Dec. 21, 1965 W. R. MAHONEY ETAL 3,224,453

FILTER CIGARETTES

Original Filed June 12, 1959 3 Sheets-Sheet 1

Fig. 1.

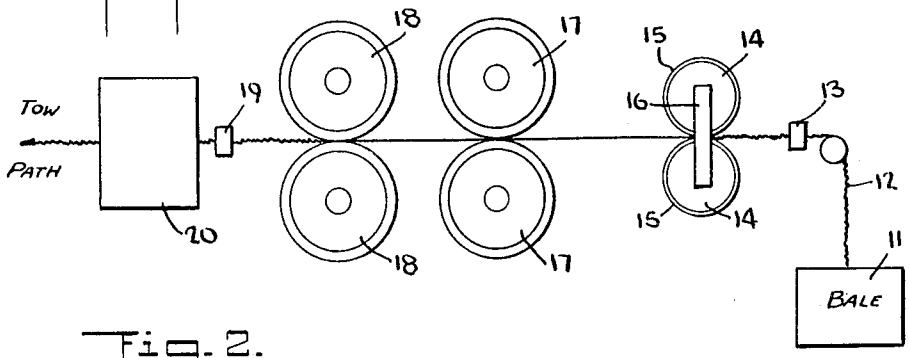


Fig. 2.

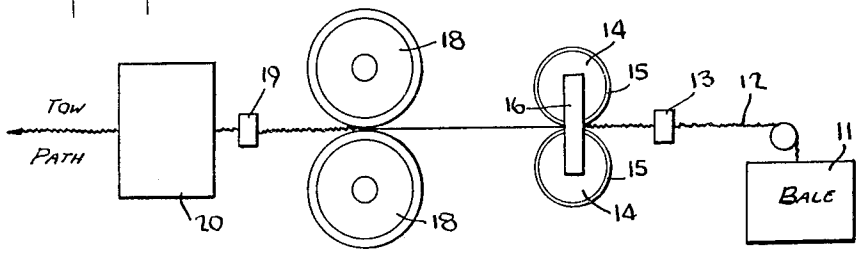


Fig. 3.

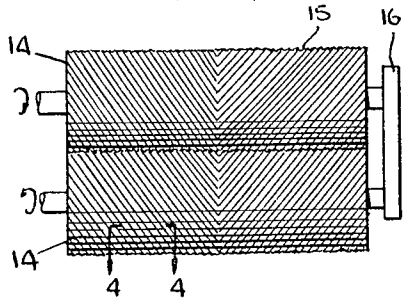


Fig. 4.

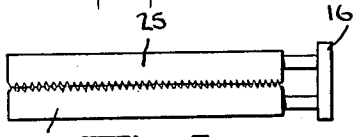
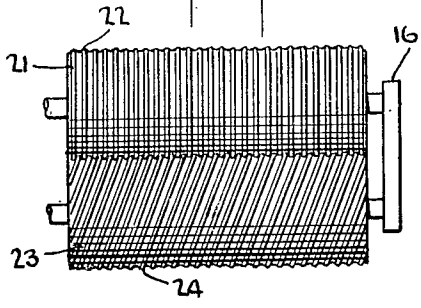


Fig. 6.

Fig. 5.



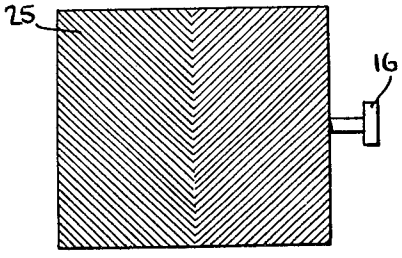


Fig. 7.

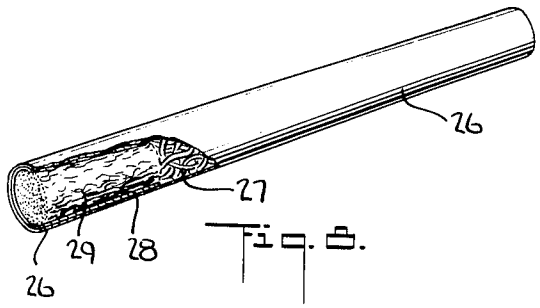
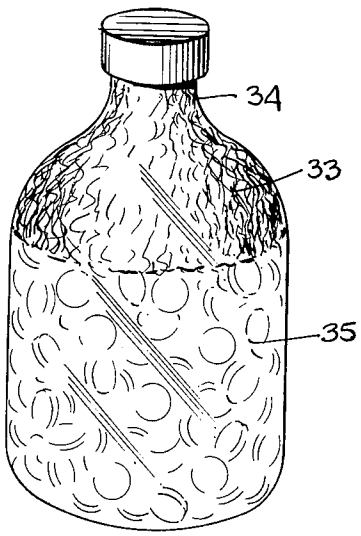


Fig. 8.

