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2,866,256

WOOL-LIKE ARTIFICIAL FIBERS

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Fig. 1

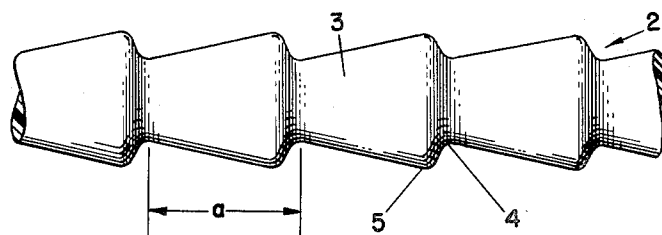


Fig. 2

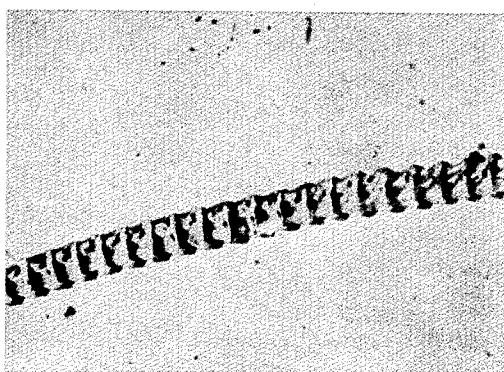


Fig. 3

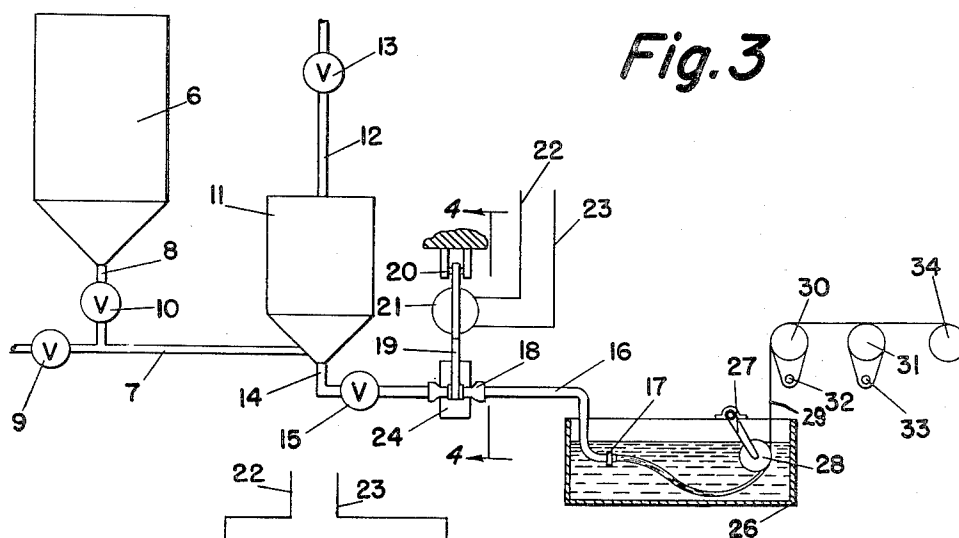
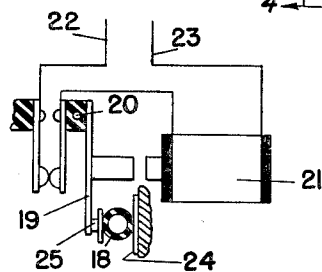


Fig.4



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WOOL-LIKE ARTIFICIAL FIBERS

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15 Claims. (Cl. 28—82)

This invention relates to new artificial fibers and filaments having certain wool-like characteristics including a multiplicity of adjoined small sections extending longitudinally of the individual fibers and having their outer surfaces unidirectionally tapered between their junctions.

Various attempts have been made heretofore to reproduce in artificial fibers the scaly surfaces of wool so that certain characteristics of natural wool could thereby be achieved such as felting, which depends on the overlapping scales of natural wool fibers. British Patents 299,291 and 300,221 disclose imparting pulsations in the flow of the spinning dope and state that by directing the emission from the spinneret in the line of flow of the coagulating medium there are produced fluctuations in the fiber diameter, "the change in diameter being more sudden on one side of the swelling than on the other." However, when conventional spinning solutions, such as those of viscose and cellulose acetate are spun in the fashion disclosed by the patent, the difference in taper on opposite sides of the swellings is negligible and this has been found to be true over a wide variety of coagulating bath speeds.

