Nov. 23, 1965 V. L. ERLICH ETAL 3,219,043

TOBACCO SMOKE FILTER PLUG

Filed June 2, 1961

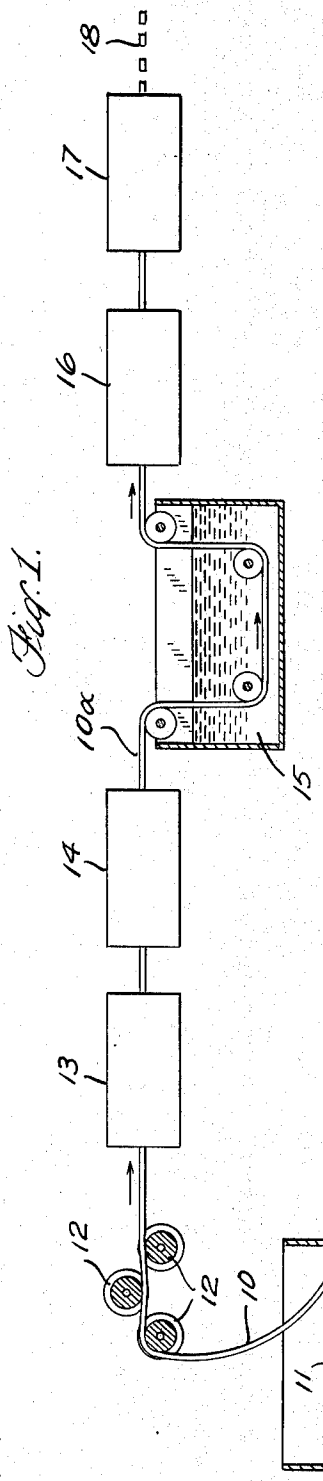

Fig. 1.

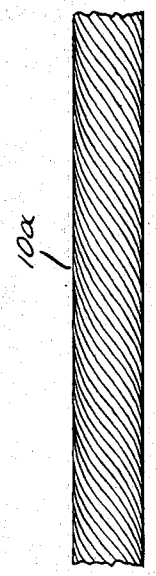

Fig. 4.

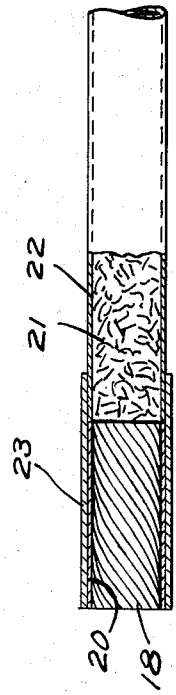

Fig. 5.

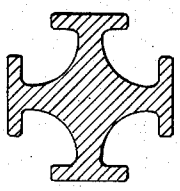

Fig. 2.

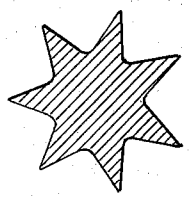

Fig. 3.

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United States Patent Office 3,219,043 Patented Nov. 23, 1965

3,219,043

TOBACCO SMOKE FILTER PLUG

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Filed June 2, 1961, Ser. No. 114,382
The portion of the term of the patent subsequent to Aug. 11, 1981, has been dedicated to the Public
3 Claims. (Cl. 131—208)

The present invention relates to new and improved tobacco smoke filters.

One object of the present invention is to provide a new and improved tobacco smoke filter, which forms a coherent unit of predetermined size, and which has improved filtration efficiency and at the same comparatively high air permeability.

Another object of the invention is to provide a new and improved tobacco smoke filter having filter elements held in a novel manner into a coherent rigid unit against relative displacement and disintegration.

Another object of the invention is to provide a tobacco smoke filter with a new and improved configuration to afford large bulk in relation to its mass.

Most common type of fibrous filter materials employed for tobacco smoke filters consists of cellulose acetate fibers bonded together by adhesives or solvents.

It has been proposed to employ poly-alpha-olefin fibers stretched in a denier of between 2 and 8 as to be molecularly oriented and highly crimped up to 40 crimps per inch. The fibers are said to be "molecularly oriented" when the long-chain molecules in each fiber are substantially parallelized and aligned along the fiber axis. Stretching of the fibers is a common procedure to provide the necessary alignment and orientation of the molecular chains making it possible to apply to the fibers the required permanent high crimp. The high crimp is necessary to obtain with these fine filaments a tow of sufficient bulk to produce a tobacco smoke filter of the required size. The high crimp is also necessary to afford sufficient surface within the filter unit to obtain the required amount of surface contact between the smoke gases and the filter material.