Fig. 9.

Fig. 11.



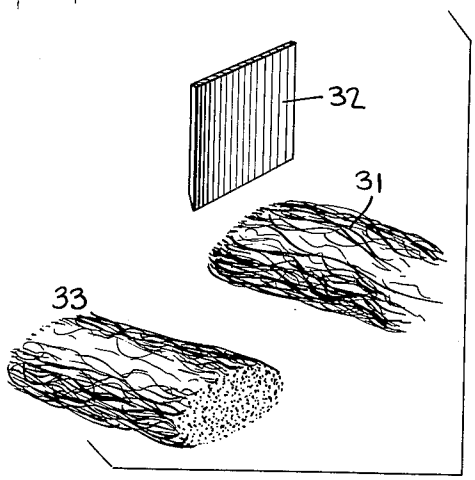


Fig. 10.

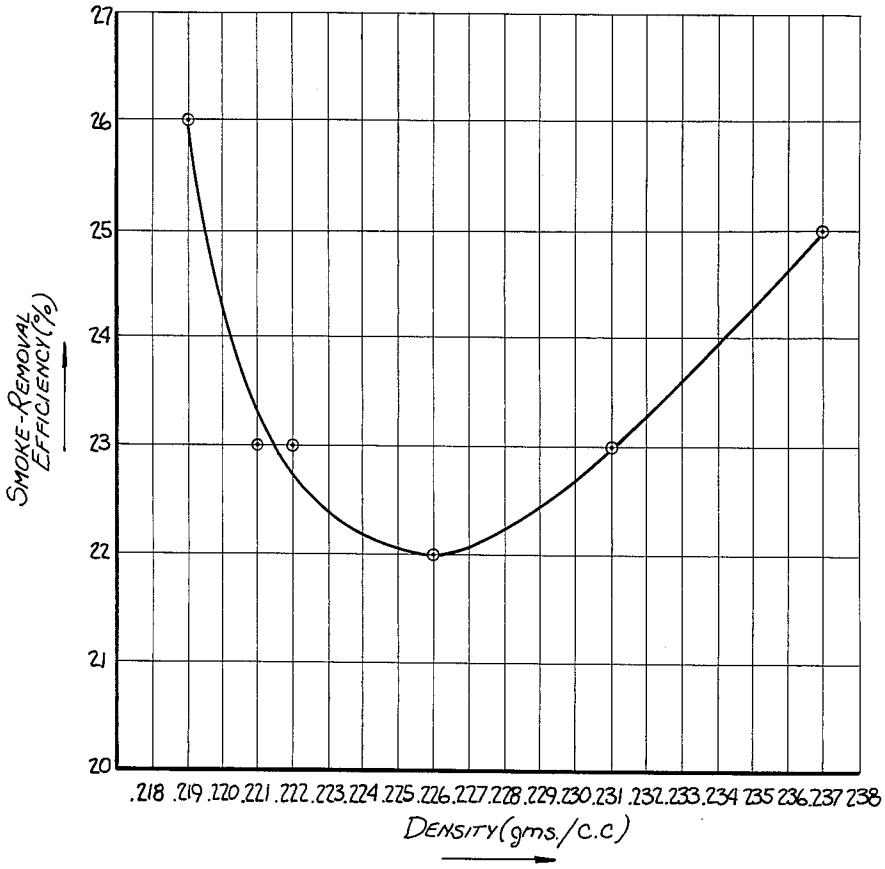

27
26
25
24
23
22
21
20
SMOKE-REMOVAL EFFICIENCY (%)
.218 .219 .220 .221 .222 .223 .224 .225 .226 .227 .228 .229 .230 .231 .232 .233 .234 .235 .236 .237 .238
DENSITY (gms./c.c.)

