Dec. 27, 1960 G. P. TOUEY ET AL 2,966,157

POLYOLEFIN TOBACCO SMOKE FILTERS

Filed June 7, 1957

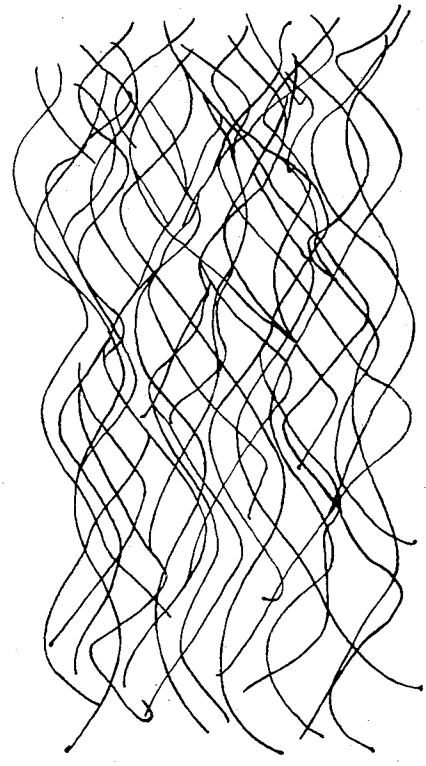
Fig. 1



Fig. 2



Fig. 3



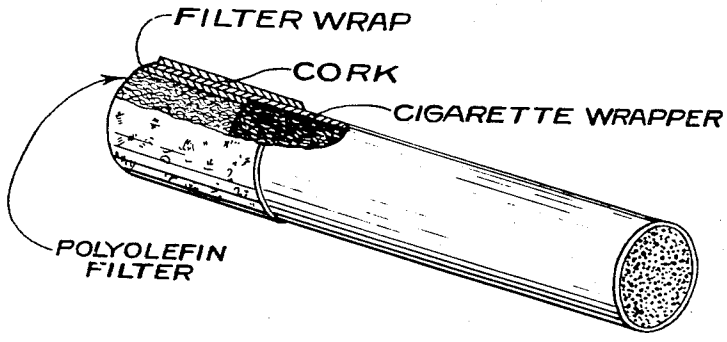



Fig. 4

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# POLYOLEFIN TOBACCO SMOKE FILTERS

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9 Claims. (Cl. 131—208)

This invention relates to tobacco smoke filters. More particularly, this invention relates to improved filters for cigarettes, which filters are made from a polyolefin material of a certain character.

The subject of tobacco smoke filters has received considerable attention in recent years. Numerous patents and publications on this subject have appeared. In general, many of the prior art filters have been comprised of wads or masses of short filaments or granules of various materials for filter purposes. Many of the tobacco smoke filters in the prior art are made from paper or the like materials. However, the prior art filters have not been entirely satisfactory in some respects. Many of the filters are not particularly efficient and others, particularly the wad or mass-type of filters, may be objectionable because of the high pressure drop.

For tobacco smoke filters in addition to the capability of the filter to filter out certain components, there are a number of other properties that need to be taken into consideration. For example, a cigarette filter should have an acceptable feel in the smoker's mouth. That is, the filter should be firm, not only initially, but it should not get soggy or detach from the cigarette. The filter should not have such a high pressure drop that the effort to draw smoke through the filter is noticeable to the smoker. The filter should be economical to make and capable of being made on automatic machinery or otherwise lend itself to mass production because a low cost item is needed in view of the relatively low price range of tobacco products of the class described.

In recent years certain cellulosic yarns have come into use to a large extent for cigaretter filters and in certain instances have replaced paper filters that have been used. While such yarn-type material gives a cigarette filter much improved over many prior art filters and also comprises a material which works well in automatic machinery there are certain disadvantages which may be encountered with such filters. That is, in cellulosic yarn filters the present manufacturing processes frequently include the application of plasticizer to this yarn so that the filaments of the yarn may be bonded by plasticizer for imparting stiffness to the filter. This, of course, involves the requirement of spray booths and the like apparatus for applying plasticizer. In addition, such prior art yarn filters have used wrappers for holding the filters in shape. Or in some instances, particularly where staple fiber yarn has been used for the filter it has been necessary to coat the yarn with a cellulosic bonding or coating material. This coating would likewise involve the use of spray apparatus and the like. Although the cellulosic filters first referred to exhibit a better efficiency than many of the prior art filters they are not as economical to manufacture nor as efficient as the filters of the present invention to be described in the present application.

