

# PATENT SPECIFICATION

DRAWINGS ATTACHED

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## COMPLETE SPECIFICATION

### 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 RICHARD FAIRBANKS DYER and JOHN M. WININGER JR.) 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:—

The present invention relates to tobacco smoke filters useful for filtering from tobacco smoke nicotine, tars and the like which are distilled off as vapours or entrained in the smoke from burning tobacco.

The efficiency of cellulose esters, particularly the continuous filaments cellulose acetate tow, as a tobacco smoke filtering material has been known for some time. It has been shown that cellulose acetate, for instance, will remove from tobacco smoke higher percentages of nicotine, tars and the like than will other materials commonly employed for filtering these substances from the smoke. In the filtration of a smoke stream the efficiency of removal of particulate matter by the filter material is related to the fineness of the cellulose acetate filter tow being used to make the filtering element. Thus, in tobacco smoke filters it is known that fine denier per filaments, such as 1.6 D/F, are considerably more effective in removing particulate matter such as tar from the smoke stream than a filter of the same size made from 8 D/F material. However, the use of fine denier filtering material to obtain high tar removal has presented problems, in that such filters are hard to make due to the weak nature of the small filaments which break easily in the processing of the fine denier per filament tow into a tobacco smoke filter. A second and equally important requirement of the filtering

material is that in any given filter the air-pressure drop through the filter must not be so high as to cause discomfort to the smoker. A tobacco smoke filter made entirely of fine denier per filament filaments tends to have too high a pressure drop.

In accordance with the present invention there is provided a tobacco smoke filter material comprising a mass of coarse flat filamentary-like ribbons, discontinuously and randomly separated from each other yet interconnected with said mass, the flat filaments as a whole being in substantial alignment longitudinally of the mass, each coarse flat filamentary-like ribbon having integral hair-like protrusions extending transversely and multidirectionally therefrom.

According to the present invention there is also provided a tobacco smoke filter comprising a structurally unitary rod-like mass of coarse flat filamentary-like ribbons and a wrapper encircling the mass, each flat filamentary-like ribbon of the mass being substantially coextensive and interconnected with the filamentary mass, the ribbons as a whole being in substantial alignment longitudinally of the mass, with each coarse ribbon having a plurality of integral hair-like protrusions extending transversely and multidirectionally therefrom.

In accordance with the present invention there is further provided a continuous method for the preparation of structurally unitary rod-like tobacco smoke filters from a continuous film of polymeric material having a high degree of longitudinal molecular orientation, said method comprising feeding the film through a jet to which a gas stream is supplied thereby effecting vibration of the film to effect a multiplicity of discontinuous slits along substantially parallel, longitudinal integral lines thereby obtaining a plurality of coarse filamentary-like ribbons each having

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hair-like protrusions extending transversely and multi-directionally therefrom thereafter gathering the ribbon mass into a substantially cylindrical form and forming said cylindrical ribbon mass into a tobacco smoke filter.

Polymeric materials useful in the present invention are those crystalline polymers susceptible to a high degree of molecular orientation, particularly olefinic polymers, including crystalline (i.e. high density) polyethylenes, crystalline polypropylenes and crystalline polyallomers. Crystalline polypropylenes are preferred.

In the accompanying drawings:—

Fig. 1 is a schematic side elevation of one system for drafting, heat setting and disintegrating the preliminary oriented film product into flat, partially fractured ribbons of the present invention;

Fig. 2 is a schematic side elevation of an alternative system for drafting, fracturing drafted film and converting into cigarette filters;

Fig. 3 is a side elevation in cross section showing one form of jet which we prefer to employ in many instances for carrying out the herein described process;

Fig. 4 is a cross-section showing another form of jet which we prefer to employ in many instances for carrying out the herein described process;

Fig. 5 is a cross-section to an enlarged scale, indicating the general nature of that which a photo-micrograph of the cross-section of our new product displays as to flat fractured ribbons;

Fig. 6 is a view, likewise to an enlarged scale, depicting a longitudinal section of the intermediate ribbon-like mass of the present invention as would be observed from certain photomicrograph pictures thereof;

Fig. 7 is a schematic diagram of a wrapped tobacco smoke filter element containing compacted flat fractured film with hair-like protrusions according to our invention;

Fig. 8 is a diagram of a ribbon-like mass made up of fractured film bonded together at intersects according to another embodiment of our invention.