Fig. 12.

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3,224,453

FILTER CIGARETTES

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Original application June 12, 1959, Ser. No. 820,041, now Patent No. 3,103,220, dated Sept. 10, 1963. Divided and this application Apr. 8, 1963, Ser. No. 271,057
The portion of the term of the patent subsequent to May 8, 1979, has been disclaimed
3 Claims. (Cl. 131—208)

This application is a divisional of application Serial No. 820,041 filed June 12, 1959, now U.S. Patent No. 3,103,220, which is a continuation-in-part of application Serial No. 714,634 filed February 11, 1958, now U.S. Patent No. 3,032,829.

The present invention relates to a voluminous mass or tow of filamentary material suited for making cigarette filters and other uses.

Voluminous or bulked filamentary tows or bundles of filaments are useful for a variety of purposes such as making efficient cigarette filters, making wool-like or bulky textiles, and the like. Cigarette filters are generally formed of a multiplicity of crimped filaments, starting with a crimped tow or bundle of several thousand continuous filaments. As received from the tow producer, the filaments may be more or less adhered to each other with the crests and vales of adjacent filaments in registry. The tow is passed through an air spreader, is fed by driven rolls through a chamber in which plasticizer is applied, and it is thereafter condensed to equal approximately the cross-sectional area of a cigarette. The condensed mass is formed into a coherent structure such as by wrapping in paper and/or curing and is cut into suitable lengths for incorporation into cigarettes.

In commercial operation it has been found that the filters so produced are not all identical in their filtering action. Specifically, it has been found that the filters occasionally differ in weight, in filtering efficiency and in the ease of draw, i.e. resistance to gas flow. In addition, after smoking many filters show uneven darkening which indicates non-uniform passage of smoke therethrough, the darkened areas identifying zones through which the smoke was preferentially drawn.

For producing bulky textiles, a continuous filament yarn may be passed through a turbulent zone of pressurized fluid, being discharged therefrom along with the fluid. The yarn is taken up at a slower speed than it is fed and is characterized by high bulk. While the product is generally satisfactory, the process entails the use of large volumes of pressurized fluid.

It is accordingly an object of the present invention to provide different types of bulked or voluminous tows or bundles of filaments.

It is a further object of the invention to provide improved voluminized tows and improved cigarette filters produced therefrom.

Another object is to provide procedures for producing such improved voluminized tows.

Other objects and advantages will be apparent from the following detailed description and claims.

Our investigations have revealed that a major cause of irregularities in the filter tips and their filtration characteristics can be traced to the procedure for opening of the tow. Specifically, in the crimping of the tow all of the filaments are simultaneously acted upon and it will be found that the crimps of adjacent filaments are in registry; if such crimp registration is not done away with there will be channels in the filter through which smoke can pass without contacting any filament surface. In addition, as produced, the tow may contain individual filaments or groups of filaments which do not extend longitudinally but rather which extend at an appreciable angle transversely of the tow. In processing, these transversely extending filaments or "cross-overs" tend to prevent those filaments which they overlie from being spread apart laterally.

If a tow has not been evenly crimped initially, the tow opening procedure may result in uneven application of plasticizer and this in turn may result in uneven density with channeling of smoke through the filter.

In accordance with one aspect of the present invention the tow is opened by passage over a ridge which is inclined to the path of movement of the tow. Conveniently the tow is passed between several pairs of opposed ridges, at least one ridge of each pair being inclined to the path of movement of the tow, preferably both being inclined in different directions. This can readily be achieved by passage between a pair of opposed ridged surfaces, the ridges of one surface being displaced laterally relative to the ridges of the other surface, thereby laterally displacing some of the filaments relative to other of the filaments and thus opening the tow. Preferably the ridged surfaces are constituted by a pair of opposed grooved or ridged cylindrical rolls which are positioned close to one another and rotate upon passage of tow therebetween. The surfaces are so formed that the ridges of one surface will not always be in registry with the grooves of the other surface.

A suitable configuration of ridges is created by forming a helical thread in an elastic, e.g. rubber, or elastic-surfaced cylindrical roll. Advantageously both rolls are threaded in the same direction so that as they rotate in opposite directions the ridges of one roll will not be in permanent registry with the grooves of the other roll. By way of illustration, at a given time a point on one ridge of one roll will contact some point on a ridge of the other roll and as the tow advances the rolls will rotate and the points on the rolls where they were previously in contact will be displaced laterally relative to each other.