German Patent 740,270 in referring to prior attempts, including that of the British patents above, states that they failed. This patentee applies high frequency ultrasonic vibration to a viscose spinning solution and produces a fiber having longitudinal sections each of 0.01 mm. length, alternate ones of which increase in diameter while intervening sections decrease in diameter. The fibers do not have an unidirectional taper but have a series of ripples, each consisting of a section 0.01 mm. in length (longitudinally of the fiber) gradually increasing in diameter joined at its large end by a section 0.01 mm. in length of gradually decreasing diameter, the taper of these sections being essentially equal.

The same sort of wavy surface is apparently obtained on viscose staple fiber by Delamare-DeBoutteville (U. S. Patent 2,549,179) as disclosed in Figs. 1 and 2 of the publication Kunstseide und Zellwolle, vol. 28, page 118 (1950).

In accordance with the present invention, artificial filaments and fibers are produced which have a multiplicity of adjoined small sections extending longitudinally of the individual fibers and having their outer surfaces essentially unidirectionally tapered between their junctions.

Fig. 1 of the drawing shows the appearance of an artificial fiber of the present invention as it appears when viewed laterally, and

Fig. 2 is a reproduction of an actual photomicrograph (approximately on a scale of 40X) of a fiber obtained in accordance with the present invention,

Fig. 3 is a somewhat diagrammatic elevation of one embodiment of an apparatus adapted to produce the fibers of the present invention, and

Fig. 4 is a section on line IV—IV of Fig. 3.

Fig. 1 shows the characteristic structure of a fiber 2 having a plurality of short sections 3 each of length a and having a gradual increase in diameter from one end having a cross-section of minimum diameter at 4 and a cross-section of maximum diameter at 5, the plane of the latter cross-section being closely adjacent to one end

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of the section 3 so as to provide a steep slope in the contour as viewed in Fig. 1 to the latter end and a gradual slope in the contour to the other end of the section 3. The planes of the maximum and minimum diameter sections are generally perpendicular to the main axis of the fiber 3 but they may also be inclined from the perpendicular. The latter relationship may be effected by directing the coagulating bath against one side of the filament-forming stream as it is extruded from the orifice or by using spinnerets whose exterior surfaces are inclined from the perpendicular to the spinneret axis.

The present invention is based on the discovery that when rapid fluctuations in pressure are imposed on a film-forming medium of thixotropic character during its extrusion through one or more orifices of a spinneret into a coagulating bath where coagulation is rapidly effected, the diameter of each filament-forming stream emerging from an orifice is suddenly enlarged on each increase in pressure but decreases only gradually during each intervening decrease in pressure. This combination of sudden increase and gradual decrease in diameter is not obtained with such conventional spinning media as viscose solutions and solutions of cellulose acetate in acetone which are not thixotropic, but has been found to be characteristic of thixotropic spinning media, apparently the inherent result of the shear-dependent viscosity variation characteristic of such thixotropic media. As used herein, a "thixotropic" medium is one in which the viscosity coefficient drops as the shear force or rate is increased.

The velocity of extrusion of the film-forming medium may vary widely such as from 1 to 300 meters per minute and the frequency of the pressure fluctuations or pulsations imparted to the spinning dope is correlated to the speed of spinning to provide the length of the individual tapered sections that is desired. To obtain a wool-like characteristic that is capable of rendering the fibers feltable, the section length (a in Fig. 1) may be from 1 to 2000 μ or 0.001 to 2 mm. Preferably, the sections may have a length of 10 to 100 μ or 0.01 to 0.1 mm. In natural wools, the exposed portions of the scales generally have a length of 0.01 to 0.04 mm. The section length a of the actual fiber from which Fig. 2 was obtained was approximately 0.1 mm. The difference in large and small diameters at 4 and 5 adjacent to the ends of any given section may amount to 1% to 20% or more of the large diameter but preferably it amounts to at least 5% up to about 20% of the large diameter. This difference in diameter is controlled by variation in the intensity or amplitude of the pressure fluctuation.

The relative lengths of the two portions of any given section having opposite slopes varies not only in dependence on length a and the difference in diameters at 4 and 5 but also on the thixotropic character of the spinning medium. To obtain adequate steepness of the short slope to provide efficient felting properties, the spinning medium should preferably have a viscosity of 1500 to 4000 centipoises at 6 R. P. M. (Brookfield) and 200 to 1000 cps. at 60 R. P. M. when determined under conditions of spinning, that is as to concentration, pH, and the like.

