April 5, 1960 C. G. EVANS 2,931,089

METHODS AND APPARATUS FOR PRODUCING YARN

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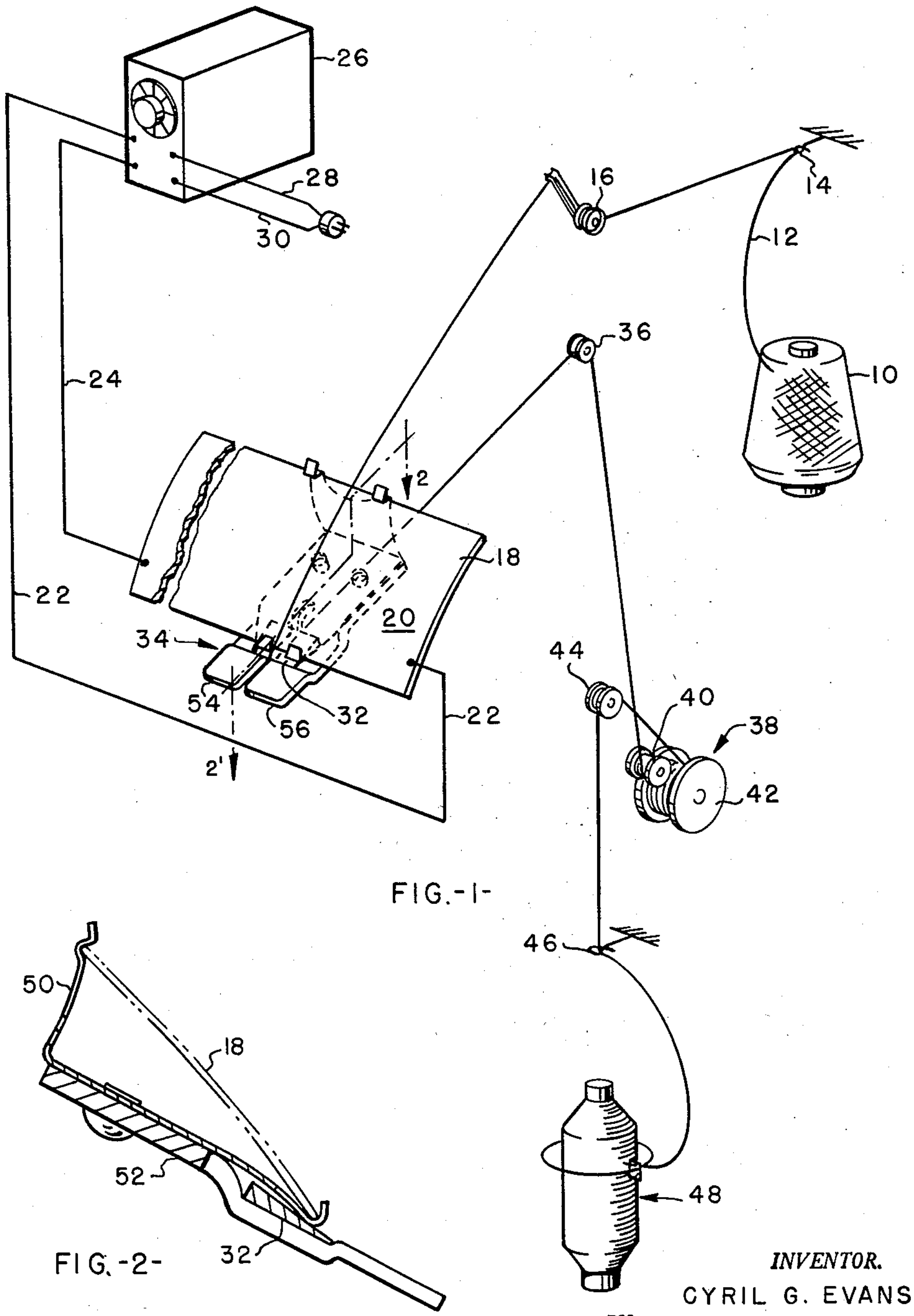