If the opposed rolls are oppositely threaded, then their pitches, circumferences or rotational speeds should be different so that there will not be permanent registry between the ridges and grooves of the rolls, i.e. so that points on both rolls where they are in contact will be laterally displaced relative to each other.

Each helical roll will tend to displace the tow laterally in the direction of advance of the helix, considering its direction of rotation, e.g., if a helically grooved roll, on which the thread as viewed from one end advances in clockwise direction, is rotated in counterclockwise direction a tow contacting the roll will tend to be displaced away from the viewer. Where the other roll is similarly threaded but rotates in opposite direction the tow will tend to be displaced toward the viewer. Both of these simultaneously acting tendencies further aid in opening the tow.

Conveniently, each roll is threaded from one end to its center in one direction, e.g. clockwise, and from its other end to its center in the opposite direction, e.g. counterclockwise. Two such rolls are assembled with their clockwise-threaded sections opposite each other and with their counterclockwise-threaded sections opposite each other. One of the rolls will thus tend to condense laterally a tow fed near its middle while the other roll will tend to expand the tow laterally.

The ridged opening surfaces can be incorporated directly into existing apparatus for forming cigarette filters from tow, including an air spreader, if desired. After passing between the ridged surfaces the tow is passed between a pair of braking rolls and then between a pair of

driven rolls. The tow is thus tensioned between the driven and braking rolls, the tension temporarily pulling out the crimp and making it more regular upon subsequent relaxation. If desired, the braking rolls may be omitted, their function being performed by the ridged opening surfaces. Following passage between the driven rolls, which operate at constant speed, the tow is advantageously passed through an air spreader, sprayed in relaxed condition with a plasticizing agent and conveyed to conventional condensing equipment to be formed into rods for incorporation into cigarettes as filter plugs.

In place of two opposed helically ridged cylindrical surfaces, one of the surfaces can be provided with circular or elliptical ridges. Alternatively, both surfaces may be provided with elliptical rings which are either oppositely canted or arranged at different angles relative to their respective axes so that the ridges on one cylinder will not always lie in registry with the grooves of the other cylinder. A similar effect will be achieved using one cylinder with circular rings and another with elliptical rings.

In another embodiment, in place of providing the ridges on a pair of cylindrical surfaces, one or both of the surfaces may be flat and the ridges can be shaped as they would appear if the rubber covering were removed from the cylindrical roll and were laid flat.

The ridges of one of the opposed surfaces can be registered with the grooves of the other surface in one position but, as noted, should not be in permanent registration. Thus, circular rings on both cylindrical rolls or straight parallel ridges on both opposed flat surfaces can be employed provided the registry is interrupted as by oscillating one or both surfaces laterally out of phase with or in opposite direction to the other surface. While circular rings are parallel to the direction of advance of the tow, such oscillation effectively inclines the rings so as to produce the effect of elliptical rings.

The tow is preferably composed of a plurality of crimped continuous filaments of an organic derivative of cellulose, e.g. esters or ethers of cellulose such as cellulose acetate, cellulose propionate, cellulose acetate propionate, highy esterified cellulose containing less than 0.29 free hydroxyl groups per anhydroglucose unit such as cellulose triacetate, and the like. Other filamentary materials such as rayon (regenerated cellulose), linear superpolyamides such as nyon-6 and nylon-66, linear polyesters, acrylonitrile polymers and copolymers, and the like, can also be employed.

The identity of the plasticizer will of course depend upon the composition of the tow. With cellulose acetate there may be employed triethyl citrate, dimethoxy ethyl phthalate and methyl phthalyl ether glycolate but glycerol triacetate (triacetin) is preferred.