The linear rate of draw-off of the fiber formed may vary widely but the permissible upper limit depends on the basic speed of extrusion, that is the linear speed at which the film-forming medium would flow through the orifice or orifices of the spinneret if the fluctuation in pressure (and consequent fluctuation in velocity) were omitted. This basic speed of extrusion can be determined by controlling the normal or basic pressure head exerted on the spinning dope in forcing it to the spinneret which may be obtained by various arrangements, such as a constant speed gear pump, by pneumatic or hydraulic pressure exerted on a spinning dope supply or storage

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tank; or by the hydrostatic head of the spinning dope in such a tank. The fluctuation in pressure required for producing the fibers in accordance with the present invention is superimposed on the basic pressure by means described hereinafter so that the pressure is alternately higher than and equal to the basic pressure. Generally, the linear speed of draw-off of the fiber should be substantially less than the maximum linear speed of flow of the film-forming medium through the orifice or orifices of the spinneret. The best results are generally obtained when the rate of draw-off is approximately equal to the basic speed of extrusion or less. Good results are also obtained when there is no exertion of any external withdrawing force on the extruded filament-forming streams so that removal from the spinneret is effected entirely by virtue of the extrusion forces.

The median diameter of the fibers may be determined by correlating the size of orifice with the basic speed of spinning. Spinnerets having one or more orifices of the conventional diameter may be employed, such as from 1 to 5 mils diameter for producing low denier filaments and larger diameters, such as up to 1 or 2 mm. for the production of larger monofilaments. The fibers produced thereby may have a denier of from 1 to 5 for normal textile use, from 5 to 20 for the production of pile yarns in carpets and the like and of greater denier from 20 to 100 or even several hundred to provide corresponding fibers and monofilaments.

Any liquid coagulating bath that is capable of rapidly coagulating the spinning medium may be employed. The particular constitution of a coagulating medium cannot be stated generally for all spinning media since the particular spinning medium employed in any given case may require a particular coagulating medium or one of several such coagulating media, whereas another spinning medium would require a different coagulating bath or one of several different coagulating media.

Figs. 3 and 4 illustrate somewhat diagrammatically an apparatus that is adapted to produce the fibers of the present invention when a thixotropic spinning medium is used. One or more supply vessels 6 containing the spinning medium or dope is or are connected to a pipe or header 7 by means of branch conduits or pipes 8. One or more valves 9 in the header 7 and a valve 10 in each of the branch pipes 8 provide means for selectively connecting one or more supply tanks 6 to the header or conduit 7. The conduit 7 is connected to a spinning tank 11 which, in the specific instance shown is at a lower level than the supply tank or tanks 6. Spinning tank 11 is provided at its top with a connection to a conduit 12 provided with a pressure regulating valve 13 and connected to a suitable source of compressed air. The valve 13 makes it possible to control the pressure in the vessel 11. Spinning tank 11 is provided with a discharge connection to a conduit 14 which is provided with a control valve 15. The conduit 14 is connected to a feed pipe or so-called "rounder" 16 which carries one or more spinnerets 17 containing one or more orifices. As shown, the conduits 14 and 16 are of rigid material and they are connected together by means of a flexible pipe or tubing 18. This flexible tubing provides a chamber through which the spinning medium must pass on its way to the spinneret and in which the spinning medium may be subjected to suitable vibration means which serves to impart a pulsating pressure to the spinning medium. As shown in Figs. 3 and 4, this vibration means comprises an armature 19 pivotally mounted at 20 and extending in proximity to an electromagnetic means 21, which is connected by wires 22 and 23 to a suitable source of direct or alternating current. A rigid plate 24 may be fixedly disposed against the back wall of the flexible tubing 18 so as to insure that the motion of the armature 19 imparted to the tubing is converted into a pressure fluctuation and not merely to a sidewise motion of the tubing as a whole.

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As shown, the outer end of the armature 19 normally rests against the flexible tubing 18 and may be provided at its terminus with a knob 25 in contact with the tubing.

While a simple electromagnetically-controlled vibrating armature 19, such as the type used for doorbells and buzzers, is shown, any other vibrating means may be substituted. When high speeds of spinning are employed and it is desirable to have a high frequency in the vibration, an ultrasonic generator may be employed having a frequency of 50,000 to several hundred thousand cycles per second. Any suitable ultrasonic system may be used and especially those based on magnetostriction devices.