FIG.-1-

FIG.-2-

INVENTOR.
CYRIL G. EVANS
BY Roger R. Jones
ATTORNEY

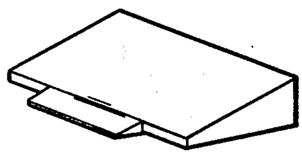

FIG. -3-

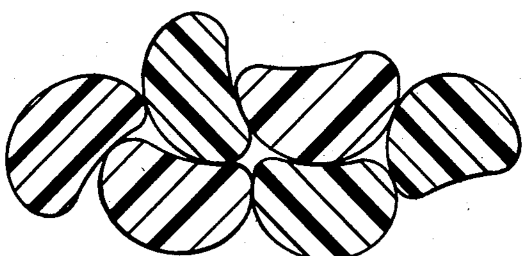

FIG. -4-

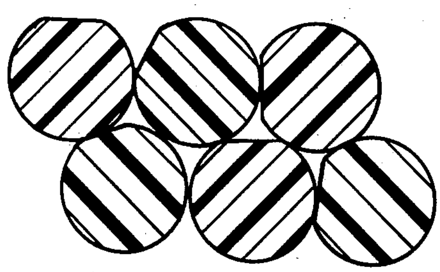

FIG. -5-

INVENTOR.
CYRIL G. EVANS
BY Roger R. Jones
ATTORNEY

United States Patent Office

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METHODS AND APPARATUS FOR PRODUCING YARN

Cyril G. Evans, Clemson, S.C., assignor to Deering Milliken Research Corporation, Pendleton, S.C., a corporation of Delaware

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10 Claims. (Cl. 28—1)

This invention relates to improved methods and apparatus for producing elasticized, bulked or crimped, thermoplastic yarns and more particularly the invention relates to improved blade members and methods employing the same for the introduction of differential transverse stresses into thermoplastic yarns.

It is well known in the art that, under proper conditions, passing a thermoplastic yarn under tension through a linear path having a sharply angular portion will impart to the yarn a generally permanent tendency to coil, crimp or the like, and nontorsionally elasticized thermoplastic yarns are conventionally made in this manner. According to conventional prior art practice, the yarn is forced to undergo an abrupt change of direction by passing it in an angular manner about the edge of a blade or the like, such as a common razor blade. Apparatus utilizing, for example, a common razor blade for the elasticization of thermoplastic yarns constitutes a part of the subject matter of U.S. applications, Serial No. 274,358, filed March 1, 1952 and Serial No. 522,156, filed July 14, 1955, and now abandoned.

When a thermoplastic yarn is passed, under proper conditions, about the edge of a razor blade or the like, the nature of the yarn is modified in at least two respects. In the first place, processing the yarn in this manner results in differential transverse stresses being created in the filaments of the yarn and it is from a release of these stresses that the elasticized yarn derives its tendency to coil. Passing a thermoplastic yarn about a razor blade edge also results in cross sectional deformation of the filaments and a flattening of one side thereof. This effect is encountered with yarns of all types but is especially severe when processing monofilament yarns. In some instances when processing monofilament yarns, the deformation may be so great that the yarn filament becomes crescent shaped in cross section.

Cross sectional deformation of the yarn was once assumed to be an inherent characteristic of edge elasticizing processes and such deformation was assumed to be necessary for a high degree of elasticization. In U.S. application, Serial No. 556,554, filed December 30, 1955, it is disclosed, however, that cross sectional deformation of the yarn is not necessary for a high degree of elasticization and that edge elasticized yarns, wherein the filaments are generally circular in cross section, have several unexpected advantages. According to the method of U.S. application, Serial No, 556,554, a monofilament yarn being elasticized is forced to retain a generally cylindrical shape by at least partially confining the yarn during such time as it is passed through the acutely angular portion of the yarn path.