With tows opened in conventional manner there will still be appreciable registry among adjacent crimped filaments which is aggravated at low deniers. By contrast, in accordance with the present invention the denier of the individual filament may be as little as 2, although 17 or more is also possible. Even with small deniers below about 7 the extensive opening and deregistry prevents channeling of the smoke so that such low deniers are permissible. At the same time the low denier filaments provide a greater surface area. In addition, they produce firm filters which can be cured with less plasticizer with attendant savings in time and material. Even at low plasticizer levels the novel plugs will be as firm as conventional plugs having much greater plasticizer content. Firmness is measured by permitting a 4-ounce load knife edge to rest transversely of a paper-wrapped filter plug for 10 seconds. The percent firmness is 100 times the height of the plug at the base of the depression divided by the original diameter of the plug. The percent compressibility is 100—percent firmness. Generally the firmness of a satisfactory cigarette filter comprising a cured plug is at least about 75% and preferably at least about 80%. Whereas with conventional plugs this requires a relatively high plasticizer content, with the novel plugs equal firmness can be achieved at plasticizer contents of about 10% and preferably 7% or even less.

The filtration efficiencies of filters prepared from the novel tow are greater than those of filters prepared from conventionally opened tow. As a corollary, the efficiency of conventional filters can be duplicated at lower plug weights and/or with less resistance to draw, i.e. lower pressure drop. The total number of filaments may be as much as 120,000 or more, preferably about 3,000 to 60,000, and the total denier may be about 40,000 to 120,000 or more, preferably about 60,000 to 80,000.

The number of crimps per inch in the tow can range up to about 20 but preferably averages between about 4 and 12. After leaving the driven rolls the tow is still crimped but is about 10 to 200%, and preferably 50 to 150%, longer than initially, i.e. the tow has been stretched so that the distance between the crests of adjacent crimps has been increased and the amplitude reduced. In addition, the crimps are deregistered and more regular than initially.

With tows opened in conventional manner filters produced therefrom will exhibit reduced pressure drops and filtration efficiencies as the weight is decreased for a given tow specification, i.e. as for a given number of filaments the stretch is increased to decrease the weight of tow in a plug of given length. If the plug weight is decreased too much, however, a limp useless plug will result. In accordance with the present invention it has also been found that the pressure drop and smoke removal or filtration efficiency generally decrease with decrease in the plug weight. Surprisingly, however, a plug weight is reached which when further decreased produces an increased pressure drop and smoke removal efficiency. The exact value for this critical weight will vary, depending upon the constitution of the tow, i.e. crimp, denier per filament and total denier, but generally lies in the neighborhood of about 0.18 gram per 15 mm.

In accordance with another aspect of the invention, the tow fed to the ridged surface may comprise relatively few filaments. The tow may be fed and taken up as a yarn of little or no twist, without having previously been partially opened. The yarn is voluminized or bulked in a manner somewhat resembling crimping, except that the filaments are not lightly adhered to one another as when employing a conventional stuffing box crimper. The voluminizing is even and regular with no filament extending straight for any appreciable distance. The degree of voluminizing will depend upon the arrangement of the ridges.

In accordance with another aspect of the invention, the opened voluminous tow may be employed as a bottle wadding, padding or stuffing material, in which capacities its high bulk results in decreased weight and material expense. The use of continuous filament material also facilitates handling since there are no short lengths of staple fibers flying about and adhering electrostatically to equipment. In addition, desired quantities can readily be severed with accuracy since the weight per unit length of the opened tow is quite uniform. Storage and shipping costs are also reduced since the tow can be handled in dense bales and will be opened only immediately prior to use.

A stuffing material can also be produced from opened tow which, advantageously without plasticization, is continuously formed into a paper-wrapped rod and severed into lengths which may be the same as or different from the length of cigarette filter plugs. The ends of such plugs are treated with solvent, plasticizer or heat to fuse the fibers and the wrapping is then removed to allow the coherent mass to balloon laterally.

The invention will now be described more fully with reference to the accompanying drawing, wherein:

FIG. 1 is a schematic elevation of a tow opening apparatus in accordance with the present invention;

FIG. 2 is a schematic elevation of a modified tow opening apparatus;

FIG. 3 is a lateral elevation of the helically threaded tow opening rolls of FIG. 1;

FIG. 4 is a section through a portion of one of the rolls taken along line 4—4 of FIG. 3;

FIG. 5 is a lateral elevation of another pair of tow opening rolls which can be employed in the practice of the present invention;

FIG. 6 is an elevation of a pair of ridged flat plates which can be substituted for the ridged rolls of FIG. 1;

FIG. 7 is a plan view of one of the plates of FIG. 6;

FIG. 8 is a perspective view of a cigarette, with the wrapper partially torn away, including a novel filter;

FIG. 9 is a view of a yarn produced in accordance with the invention;

FIG. 10 is a schematic perspective view of an apparatus for treating the opened tow;

FIG. 11 is a perspective view of a bottle containing a short length of the product of the apparatus of FIG. 10; and

FIG. 12 is a graph showing smoke removal efficiency plotted against density for plugs in accordance with the invention.