Referring to Fig. 1, 1 represents the supply package for the film to be processed in the present invention. This supply package 1 may comprise a conventional roll or drum of the film or other similarly convenient rotatable supply source.

The supply source is in series with one or more canted rollers 2 about which the film may be wrapped one or more times before passing into a drafting oven 3. This oven 3 may be of any of the usual constructions employed in the film manufacturing industry. It can be heated electrically or with air or any other convenient and controllable source of heat.

The film discharging from oven 3 is wrapped around canted rollers 4 for feeding into an oven 5. These canted rollers 4 may be the same as rollers 2 or rollers 6 to be referred to shortly. Likewise oven 5 may be of the same general construction as oven 3 but in this particular embodiment of Fig. 1 oven 5 is employed for heat setting as will be explained in more detail hereinafter.

Oven 5 discharges the drawn film on to and around canted rollers 6 which feed into a rather large jet the construction of which is shown in detail in Figs. 3 and 4. This large jet 7 discharges to a smaller jet 8 the construction of which may likewise be the same as just mentioned, differing primarily only in being of smaller size.

The flat film from the jet 8 is picked up between the nip of a pair of pressure rollers 9, passes through a conventional transverse guide 10 on to a roller 11 or other desired packaging device or other utilization.

The construction shown in Fig. 2 will now be described. The construction is generally similar to that shown in Fig. 1 and comprises a film supply 21 which may be a roll or drum of film or film extruder or other convenient source of the film to be processed. The film or sheeting withdrawn from 21 is passed through feed rollers 22 into an oven 23, which may be the same as the oven referred to in Fig. 1. The heated film from this oven is withdrawn through draft rollers 24. The drafted film is then fractured in a treating jet 25 and is delivered by rollers 26 to a cigarette filter plug maker 27. From the foregoing it will be observed that the arrangement in this Fig. 2 is generally similar to that of Fig. 1 except that the several jets in series, the heat-set oven and canted rollers have been omitted and a cigarette filter plug maker has been added.

The draw or stretch ratio that can be imparted to a film is related to the thickness of the film and its polymeric composition. Thus a 1 mil thick polypropylene film may be drawn about 6 times its extruded length, whereas a 5 mil thick extruded polypropylene film may be drawn to 12 or more times its extruded length. The range from 3:1 to 15:1 is considered to contain the preferred drafting ratios for polypropylene film.

For any given combination of extruded film thickness, draw ratio, and fracturability factor the fracturing action of the air jet may be controlled to achieve a given percentage of the potential amount of fracturing possible. The potential fracturability may be determined by calculating the number of filaments which could be produced in a drawn film that would have a width equal to three times their thickness. Thus, a 1 mil thick drawn film three inches wide could be fractured into 1000 filaments of a 1 mil thick by 3 mil

wide rectangular cross section of greater than 1 inch length.

In general it is not desired to achieve 100% fracturing of the film. For example it has been found that if less than 90% of the potential fracturing is present in the final mass, a further fracturing can take place when the flat ribbons are conveyed to the filter plug making machine. Such a residual fracturability characteristic tends to impart greater adhesion among the adjacent ribbons giving a firmer and more compact filter.

In the type of jet used such as shown in detail in Figs. 3 and 4 the oriented film is acted upon by a high velocity fluid. This action, as will be explained in greater detail hereinafter and as will be more apparent by the several examples which follow, causes the oriented film ribbon to fracture laterally and longitudinally into a plurality of flat fractured ribbons.

Extended further description of Figs. 3 to 8 is unnecessary since some of these figures have been made from photomicrographs or other photographs of products of the present invention and others are appropriately marked with descriptive terminology thereon.

In its broader aspects the process of this invention may be divided into a number of suboperations as follows: film extrusion, slitting, orienting the film, forming the flat fractured ribbon in a fluid jet, and processing the flat fractured ribbons into filters. These separate steps in the operation may be carried out in one continuous process or in various combinations of subprocessing steps. For example, the film may be extruded and slit in one operation. In the second operation, it may be oriented. The third operation would then consist of forming and processing fractured ribbon into filters. A second approach would be to extrude and wind the film full width. The full width roll of film would then be used as a supply for the orienting operation, in which case it would be slit into the desired widths and a plurality of narrow widths of film would be fed through the drafting process. These drafted ends of film might then be wound up on individual packages. These packages would then be transferred to a third operation wherein the individual ends of film would be passed through fluid jets and combined into a further product. In other cases, the extrusion drafting and fracturing film formation and filter formation may be carried out in one continuous operation. Depending on the type of end product filter desired, various types of jets may be used so as to induce a range of effects in the finished product. As indicated above, the fractured coarse ribbons of our invention contain fine protrusions or hair-like fibrils extending transversely from the coarse ribbon. The protrusions constitute less than ten percent of the total filter structure by weight. The filtration potential

of the filters is as high as filters composed entirely of the fine denier filaments of the prior art as for example 1.6 D/F.

