Feb. 12, 1946. T. G. FINZEL 2,394,540

STRETCHING OF ARTIFICIAL YARN

Filed Aug. 20, 1943

Fig. 1.

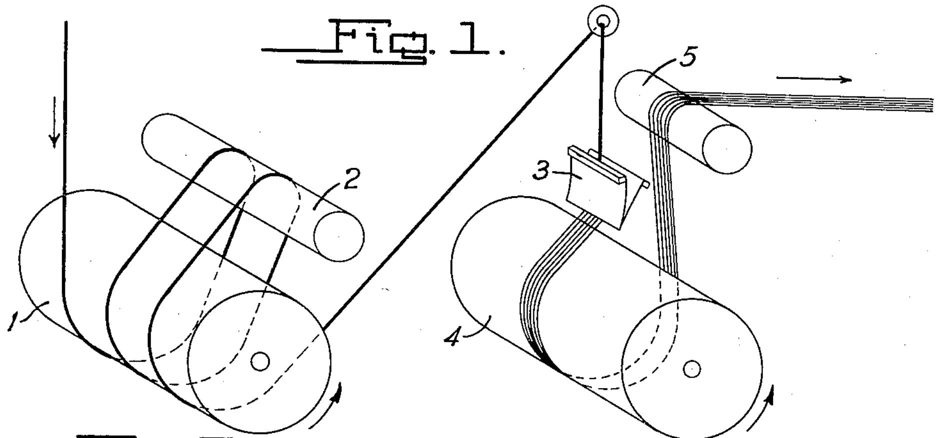


Fig. 2.

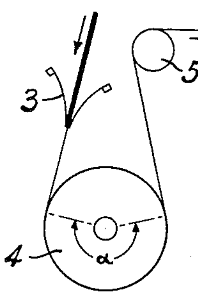


Fig. 3.

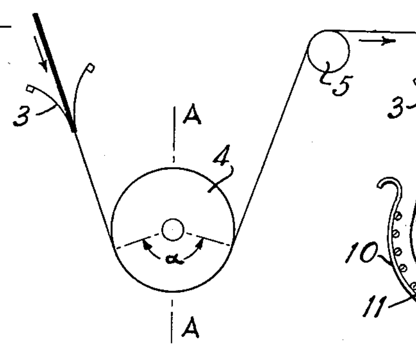


Fig. 5.

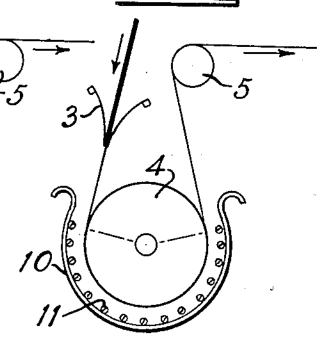


Fig. 7.

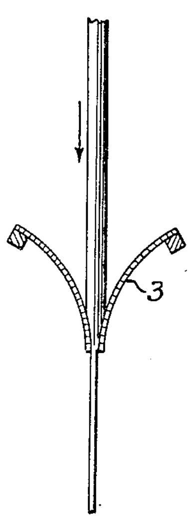


Fig. 6.

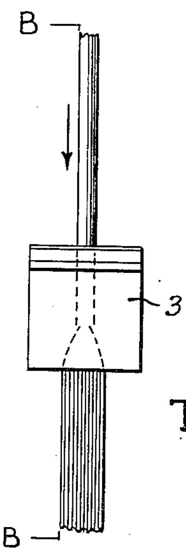
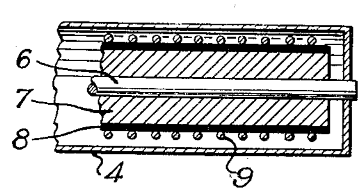


Fig. 4.



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Patented Feb. 12, 1946 2,394,540

UNITED STATES PATENT OFFICE

2,394,540

STRETCHING OF ARTIFICIAL YARN

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Application August 20, 1943, Serial No. 499,327

3 Claims. (Cl. 8—132)

This invention relates to a method for increasing the tenacity of artificial thermoplastic yarn. More particularly, the invention relates to a method for heat-treating and stretching untwisted yarn of synthetic, thermoplastic, filament-forming material whereby to increase the tenacity of the yarn.

This application is a continuation-in-part of my copending application Serial No. 366,769 filed November 22, 1940.

It is known to stretch artificial thermoplastic yarn and particularly cellulose derivative yarn which has been softened by heat. All of the known processes, however, suffer from the defect that filaments making up the yarn invariably adhere to one another, thereby imparting harshness to the yarn and rendering the same inferior in quality.

This invention has as an object a method for plasticizing yarn of synthetic, thermoplastic, filament-forming material and stretching the same without causing the filaments to adhere to each other. A further object is the provision of a method for heat treating thermoplastic cellulose derivative yarn, such as cellulose acetate yarn, to plasticize the same and stretching the yarn while in the plastic state to produce a yarn free of stuck or adhering filaments. These and other objects will more clearly appear hereinafter.