It has now been unexpectedly found that cross sectional deformation of yarn filaments in an edge elasticizing process appears to be due primarily not to the sharp bending of the yarn but rather to the friction between the yarn filaments and the edge about which the yarn is being passed and according to this invention a blade is employed which presents a very low frictional resistance

to thermoplastic yarns being passed about the blade edge. According to a preferred specific embodiment of this invention a blade is employed which is formed from sintered oxide particles of colloidal size at least about 80% of which are aluminum oxide.

The filaments of yarn produced according to this invention still display a noticeable cross sectional deformation when examined under a microscope, presumably because at least part of the cross sectional deformation in an edge elasticizing process results solely from bending the yarn through a very sharp angle and because even with a blade according to this invention there is still some frictional resistance to passage of the yarn about the blade edge. It has been found, however, that by carefully controlling the tension, the cross sectional deformation of the yarn filaments can be, in each instance, limited so that no more than about 10 to 20% of the peripheral surface of the filament is flattened to such an extent that it has a radius of curvature appreciably above the mean radius of curvature of the peripheral surface of the filament, or to such an extent that the minimum diameter of the filament is less than about 70 to 90% of the maximum diameter. Yarns wherein the filaments have such a cross sectional configuration have the advantages, above mentioned, of a yarn composed of filaments of generally round cross section and do not have to an appreciable degree the disadvantages of yarns composed of filaments of crescent shaped or flattened cross section. For example, yarn composed of filaments having a cross sectional configuration within the above limits can be formed into fabrics having a very dull and uniform appearance and which are devoid of areas having an undesirable sheen. Likewise monofilament yarns having a cross sectional configuration within these limits can readily be passed through a guide or the like without an accumulation of twist on the entry side of the guide so that the yarn can be employed for knitting or the like without resulting in bands and streaks in the finished fabric due to uneven twist distribution in the yarn.

This invention has several advantages over that disclosed in copending application, Serial No. 556,554, above mentioned. A first such advantage is that the process and apparatus of this invention are operable with multifilament strands as well as with monofilament yarns. Still another advantage is that a blade member according to this invention can be readily produced to conform to precise specifications so that there need be no appreciable variation in yarn quality from position to position in apparatus for simultaneously processing a plurality of strands. This is an important advantage since, if there are differences in the quality of the yarn produced by adjacent positions of a multi-position yarn processing apparatus, the yarn from the various positions cannot readily be combined in the formation of fabrics without resulting in areas of different appearance.

A blade member according to this invention can be formed primarily of sintered aluminum oxide particles of colloidal size. The size of the aluminum oxide particles has a definite effect on the properties of the finished blade and, as a general rule, the smaller the initial particle size of the aluminum compound (anhydrous alumina or partially hydrated alumina) used in forming the blade, the more satisfactory is the finished article. Reasonably satisfactory results can generally be obtained when employing particles of the aluminum compound having an average diameter of approximately 50 microns, but for best results, the average particle size should be considerably smaller. For example, the particles of the aluminum compound should generally have an average size of not more than about 15 microns and an average particle size of about 1 to 2 microns is preferred.

In addition to the aluminum compound, the composition from which the blade is formed may also contain small amounts of other metallic compounds and/or acidic oxides and in most instances the presence of certain such compounds is advantageous since they serve as sintering catalysts. These compounds should be evenly distributed throughout the mixture and the particle size should be no larger than that of the aluminum compound. In the case of the metal compounds, either an oxide or a salt which is capable of being largely transformed into an oxide during the sintering operation or, in other words, almost any simple salt of the metal, may be employed. Compounds of the alkali or alkaline earth metals have a catalytic effect and small amounts of one or more such compounds can generally be present to advantage in the mixture from which the blade is formed. Illustrative examples of such compounds are sodium oxide, magnesium oxide or hydroxide, magnesium acetate, magnesium chloride, magnesium chromate and magnesium ammonium chromate. Generally a compound of a metal which forms relatively water insoluble oxides should be employed and compounds of magnesium are preferred. Basic oxides of this type may advantageously be present in amount of at least about 0.2%, on a dry weight basis, but the presence of more than about 8% is seldom, if ever, advantageous. The preferred range is from about 0.4% to 2% on a dry weight basis. Other metallic compounds which may advantageously be present in small amounts, for example from about 0.01 to 1% and preferably about 0.05 to 0.5% in each instance, include iron and titanium oxides or compounds capable of being transformed into the oxides during the sintering operation as illustrated by ferrous acetate and titanium tri-chloride. Other metallic salts or oxides as illustrated by chromic nitrate, vanadous chloride, cobaltous acetate or other derivatives of cromium, vanadium and cobalt may be present in amounts not greater than about 2 or 3% and preferably not greater than about 1% and are sometimes employed to impart color. Acidic oxides which may advantageously be employed in amounts of from about 0.3% to 12% and preferably in amounts of from about 0.5% to 3.0% include boron oxide and silicon dioxide with the latter being preferred. Total amounts of all of the above compounds should generally not exceed 20% of the mixture on a dry weight basis, and the aluminum compound preferably constitutes from about 95 to 99% of the mixture on a dry weight basis.