#### EXAMPLE I

With reference to Fig. 1, a 37" wide roll of 5/mil thick polypropylene film was extruded and slit into 1" widths and wound on spools. A spool of this slit film 1 served as the supply for the operation of Fig. 1. The film was withdrawn from the supply spool by canted roller pair 2 and fed into the hot air drafting oven 3 at a speed of 33-1/3 feet per minute. The temperature of the draft oven was 340°F. The film was withdrawn from the draft oven 3 by roller pair 4 at a speed of 400 feet per minute for a draft ratio of approximately 12:1. The drafted film was then fed to the heat set oven 5 in which the air temperature was 300°F. It was withdrawn from the heat set oven 5 by means of the roller pair 6 at a speed of 400 feet per minute. The heat set film was then fed to the jet 7 of the type shown in Fig. 4 of this case.

The jet was supplied with air at 60 pounds per square inch gauge pressure. The air was at approximately room temperature. The action of the high-velocity, high-pressure air on the film caused it to spit into flat, partially fractured, substantially continuous ribbons which were removed from the jet by pinch rollers 9 at a speed slightly less than 400 feet per minute. The flat fractured ribbons were then wound up on a spool by means of transverse guide 10 and winder 11.

When producing battings or tows suitable for conversion into filter capable of high impurity removal it is desirable to subject the polymeric film to further fracturing action by passing it through a second jet to achieve 20% or so of additional potential fracturability. This additional fracturing action induced the further formation of short hair-like protuberances from the basic two dimensional fractured film ribbons. These hair-like protuberances are formed both on the tops and sides of the coarser 10 micron by 30 micron filaments and are in the order of 1 to 5 microns in width and thickness and may be of square or rectangular cross-section.

Examples II—V illustrate preparation of tobacco smoke filter elements according to our invention.

#### EXAMPLE II

A one-mil thick by 1" wide film was extruded from polypropylene pellets and drawn in a hot oven. The film was drawn with a ratio of 6.2 to 1 in steam at 140°C. The film input speed was 20 feet/minute and the output speed was 124 feet/minute. The film as it left the output draw roller was treated with 35 psi air in a jet and was wound up on a bobbin with 2 turns per inch twist. One

hundred and twenty-five (125) ends of the fractured flat ribbons which had a denier of 830, were combined by hand and wrapped in cigarette papers to make a cigarette filter.

5 The filter was tested for tar removal efficiency according to the procedure given in Tobacco Science 4, 55-61, 1960 with the following results

|    |                          |                   |
|----|--------------------------|-------------------|
| 10 | Length of filter tip     | —17 mm            |
|    | Circumference            | —25 mm            |
|    | Weight of tip less paper | —0.18 gram        |
|    | Pressure drop            | —3.4 inches water |
|    | Tar removal              | —50%              |

15 By way of comparison, a cellulose acetate, 15-mm long filter rod weighing 0.13 grams, made from 1.6 D/F tow of 37,000 total denier, had a pressure drop of 3.07 and a tar removal of 43.8%. In another comparison, a cellulose acetate filter rod 15-mm long and weighing 0.165 gram was made from a 2.0 denier per filament (D/F) tow of 72,000 total denier and had a pressure drop of 2.4 and a tar removal efficiency of 34%. In a further comparison, a 5 denier per filament (D/F) 80,000 denier cellulose acetate filter tip 15-mm long weighing 0.17 gram and having a hardness of 5.5 had a pressure drop of 1.2 inches of water and a tar removal efficiency of 17%.

The appearance of the film filter material was substantially as shown in Fig. 7. The size of the large fractured ribbons average 6 denier/ribbon, and they were 10 to 90 microns wide by 10 microns thick. As can be seen from Fig. 7 there were present, in an amount less than 10% by weight of the filter element, a number of fine hair-like protrusions that were less than about 2 microns wide and thick.