The point at which the vibration is exerted upon the spinning medium, so that pressure fluctuations are introduced within it as it flows through the spinneret, is preferably reasonably close to the spinneret so that the pulsations in pressure imparted are not damped out before the spinning medium leaves the orifices of the spinneret. The distance that the vibration means may be disposed away from the spinneret may be increased in proportion to the rigidity of the connections or conduits through which the spinning medium flows in approaching the point where the vibration is exerted upon the spinning medium and in passing from that point to the spinneret. The more rigid these connections or conduits, the greater the distance from the spinneret that the point where the vibrations are imposed on the spinning medium may be put. A gear pump may be used to provide the basic or constant pressure. For this purpose, it should be mounted in line 14 so that the vibrating means will be positioned between the pump and spinneret.

The spinneret 17 is disposed in a coagulating liquid or both contained in the vessel 26 which may be a trough or other open-topped receptacle containing a plurality of such spinnerets. A bracket 27 may support a rotary spool-shaped guide 28 about which the fibers 29 may be drawn as they proceed to a godet 30. The godet 30 is driven positively at a peripheral speed which is correlated as stated above so as not to exceed the permissible speed of draw-off from the spinneret. From the godet 30, the filaments may be advanced to a second godet 31 and hence to any number of stations where liquid or any other treating material may be imposed on the filaments, such as hot air for drying and ultimately to a collecting device, such as a bobbin 34, on which the filaments or fibers may be wound. The godets 30 and 31 are shown as associated with adjacent guides 32 and 33 respectively which are mounted on axes inclined to the axes of godets 30 and 31 so that successive laps of bundle or yarn filaments, as they proceed about the periphery of each godet-guide system, are displaced laterally in succeeding wraps therearound. Instead of the godet-guide system shown, any other thread-advancing, thread-storage device or reel may be employed. The thread-advancing device or godet-guide system 31, 33 may be driven at higher peripheral velocity than the preceding device 30, 32 so as to stretch the filaments as they proceed from the latter to the former.

The frequency of vibration of the vibrating means is correlated with the velocity of extrusion of the spinning medium through the orifice or orifices of the spinneret to provide the distance *a* (Fig. 1) within the range specified hereinabove. The amplitude of the vibration may be controlled to provide any predetermined difference in diameters at 4 and 5 respectively, and the thixotropic nature of the spinning medium may be pre-selected to vary the steepness of the slopes of the oppositely inclined faces of each section 3 of the filament.

Any thixotropic spinning medium may be employed. Particularly suitable and useful thixotropic spinning compositions are the aqueous dispersions of water-insoluble polymers of monoethylenically unsaturated compounds containing in the polymer molecule from 1% to 25% by

weight of units containing hydrophilic groups, such as carboxyl groups, either free or in salt form (in which case they may be termed carboxylate salt groups), including alkali metal, ammonium, and amine salts wherein the amine is of water-soluble type including methylamine, dimethylamine, trimethylamine, diethanolamine, and so on. Other hydrophilic groups may be amine groups or alkyl, aralkyl, or aryl-substituted amine groups (such groups being in the form of free base amine or as aminium salts), amide groups or alkyl, aralkyl or aryl-substituted carbonamide groups, and hydroxyl groups. The proportion of hydrophilic groups in the copolymer should be sufficiently low so that the fibers obtained are not undesirably water-sensitive. Generally, this requirement is met if the copolymer containing such hydrophilic groups is water-insoluble. Preferably, the copolymer contains 1% to 5% of hydrophilic units, this proportion assuring high resistance to water in the fibers thereof while still providing the necessary thixotropic character in the spinning dope.

The polymer should be of linear thermoplastic character and may have a T_g of 0° to 150° C. The T_g is the apparent second order transition temperature and is defined as that temperature at which the first derivative of thermodynamic variables, such as coefficient of expansion or heat capacity, changes abruptly. This transition temperature is an inflection temperature which is conveniently found by plotting the modulus of rigidity against temperature. A convenient method for determining such modulus and transition temperature is described by Williamson, British Plastics 23, 87-90. The T_g values here used are generally those temperatures at which the modulus is 300 kg./cm.².

These aqueous copolymer dispersions may advantageously be formed by the emulsion polymerization of one or more monoethylenically unsaturated compounds, such as vinyl acetate, vinyl chloride, acrylonitrile, methacrylonitrile, styrene, vinyl styrene, ethylene, isobutylene, chlorotrifluoroethylene, vinylidene chloride, or esters of various acids, such as acrylic acid, methacrylic acid, itaconic acid, citraconic acid, aconitic acid, maleic acid, fumaric acid, crotonic acid and the like with aliphatic or arylaliphatic alcohols having from 1 to 18 or more carbon atoms.

