United States Patent

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[54] METHOD AND APPARATUS FOR BULKING YARN

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[73] Assignee: **The United States of America as represented by the Secretary of Agriculture**

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[52] **U.S. Cl.**.....**57/34 B**, 28/1 R, 57/34 HS, 57/157 TS

[51] **Int. Cl.**.....**D02g 1/02**, D02h 1/20, D02h 13/00

[58] **Field of Search**.....57/34, 34 B, 34 HS, 156, 157, 57/157 TS, 157 MS, 157 F; 28/72.1, 1

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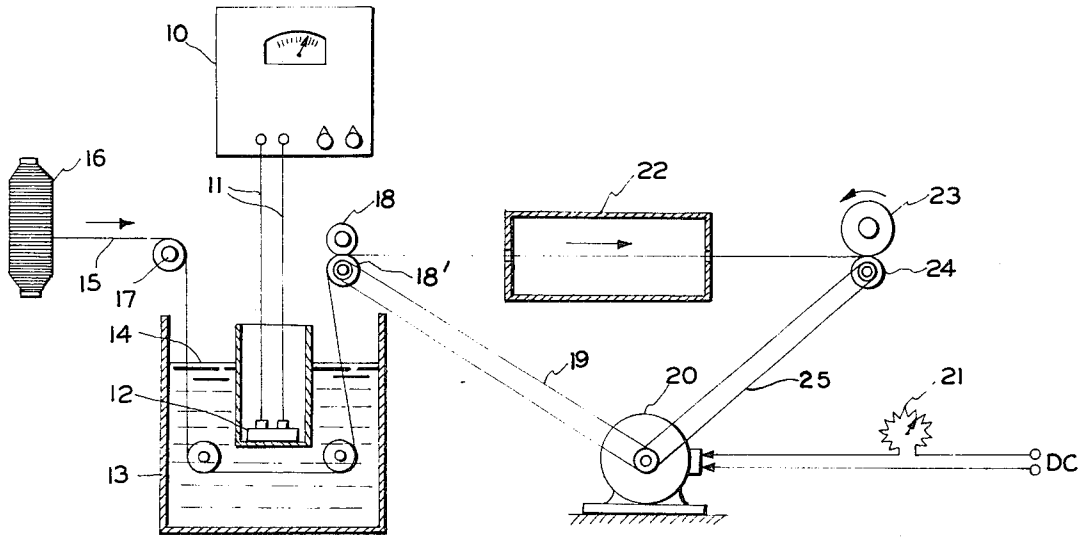
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[57] **ABSTRACT**

An apparatus utilizing ultrasonic components was designed and used in combination with select chemicals to produce permanent bulking in cotton and other yarns. The method constitutes immersing the yarns in cross-linking formulations and subjecting these while immersed to ultrasonic irradiation. An extension of the method comprises imparting resiliency to the bulked yarns. This is accomplished both by mechanical and by chemical means.