Based on the comparison of the 5 denier per filament (D/F) acetate filter with the fractured film filter, it can be seen that the film filter with ribbons having these fine hair-like protrusions not present on the prior art acetate filter was significantly more efficient in tar removal.

#### EXAMPLE III

50 A sample of drawn and jet-treated film was prepared as in Example II except that the film was drafted 6.4/1 with an input speed of 47 feet/min. and an output speed of 300 feet/min. The film was jet treated at 50 psi air pressure and wound up as zero-twist yarn. Ninety-five (95) ends of this yarn were beamed on to spools and used as the supply for a cigarette filter plug making machine.

60 Several hundred 90-mm long  $\times$  24.9-mm circumference cigarette filters were made. These filters were cut into 17-mm lengths and tested for tar removal. The 17-mm tips weighed 0.177 gram, each had a pressure drop of

2.8" water, and had a tar removal of 36%. No binder was applied to these rods. If desired a polyethylene powdered binder may be used.

Fractured-film filters similarly prepared from a 50/50 mixture of polypropylene and polystyrene were substantially firmer. Filters prepared with this type of fractured film may be plasticized with such materials as dimethyl azelate, diethyl adipate, diethyl phthalate or the like.

There is also some increase in hardness brought about by combining the jet-treated film with a small amount of tow of cellulose acetate plasticized, for example, with triacetate or the like.

#### EXAMPLE IV

80 Thirty-four (34) ends of 1000-denier, jet-treated polymeric film prior to pretensioning were combined with a 33,000 denier cellulose acetate tow made up of 5 denier per filament (D/F) substantially oval filaments. Triacetin plasticizer (7.1% by weight based on the total rod weight) was applied. Rods 102-mm long  $\times$  24.8-mm circumference were made which weighed 1.02 grams. These rods had a hardness of 6.4 and a pressure drop of 9.4" of water. When cut into 17-mm tips and tested for tar removal, these tips weighed 0.17 gram, had a 2.07" water pressure drop, and 25% tar removal. As can be seen in comparison with the data given previously for a 5 denier per filament (D/F) 100% acetate filter tip, the tar removal for the rod of Example IV was considerably higher.

The fractured film used to prepare filters as in preceding Examples II-IV was prepared substantially as shown in Fig. 1 described hereinabove. According to this procedure the drawn film was prepared by extruding, e.g., a 1-mil polypropylene film about 90 inches wide, and drafting it to a 6.4/1 ratio before winding it up on a mandrel. Or, if desired, a 5-mil thick  $\times$  35-inch wide film may be similarly extruded and drawn at a 12 or 13 to 1 ratio. In either case, the roll of drawn film is mounted so as to unroll freely as the film is pulled by feed rollers. From the feed rollers the film is then fed to a treating jet. In the jet the film is coarsely shredded or fractured into strips about 5 to 20 denier per filament (D/F) in size, and tiny hair-like short extensions of less than 5-microns size, are torn loose at one end from the coarse filaments, remaining attached at the other end as shown in Figs. 6 and 7. If additional fracturing action of the film is desired to induce formation of a greater number of hair-like fibrils, a second jet 8 can be added to the process. The treated film then passes over delivery rolls in to the garniture of a cigarette filter plug making machine.

If the film is made from a blend of poly-

phthalate

propylene and polystyrene, a plasticizer may be added to give greater hardness to the rods, if this is desired. In other cases, the rod may be wrapped in a stiff, heavy paper to give the desired rigidity.

If desired, the feed rolls of Figs. 1 and 2 may be replaced with a driven unrolling stand for the film supply roll.

When starting with non-stretched film a draft oven zone is used between the supply of such unstretched film and the feed rollers, which in such case act also as output draw rollers. A set of input draw rollers may be placed at the entrance to the hot draft zone to pull the film from the supply roll at the desired rate.

According to the procedure of our invention described above in Examples II—IV the film used may be prepared by extruding from a hopper source pellets of a polypropylene, polyethylene, polystyrene, polyallomer, polyester, polyamide copolymer or mixture of these materials, or the like as desired.

The extruded film passes a draw zone, which may consist of draw input and output rollers and a heated draft oven. The drafted film is then fed to the treatment jet, next to the delivery rollers and finally in the garniture of a filter maker.