In view of the current interest in filters of the class described, it is apparent that the development of an improved filter represents a highly desirable result.

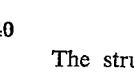
This invention has for one object to provide a more



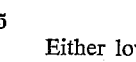
efficient and more economical tobacco smoke filter. Another object is to provide a cigarette filter which is not only relatively firm initially but which does not get soggy or soft from mouth or smoke moisture. Still another object is to provide a filter which because of its hydrophobic properties does not dry the tobacco smoke. Still another object is to provide a method for manufacturing improved filters as aforesaid. Other objects will appear hereinafter.

In the broader aspects of the present invention we have found that certain polyolefins may be made into continuous filaments. We have found that these continuous filaments may be highly crimped. That is, the crimping may be much greater than heretofore applied to filter material. We have found that this high crimping permits the obtaining of a relatively rigid filter without plasticizer addition or without the addition of a bonding material, such as the addition of cellulosic adhesive components heretofore described in the prior art. We have found that the crimped material of the present invention can be used in existing automatic equipment if this is desired and the cigarette filters made generally the same as is now customary. That is, the filter element is finally enclosed in a wrapper before being inserted in the cigarette. On the other hand, we have found that the improved crimped filter material of the present invention may readily be fused on the outside to form a self-sustaining filter element not requiring a wrapper.

The polyolefin material which we prefer to use has a molecular weight above 10,000 and below 1,000,000. Preferably the molecular weight of the polyolefin material would be between 30,000 and 200,000. The softening point of the polyolefin polymer which we prefer to use is between 85° C. and 160° C. Of the several polyolefin materials produced industrially we prefer those known as polyethylene and polypropylene. The structural unit for polyethylene can be represented as:



The structural unit for polypropylene can be represented as:



Either low density polyethylene, namely polyethylenes having a softening point of about 90° C. to 100° C. or high density polyethylenes which have a softening point of 110° C. to 140° C. can be used in preparing the fibers used in the filters of the present invention. By using the low density polyolefins a lower bonding or fusing temperature is needed to give rigidity or firmness to the finished plug. The high density of polyolefins require a slightly higher bonding temperature be used on the filter plugs.

The particular method of manufacturing the polyolefin material is not a part of the present invention and is known to the industry concerned with such manufacture. In other words, the desired polyolefin material can be obtained from a manufacturer by giving the above specifications of molecular weight and other properties to such manufacturer. It will be noted, however, that the polyolefin material used in the present invention is a material resistant to moisture.

After obtaining a suitable polyolefin composition it is spun into filaments of the proper denier. The number of filaments required to make a satisfactory filter plug tow will depend on the thickness of the individual fibers and the amount of crimp they have been given. In general, it will require 20,000 to 40,000 filaments when the fibers are in the range of four to two denier per filament, and 2,000 to 5,000 filaments when the fibers are

in the 30 to 8 denier-per-filament range. Also with higher crimp a suitable rigid filter can be obtained with filament count toward the lower side of the aforementioned ranges. The exact process used for spinning the polyolefin materials into filaments is not a limitation on the present invention. Any of the methods known in the textile industry for preparing polyolefin filaments may be used for preparing the filaments of the present invention provided that a suitable denier is obtained.

The filaments of suitable denier are then crimped. As indicated above in accordance with the preferred embodiments of the present invention a relatively high degree of crimp is imparted to the filaments. However, if it is desired to make filaments somewhat similar to the prior art filaments which have been used for filters, a lower degree of crimp, say a degree of crimp of the order of 6–12 crimps per inch, can be put into the filaments of the present invention. However, when this is done, even then a superior filter will be obtained by using the polyolefin materials of the present invention.