The emulsion copolymerization may be effected in the presence of one or more emulsifying agents either of anionic, non-ionic, or cationic type, including mixtures of a non-ionic type with either an anionic or cationic type in the presence of the conventional initiators, accelerators, and promoters, commonly termed "catalysts," for effecting the polymerization.

The polymer units containing the hydrophilic groups may be obtained by including as a portion of the monomer mixture from which the polymer is obtained the proper proportion of monoethylenically unsaturated monomers containing such groups, such as in the case of carboxyl groups, acrylic acid, methacrylic acid, itaconic acid or any other of the acids mentioned above, in connection with their esters. Examples of monomers containing amino groups include N,N-dimethylaminoethyl acrylate or methacrylate, N-tert-butylaminoethyl acrylate or methacrylate, morpholinoethyl acrylate or methacrylate, β -aminoethyl vinyl ether and the like. Examples of comonomers containing amide groups include acrylamide, methacrylamide, the diamides of itaconic, maleic and fumaric acids and the like and the half-ester/half-amides or the half-acid/half-amides of the last di-acids and their substituted derivatives, such as N-methyl acrylamide, N,N-diethyl acrylamide, and N-benzyl methacrylamide.

The units in the polymer containing hydrophilic groups may also be obtained by chemical reaction with or on a polymer or copolymer containing no such groups. For example, copolymers containing hydroxyl groups may be obtained by saponification of an aqueous dispersion

of polyvinyl acetate or of copolymers containing any proportion of polyvinyl acetate. Similarly, carboxyl groups may be introduced by hydrolysis of polymers containing esters of such unsaturated acids as acrylic acid, methacrylic acid, and so on. Similarly, amide groups may be introduced by the aminolysis of the latter types of copolymers.

A preferred group of comonomers adapted to form the larger portion of the copolymer molecule are the esters of acrylic acid or methacrylic acid and, particularly, the lower alkyl esters having from 1 to 4 carbon atoms in the alkyl portion thereof.

Examples of emulsifiers that may be used include alkylphenoxypolyethoxyethanols having alkyl groups of about seven to eighteen carbon atoms and 2 to 60 or more oxyethylene units, such as heptylphenoxypolyethoxyethanols, octylphenoxypolyethoxyethanols, methyl-octylphenoxypolyethoxyethanols, nonylphenoxypolyethoxyethanols, dodecylphenoxypolyethoxyethanols, and the like; polyethoxyethanol derivatives of methylene linked alkyl phenols; sulfur-containing agents such as those made by condensing 2 to 60 or more moles of ethylene oxide with nonyl, dodecyl, tetradecyl, t-dodecyl, and the like mercaptans or with alkylthiophenols having alkyl groups of six to fifteen carbon atoms; ethylene oxide derivatives of long-chained carboxylic acids, such as lauric, myristic, palmitic, oleic, and the like or mixtures of acids, such as found in tall oil containing 2 to 60 oxyethylene units per molecule; analogous ethylene oxide condensates of long-chained alcohols, such as octyl, decyl, lauryl, or cetyl alcohols, ethylene oxide derivatives of etherified or esterified polyhydroxy compounds having a hydrophobic hydrocarbon chain, such as sorbitan monostearate containing 2 to 60 oxyethylene units, etc.; block copolymers of ethylene oxide and propylene oxide comprising a hydrophobic propylene oxide section combined with one or more hydrophilic ethylene oxide sections. Suitable anionic agents include higher fatty acid soaps, such as sodium oleate, laurate, palmitate, and stearate, the sulfates of higher fatty alcohols and their alkali metal salts, such as sodium lauryl sulfate; aryl and/or alkyl substituted phenol sulfonates; sulfonated alkylphenoxypolyethoxyethanols having from 1 to 5 oxyethylene units per molecule; sulfonated higher alkyl succinates, such as di-t-octyl sodium sulfosuccinate. Suitable cationic agents include quaternary ammonium compounds having at least one long-chain hydrocarbon group on the quaternary nitrogen, such as dodecylpyridinium chloride, sulfate, phosphate, or the like, trimethyloctadecylammonium chloride, didodecenyldimethylammonium chloride, etc.