It has been found in accordance with the present invention, that molecularly unoriented poly-alpha-olefin material, and particularly polypropylene fibers have greater filtration efficiency than have molecularly oriented fibers presenting the same exposed surface area. It is believed that this enhanced filtration efficiency is due to the fact that the stretching and the resulting orientation hardens the fiber including the fiber surface and thus impairs its surface filtering reaction with the materials to be filtered.

The molecularly unoriented fibers cannot be highly crimped and particularly cannot be permanently crimped, and this poses a diifficult problem because of the necessity of creating sufficient surface contact between the smoke gases and the filter material and of creating the required bulk in the tow. However, in accordance with certain features of the present invention, the required surface contact and tow bulk is attained as follows without crimping the fibers:

The fine poly-alpha-olefin fiber as produced in normal manufacturing processes have circular or slightly oval perimeters and, therefore, present the smallest surface area for any given cross-sectional area or denier of fiber. The ratio of the perimeter to the square root of the cross-sectional area in such a fiber is 3.52. By increasing this ratio, greater surface area and in turn higher surface contact for a given cross-sectional area or denier of the fiber is assured. In accordance with the present invention, the individual filaments are extruded with a cross-section other than round or slightly oval, so that the ratio

of the perimeter to the square root of the cross-sectional area in such a fiber is greater than 3.52. By increasing this ratio of 3.52, greater fiber surface area and in turn higher surface contact for the tobacco smoke for a given cross-sectional area or denier of fiber is assured.

In accordance with the present invention, the individual filaments are extruded with a cross-section other than round or slightly oval, so that the ratio of the perimeter to the square root of the cross-sectional area is at least 6, and may preferably be as high as 10 or even higher. This greater ratio at least doubles the surface activity of the fiber compared with that of a circular one.

A desirable form in which the filament may be extruded is one in which the filament is provided with a series of surface flutes extending longitudinally thereof. The filament in that form desirably has a cross-section comprising projections or arms radiating from a central core and more specifically may assume the cross-sectional shape of a cross or a star with a comparatively small central core or backbone from which the arms or points radially project.

As an additional feature of the present invention, the filters are helically twisted in the range of ¼ to 2 turns per inch. This twisting can be done without molecularly orienting the individual fibers by twisting the fibers individually or by twisting bundles of the fibers but desirably the twisting is done on the tow which has the bulk and size necessary to form the final filter rod from which the individual filter units are cut. This twisting brings the filaments or bundles into helical shape, which further improves the surface efficiency of the filter, increases the bulk and simultaneously provides a mechanical bond of the filament within the filter body. This mechanical bond is sufficient to make the use of adhesives or other bonding processes less imperative, and such other bonding processes may even be dispensed with. However, such additional bonding can be applied if it should be found to be desirable.

Filter bodies prepared as described may be subjected to a surface treatment before or after twisting in order to stiffen the filter rod. Such treatment can be performed by passing the filter rod through a bath holding, for example, low melting paraffin wax at a temperature above its melting point, so that the wax will be in sufficiently fluid condition. A bath temperature of between 90° and 120° C. will be adequate to deposit a thin layer of wax on the surface of the filter rod when the latter passes at high speed through the wax bath. The filter rod in its final twisted form is cooled in air and the then solidified wax layer on the surface will stiffen the rod without impairing the permeability of the filter body or plug cut from said rod.

In place of the melted wax, a bath made up of a solution of paraffin wax in a low boiling solvent, as for example, pure hexane, or a fine dispersion of the wax in water may be employed. After the rod has been passed through this bath, it may, for example, be heated in a stream of hot air, to cause the solvent or water to be evaporated, leaving behind a thin outer surface of wax over the rod.

While the basic principles of the invention can be applied to a variety of synthetic fiber materials, the preferred fibers are those of the poly-alpha-olefin group, generally because of their specific filtration efficiency and inertness. Such poly-alpha-olefin fibers encompass those which are or can be produced from the broad range of polymers, such as the polyethylenes having low melting points of between 110 and 120° C., the stereospecific polypropylenes having low melting points of between 170 and 180° C. and the higher polyolefins having higher melting points, as for example, around 250° C.

By stereospecific polypropylenes is meant a polypro-

pylene having a molecular structure in which the side chains branch out from the linear paraffinic backbone or nucleus into the molecular space in orderly predetermined directions as distinguished from a molecular structure in which the side chains branch out randomly in opposite directions from the linear paraffinic backbone. Such stereospecific polymers are sometimes also designated as isotactic or syndiotactic depending on the specific orderly arrangement of the side chains in one or in alternate directions.

In forming the tow for the filter, it is desirable for this tow to contain not less than 60% by weight of stereospecific polypropylene and especially isotactic propylene.