Referring now more particularly to the drawing wherein like numerals have reference to the same element, in FIG. 1 there is shown a bale **11** of a multifilament tow **12**, which tow is passed through an air spreader **13** comprising a pair of spaced plates provided on their opposed faces with longitudinal slits through which compressed air is directed against the tow.

From the air spreader **13** the tow **12** is drawn between rolls **14**, **14** each of which is elastically surfaced as at **15**. The rolls **14** have the configuration shown in FIGS. 3 and 4 and described more fully hereinafter. A yoke **16** determines the spacing between the rolls **14** and includes means for oscillating the rolls **14** in opposite directions perpendicular to the plane of the drawing although preferably the rolls are not oscillated but are merely supported for rotation. The tow **12** is then drawn between rubber braking rolls **17** which may be driven or which may be idly mounted for rotation.

The tow **12** then passes to positively driven rolls **18** which are also elastically surfaced and supply the force necessary to draw the tow along. These rolls **18** operate at a constant speed attuned to the operating speed of the cigarette making machinery. If the braking rolls **17** are positively driven, they are driven at a slower speed than rolls **18** so as to exert a braking action on the tow.

The tow passes through another air spreader **19** and enters a plasticizing chamber **20** wherein there is provided a mist of plasticizer. The plasticized tow upon emerging from chamber **20** is now in condition for passage to rod-forming equipment (not shown) in order to be formed continuously into cigarette filter plugs. Although the tow **12** is now relaxed the spacing between crests of adjacent crimps is greater than it was initially.

Filter rods and plugs formed from the tow are characterized by uniformity in weight, filtering characteristics and density. Smoke passing therethrough is not channeled as can be seen from the absence of unevenly discolored areas at the end of the filter. The plugs are firm and the paper wrapping does not wrinkle, indicating a tight uniform packing. These advantages are noted even when the original tow was irregularly crimped and contained many cross-overs.

As shown more clearly in FIGS. 3 and 4, the rolls **14** as viewed from the right-hand side are helically threaded for half their lengths in counter-clockwise direction and for the other half in clockwise direction. The base of each groove is V-shaped whereas the tops of the ridges separating adjacent grooves are slightly flattened. In operation, the rolls **14** are moved closer toward each other, the distance being set so that the predetermined speed of driven rolls **18** will result in a tow having the desired percent crimp, i.e. the rolls **18** are driven at the selected speed and the rolls **14** are moved toward each other until the tow emerging from between rolls **18** has the desired properties. The force of rolls **17** against each other may also be varied to avoid unduly increasing the spacing between rolls **14** which might reduce the opening action. The rolls **14** may also be reciprocated in axial direction to aid in opening.

The rolls **14** rotate in the direction indicated by the arrows and it will be seen that the upper roll will tend to reduce the width of the tow passing therebetween while the lower roll will tend to increase the width of the tow. In practice it has been found that with identical rolls grooved as shown the lower roll apparently exerts a greater influence so that there is a net increase in width of the tow.

The modified apparatus shown in FIG. 2 is identical with that of FIG. 1 except that the braking rolls **17** have been omitted. In this embodiment the grooved rolls **14** take over the braking function to control the stretching of the tow. Control over the uniformity of crimp, i.e. uniformity of tow density in longitudinal direction of the tow, is less exact but if a regularly crimped tow is initially employed the product will be almost as uniform as that produced by the apparatus of FIG. 1, whereas the apparatus of FIG. 1 will give excellent results with tows which are regularly crimped, e.g. by toothed gear wheels, as well as with more randomly crimped tow.