There are various types of crimping apparatus that may be used. Examples of satisfactory crimping devices are described in the following U.S. Patents: 2,090,669, 2,311,174, 2,505,618, 2,698,970, 2,734,228, 2,734,229, 2,734,251, 2,740,992 and 2,749,233. Most of the commercial crimping devices for textile tows are of the "stuffing-box" type, although in some instances the "gear type" is used. Both of these types are discussed in the patents listed above. We prefer the "stuffing-box" type of textile tow crimping apparatus since it readily permits putting in a range of crimp from about six crimps per inch up to, for example, 40 crimps per inch of an amplitude between about 0.10 inch and 0.01 inch.

By crimps per inch we mean the number of convolutions per inch of fiber length. By amplitude of crimps we mean the height of each convolution.

It is apparent from the foregoing that the actual length of a fiber segment which is expressed in terms of crimps per inch, depending upon the number of crimps and the amplitude thereof, may, for example in a segment of one inch length in crimped form, actually occupy 1¾ to 2 inches when in an uncrimped condition. It is apparent from this that there is considerable filling capacity added to the yarn when it is given a high degree of crimp and with the filaments of the present invention considerable rigidity is imparted to the resultant filter from a high degree of crimp.

The crimped filaments of polyolefin produced as above described and in the form of continuous filaments can readily be fed into existing automatic filter-making machinery. In such machinery a bundle of crimped filaments are formed into a filter element, which element is enclosed in the wrapper and cut into segments, which segments feed into cigarette machines to apply the filter to the cigarette. Our material may be manufactured into cigarette filters as just mentioned and in accordance with presently used operations but there is a saving because spray booths and the like parts may be omitted or not used in existing equipment. Or if it is desired the filaments of the present invention may be passed into a heated metal-forming block. By heat the filaments of the present invention may be not only fused at the surface but the heat will cause some fusing within the filter element where the highly crimped filaments contact one another. By this procedure self-contained filter elements may be manufactured without the need of an external wrapper or plasticizer addition or coating the filaments.

Hence, it is apparent that our crimped polyolefin multifilament material of the present invention may be used in several ways to make filter elements either in presently used equipment wherein the filter element is encased in a wrapper or in a more simple manner where a wrapper is not required.

Tests of tobacco smoke filters consisting essentially of the continuous crimped polyolefin filaments of the present invention shows that such filter elements in accordance with the present invention will remove a greater quantity of tar and nicotine with about the same or less pressure drop than commercial filter elements now available in the industry.

As of assistance to a more detailed understanding of the instant invention reference may be made to the attached drawing forming a part of the instant application. In the drawing:

Fig. 1 is an illustration on a somewhat enlarged scale of a single strand of polyolefin filament containing of the order of 30 crimps per inch;

Fig. 2 represents somewhat on an exaggerated scale a small section of a crimped tow before the blooming thereof, said tow being made up of crimped polyolefin filaments;

Fig. 3 likewise illustrates on an exaggerated scale a small section of such crimped tow after it has been bloomed for the manufacture of tobacco smoke filters therefrom; and

Fig. 4 shows the assembly of a filter in accordance with the present invention onto a conventional cigarette. In this figure certain parts have been broken away in order that the interior of the filter may be better observed.

Since the various figures of the drawing appear readily understandable on inspection, extended description thereof appears to be unnecessary.

A further understanding of our invention will be had from a consideration of the following examples, with respect to which Examples I and II are set forth for illustrating our preferred embodiment. Examples III and IV are set forth primarily for comparison purposes. That is, in order to compare a product generally in accordance with the present invention but having only a relatively low degree of crimp with a prior art product having the same amount of low crimp, Examples III and IV have been set forth.