When it is desired to jet treat the film in an operation which is separate from the plug making, the drawn jet-treated film may be puddled into a baler, with or without imparting crimps to the mass of flat ribbons, as desired, and then compressed and wrapped. The baled material may be converted into filter plugs by merely pulling it from the bale with feed rollers, fluffing it in an air jet, and passing it to the delivery rollers and garniture of the filter plug maker.

It may be desired to place addenda on the jet-treated film. For example, activated charcoal may be added to provide high removals of the gaseous phase components of cigarette smoke, such as acrolein, isoprene, and others. In such instance the jet-treated film may be fed to a slurry applicator where a mixture of water, binder and activated charcoal is applied to the treated film. The hairy fractured film containing additive then passes through a drying oven where the water is evaporated and the binder activated and cured. The binder holds the activated charcoal on the treated film so that it may be then fed by the delivery rollers into the garniture of the filter plug maker with minimum loss of addendum.

#### EXAMPLE V

A bale of 50,000 denier, jet-treated stuffer box crimped black film, having an average denier ribbon of 30 was used as supply source. The treated film was coated with a slurry of activated charcoal of 325 mesh (U.S. Sieve Series) or finer, binder (methyl

cellulose) and water. The binder was cured and the water evaporated in an oven, and the coated treated film was fed to the cigarette plug maker in which filter rods were prepared.

#### EXAMPLE VI

A 35,000 denier jet fractured crimped ribbon film having 15 crimps per inch was produced by continuously extruding polypropylene into a film longitudinally orienting said film with a draw/neck length ratio of 5:1, a fracturability factor of over 3000 and a fracturability angle of less than 1°, jet fracturing the oriented film to the extent of about 10 to 20% of its potential fracturability and then crimping to 15 crimps per inch in a stuffer box type crimper and packaging in a bale. The bale of crimped fractured film material was then fed to a tobacco smoke filter forming machine wherein about 10% by weight of a low melting point polyethylene binder powder of about 50 mesh was dusted on to the spread-out fractured film. Heat was applied to activate the binder powder and the film and binder were shaped into a tobacco smoke filter rod having a pressure drop of about 5" of water for a 90-mm length rod of 24.8-mm circumference and a tar removal efficiency of about 10%. The filter rods had acceptable firmness or hardness due to the bonding action of the polyethylene binder powder.

In the case of forming cigarette filters from our material, it is desirable to obtain 50% to 90% or more of the potential fracturability by the jet action. The exact percentage will however depend upon the degree of tar removal efficiency desired. Thus if a high tar removal filter, say 40 to 50% is desired, 80 to 95% of the potential fracturability should be carried out in the jet treatment step of the process. However, if low tar removal is desired, say 20%, then only about 50% or less of the potential fracturability is carried out in the jet treatment stage of the process. Actually if desired tar removal of as low as 10% may be attained by effecting only 5 to 20% of the potential fracturability of the film in the jet treating process. In our process it is usually only necessary to raise or lower the jet pressure to raise or lower the tar removal properties of the filter. In the prior art if a given spinnerette spun tow could not produce the desired tar removal, it was necessary to discard that tow and manufacture new spinnerettes to produce a finer or coarser denier per filament filamentary tow at great expense and loss of production time.

#### EXAMPLE VII

As indicated above, the fracture process of the present invention has a wide range of application in the cigarette filter area. For ex-

ample, 1-mil thick by 1" wide film may be disintegrated at 40 psi air pressure and 20 feet per minute film speed through the jet to produce a highly dispersed fractured film which is wound up with little or no twist. Such a product would have an average denier per fractured ribbon in the order of about 5 to 6.

The fractured ribbons being rectangular in cross section have a very large surface area as compared to a round filament of the same size in denier. Since in many filtration applications a large surface area is conducive to good filtration, it will be apparent that the flat fractured ribbon of the present invention has many uses for filtration fabrics or packs.

Several ends of flat fractured ribbon produced as described herein were combined to-

gether and processed into a cigarette filter rod. It was found that good removal rates are obtained due to the large surface area of the flat fractured ribbons. In examining the fractured ribbons under a microscope it is noted that a number of very small hair-like short fine extensions protrude from the large coarse ribbons. These short fine extensions have a width of about 2 to 5 microns and appear as tiny hairs protruding from the large coarse ribbons of 12 to 90 micron width as shown in Fig. 6. It is thought that these tiny protrusions attached to the coarse ribbons greatly assist in obtaining higher removal rates in tobacco smoke filters.