The aluminum compound employed in the formation of the molding mixture may initially be in the form of anhydrous alumina, partially hydrated alumina or aluminum hydroxide. If, however, aluminum hydroxide or partially hydrated alumina containing more than about 7% combined moisture, is the raw material from which the molding composition is formed, it should be heated, for example at a temperature of from about 500° C. to 1400° C., to reduce the moisture content to not more than about 7% and preferably not more than about 4%, and if such a heating operation is performed, it is then generally necessary to grind the dehydrated material to a suitable particle size for the molding operation.

To mold the blade, sufficient moisture is added to the aluminum oxide mixture to furnish a degree of adhesiveness and the damp mixture is molded under pressure. The amount of moisture in the mixture at this point is not extremely critical but the lower the moisture content, the less is the shrinkage during sintering and the greater is the pressure required for molding. As a general rule, the moisture content should not be so low that more than about 10 tons per square inch of pressure is required for molding nor so high that the shrinkage during sintering is greater than about 10%. As a general rule, a moisture content such as requires about 1 to 6 tons per square inch of pressure for molding is preferred.

The sintering operation can be conducted at any suitable temperature from about 100° C. below the fusion point of the mixture down to about 1400° C. and may be conducted for a period of from 30 minutes to 5 hours or more depending upon the composition employed and the qualities desired in the finished blade. A temperature of about 1500 to 1700° C. for a period of from 2 to 3 hours is generally preferred. By varying the temperature, the time of heating and the rate of cooling, the finished blade can be caused to display almost any degree of microcrystallinity. For example, by sintering at a temperature of at least about 1700° C. for a period of at least about 3 hours and thereafter slowly cooling the blade over a period of several hours, a finished blade which is almost totally microcrystalline can be formed, or by sintering at a temperature below about 1500° C. for a period of no more than about one hour, a blade displaying very little microcrystallinity can be formed. Best results are generally achieved when the sintering is conducted under such conditions that the finished blade member is from about 25 to 75% microcrystalline.

After the blade has been properly sintered, the edge can, if necessary, be polished and ground to a proper radius of curvature. Any suitable abrasive material having a hardness greater than corundum can be employed for this purpose although diamond dust is usually preferred.

The following is an example, according to a presently preferred procedure, for making a blade member according to this invention: Approximately 100 parts of alumina having an average particle size of about 2 microns are placed in a mixer and 1 part of silica, 1 part of magnesium hydroxide, 0.1 part of titanium hydroxide and 0.1 part of iron oxide, in each instance in finely divided form, are added. After the materials are thoroughly mixed, 50 parts of water are added and the mixing continued until the mixture is of uniform consistency. The mixture is then dried for 30 minutes at about 100° C. and the dried mixture is pulverized to as great an extent as is feasible. Approximately 900 mg. of this mixture is then placed in a mold at 6 tons per square inch pressure and is molded into a blade member approximately 0.5 inch long, 0.38 inch wide and 0.12 inch thick at the thickest point. The blade is then heated at 1600° C. for 2 hours and cooled over a period of about 1 hour. The edge of the blade is then polished with diamond dust to a radius of curvature of approximately 4 ten-thousands of an inch.