The emulsifier may be pre-selected to assist in the rapid coagulation when particular types of coagulating baths are intended to be used. For example, an anionic emulsifier, such as sodium oleate, which is sensitive to acid, may be employed when an acid spinning bath is to be used.

The coagulating baths used for these various spinning media may be aqueous solutions of organic solvents, such as ethanol or acetone which break the dispersion; they may be acid baths containing a mineral acid like hydrochloric or sulfuric acid or an organic acid such as acetic, propionic; or, in many cases, the baths may be alkaline, such as solutions of caustic soda, caustic potash, or potassium or sodium carbonates. Aqueous salt solutions may also be used as coagulating baths, especially highly concentrated or saturated solutions thereof. The salt solutions, such as of sodium chloride or sulfate, are particularly useful with polymers containing hydroxyl groups or amide groups whereas the acid and alkaline baths are generally most useful with spinning dispersions which contain polymers having carboxyl groups or amine groups therein. The temperature of the coagulating baths may be anywhere from 0° to 100° C. or higher but short of the boiling point of the coagulating bath.

A. temperature of 40° to 100° C. is a quite suitable range with acid baths containing from 1% to 10% and possibly from 2% to 5% of the acid, such as hydrochloric or sulfuric acid, which baths may or may not contain salts of such acids and particularly the alkali metal or ammonium salts thereof. In any case, a temperature of 95° to 100° C. is generally preferred for the spinning bath. When salt and alkaline baths are used, they also may be advantageously used at the higher portion of the broad temperature range cited.

The temperature of the spinning medium may vary from 0° C. up to 100° C. or more, but in all cases short of the boiling point since boiling generally breaks the dispersion. The higher the temperature of the spinning medium, however, the more rapidly it may be coagulated and, for this reason, the higher temperatures may be preferred where it is convenient to impose such temperatures on the spinning medium. For most practical purposes, however, the temperature of the spinning medium will usually be from 15° to 40° C. Generally, also the thixotropy is most pronounced at room temperature or thereabout so that for this reason the narrower range specified is generally preferred.

The concentration of the aqueous dispersion may be from 10% to 70% resin solids and is preferably from 25% to 60% resin solids.

The filaments or fibers may be stretched after removal from the coagulating bath as between godet or thread-advancing systems. While stretching may be sufficient to elongate the filaments as much as several hundred percent, it generally is preferable to stretch a moderate amount of about 20% to 100% in length to avoid excessive reduction in the slopes of the tapered surfaces of the unit section 3. If desired, the thermoplastic copolymers may be subjected to reagents which are capable of cross-linking the polymer molecule and this cross-linking action may be effected before, during, or after the stretching. Simply heating the fibers, when formed of polymers containing certain units, such as those obtained from glycidyl methacrylate or acrylate may be used to effect cross-linking thereof. Any other treatment of chemical, physical, or physico-chemical nature, including crimping, curbing, or crinkling operations, may be imposed upon the filaments before or after they are collected on the bobbin or other collecting device 34, such as washing, bleaching, dyeing, or the like.

If desired, pigments, dyes, or delusterants may be incorporated into the aqueous dispersion so as to produce delustered yarns or what are commonly known in the art as "spun-dyed yarns."

Instead of collecting the filaments on a bobbin, they may be collected in a centrifugal spinning pot so as to be twisted simultaneously with their initial collection. Instead of collecting the filaments on a bobbin or in a centrifugal pot, they may be instead cut into short lengths to form what is commonly termed "staple fiber." The yarns whether collected as continuous filaments on bobbins or in centrifugal spinning pots may be subsequently further twisted or subjected to stretch breaking and spinning operations to form continuous filament yarns or broken fiber yarns. Alternatively, the filaments and twisted yarns either of continuous or broken-filament type may be doubled with each other to form plied structures useful as tire cords. The staple fiber may be subjected to the usual fiber spinning operations.

In the following examples, which are illustrative of the present invention, the parts and percentages are by weight unless otherwise indicated:

Example 1

An aqueous dispersion containing 46% by weight of the ammonium salt of a copolymer of about 66% ethyl acrylate, about 33% of methyl methacrylate, and about 1.5% of methacrylic acid is prepared by emulsion co-

polymerization in the presence of a non-ionic emulsifier (t-octylphenoxypolyethoxyethanol containing about 10 oxyethylene units). This aqueous polymer dispersion is supplied to the tank 6 of an apparatus essentially constructed as shown in Fig. 3.

