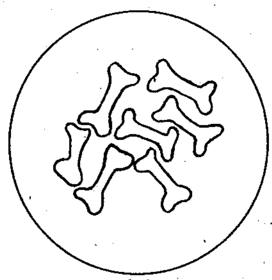
April 17, 1945. R. B. HICKEY 2,373,892

PRODUCTION OF RESILIENT FILAMENTS AND FIBERS

Filed Dec. 30, 1942

FIG. 1



(c)

FIG. 2

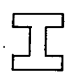


FIG. 3

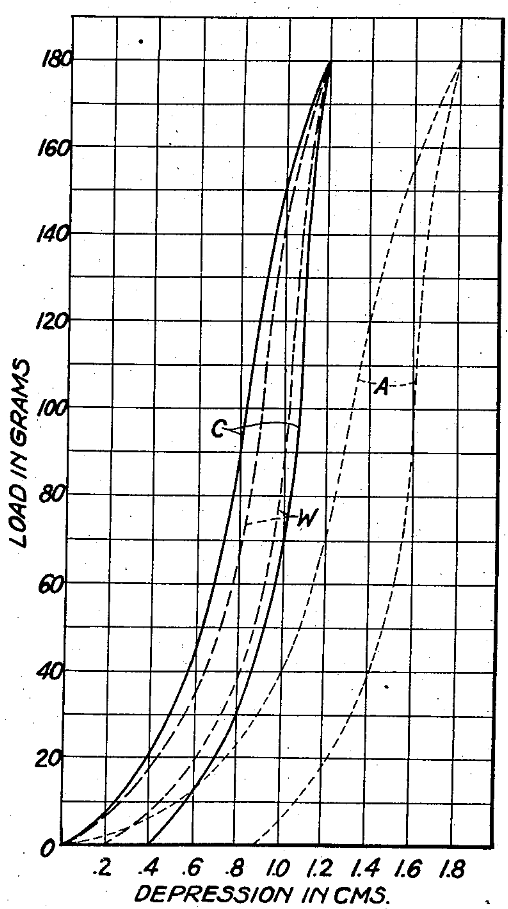


FIG. 4

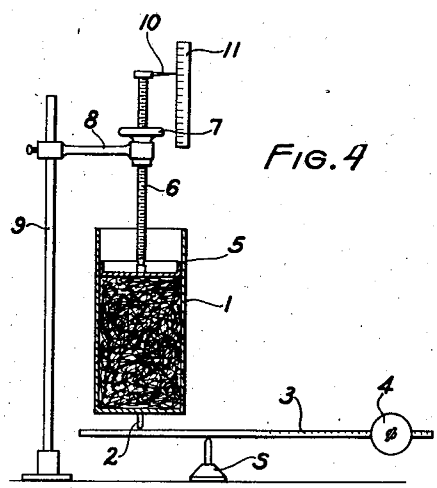
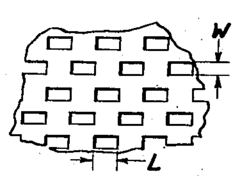


FIG. 5



$\frac{L}{W}$ = 1.35 to 1.65

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2,373,892

UNITED STATES PATENT OFFICE

2,373,892

PRODUCTION OF RESILIENT FILAMENTS AND FIBERS

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Application December 30, 1942, Serial No. 470,606

3 Claims. (Cl. 18—54)

This invention relates to the preparation of resilient filaments and fibers composed of or containing organic derivatives of cellulose such as cellulose acetate or other single or mixed cellulose organic acid esters, and more particularly to the preparation of filaments and fibers having a characteristic cross-section and especially adapted for use in the manufacture of carpet materials and of rugging and other pile fabrics.

As is well known, in the manufacture of pile fabrics, particularly those of the coarser varieties such as carpeting, rugs and the like, the matter of resiliency and durability of the fibers employed is of critical importance. Most natural wools employed in the manufacture of such fabrics are of the coarser, stronger and more resilient types. Carpet materials and rugging are generally of the pile type of construction and it is highly important that the fibers employed in such fabrics have a high crush resistance, that is, they must possess the ability to return readily to their original positions in the fabric after having been bent, displaced or distorted by application of a weight or other deforming force, such as is the case when one walks on a carpet or rug.

Heretofore, many different types of filaments and fibers useful in the production of pile fabrics have been referred to in the prior art. Likewise, a large number of different fiber cross sections have been referred to. However, so far as I am aware, no synthetic filament or fiber has proved to be wholly satisfactory for use as a substitute for natural carpet wool, such synthetic fibers not possessing the required degree of crush resistance or resiliency to enable them to be successfully used in such pile fabrics as carpets and rugging.