I have found that if an untwisted yarn or synthetic, thermoplastic, filament-forming material, such as cellulose acetate or acrylonitrile polymer, is first spread to a ribbon whereby to separate and to align all of the filaments in substantially the same plane, and the ribbon is softened through contact with a heated roll and then stretched in the softened condition, a yarn of greatly enhanced tenacity is produced which yarn is at the same time soft to the touch and is of all around superior quality. By first spreading the yarn to a ribbon, substantially all filaments thereof are brought into direct contact with the surface of the heated roll. The yarn may be stretched to any desired degree, say two, five, ten or even more times its original length. Cellulose acetate spun in the conventional manner possesses a tenacity of about 1.4 to about 1.7 grams per denier. Improvement in tenacity to 2.5 or more grams per denier is achieved by the herein described method.

Untwisted yarn of any synthetic, thermoplastic, filament-forming material may be treated in accordance with the principles of this invention. As representative of these thermoplastic filament-forming materials may be mentioned cellulose esters such as cellulose acetate, cellulose propionate, cellulose butyrate, and cellulose nitrate; cellulose mixed esters such as cellulose acetate propionate, and cellulose acetate butyrate; cellulose ethers such as ethyl cellulose and benzyl cellulose; mixed cellulose ethers, e. g. ethyl lauryl cellulose; mixed cellulose ether-esters such as ethyl cellulose acetate and methyl cellulose propionate; and noncellulosic thermoplastic materials such as acrylonitrile polymers, nylon, vinyl esters, vinyl ethers, methacrylates, polystyrene, and Vinyon.

Referring to the accompanying drawing wherein the method and apparatus suitable for carrying out the method of this invention are illustrated diagrammatically, Fig. 1 is a diagrammatic representation of an arrangement of means suitable for carrying out the invention; Figs. 2 and 3 show one method for varying the time contact of the yarn with the hot roll; Fig. 4 is a cross-section on the line A—A of Fig. 3; Fig. 5 shows auxiliary means for heating the yarn on the heated roll; Fig. 6 is a plan view of a preferred means for spreading the yarn; and Fig. 7 is a section on the line B—B of Fig. 6.

In Fig. 1, a thermoplastic yarn such as cellulose acetate yarn possessing no twist and of any reasonable denier and comprised of a plurality of filaments is unwound from a supply package (not shown) and passed around a feed or snubbing roller 1 and thread advancing roller 2 used to feed the untwisted cellulose acetate yarn over a guide and then through a yarn spreading device 3 onto a heated cylinder roll 4. Rolls 1 and 4 rotate at the same peripheral speed. The yarn is softened on the hot surface of roll 4 and is withdrawn from roll 4 over a guide roller 5 at a speed greater than the peripheral speed of roll 4. The ratio of yarn draw-off speed to the peripheral speed of roll 4 may be two, five, ten or more. Rolls 1 and 4 are driven in a counterclockwise direction, as indicated. After the yarn is cooled below the softening temperature, it may be twisted in any well-known manner. After stretching, the tenacity of the yarn is materially increased and the yarn denier is reduced in proportion to the stretch ratio.

The yarn must remain in contact with roll 4 for such a length of time to effect sufficient softening so as to allow stretching of the cellulose acetate yarn at a tension of from 0.01 to 0.5 gram per denier of the stretched yarn. The time of contact may be controlled by the diameter of the heating roll, the speed of the roll, or the angle of contact alpha (α) (Figs. 2 and 3) of the yarn on the roll. Obviously, the higher the peripheral speed of the roll, the greater must be the angle of contact alpha.

The cylinder 4 is heated in any suitable manner, as for instance, by electrical means, high pressure steam, or vapor or liquids, to sufficiently high temperature to effect a suitable softening of the yarn in contact therewith.

Fig. 4 shows a section through A—A of Fig. 3. This illustrates one method of heating roll 4. Shaft 6 of roll 4 is supported by a bearing 7 around which bearing an insulating layer 8, such as mica, etc., is wound. On top of the insulating layer 8 and close to the inner surface of roll 4, there is wound a helical coil 9 of alloy wire having a high electrical resistance to act as an electrical heating element for the purpose of uniformly heating roll 4. Other methods of heating, such as by means of hot vapors or liquids, may be used for heating roll 4.

Fig. 5 shows the use of a supplementary heating element affixed around, but not in contact with roll 4. This auxiliary heater consists of a support 10 for an electrical heating element 11. The yarn in ribbon form is thus heated from two sides, reducing the necessary time of heating and improving the uniformity of heating as compared with the heating characteristics of the simple hot roll.