The pressure to which the spinning dispersion in tank 11 is subjected by the compressed air supply is 40 lbs./in. gauge resulting in a basic linear speed through the spinneret orifices of 0.5 meter/sec. The vibrating device is supplied with 60 cycle alternating current at 12 volts. The filament streams extruded from the spinneret are allowed to completely relax in the coagulating bath before being removed therefrom so that for all practical purposes, no draw-off tension or force is applied to the filaments or filament-forming streams as they pass into and through the coagulating bath. The coagulating bath is a solution of 2% hydrochloric acid in water at a temperature of approximately 98° C. to 100° C. The fibers obtained after drying the filaments have the form shown in Fig. 2 of the drawing and the distance *a* (Fig. 1) is approximately 0.1 mm.

Example 2

The procedure of Example 1 is repeated in a system wherein a gear pump is disposed in a rigid feed line to the spinneret within about 12 inches from the spinneret and, instead of using the vibrator system comprising elements 19 and 25 of Figs. 3 and 4, a magnetostrictive ultrasonic generator is mounted in a bend of the feed line just before the spinneret so that the oscillations are directed against the back wall of the spinneret face through the spinning dispersion in the same direction as the dispersion takes in flowing to the orifices of the spinneret. The basic linear speed of extrusion through the spinneret orifice is 60 meters/min. and the frequency of vibration used is 100,000 cycles/sec. The fibers produced have the structure of Figs. 1 and 2 in which the distance *a* is 0.01 mm.

Example 3

A spinning medium is prepared by emulsion copolymerization of 65 parts of methyl acrylate, 25 parts of acrylonitrile and 10 parts of the acetic acid salt of N-t-butylaminoethyl acrylate in 180 parts of water containing 2 parts of laurylpyridinium acetate as an emulsifier. It is spun into a coagulating bath comprising an aqueous solution containing 3% sodium hydroxide in a system like that of Figs. 3 and 4 but using ultrasonic vibrations having a frequency of 300,000 cycles per second. The basic linear speed of the dispersion through the orifices (when the vibrator is momentarily stopped) is 150 meters/min. and the rate of draw-off of the filaments from the spinneret is the same as the basic linear speed of extrusion. Filaments are obtained with the wool-like structure of Figs. 1 and 2 in which the distance *a* is about 0.008 mm., the difference in diameters at 4 and 5 is about 0.0015 mm., and the plane of the maximum diameter is spaced from the plane of the closest minimum diameter by a distance of about 0.001 mm.

It is to be understood that changes and variations may be made without departing from the spirit and scope of the invention as defined in the appended claims.

I claim:

1. An article of manufacture comprising an artificial fiber formed of a water-insoluble synthetic polymeric material, said fiber having a size of 1 to 100 denier and comprising a multiplicity of adjoined small sections extending longitudinally of the fiber and having their outer surfaces essentially unidirectionally tapered between their junctions, the length of the individual sections being from 0.001 to 2 mm.

2. An article of manufacture comprising an artificial fiber formed of a water-insoluble synthetic polymeric material, said fiber having a size of 1 to 5 denier and comprising a multiplicity of adjoined small sections extending longitudinally of the fiber and having their outer

surfaces essentially unidirectionally tapered between their junctions, the length of the individual sections being from 0.001 to 2 mm.

3. An article of manufacture comprising an artificial fiber formed of a water-insoluble synthetic polymeric material, said fiber having a size of 1 to 100 denier and having a T_g between about 0° C. and 150° C., said fiber comprising a multiplicity of adjoined small sections extending longitudinally of the fiber and having their outer surfaces essentially unidirectionally tapered between their junctions, the length of the individual sections being from 0.001 to 2 mm.

4. An article of manufacture comprising an artificial fiber formed of a water-insoluble synthetic polymeric material, said fiber having a size of 1 to 100 denier and comprising a multiplicity of adjoined small sections extending longitudinally of the fiber and having their outer surfaces essentially unidirectionally tapered between their junctions, the length of the individual sections being from 0.001 to 2 mm., and the difference between the large and small diameters being from 1% to 20% of the length of the section.

5. An article of manufacture comprising an artificial fiber formed of a water-insoluble synthetic polymeric material having a T_g between about 0° C. and 150° C., said fiber having a size of 1 to 5 denier and comprising a multiplicity of adjoined small sections extending longitudinally of the fiber and having their outer surfaces essentially unidirectionally tapered between their junctions, the length of the individual sections being from 0.001 to 2 mm., and the difference between the large and small diameters being from 1% to 20% of the length of the section.