## EXAMPLE I

*Polyethylene filters.*—A drafted, high-density polyethylene yarn of 2.6 denier per filament was prepared by melt spinning polyethylene using a 50-hole spinneret with 0.30 mm. openings. The drafted yarn had a strength of 2.9 grams per denier, a stretch of 30% and a softening point around 115° C. It was plied into a tow (33,000 filaments) and a portion of the tow was crimped on a textile crimper which produced 18 crimps per inch, all in a direction perpendicular to the length of the fibers. The crimped tow was fluffed out to a width of 12 inches and fed into a filter plug-making machine which produced paper-wrapped filter plugs, 90 mm. in length and 25.5 mm. in circumference. After being heated for 10 seconds at 120° C. the plugs were quite firm and had an average pressure drop (resistance to draw) of 8 inches at an air flow rate of 17.5 ml. per second. Two of the plugs were cut into lengths of 15 mm. and these filter tips were attached to 10 king size cigarettes (Brand A) which had been shortened by 15 mm. These filtered cigarettes were smoked to butt lengths of 35 mm. on an automatic smoking machine similar in design and operation to the one described by J. A. Harlan and H. R. Hanmer of Ind. and Eng. Chem. 28, 836–839 (1936). The smoke which passed through the filters was collected and analyzed for nicotine and tar content. The results of this smoking test and the pressure drop of the filtered cigarettes before smoking are shown in Table 1.

## EXAMPLE II

*Polypropylene filters.*—A drafted polypropylene yarn of 2–8 denier per filament was prepared by melt spinning polypropylene using a 50-hole spinneret with 0.30 mm. openings. The drafted yarn had a strength of 4.7 grams per denier, an elongation of 35% and a softening point around 126° C. It was plied into a tow (30,000 filaments) and given 18 crimps per inch. Thus crimped tow

was fluffed out to a width of 12 inches and fed into a filter plug-making machine which produced paper-wrapped plugs 90 mm. in length and 25.7 mm. in circumference. The plugs, after a 10 second heat cure at 135° C. were very firm and had an average pressure drop of 7.3 inches. Two of the plugs were cut into lengths of 15 mm. and these filter tips were attached to 10 king size cigarettes (Brand A), shortened by 15 mm. These filtered cigarettes were smoked to butt lengths of 35 mm. on the automatic smoking machine and the collected smoke was analyzed for nicotine and tar content. The results of this test are listed in Table 1.

## EXAMPLE III

*Cellulose acetate filters.*—For the purposes of comparison a prior art commercial cellulose acetate filter was obtained. This was made from a commercial grade of cellulose acetate (40% acetyl) by dope spinning into a 2.5 denier per filament yarn in the conventional manner. The finished yarn had a strength of 1.2 grams per denier and an elongation of 32%. Its softening point was around 195° C. It was plied into a tow of 33,000 filaments and crimped to 12 crimps per inch (the amount of crimps used for commercial cellulose acetate filter tow). The crimped tow was converted to filter plugs (25.7 mm. circumference) which were heated in an oven at 150° C. for one hour. These plugs were relatively soft and were not used in the comparison. The other part of the tow was sprayed with a plasticizer (glycerol triacetate) until the combined weight of the sprayed tow was 85% yarn and 15% plasticizer. The sprayed tow was converted to filter plugs in the manner described. After about an hours' storage time at room temperature (75° F.) these plugs were as firm as our preferred heat-treated polyethylene and polypropylene plugs of Examples I and II. The plasticized plugs were cut into 15 mm. filter tips and placed on 10 king size cigarettes (Brand A) shortened by 15 mm. These filter cigarettes were smoked to butt lengths of 35 mm. on the automatic smoking machine. The results of this experiment are shown in Table 1.

## EXAMPLE IV

*Polyethylene filter.*—For the purposes of comparison with Example III a filter was made as set forth below (rather than by our preferred procedure of Examples I and II). That is, this run was designed to test a polyethylene filter at a crimp level equal to the crimp that is usually given to cellulose acetate filters.

Hence, a portion of the polyethylene tow (33,000 filaments) of Example I was given only 12 crimps per inch. This crimped tow was converted to plugs, hardened, and tested as 15 mm. filter tips as described in Example I. The pressure drop of the filtered cigarettes and the amounts of nicotine and tar obtained are reported in Table 1.