The filter rods were prepared by plying together 96 ends of the fractured ribbon product and pulling through filter rod-making equipment.

|  |                                                |             |
|--|------------------------------------------------|-------------|
|  | Estimated denier                               | 6 den./fil. |
|  | Estimated total denier                         | 105,000     |
|  | Length of filter tip                           | 17 mm.      |
|  | Circumference of filter tip                    | 25 mm.      |
|  | Weight of filter tip without paper (Av. of 20) | 0.18 g.     |
|  | Amount tars removed by filter tip              | 50%         |
|  | Pressure drop of filter tip (Av. of 20 tips)   | 3.4 inches  |

The amount of tar removed at this pressure drop is useful. It approaches the efficiency of a 1.6 D/F crimped acetate tow which can remove up to 50% tar at a pressure drop of 3 inches. A heavy paper wrap obtains the desired rod stiffness.

While in the foregoing examples the jets used have usually been of a circular cross section, a wider variety of jets can be used. For example, the slot venturi-type jet may be used to fracture oriented films of five or more inches in width. When films of this width are fractured in this jet, they may be collected for use in cigarette filters. Alternatively they may be left in a continuous flat web-like form and one or more layers superimposed upon each other to form a non-woven batting which has considerable coherency due to the interconnection between the fractured ribbons in the fractured film. If desired, these superimposed layers of flat fractured ribbons may be bonded with heat to increase their strength.

While in the foregoing discussion the process has been described principally in relation to polypropylene film, a number of other materials may also be used in the process.

#### EXAMPLE VIII

A 1"-wide by 3-mil thick polyallomer film was drafted 5.8:1 in 350°F. air, heat set at 300°F. in air and passed through the air jet feed of Fig. 4 with 60 pounds per square

inch air. A flat, fractured-ribbon yarn was produced.

#### EXAMPLE IX

A polyester film 1-1/4" wide by 1-mil thick was drafted in hot air at 250°F., at a draft ratio of 5.1 to 1, and heat set at 450° in air. The drafted polyester film was then fed through an air jet using 60 pounds air pressure. The resultant product was a staple-like, fractured-film material. It was observed that under equal conditions, the polyester film produced a more staple-like material than is obtained with polypropylene film. That is, there were fewer interconnections between the fine fractured ribbons in a polyester material than in a fractured polypropylene material.

From the foregoing two examples, it will be apparent that any of these materials could be blended with polypropylene or with each other by feeding the two different films through the jet in the desired proportions. The flat fractured ribbons described herein may be textured, if desired, by several of the known means of texturing conventional continuous filament or staple fibre yarns. For example, if desired, prior to twisting the fractured film may be subjected to a stuffer-box crimping texturing method. If desired, prior to twisting, the flat, fractured-film product may be subjected to a texturing process where-in the texturing is done by a swirling air current or by passing it through any of the known mechanical false-twist texturing pro-

cesses. The highest degree of orientation preferred above is in direct relation to the orientation temperature, the oven hold-up time, and the width and thickness of the unoriented film. Assuming a constant film width of 1 inch and a variation in film thickness from 1/2 to 5 mils, the maximum draft ratio is seen to vary from about 3:1 for the 1/2 mil to about 15:1 for the 5 mil using an optimum combination of hold-up time and temperature. However, the ratios reached with hot air ovens do not necessarily represent the absolute maximum attainable, since some increase may be effected with another type of orientation heat such as steam. The range from 3:1 to 15:1 is considered to contain the preferred drafting ratios for polypropylene film as used above.

When less than the maximum drafting ratio is used, all other conditions remaining constant, it becomes apparent that the degree of fracture and separation effected in the fluid jet is reduced, and the resulting fractured ribbons are thicker and wider.

The take-up rate or production speed is not seen limited to any particular value. The hold-up time is directly proportional to the take-up rate; but for any given rate, the length and temperature of the oven can be designed to produce the necessary film temperature. In the various examples, take-up rates ranging from 300 ft./min. to 600 ft./min. were successfully used without indication of reaching a limit in either direction. The upper limits in production would be determined by the maximum speed at which the equipment operators could handle the materials in hookup and doffing operations.