6. An article of manufacture comprising an artificial fiber formed of a water-insoluble polymeric material, said fiber having a size of 1 to 100 denier and comprising a multiplicity of adjoined small sections extending longitudinally of the fiber and having their outer surface essentially unidirectionally tapered between their junctions, said polymeric material comprising an addition copolymer containing from 1% to 25% of units having hydrophilic groups therein, and having a T_g between about 0° and 150° C., the length of the individual sections being from 0.001 to 2 mm., and the difference between the large and small diameters being from 1 to 20% of the length of the section.

7. An article as defined in claim 6 in which the hydrophilic groups are selected from the class consisting of carboxyl groups, carboxylate groups, hydroxyl groups, amide groups, amine groups, and aminium salt groups.

8. An article as defined in claim 6 in which the hydrophilic groups are selected from the class consisting of carboxyl groups, carboxylate salt groups, hydroxyl groups, amide groups, amine groups, and aminium salt groups, and the copolymer contains units of at least one ester of a monoethylenically unsaturated acid.

9. An article of manufacture comprising an artificial fiber formed of a water-insoluble polymeric material, said fiber having a size of 1 to 100 denier and comprising a multiplicity of adjoined small sections extending longitudinally of the fiber and having their outer surfaces essentially unidirectionally tapered between their junctions, said polymeric material being a copolymer of an ester of an acid selected from the group consisting of acrylic and methacrylic acids with 1% to 25% by weight of at least one monoethylenically unsaturated monomer having hydrophilic groups therein, the length of the individual sections being from 0.001 to 2 mm., and the difference between the large and small diameters being from 1 to 20% of the length of the section.

10. An article of manufacture comprising an artificial fiber formed of a water-insoluble polymeric material, said fiber having a size of 1 to 100 denier and comprising a multiplicity of adjoined small sections extending longitudinally of the fiber and having their outer surfaces

essentially unidirectionally tapered between their junctions, said polymeric material being a copolymer of an ester of an acid selected from the group consisting of acrylic and methacrylic acids with 1% to 5% by weight of at least one monoethylenically unsaturated monomer having hydrophilic groups therein, the length of the individual sections being from 0.001 to 2 mm., and the difference between the large and small diameters being from 1 to 20% of the length of the section.

11. An article of manufacture comprising an artificial fiber formed of a water-insoluble synthetic polymeric material having a T_g between about 0° C. and 150° C., said fiber having a size of 1 to 100 denier and comprising a multiplicity of adjoined small sections extending longitudinally of the fiber and having their outer surfaces essentially unidirectionally tapered between their junctions, the length of the individual sections being from 0.01 to 0.1 mm., and the difference between the large and small diameters being from 1 to 20% of the length of the section.

12. An article of manufacture comprising an artificial fiber formed of a water-insoluble synthetic polymeric material having a T_g between about 0° C. and 150° C., said fiber having a size of 1 to 5 denier and comprising a multiplicity of adjoined small sections extending longitudinally of the fiber and having their outer surfaces essentially unidirectionally tapered between their junctions, the length of the individual sections being from 0.01 to 0.1 mm., and the difference between the large and small diameters being from 1 to 20% of the length of the section.

13. An article of manufacture comprising an artificial fiber formed of a water-insoluble synthetic polymeric material having a T_g between about 0° C. and 150° C., said fiber having a size of 1 to 100 denier and comprising a multiplicity of adjoined small sections extending longitudinally of the fiber and having their outer surfaces essentially unidirectionally tapered between their junctions, the length of the individual sections being from 0.01 to 0.1 mm., and the difference between the large and small diameters being from 5 to 20% of the length of the section.

14. An article as defined in claim 13 in which the hydrophilic groups are selected from the class consisting of carboxyl groups, carboxylate groups, hydroxyl groups, amide groups, amine groups, and aminium salt groups.

15. An article of manufacture comprising an artificial fiber formed of a water-insoluble polymeric material having a size of 1 to 5 denier and comprising a multiplicity of adjoined small sections extending longitudinally of the fiber and having their outer surfaces essentially unidirectionally tapered between their junctions, said polymeric material being a copolymer of an ester of an acid selected from the group consisting of acrylic and methacrylic acids with 1 to 25% by weight of at least one monoethylenically unsaturated monomer having hydrophilic groups therein, the length of the individual sections being from 0.01 to 0.1 mm., and the difference between the large and small diameters being from 5 to 20% of the length of the section.

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