In the following description and in the accompanying drawings, there are described and shown specific examples of cigarette tobacco filters which embody the present invention and specific examples of a process of making the same. In these drawings,

FIG. 1 is a flow diagram showing in side elevation an apparatus for carrying out an embodiment of the process of the present invention;

FIG. 2 shows a specific embodiment on an enlarged scale of a form of cross-section of a filament from which the cigarette filter of the present invention can be made;

FIG. 3 shows a specific embodiment on an enlarged scale of another form of cross-section of a filament from which the cigarette filter of the present invention can be made;

FIG. 4 is a side elevation on an enlarged scale of the tow after it has been twisted and before it has been cut into cigarette elements and the elements wrapped for incorporation into a cigarette; and

FIG. 5 is an enlarged longitudinal section through a portion of a tipped cigarette assembled with a filter plug of the present invention.

In accordance with a specific embodiment of the invention, the fibers for the tobacco smoke filter unit are made of poly-alpha-olefins and desirably of stereospecific polypropylene, and more specifically isotactic polypropylene having a molecular weight of around 300,000. In producing the filaments, the polymer is melted and extruded through dies or spinnerettes which have orifices or holes therein in the shape of the desired cross-section determining the shape of the filaments after extrusion and cooling. As far as certain aspects of the invention are concerned, this shape may be of any non-circular form provided it gives the above mentioned high ratio of perimeter to the square root of the cross-sectional area, but it is desirably in the form of a star with a small central backbone, as described. FIGS. 2 and 3 show filaments extruded in different forms in accordance with the present invention.

For forming the filaments and bundling them into a tow for processing, each die has a number of orifices or holes through which a number of filaments respectively are extruded. These filaments solidify upon cooling and prior to being collected to form a bundle. A number of such bundles are combined to form a continuous tow having the bulk of the cigarette filter plug or unit, which usually is 25 mm. in circumference. The number of individual filaments necessary to form such a tow depends on the size and shape of the individual filaments. These filaments will not be molecularly oriented, and desirably should have a denier of between 2 and 30.

In accordance with a specific example, 5000 continuous undrawn filaments of isotactic polypropylene, each of cross potent cross-section, i.e. of cruciform cross-section with T-shaped radiating arms, as shown in FIG. 2 are combined to form a tow. Each filament has a size corresponding to 13 denier, i.e. a weight of 13 grams for a length of 9,000 meters, so that the tow will have a total denier of 65,000 and has a ratio of perimeter to the square-root of the cross-sectional area of 11 to 1.

To determine the filtering effectiveness of tobacco smoke plugs or bodies produced from a tow made of molecularly unoriented filaments of 65,000 denier modified in cross-section, as shown in FIG. 2, and having a circumference of 25 mm., cigarettes were made incorporating these filter plugs in lengths of 17 mm. Cigarettes were also made with filter plugs 25 mm. in circumference and 17 mm. in length from a tow formed of the same number of polypropylene filaments, which were made of the same size and shape as the molecularly unoriented filaments but which were molecularly oriented after being extruded.

Cigarettes with and without filters were smoked on smoking devices well known in the art for testing, and the respective nicotine and total contents were determined in mg. per cigarette. In each case, the draft resistance was determined and the results were compared on the basis of the same draft resistance. Under these conditions, the nicotine absorption was 59.5% for the filters containing the molecularly oriented fibers and 77.1% for those containing the molecularly unoriented fibers. The total solids contents absorbed by the filters were respectively 58.5% and 78.2% of that contained in the smoke when smoking the cigarettes without filters.

In accordance with another specific example of the invention, 11,000 molecularly unoriented isotactic polypropylene filaments of 5 denier having a seven-pointed star cross-section as shown in FIGURE 3, and with a ratio of perimeter to square root of the cross-sectional area of 9:1, are combined to form a tow having a total of 55,000 and having the required circumference of 25 mm.

Referring to FIGURE 1 of the drawings, the tow **10** which is made in accordance with either of the two embodiments described above and which consists of molecularly unoriented filaments of isotactic polypropylene shaped as shown in FIGURE 2 or 3, is supplied in the form of a compressed bale **11** from which the tow is taken off continuously at high speed by means of driven Godet rolls **12**. The tow **10** is then passed through the field of action of a yarn twisting machine **13** well known in the art for helically twisting yarn or rope. The twisting is done with little or no tension on the filaments to prevent orientation. The higher the twist, the greater the draft resistance; the twist should not be less than ¼ turn per inch and need not be higher than 2 turns per inch and preferably should be between ½ turn an 1 turn per inch.

The twisted tow is then passed through a heating device **14** where the tow is exposed for a short period to a temperature of about 135° C., so that the tow is heat set in its twisted condition and its helical formation thereby stabilized to form a continuous filter rod **10***a*.