4 Claims, 3 Drawing Figures



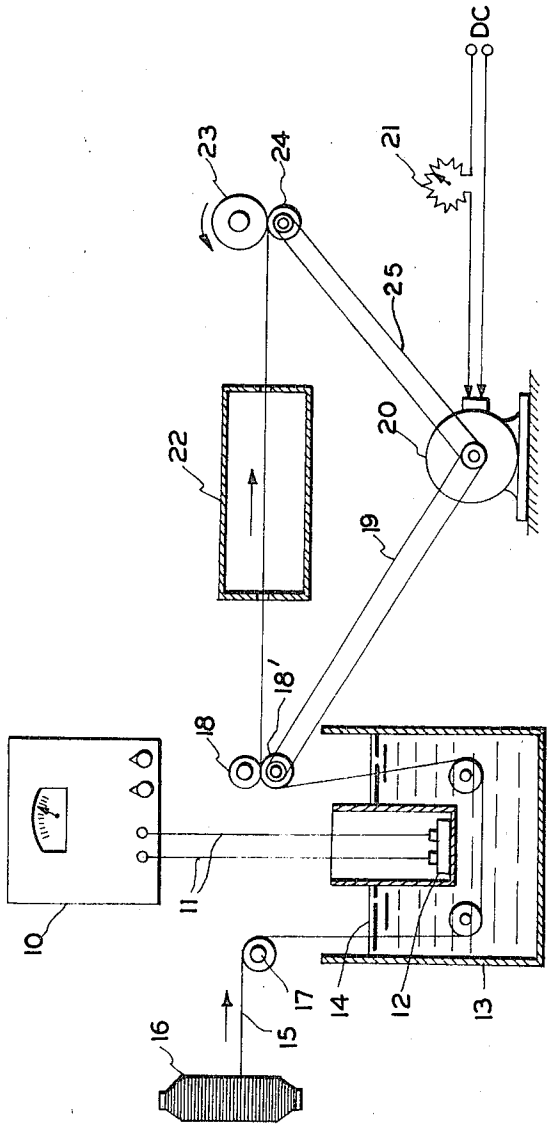


FIG. 1

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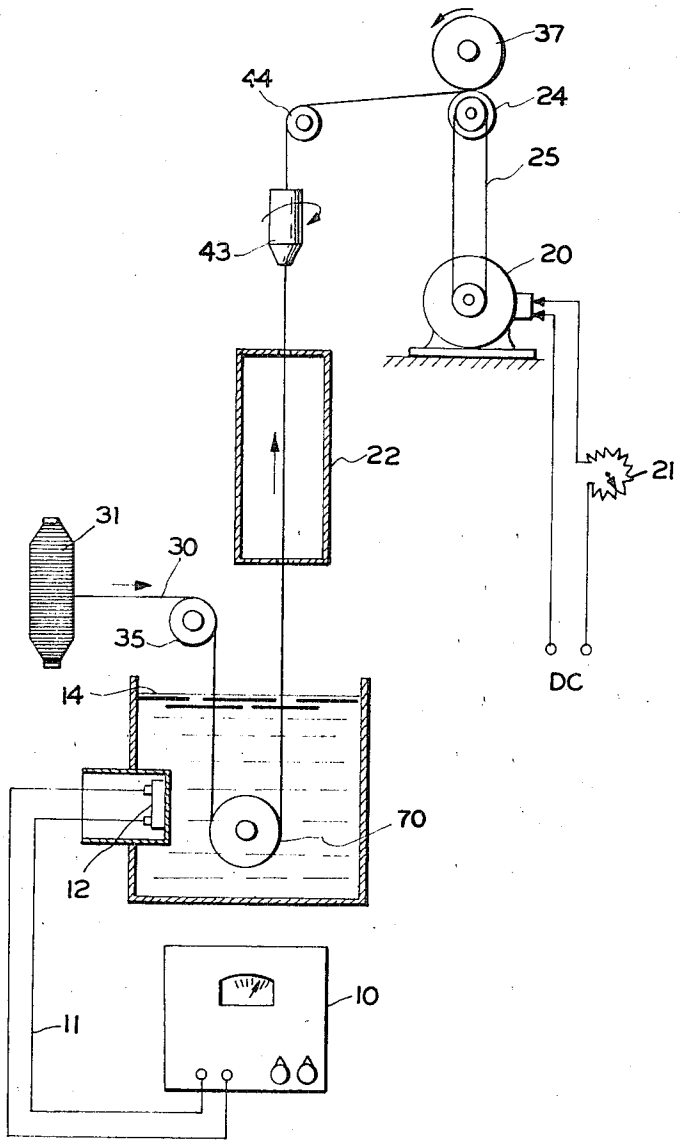