The present invention has as its principal object to provide a process for producing filaments and fibers having a high degree of crush resistance and resiliency. A further object is to provide a process for producing filaments and fibers having properties which especially adapt them for use in pile fabrics, either when used alone or in admixture with other natural or synthetic filaments and fibers. A still further object is to provide a process of producing filaments and fibers of a characteristic cross section. Other objects will appear hereinafter.

These objects are accomplished by the following invention which, in its broader aspects, is based upon the discovery that filaments or fibers having a high degree of resiliency and crush resistance when used in pile fabrics must have a cross section corresponding to the cross section of an I-beam and that such I-beam cross section filaments can be produced only by extruding a filament-forming solution through a spinneret having rectangular orifices, the ratio of the length to the width of which lies within certain specific numerical limits. Specifically, I have found that only by employing rectangular spinneret orifices in which this ratio of length to width lies between 1.35 and 1.65 can such I-beam type cross section filaments and fibers be produced. In other words, I have found that this particular range of ratios is critical in the production of crush-resistant filaments and fibers of the type herein set forth.

In the following examples and description, I have set forth several of the preferred embodiments of my invention, but they are included merely for purposes of illustration and not as a limitation thereof.

My invention will be more readily understood by reference to the accompanying drawing in which,

Fig. 1 is a cross-sectional view, on a greatly magnified scale, of a group of filaments produced in accordance with the instant invention.

Fig. 2 is a cross-sectional view illustrating the theoretical form of an I-beam type filament.

Fig. 3 is a graphical representation of the resiliency characteristics of filaments produced in accordance with my invention as compared both to natural wool and to filaments produced in accordance with prior art practice.

Fig. 4 is an elevational view, partly in section, illustrating one form of device for measuring resiliency.

Fig. 5 is a fragmentary plan view, greatly magnified, illustrating the general rectangular contour of the spinning orifices employed in accordance with my process and the critical ratio of length to width of the spinning orifice.

It may be stated in the beginning that the use of my process does not involve any drastic alteration in standard cellulose acetate spinning practice. On the contrary, I may employ any standard spinning equipment and spinning conditions in the production of resilient and crush-resistant cellulose acetate rayon filaments in accordance with my invention, a typical example of such apparatus and spinning conditions being set forth in the U. S. patents to Stone 2,000,047 and 2,000,048. While my process is, as indicated above, fundamentally concerned with extrusion of the spinning solution through a spinneret, the orifices of which are characterized by the fact that their ratio of length to width falls within a certain critical range, it will of course be understood that the ultimate properties of the yarn may be altered, not only by the specific spinning conditions employed, as is well known, but also by the type of cellulose acetate or other cellulose ester it may be desired to use in making up the spinning solution. For example, although not in any way limited thereto, I prefer to employ the spinning solutions and spinning conditions described and claimed in my U. S. Patent No. 2,338,641.

As stated, the distinguishing feature of my invention is the discovery, wholly contrary to what might be expected from a consideration of the prior art, that in order to obtain filaments having a true I-beam cross section, as distinguished from a mere flat or flattened cross-section, it is necessary to employ a rectangular spinning orifice in which the ratio of length to width lies within the critical range of 1.35 to 1.65. I have found that if one goes appreciably beyond this ratio or appreciably below it, the desired and highly characteristic I-beam cross-section is not obtained, notwithstanding many loose references to obtaining such filaments found in the prior art.

The highly characteristic and distinguishing features of filaments produced in accordance with my invention is that the cross-section of such filaments is very definitely of the I-beam type. The resiliency of such filaments compared to filaments of rounded or merely flattened cross-section produced in accordance with the technique of the prior art will now be discussed, both from the standpoint of the theoretical mechanics involved, and from the more practical standpoint of crush resistance as measured by a somewhat empirical test.

The mechanical characteristics of different types of filaments may be shown by a consideration, respectively, of the three theoretical cross sections, namely, (A) circular, (B) oblong, and (I) beam. On the basis of mechanics the theoretical moment of inertia, modulus of elasticity, stiffness, relative stiffness and bending moment of filaments of the respective cross sections may readily be calculated employing the values of the different dimensions given on the drawing. These data are listed in the following tabulation:

	(A)	(B)	(C)
Moment of inertia, $mm.^4$	2.72×10^{-7}	$.26\times10^{-7}$	5.67×10^{-7}
Modulus of elasticity, $kg./mm.^2$	272	325	328
Stiffness, $kg./mm.^2$	7.4×10^{-5}	$.68\times10^{-5}$	18.6×10^{-5}
Relative stiffness	1	.092	2.51
Bending moment—to produce bend of 100 mm. kg./mm	7.4×10^{-7}	$.68\times10^{-7}$	18.6×10^{-7}

It will be readily observed that a filament of I-beam cross section produces a much stiffer fiber which, in all probability, accounts for the considerable improvement in resiliency and crush resistance observed when such filaments are employed in various fabric constructions, particularly pile fabrics of the rug and carpet varieties.

