filter tow, passing the tow into and through a jet treating zone supplied with high velocity gas which gas acts to separate uniformly and completely the filaments of the plasticized tow and uniformly distribute the plasticizer therein, and thereafter shaping the tow to form it into a substantially cylindrical tobacco smoke filter rod.

2. Process according to claim 1, in which after the tow has passed through the jet treating zone a predetermined amount of solid particulate additive is deposited on the upper surface of the moving band of tow.

3. Process according to claim 1 or 2, in which the tow is composed of continuous crimped filaments having a denier of less than 3.

4. Process according to claim 3, in which the tow is composed of crimped filaments of cellulose acetate and the liquid plasticizer is triacetin.

5. A continuous process for the production of tobacco smoke filters from a bundle of crimped, continuous filaments according to claim 1, substantially as hereinbefore described.

6. Apparatus for the production of fine denier per filament filamentary tobacco smoke filters, comprising means for continuously withdrawing a crimped, plasticizable synthetic polymeric tow from a supply thereof, means for forming the tow into a relatively flat band or ribbon, means for pretensioning the tow and removing secondary crimps therefrom, means for mechanically separating the filaments of the tow one from another by filament-to-filament lengthwise displacement, a second means

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for further spreading the tow to a uniform constant width, means for applying a thin uniform coating of liquid plasticizer to one or both surfaces of the spread or banded tow, means for further uniformly separating the filaments and uniformly distributing plasticizer therein, and means for forming the plasticized tow into a substantially cylindrical tobacco smoke filter rod.

7. Apparatus according to claim 6, in which the means for, respectively, forming the tow into a flat band or ribbon, for spreading the tow to a uniformly constant width, and for separating the filaments and uniformly distributing plasticizer therein is in each instance air jet means.

8. Apparatus according to claim 6 or 7, in which the means for pretensioning the tow is a pair of feed rollers which impose a drag force on the tow as it passes therebetween.

9. Apparatus according to claim 6, 7 or 8, in which the mechanical means for separating the filaments one from another by filament-to-filament displacement is a pair of rollers one of which has a square-grooved surface and the other has a resilient surface.

10. Apparatus according to claim 6, 7, 8 or 9, in which the means for applying a thin uniform coating of liquid plasticizer to both surfaces of the tow is a pair of vertically disposed rollers the surface of each of which is supplied with a constant feed of liquid plasticizer.

11. Apparatus according to claim 6, constructed substantially as hereinbefore described with reference to and as shown in Figs. 1 to 3 of the accompanying drawings.

12. Tobacco smoke filters whenever made by the process according to any one of the preceding claims 1 to 5.

13. Tobacco smoke filters according to claim 12, having a hardness value of less than 8 with a plasticizer content of less than 8% of the weight of the filaments in said filters and a standard deviation of filter pressure drop of less than 5% from the average filter pressure drop.

14. A tobacco smoke filter according to claim 13 having a yield of 25 inches of pressure drop per gram of tow.

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