The air or steam pressures used in the fluid jet are in many instances also in direct relation to the thickness of the film. An unoriented 5-mil film may be drafted and processed into flat fractured ribbons with a 90 psi jet pressure, but the jet pressure used in this instance will be higher than for a 1-mil film, assuming the same degree of fracture is effected in both thicknesses. The pressure ranges used in various runs have varied from 5 to 90 psi with maximum unoriented film thickness of 5 mils. It is possible that higher jet pressures would be desirable for even thicker films (6—10 mils) to produce the desired amounts of fracture.

#### WHAT WE CLAIM IS:—

1. A tobacco smoke filter material comprising a mass of coarse flat filamentary-like ribbons, discontinuously and randomly separated from each other yet interconnected with said mass, the flat filaments as a whole being in substantial alignment longitudinally of the mass, each coarse flat filamentary-like ribbon having integral hair-like protrusions extending transversely and multidirectionally therefrom.

2. A material according to Claim 1, wherein the flat filamentary-like ribbons comprise fractured molecularly oriented polymeric film.

3. A material according to Claim 2, wherein the fractured ribbons are at least 10 microns thick and 10 to 90 microns wide with a plurality of hair-like protrusions 1 to 10 microns thick.

4. A material according to Claim 2 or 3, wherein the polymeric film is polypropylene.

5. A material according to Claim 2 or 3, wherein the polymeric film is composed of a blend of polypropylene and polystyrene.

6. A tobacco smoke filter material substantially as hereinbefore described.

7. A tobacco smoke filter comprising a structurally unitary rod-like mass of coarse flat filamentary-like ribbons and a wrapper encircling the mass, each flat filamentary-like ribbon of the mass being substantially coextensive and interconnected with the filamentary mass, the ribbons as a whole being in substantial alignment longitudinally of the mass, with each coarse ribbon having a plurality of integral hair-like protrusions extending transversely and multi-directionally therefrom.

8. A tobacco smoke filter according to Claim 7, wherein the coarse ribbons are fractured molecularly oriented polymeric film material.

9. A tobacco smoke filter according to Claim 8, wherein the material is polypropylene.

10. A tobacco smoke filter according to Claim 8, wherein the material is composed of a blend of polypropylene and polystyrene.

11. A tobacco smoke filter according to Claim 8, 9 or 10, wherein the coarse ribbons are at least 10 microns thick and 10 to 90 microns wide with a plurality of hair-like protrusions being 1 to 10 microns thick and said protrusions being 10% by weight of said filter element.

12. A tobacco smoke filter according to Claim 9, wherein a plurality of the coarse filamentary-like ribbons are bonded to contiguous ribbons through the application of a polyethylene binder powder and heat sufficient to fuse said powder.

13. A tobacco smoke filter according to Claim 10, wherein a plurality of the coarse filamentary-like ribbons are bonded to contiguous ribbons at random points of contact by surface solvation bonds from the action of a plasticizer.

14. A tobacco smoke filter according to any one of the preceding claims 7 to 13, wherein solid particulate additives are adhered to the filamentary-like structure to enhance removal of gaseous contaminants from the smoke stream.

15. A tobacco smoke filter substantially as hereinbefore described.

16. A continuous method for the preparation of structurally unitary rod-like tobacco smoke



cesses. The highest degree of orientation preferred above is in direct relation to the orientation temperature, the oven hold-up time, and the width and thickness of the un-oriented film. Assuming a constant film width of 1 inch and a variation in film thickness from 1/2 to 5 mils, the maximum draft ratio is seen to vary from about 3:1 for the 1/2 mil to about 15:1 for the 5 mil using an optimum combination of hold-up time and temperature. However, the ratios reached with hot air ovens do not necessarily represent the absolute maximum attainable, since some increase may be effected with another type of orientation heat such as steam. The range from 3:1 to 15:1 is considered to contain the preferred drafting ratios for polypropylene film as used above.

When less than the maximum drafting ratio is used, all other conditions remaining constant, it becomes apparent that the degree of fracture and separation effected in the fluid jet is reduced, and the resulting fractured ribbons are thicker and wider.

The take-up rate or production speed is not seen limited to any particular value. The hold-up time is directly proportional to the take-up rate; but for any given rate, the length and temperature of the oven can be designed to produce the necessary film temperature. In the various examples, take-up rates ranging from 300 ft./min. to 600 ft./min. were successfully used without indication of reaching a limit in either direction. The upper limits in production would be determined by the maximum speed at which the equipment operators could handle the materials in hookup and doffing operations.