In place of a pair of rolls **14** which are helically threaded in opposite direction from each end, each roll may be threaded only in one direction. Alternatively, as shown in FIG. 5, one roll **21** may be provided with parallel circular ridges or rings **22** each extending in a plane perpendicular to the axis of the roll **21** while the other roll **23** is provided with parallel elliptical ridges or rings **24** each extending in a plane inclined relative to the axis of roll **23**. It is apparent that upon rotation there will be relative lateral movement between the ridges **22** and the ridges **24**. This will also be achieved if either roll **21** or **23** is used in conjunction with one roll **14**, if two rolls **23** are used with their ridges inclined in opposite directions, if two rolls **21** are used and one is reciprocated laterally relative to the other, etc.

FIG. 6 shows a pair of plates **25** which can be substituted for the rolls **14**. In use the plates may be reciprocated laterally but they are preferably stationary. Each plate **25** has a ridged surface and as can be seen in FIG. 7 the surface has the appearance which would result from cutting rubber covering **15** of roll **14** parallel to the roll axis and flattening out the covering.

In FIG. 8 there is shown a cigarette comprising an outer paper wrapping **26** enclosing tobacco **27** and a filter composed of a paper wrapper **28** surrounding filaments **29**. The filter comprising wrapper **28** and filaments **29** may be made by wrapping tow **12** with paper in conventional manner as it leaves plasticizer chamber **20** (FIGS. 1 and 2), cutting it into predetermined lengths (not shown) and curing. To the naked eye the filter will look the same as conventional filters, but it will feel more firm than conventional filters of equal filament and plasticizer content. If the filter is broken apart, or if the tow is examined as it leaves rolls **18** it will be apparent that the tow is more voluminous than tows of the same number of filaments and total denier which have not been passed between ridged rolls **14**. In addition, there will be but little registry in the crimps of adjacent filaments.

The yarn **30** shown in FIG. 9 comprises many filaments which appear to be voluminized in more or less registry. The filaments, however, are individual rather than lightly adhered as when crimped in conventional manner.

In place of being plasticized and formed into cigarette filter plugs, as shown in FIG. 10, the opened tow **31** can be cut by cutter **32** into predetermined lengths **33** suited for stuffing, padding or bottle wadding. Because of their open structure, lengths **33** fill out any space into

which packed. They are free of short fibers which can work their way loose, thereby eliminating the problems and inconveniences attending such loose particles. In addition, they are clean, highly absorbent and inert. FIG. 11 shows such a mass **33** stuffed into a bottle **34** containing material such as aspirins **35**, the mass **33** keeping the aspirins from moving about or becoming soggy and losing their individual shapes or identities.

The following examples are given to illustrate this invention further.

EXAMPLE I

(a) Using the apparatus shown in FIG. 1, an 80,000 denier tow of 20,000 cellulose acetate continuous filaments, averaging 8 crimps per inch, is passed through air spreader **13** and is subjected to compressed air at 3 p.s.i.g. The tow passes between grooved rolls **14** which are 14 inches long and 5.5 inches in diameter, eighteen helical threads per inch being cut about 1/16 inch deep into the rubber covering. Next, the tow passes between braking rolls **17**, idly mounted for rotation and forced against each other sufficiently hard to require a force of 15 pounds to pull the tow manually therethrough. Driven rolls **18** are rotated at a peripheral speed of 37.25 yards per minute and the tow picks up 7% of its weight of triacetin in chamber **20**. The tow leaving chamber **20** is wrapped with paper on conventional cigarette making equipment and cut into 15 mm. lengths which are cured for 24 hours at room temperature. One hundred such plugs are tested for weight, pressure drop and smoke removal efficiency. The pressure drop is the suction necessary to maintain a flow rate of 17.5 cc. of air per second through the plug, not incorporated into a cigarette. In determining smoke removal efficiency, 12 puffs of 35 cc., i.e. 2 seconds of puffing, are drawn from a lit cigarette through the filter and through a trap having on its bottom a sintered glass disk. 2 grams of sifted alpha cellulose are placed on the disk, producing a pressure drop of about 5 centimeters of water. The trap is immersed half way in a Dry Ice-acetone bath. The formula for the smoke removal efficiency is as follows:

$$\text{Percent efficiency} = \frac{\Delta \text{ weight of filters}}{\Delta \text{ wt. of filters} + \Delta \text{ wt. of trap}} \times 100$$

The plugs average 0.172 gram in weight, have a pressure drop of 56.7 mm. H_2O, and a smoke removal efficiency of 21.6%.