The resiliency and crush resistance of a given mass of filaments or fibers may be measured by the somewhat empirical test illustrated in Fig. 4 of the drawing. In carrying out this test the fibers, preferably in staple form, are placed in a metal or other cylinder 1 of convenient size, open at one end and provided on its closed end with a lug or knife edge 2 or other means of obtaining point or line contact with the beam 3. The cylinder is supported on the gram scale S, the weight or applied load being indicated by adjustment of rider weight 4. Positioned within and freely movable in cylinder 1 is piston or presser 5 which is lowered or raised in the cylinder by means of loading screw 6 threadedly engaging collar 7 which is rotatably mounted in bracket 8 which in turn is fixedly mounted on ringstand 9. Pointer 10 is fixedly mounted to the end of loading screw 6 and is so positioned as to read along scale 11 which is fixedly mounted with respect to ring stand 9.

A load is applied to the fiber mass by rotating collar 7 in such manner as to depress the piston 5. The load, when the beam 3 is in a horizontal position is read from scale S. The distance in centimeters the fibers are depressed by increasing the load and the amount they expand as the load is removed as indicated by travel of pointer 10 on scale 11 is an approximate measure of their resiliency. In other words, the less they are depressed by a given load and the more they recover when the load is removed, the more resilient and crush resistance the fibers are said to be.

The results obtained when applying this test, respectively, to the 20 denier per filament cellulose acetate staple fibers having the so-called standard clover-leaf or round cross section, to cellulose acetate staple of the same denier having an I-beam cross section and produced in accordance with my invention, and to natural wool of approximately the same fiber size, are indicated in the graphs of Fig. 3, in which graph W indicates the results obtained with natural wool, graph A with cellulose acetate fibers of clover-leaf or round cross section and graph C with cellulose acetate fibers of I-beam cross section, all under the same load.

It will be seen from these curves that the ability to return after depression is approximately the same for natural wool and for cellulose acetate fibers of I-beam cross-section produced in accordance with my invention. Contrasted to the resiliency and crush resistance of such fibers is the rounded cross-section fiber of curve A in which the ability to return to its original position after depression is markedly less.

As a further and even more practical test of the comparative quality of I-beam cross section filaments produced in accordance with my process and standard rounded cross section filaments of the same denier, carpets were made up from each type of staple fiber produced from such filaments. In evaluating such a carpet several tests were run to determine wear, resistance to abrasion, "luxuriousness" (or resistance to or recovery from compression) and resistance to soil. Tabulated below are comparative results obtained in the test.

Type material	Acetate staple	Acetate staple.
Shape of cross-section	Clover-leaf	I-beam.
Shawmut wear test	Not as good as wool	As good as wool.
Resistance to abrasion		Very good.
Luxury index (wool=100%)	75%	93%.
Resistance to soiling	Poor	Good.

It will be readily seen from a consideration of the results obtained in the various tests described above that an I-beam cross section material is superior in every respect to material composed of filaments or fibers of the standard rounded or clover-leaf cross section.

In view of the known use of spinneret orifices of many different types, contours, and dimensions, it is indeed a remarkable and unexpected phenomenon that only by the use of a rectangular spinneret orifice in which the ratio of length to width lies between 1.35 and 1.65 can I-beam type cross-section filaments having the properties above described be produced. It will thus be seen that I have provided a valuable improvement in the dry spinning art in which filaments having especially valuable properties, such as high resiliency and crush resistance, and especially adapted for the manufacture of carpets and rugs, can be consistently produced with the very minimum of change in standard spinning practice.

What I claim is:

1. The process of producing filaments of true I-beam cross-section having a high degree of resiliency and crush resistance and adapted for the manufacture of pile fabrics which comprises extruding a filament-forming solution composed of a cellulose derivative dissolved in a volatile solvent in the form of filaments through a spinneret having rectangular extrusion orifices in which the ratio of orifice length to width is between 1.35 and 1.65 and coagulating the filaments by conducting them through a current of heated evaporative medium.

2. The process of producing filaments of true I-beam cross-section having a high degree of resiliency and crush resistance and adapted for the manufacture of pile fabrics which comprises extruding a filament-forming solution composed of a cellulose organic acid ester dissolved in a volatile solvent in the form of filaments through a spinneret having rectangular extrusion orifices in which the ratio of orifice length to width is between 1.35 and 1.65 and coagulating the filaments by conducting them through a current of heated evaporative medium.

3. The process of producing filaments of true I-beam cross-section having a high degree of resiliency and crush resistance and adapted for the manufacture of pile fabrics which comprises extruding a filament-forming solution composed of cellulose acetate dissolved in acetone in the form of filaments through a spinneret having rectangular extrusion orifices in which the ratio of orifice length to width is between 1.35 and 1.65 and coagulating the filaments by conducting them through a current of heated air.

ROBERT B. HICKEY.