Procedures for forming shaped articles from aluminum oxide particles by sintering, as well as suitable compositions for this purpose, are well known to those skilled in the art and no improvement in the basic process of sintering or in compositions suitable for this purpose is intended to constitute a part of this invention. For this reason, the description has been made as brief as possible and for further details, reference may be made to the published patents on this subject as illustrated by U.S. Patents 2,391,454, 2,427,454 and Re. 22,648.

One embodiment of the invention will now be described with reference to the accompanying drawings in which:

Figure 1 is a schematic view in perspective of yarn elasticizing apparatus according to this invention showing principal parts in location;

Figure 2 is a cross sectional view taken along the line 2—2' of Figure 1 of the drawings;

Figure 3 is a perspective view of the blade member of Figure 1;

Figure 4 is a cross sectional view of several prior art edge elasticized monofilaments;

Figure 5 is a cross sectional view of several monofilaments elasticized according to this invention.

With particular reference to Figures 1 and 2 of the drawings, there is illustrated a yarn supply means **10** mounted on a suitable frame or support member not illustrated. A yarn end, indicated by the reference numeral **12**, passes from supply package **10** through a guide **14**, and to a tension regulating device indicated by the reference numeral 16. The tension regulating device 16 serves to remove fluctuations in tension resulting from the removal of the yarn from supply package 10 and to further tension the yarn 12, while the guide 14 is to permit removal of the yarn from the yarn supply package in an overend manner. From the tension regulator 16, the yarn passes into contact with a yarn heater 18 which is illustrated as comprising a relatively narrow elongated plate or strip and which may be formed from any suitable material such as stainless steel. The upper face, indicated by the reference numeral 20, of the heater strip is preferably convexly curved to a radius of about 4 to 10 inches so that continuous contact of the yarn therewith is obtained. The heater strip 18 should be of sufficient width to result in an end of yarn drawn thereover being heated to the desired temperature and is adapted to be heated by means of an electric current passed therethrough. For this purpose there is provided a pair of electric conductors 22 and 24 which are connected to a variable transformer 26 supplied with power from any suitable source not illustrated through leads 28 and 30.

After passing over the face 20 of heater strip 18, the yarn end 12 passes about the edge of a blade member 32 carried by a blade holding means 34 which will subsequently be described in greater detail. The yarn end is then passed in contact with the bottom face of the blade 32, to a guide roller 36 and thereafter to a yarn feeding or transporting device generally indicated by the reference numeral 38 and illustrated as comprising a pair of driven capstans or rolls 40 and 42. The yarn passes one or more times about rolls 40 and 42, then about an idler roll 44 and thereafter through a guide 46 to a conventional yarn takeup means 48 here illustrated as comprising a ring and spindle array. The yarn is then collected by the takeup means 48 in form of a conventional yarn package.

The blade holding means 34 comprises an elongated clip member 50 which may be formed of any suitable resilient material and which extends across the back face of the heater strip 18. A heat dissipating member or plate, generally indicated by the reference numeral 52, is attached to clip member 50 by any suitable means and is provided with a suitable indentation for holding the blade member 32. One end of plate member 52 is bifurcated, as will be clearly seen in Figure 1 of the drawings, to form a pair of extending legs 54 and 56 and so that an end of yarn may be drawn over the heater strip 18, and about the edge of blade member 32 between the two legs. Plate member 52 serves not only to precisely position the edge of blade member 32 with respect to heater strip 18 but also serves to conduct heat away from the blade member and retain it at a relatively low temperature with respect to the heater strip. The particular construction of the blade holding means, however, constitutes no part of the present invention and, in fact, a blade holder such as described constitutes a part of the subject matter of U.S. application, Serial No. 547,682, filed November 18, 1955.