FIG.2

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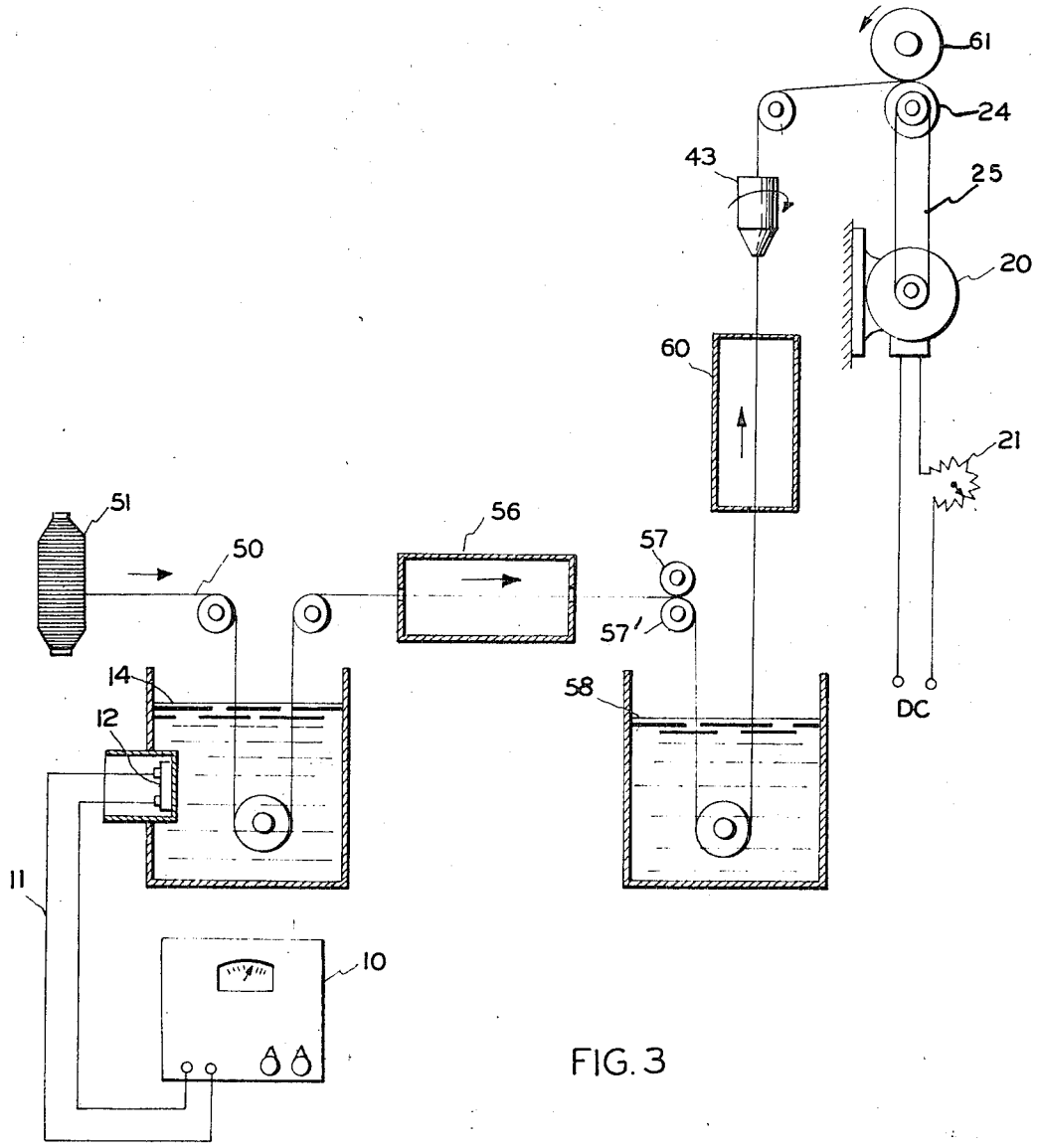


FIG. 3

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METHOD AND APPARATUS FOR BULKING YARN

A nonexclusive, irrevocable, royalty-free license in the invention herein described, throughout the world for all purposes of the United States Government, with the power to grant sublicenses for such purposes, is hereby granted to the Government of the United States of America.