The air or steam pressures used in the fluid jet are in many instances also in direct relation to the thickness of the film. An unoriented 5-mil film may be drafted and processed into flat fractured ribbons with a 90 psi jet pressure, but the jet pressure used in this instance will be higher than for a 1-mil film, assuming the same degree of fracture is effected in both thicknesses. The pressure ranges used in various runs have varied from 5 to 90 psi with maximum unoriented film thickness of 5 mils. It is possible that higher jet pressures would be desirable for even thicker films (6—10 mils) to produce the desired amounts of fracture.

#### WHAT WE CLAIM IS:—

1. A tobacco smoke filter material comprising a mass of coarse flat filamentary-like ribbons, discontinuously and randomly separated from each other yet interconnected with said mass, the flat filaments as a whole being in substantial alignment longitudinally of the mass, each coarse flat filamentary-like ribbon having integral hair-like protrusions extending transversely and multidirectionally therefrom.

2. A material according to Claim 1, wherein the flat filamentary-like ribbons comprise fractured molecularly oriented polymeric film.

3. A material according to Claim 2, wherein the fractured ribbons are at least 10 microns thick and 10 to 90 microns wide with a plurality of hair-like protrusions 1 to 10 microns thick.

4. A material according to Claim 2 or 3, wherein the polymeric film is polypropylene.

5. A material according to Claim 2 or 3, wherein the polymeric film is composed of a blend of polypropylene and polystyrene.

6. A tobacco smoke filter material substantially as hereinbefore described.

7. A tobacco smoke filter comprising a structurally unitary rod-like mass of coarse flat filamentary-like ribbons and a wrapper encircling the mass, each flat filamentary-like ribbon of the mass being substantially coextensive and interconnected with the filamentary mass, the ribbons as a whole being in substantial alignment longitudinally of the mass, with each coarse ribbon having a plurality of integral hair-like protrusions extending transversely and multi-directionally therefrom.

8. A tobacco smoke filter according to Claim 7, wherein the coarse ribbons are fractured molecularly oriented polymeric film material.

9. A tobacco smoke filter according to Claim 8, wherein the material is polypropylene.

10. A tobacco smoke filter according to Claim 8, wherein the material is composed of a blend of polypropylene and polystyrene.

11. A tobacco smoke filter according to Claim 8, 9 or 10, wherein the coarse ribbons are at least 10 microns thick and 10 to 90 microns wide with a plurality of hair-like protrusions being 1 to 10 microns thick and said protrusions being 10% by weight of said filter element.

12. A tobacco smoke filter according to Claim 9, wherein a plurality of the coarse filamentary-like ribbons are bonded to contiguous ribbons through the application of a polyethylene binder powder and heat sufficient to fuse said powder.

13. A tobacco smoke filter according to Claim 10, wherein a plurality of the coarse filamentary-like ribbons are bonded to contiguous ribbons at random points of contact by surface solvation bonds from the action of a plasticizer.

14. A tobacco smoke filter according to any one of the preceding claims 7 to 13, wherein solid particulate additives are adhered to the filamentary-like structure to enhance removal of gaseous contaminants from the smoke stream.

15. A tobacco smoke filter substantially as hereinbefore described.

16. A continuous method for the preparation of structurally unitary rod-like tobacco smoke

- filters from a continuous film of polymeric material having a high degree of longitudinal molecular orientation, said method comprising feeding the film through a jet to which a gas stream is supplied thereby effecting vibration of the film to effect a multiplicity of discontinuous slits along substantially parallel, longitudinal lines thereby obtaining a plurality of coarse filamentary-like ribbons each having integral hair-like protrusions extending transversely and multi-directionally therefrom, thereafter gathering the ribbon mass into a substantially cylindrical form and forming said cylindrical ribbon mass into a tobacco smoke filter.
17. Method according to Claim 16 wherein an adhesive condition is created among the filamentary-like ribbons by the application of a plasticizer which is compatible with and is a solvent or softener for said ribbons, thereby bonding contiguous ribbons at random points of contact.
18. Method according to Claim 16 or 17, wherein solid particulate additives are applied and adhered to the band of filamentary-like ribbons to enhance the ability of the tobacco smoke filter to remove gaseous contaminants from the smoke screen.
19. The method of producing tobacco smoke filters substantially as hereinbefore described.
- L. A. TRANGMAR, B.Sc., C.P.A.,  
Agent for the Applicants.

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