In operation, an end of yarn from supply package 10 is threaded through the apparatus in the manner previously described so that it is in contact with the upper yarn engaging surface of the heater strip 18 and passes about the edge of blade member 32 in a sharply angular manner. With the heater strip at a proper operating temperature, the yarn advancing means 38 and the collecting means 48 are placed in operation so that the yarn is drawn through the yarn path at a proper operating linear velocity. Tension regulator 16 is then adjusted so that the yarn passing about the blade edge is at a proper operating tension. The apparatus thereafter operates without further attention unless the yarn end breaks or unless a yarn supply becomes depleted.

With reference to Figure 3 of the drawings, there is illustrated a blade means of a design which has proven quite satisfactory. It will be noted that the blade is substantially wedge shaped except that two small indentations have been made in two corners of the blade to reduce the length of the sharpened edge. The sharpened edge need only be of sufficient length to provide contact with the yarn and a short edge can be more readily ground with precision than could an edge extended the full length of the blade. The included angle between the two converging faces of the blade is illustrated as being approximately 15° but may vary within wide limits, as long as the angle of convergence is sufficient to permit a proper yarn path, and satisfactory results may be achieved when employing blade members having faces which converge at angles of from about 5 to 90°. Preferably the angle between the two converging faces of the blade should be from about 10 to 40°.

When a thermoplastic yarn is elasticized by a procedure which comprises passing the same about a blade member, the radius of curvature of the blade edge is an important consideration and, as a general rule, the smaller the radius of curvature of the edge, the greater is the elasticity of the processed yarn, however it is not usually advantageous to attempt to provide a blade according to this invention with an edge having a radius of curvature less than about 6 microns, since with very sharp blade edges, chipping becomes a severe problem, and because of chipping, a blade edge having a radius of curvature of at least about 8 microns is generally preferred. The maximum satisfactory radius of curvature for the blade edge depends upon the size of the yarn filaments in the yarn being elasticized, and as a general rule the radius of curvature of the blade edge should be no more than about four times the diameter of the yarn, and is preferably less than the diameter of the yarn. For example, with 15 denier monofilament yarn, the radius of curvature of the blade edge should be no greater than about 150 microns, and for best results the radius of curvature should be less than about 30 microns. With yarns having smaller diameter filaments, such as 70 denier, 34 filament nylon, the radius of curvature is preferably even less, and best results are achieved with a blade having a radius of curvature of no more than about 15 microns. In view of these considerations, it can be seen that the preferred range for the curvature of the blade edge is from about 8 to 15 microns.

The apparatus and method of this invention may be employed for processing any yarn which is conventionally elasticized by an edge elasticizing technique and in processes employing a blade according to this invention the process variables may advantageously be given conventional values for the particular type of yarn employed. For example, the included angle between the yarn approaching the blade edge and the yarn departing the blade edge may vary from about 120° to 10° or even less if the angle of grind of the blade member permits, and as a general rule, the smaller the included angle between the approaching and departing yarn, the higher the degree of elasticization obtained. In some instances, however, it may be advantageous to make the angle of approach relatively large, for example from 30° to 100°, so that the yarn may be more readily heated to a proper temperature at the time it contacts the blade edge, and to make the angle of departure relatively small so that the departing yarn may be passed against the face of the blade for more repaid cooling.

The linear rate of travel of the yarn about the blade edge and the tension in the yarn as it passes about the edge may also be conventional. For example, the linear velocity of the yarn may vary from about 1 to 600 yards per minute, and the tension in the yarn passing about the blade edge may vary from about 0.05 to 2.5 grams per denier depending upon the type of yarn employed. It should be emphasized at this point that the tension referred to is the tension in the yarn immediately following its passage about the blade edge, or in other words, the output tension in the yarn. The tension in the yarn immediately preceding its contact with the blade edge is not conventionally measured because of the difficulties involved, but is considerably higher according to this invention than when employing prior art apparatus because less tension is imparted to the yarn in passing about the blade edge in the apparatus of this invention. This means that the input tension regulator may be set to impart considerably more tension to the yarn in the apparatus of this invention than with conventional apparatus and this is a distinct advantage, particularly when a yarn heater is employed, since the higher tension results in more uniform and constant contact of the yarn with the surface of the heater.