The twisted heat set filter rod **10***a* is then passed through a bath **15** holding low melting wax, preferably paraffin wax, at a temperature of about 100° C., which is above the melting point of the wax and which renders the bath fluid enough to deposit a thin layer of wax on the outer surface of the filter rod as the rod passes at high speed through the bath. The rod **10***a* in its final twisted form, covered with a thin layer of wax, is cooled in air, causing the wax to solidify and thereby to exert a stiffening effect on the rod without impairing the permeability of the filter rod.

The rod **10***a* formed as described, may then be processed by the usual well-known cigarette filter making mechanism to form the filter mouthpieces or plugs for combination with the tobacco holding parts of the cigarettes. For example, the rod **10***a* may be wrapped with cigarette paper by a wrapper folding device **16** and then cut by cutter **17** into segments to form filter pieces or plugs **18**. These filter pieces **18** with individual wrappers **20** are then combined with the tobacco holding parts **21** of the cigarettes in their paper wrapper **22** by overlapping folios **23**.

The length of the filter mouthpieces **18** varies, and

may be for instance 17 mm. in a cigarette having a total length of 85 mm.

In certain known apparatuses, the length of the filter plugs cut from the continuous filter rod may be 102 mm. and these may then be later subdivided to the lengths of the filter units required for one cigarette.

Instead of producing the tow **10** from continuous filaments as described, the tow may be blended from cut staples ranging in length, for example, from about 1 cm. to about 5 cm. or may be blended from a combination of continuous monofilaments and cut staples.

In the specific embodiment of the invention described, the tow of molecularly unoriented filaments was conducted through the yarn twisting device **13** as is known in regular textile operation. As another alternative, the individual filaments or individual bundles of filaments supplied by the extruder or spinnerette units were helically twisted prior to being combined into the final tow. In a third embodiment of the invention, the final tow formed from individually twisted filaments or twisted bundles was itself twisted to produce the rod used for the cigarette filter. The first and third embodiments are particularly advantageous because the twist serves to hold the filaments against relative axial displacement.

The mechanical bond afforded by the twisting of the tow as described is sufficient to dispense with additional bonding expedients, such as adhesive or solvents. However, if additional bonding is desired, this can be accomplished in the case of filaments such as those made of cellulose acetate by means of adhesive or solvents in the manner well known in the art, and in the case of polyolefin fibers which are inert to these bonding expedients, a blend of two types of polyolefin fibers having different melting points may be employed to form the tow, and the tow is heated to melt the fibers of lower melting point without melting the fibers of higher melting point, as described in copending application Serial No. 24,328 filed April 25, 1960 now Patent No. 3,144,025.

Besides the advantages of the invention described hereinbefore, the construction of the filter plugs are such as to lend themselves to manufacture by continuous mass-producing processes employing some of the devices now being employed in the manufacture of existing filter plugs.

While the invention has been described with particular reference to specific embodiments, it is to be understood that it is not to be limited thereto but it is to be construed broadly and restricted solely by the scope of the appended claims.

What is claimed is:

1. A rod-like filter element short enough and slender enough to form a filter plug in a tobacco smokable article, such as a cigarette, and having sufficient permeability to draw tobacco smoke easily therethrough in the process of smoking said article, said element being made up essentially of substantially molecularly unoriented poly-alpha-olefin fibers extending side by side along the length of said element, said fibers being bonded into a plug unit by a poly-alpha-olefin material of a melting point lower than that of said unoriented fibers, said fibers being uncrimped and helically twisted together below the point where the fibers would be stretched sufficiently to produce molecular orientation.

2. A rod-like filter element short enough and slender enough to form a filter plug in a tobacco smokable article, such as a cigarette, and having sufficient permeability to draw tobacco smoke easily therethrough in the process of smoking said article, said element consisting essentially of substantially molecularly unoriented poly-alpha-olefin fibers, said fibers being a blend of two types having different melting points, the fibers of lower melting point being integrally bonded to fibers of higher melting point, said fibers being uncrimped and helically twisted together below the point where the fibers would be stretched sufficiently to produce molecular orientation.

3. A rod-like filter element short enough and slender enough to form a filter plug in a tobacco smokable article, such as a cigarette, and having sufficient permeability to draw tobacco smoke easily therethrough in the process of smoking said article, said element consisting essentially of substantially molecularly unoriented poly-alpha-olefin fibers, said fibers being a blend of two types having different melting points and extending side by side along said element, the fibers of higher melting point constituting the major portion of the fibers and consisting of polypropylene, said fibers being uncrimped and helically twisted together below the point where the fibers would be stretched sufficiently to produce molecular orientation.

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