In Figs. 6 and 7, details of a preferred form of spreading device are shown. The device consists of two resilient thin sheets such as spring steel or spring brass leaves or other sheets which are suitably supported and allowed to exert a mild pressure against each other. As yarn passes between these flat surfaces, sufficient pressure is brought to bear on the untwisted yarn to flatten the yarn into a form of a ribbon wherein the filaments lie in substantially a single plane. If yarn of a heavy denier is used, a number of the above described spreading devices may be used in series to an advantage. Another method for spreading and separating the filaments of a yarn into ribbon-like form may consist of a series of rods over the surfaces of which the untwisted yarn is passed. Other methods for spreading the filaments of a yarn may consist of a device which directs air jets against the yarn and then allows the separated filaments to pass over a flat surface. The use of an electrical charge applied to the yarn which causes the filament to balloon out and then passing the separated filaments over a flat surface may be applied to advantage.

Application of the method of this invention is further illustrated by the following examples.

Example I

A 3000 denier cellulose acetate yarn (about 54% combined acetic acid) containing 150 filaments and possessing no twist was fed onto a heated roll set-up, the diagrammatic sketch of which is shown in Fig. 2. The yarn was fed onto the heated roll at the rate of 242'' per minute and drawn from the roll at the rate of 1280'' per minute. The diameter of the heated roll was 2'' and its temperature was approximately 240° C. The filament spreading device consisted of two spring steel leaves 0.0045'' thick, pressing mildly against each other. The average tension of the yarn as it was drawn from the heated roll was approximately 65 grams. After cooling, the stretched yarn was twisted to the extent of two turns per inch. Upon testing at 70° F. and 60% relative humidity, it showed a tenacity of 2.5 grams per denier.

Example II

A 3000 denier, 150 filament cellulose acetate yarn (about 54% combined acetic acid) possessing no twist was fed through a filament spreading device onto a heated roll, as illustrated in Fig. 2, at the rate of 128'' per minute and was withdrawn from the heated roll at the rate of 1280'' per minute with an average yarn tension of 60 grams. The roll was heated to a temperature of 256° C. and the angle of contact of the yarn with the roll was approximately 150°. The stretched yarn showed a tenacity of 2.2 grams per denier.

Example III

A 580 denier, 58 filament cellulose acetate yarn (about 54% combined acetic acid) possessing no twist was passed through a spreading device and heated roll, as illustrated in Fig. 5, at the rate of 256'' per minute and was drawn from the heated roll at the rate of 1280'' per minute under an average tension of approximately 10 grams. The angle of contact of the yarn with the roll was approximately 203° and the temperature of the heated roll was approximately 240° C. The temperature of the air between the heated roll and the auxiliary heating element 11 as shown in Fig. 5 was approximately 215° C. After twisting the cold yarn to the extent of approximately two turns per inch, the yarn showed a tenacity of 2.3 grams per denier.

Example IV

A 440 denier, 40 filament, no twist yarn prepared by dry spinning a solution of acrylonitrile polymer of 103,000 average molecular weight (as determined by viscosity data using the Staudinger equation) dissolved in dimethyl formamide, was passed through a spring leaf filament spreading device and around a hot roll as shown in Fig. 2. The yarn was fed onto a heated roll at the rate of 145 inches per minute and drawn from this roll at the rate of 1450 inches per minute, thereby stretching the yarn ten times. The diameter of the hot roll was 1⅞'' and the angle of contact of the yarn with the hot roll was approximately 330° while the temperature to which the roll was heated was 165°–180° C.

The unstretched yarn of 440 denier showed a tenacity of 0.6 gram per denier. The yarn was stretched down to 42–45 denier and showed a tenacity of 4.3 grams per denier.

The copending application of George Henry Latham, Serial No. 562,012, filed November 4, 1944 (a continuation-in-part of his copending application Serial No. 447,466, filed June 17, 1942) describes the dissolving of acrylonitrile polymers in dimethyl formamide and in other solvents and the formation of shaped articles from such solutions. The copending application of Daniel C. Meloon, Serial No. 496,397, filed July 28, 1943, describes the heat-stretching of acrylonitrile polymer articles. No claim is made in the present application to the inventions of said Latham and Meloon copending applications and the invention of this application is limited as set forth in the claims.

It is understood that my invention is not limited to the precise details described, but is susceptible rather to wide variation and comprehends all modifications and equivalents falling within the spirit of the invention as defined by the claims.

I claim:

1. The process which comprises spreading an untwisted yarn comprised of a plurality of filaments of synthetic, thermoplastic, filament-forming material to the point where all of the filaments are separated and lie in substantially

the same plane, passing the spread yarn over a heated rotating roll whereby to render the yarn plastic, and stretching the yarn while it is in the plastic and separated state.

2. The process which comprises flattening an untwisted yarn comprised of filaments of cellulose acetate to the point where all of the filaments are separated and lie in substantially the same plane, passing the flattened yarn over a heated rotating roll whereby to render the yarn plastic, and stretching the plastic yarn while it is in the separated state.

3. The process which comprises flattening an untwisted yarn comprised of filaments of acrylonitrile polymer to the point where all of the filaments are separated and lie in substantially the same plane, passing the flattened yarn over a heated rotating roll whereby to render the yarn plastic, and stretching the plastic yarn while it is in the separated state.

THERON G. FINZEL.