The yarn passing about the blade edge is preferably at a temperature such as is conventional for the yarn at this point in the yarn path and, depending upon the type of yarn being elasticized and other factors, this temperature may vary from room temperature up to a temperature approaching the sticking temperature of the yarn. For nylon yarns, elevated temperatures are generally advantageous and the preferred temperature range is generally from about 280° F. to 380 °F. The yarn, if passed about the blade edge at an elevated temperature, should be cooled as rapidly as possible after contact with the edge to a temperature below about 180° F.

Having thus described my invention, what I desire to secure and claim by Letters Patent is:

1. Apparatus for elasticizing a thermoplastic filamentary yarn comprising in combination a yarn supply means, a yarn takeup means, means for withdrawing an end of yarn from said supply means and for advancing the same under tension over a linear path to said take-up means, and a blade member positioned adjacent the yarn path, said blade member having an edge about which the yarn is drawn to cause it to follow an acutely angular course, said edge having a radius of curvature not greater than about four times the diameter of the yarn to be elasticized and said blade member being formed primarily of unfused aluminum oxide particles sintered together and forming a coherent mass, said aluminum oxide particles having an average maximum diameter of not more than about 50 microns.

2. The combination with a yarn supply means, a yarn take-up means and means to withdraw an end of yarn from said supply means and to advance the same under tension through a linear path to said take-up means; of a blade member positioned adjacent the yarn path, said blade member having an edge about which the yarn is drawn to cause it to follow an acutely angular course, said edge having a radius of curvature of not more than about 150 microns and said blade member being formed of aluminum oxide particles sintered together and forming a coherent mass, said aluminum oxide particles constituting at least about 80% of the mass of said blade member, and said aluminum oxide particles having an average maximum diameter of not more than about 15 microns.

3. A combination according to claim 2 wherein said edge has a radius of curvature of from about 6 to about 30 microns, said aluminum oxide particles constitute at least about 95% of the mass of said blade member, and said aluminum oxide particles have an average maximum diameter of not more than about 2 microns.

4. A combination according to claim 3 wherein said blade member additionally contains an acidic oxide and an alkaline earth metal oxide, said acidic oxide being selected from the group consisting of boron oxide and silicon dioxide.

5. A combination according to claim 4 wherein said acidic oxide is silicon dioxide and said metal oxide is magnesium oxide, said silicon dioxide constituting from about 0.5% to 3.0% of the mass of said blade member and said magnesium oxide constituting from about 0.4% to 2.0% of the mass of said blade member.

6. A blade member for use in apparatus for elasticizing continuous filament thermoplastic yarns, said blade member having an edge with a radius of curvature not greater than about 4 times the diameter of the filaments in the yarn to be elasticized, and said blade member being formed from a non-fused, non-porous ceramic material comprising coherent, agglomerated particles of alumina, said particles of alumina having an average diameter of not more than about 15 microns and said particles of alumina constituting at least about 95% of the mass of said blade member.

7. A blade member according to claim 6 having an edge with a radius of curvature of from about 6 to 30 microns.

8. In a method for elasticizing thermoplastic yarns wherein an end of the yarn is passed under tension through a linear path and about the edge of a blade member to cause the yarn to undergo an acute change of direction, the improvement which comprises employing a ceramic blade formed of a material having a reduced, as compared to steel, coefficient of friction relative to said yarn, whereby the cross-sectional deformation of the yarn is appreciably less than is obtained with a steel blade.

9. A process according to claim 8 wherein said blade edge has a radius of curvature of from about 6 to 30 microns and said blade is formed of coalesced particles of ceramic materials sintered together to form a cohesive, non-porous mass, said blade member being composed at least about 95% by weight of aluminum oxide.

10. A process according to claim 9 wherein said blade additionally contains from about 0.5% to 3.0% by weight of magnesium oxide and from about 0.4% to 2% by weight of silicon dioxide.

References Cited in the file of this patent

UNITED STATES PATENTS

2,427,454	Heany	Sept. 16, 1947

FOREIGN PATENTS

558,297	Great Britain	Nov. 29, 1945