*Table 1*

| Type of Cigarette Smoked to 35 mm. Butt (85 mm. in length) | Av. Pressure Drop of Cigarettes (in $H_2O$) | Mg. Tar in Smoke (10 cigarettes) | Mg. Nicotine in Smoke (10 cigarettes) | Percent Tar Removed By Filter | Percent Nicotine Removed By Filter |
|---|---|---|---|---|---|
| Brand A—no filter | 3.2 | 170 | 26 | -------- | -------- |
| Brand A—polyethylene filter, Example I | 4.0 | 110 | 17 | 35 | 35 |
| Brand A—polypropylene filter, Example II | 3.9 | 112 | 17 | 34 | 35 |
| Brand A—cellulose acetate filter, Example III | 3.8 | 131 | 20 | 22 | 23 |
| Brand A—polyethylene filter, Example IV | 3.6 | 120 | 18 | 29 | 31 |

The results of Table 1 show that the polyethylene and polypropylene filters removed more tar and nicotine from the smoke of a cigarette than the prior art filter of the same number of fibers and same pressure drop. The results also indicate that this increased efficiency of the polyethylene and polypropylene filters is only partly due to the presence of more crimps (18) in these filters. The polyethylene filter with the same number of crimps (12) as the acetate filter still removed more nicotine and tar. This indicates that polyethylene and polypropylene fibers are better cigarette smoke filters than the prior art cellulosic filters. Aside from their simple mechanical operation of removing tar and nicotine particles by impingement, our new filters can also develop an electrostatic charge which attracts the smoke particles to their surface.

It is believed apparent from the foregoing that we have provided a relatively efficient new and economical tobacco smoke filter. In addition to the advantages discussed above, our filter possesses certain other advantages. For example, the rigidity of our filter is such that in automatic cutting machinery the cutting can readily be accomplished without a fraying effect thereby giving a filter of excellent appearance which is free of roughness which might be noticeable if a smoker brought his tongue against the end of the filter.

We claim:

1. A tobacco smoke filter consisting essentially of a bundle of crimped continuous polyolefin fibers which fibers have been drafted, said polyolefin having a molecular weight between 30,000 and 200,000 and a softening point between 85° C. and 160° C., said fibers being of a denier between 2 and 8 per filament and present in the filter in an amount between 2,000 and 40,000 filaments, said crimp being up to 40 crimps per inch.

2. A tobacco smoke filter in accordance with claim 1 wherein the crimp is between 16 and 40 per inch.

3. A tobacco smoke filter in accordance with claim 1 wherein the surface of the side wall portion of the filter is fused.

4. A tobacco smoke filter element in accordance with claim 1 wherein the filaments are contained in a wrapper.

5. A fibrous tobacco smoke filter comprising a plasticizer-free, transversely-cut segment of a tow of 2,000 to 40,000 continuous filaments of 8 to 2 denier per filament of a polyolefin from the group consisting of polyethylene and polypropylene, the fibers of the filter (*a*) being generally oriented substantially longitudinally thereof, (*b*) having a high crimp of the order of about 18 to 40 crimps per inch, and (*c*) being fused to adjacent filaments at random points of contact.

6. As a new article of manufacture an improved cigarette filter essentially comprised of several thousand polypropylene filaments of a denier not greater than 8 denier per filament, the filaments having a strength of at least 4 grams per denier and an elongation of at least 35%, said polypropylene filaments being highly crimped and a paper wrapper enclosing the crimped polypropylene filaments and holding them in place.

7. As a new article of manufacture a tobacco smoke filter which consists substantially entirely of a bundle of crimped continuous polyolefin filaments which filaments extend substantially the entire length of the filter, a wrapper around the periphery of said bundle, said polyolefin filaments being characterized in that they are of a denier per filament of not greater than 8 and are crimped up to 40 crimps per inch.

8. A tobacco smoke filter in accordance with claim 7 wherein the filaments are comprised of polyethylene which has a molecular weight above 10,000 and below 1,000,000 and a softening point between 85° and 160° C.

9. A tobacco smoke filter in accordance with claim 7 wherein the filaments are comprised of polypropylene.

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