(b) The same starting tow is formed into plugs without being acted upon by the grooved rolls. Based on the values for (b) the poorly-opened plugs weigh 4% more than in (a). While their pressure drop is 14% less than in (a), their smoke removal efficiency is 47% less than (a).

EXAMPLE II

(a) The process of Example I(b) is repeated with a tow made up of 21,000 of the same filaments. The plugs weigh 0.188 gram, have a pressure drop of 62.1 mm. H_2O and a smoke removal efficiency of 15.1%.

(b) Inserting the grooved rolls into the process of Example II(a) and increasing the stretch, the plugs weigh 8% less. While the pressure drop of the well-opened tow goes up 4%, the smoke removal efficiency goes up 42%.

While the extensive opening of the tow resulted in a somewhat increased pressure drop for the novel filters, it will be noted that the percent increase in smoke removal efficiency exceeded the percent increase in pressure drop

$$\left(\frac{b-a}{a} \times 100 = \text{percent increase}\right)$$

EXAMPLE III

The process of Example I is repeated with a tow of 40,000 filaments each of 2 denier. The speed of rolls **18** is varied in successive runs to produce plugs of varying weight. The results of tests on weight, pressure drop and smoke removal efficiency of 13 mm. plugs are given in the following table. The weight in grams set forth in the table below is for a constant volume of about 0.649 cubic centimeters which is the standard cigarette filter volume.

Table

Run	Weight, Grams	Pressure Drop, mm. H_2O	Smoke Removal, Percent	Density (gms./cc.)
1	0.153	88	25	0.237
2	0.149	79	23	0.231
3	0.146	71	22	0.226
4	0.144	70	23	0.222
5	0.143	74	23	0.221
6	0.142	80	26	0.219

It can be seen that as the plug weight decreases initially, the pressure drop and smoke removal efficiency also decrease. In reducing the plug weight going from Run 3 to Run 4 surprisingly the smoke removal efficiency increases. In going on to Run 5 it is found that although the weight is less both the pressure drop and smoke removal efficiency are greater than in Run 3. This effect is further evidenced in Run 6.

FIG. 12 shows the curve obtained by plotting the smoke removal efficiency of these runs against density. Consideration of the graph points out that as the density decreases, the smoke-removal efficiency decreases but that this reaches a minimum and thereafter a decrease in filter-plug density results in an increase in smoke-removal efficiency.

EXAMPLE IV

Using the grooved rolls shown in FIG. 1 a cellulose acetate yarn composed of 240 4-denier filament united with 4.5 Z turns per inch are pulled between the grooved rolls by rolls driven at 37.25 yards per minute, emerging from the driven rolls as a crimped yarn.

EXAMPLE V

The same tow used in EXAMPLE I, after leaving rolls **18**, is cut into 1 centimeter length used as a wadding in medicine bottles.

It is to be understood that the foregoing detailed description is given merely by way of illustration and that many variations may be made therein without departing from the spirit of our invention.

Having described our invention what we desire to secure by Letters Patent is:

1. A plug of substantially uniform cross-sectional density for cigarette filters comprising a tow of about 3000 to 120,000 crimped continuous filaments of less than about 25 denier per filament, the crimps of said filaments generally being out of registry with one another, said crimps having been deregistered by a method comprising longitudinally moving the tow having filaments the crimps of which are generally in registry, while contacting the tow with at least one ridge, said ridge being inclined to the path of movement of the tow, thereby to displace some of the filaments of the tow relative to other filaments of the tow whereby the crimps of the filaments are generally moved out of the registry, said plug having a density less than about 0.23 gram per cubic centimeter and a smoke-removal efficiency of at least about 15%.

2. A plug of substantially uniform cross-sectional density as claimed in claim **1** wherein said filaments are cellulose acetate.

3. A plug of substantially uniform cross-sectional density for cigarette filters comprising a tow of crimped continuous cellulose acetate filaments, the crimps of said filaments generally being out of registry with one another,

said crimps having been deregistered by a method comprising longitudinally moving the tow having filaments the crimps of which are generally in registry, while contacting the tow with at least one ridge, said ridge being inclined to the path of movement of the tow, thereby to displace some of the filaments of the tow relative to other filaments of the tow whereby the crimps of the filaments are generally moved out of registry, said plug having a density less than aobut 0.23 gram per cubic centimeter and a smoke-removal efficiency of at least about 15%.

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