This invention relates to an apparatus and a method for bulking yarns. Specifically, this invention relates to the use of combined chemical and physical means to cause and retain a bulked configuration of yarns. More specifically, this invention relates to imparting to cellulosic and noncellulosic yarns a permanent bulked configuration simply by applying ultrasonic irradiation to a bath solution which contains the yarns being treated in a cross-linking chemical formulation. The yarns thus bulked can be used in a great variety of fabrics which go into the home either as articles of wear or as bedspreads, towels, draperies, and many other such.

It is well known to those skilled in the art of bulking or texturizing textile yarns that yarns produced from manmade staple fibers can be bulked by a variety of processes and apparatuses, and that yarns produced from natural fiber cannot be bulked successfully. Yarns made from cotton fibers particularly, have not been responsive to conventional bulking methods of the prior art. Prior to the disclosure of the instant invention four general methods have been used for bulking yarns. These are (1) the application of air jets, (2) use of a stuffer box or similar crimping techniques, (3) drawing the yarn over a sharp edge, and (4) falsetwisting. Following the bulking process the yarns are fixed in the bulked condition by the application of heat that causes plastic flow (in some fibers) and permanently sets the yarn. Efforts to produce bulked yarns of natural fibers by these methods have failed because natural fibers do not have the plastic flow or heat setting properties of manmade fibers.

The main object of the present invention is to provide bulked textile yarns produced by a unique and novel method.

A second object of the instant invention is to provide the apparatus to use with the method for producing the new bulked yarns.

These objects are accomplished by utilizing acoustic energy in a liquid medium to bulk the yarns, the liquid medium being a resin treating formulation to set the bulked configuration permanently upon curing.

A further object of the invention is to produce bulked yarns having stretch properties by falsetwisting the bulked, resin-treated yarn and permanently setting the yarn in this state.

While the invention herein disclosed utilizes description applicable to yarns made from cotton fibers this should not be misconstrued to imply restriction to cotton yarns. The instant invention can be used with cotton and other cellulosic yarns, with noncellulosic yarns, and it can also be used with blends. The yarns can be mixed staple fiber or monofilamentous.

To restate the description of the instant invention, one facet of the invention is the apparatus consisting of a select combination of components comprising mainly an acoustic energy generator, a transducer unit for applying the acoustic energy to the yarn, a means for treating the yarn with suitable resins, a means for drying and curing the treated yarns, a yarn supply device (for holding a feed package), a yarn takeup device (for receiving a treated package quantity), and associated means for driving the component rotating parts.

Another facet of the invention is the method of using the apparatus of the invention. The method generally consists of subjecting the yarns to acoustic energy irradiation while the yarns are immersed in a select cross-linking formulation, then drying and curing the bulked, impregnated yarns to impart to these a permanent configuration.

Projections of the instant invention include the production and method of producing bulked yarns with stretch properties, or with resistance to weather, biological degradation, flame, or physical deformation. These objectives are accomplished by chemical means, physical means, or a combination thereof. Falsetwisting is one way of accomplishing the physical means of adding stretch to the bulked yarns. Chemically, stretch may

be added to the bulked yarns by treating the bulked yarn with a chemical agent selected from known swelling agents, such as sodium hydroxide, zinc chloride, ethylene diamine, and the like, but bearing in mind that the swelling agent selected must be inert to the cross-linking agent employed in the bath of the earlier process.

Another manner of introducing stretch to a bulked yarn is by a chemical-physical combination treatment which can be made to follow and continuous with the bulking process. This is explained later. This and other specific supplementary properties can be imparted to a bulked yarn by supplementary treatments with known formulations employed during or after bulking.

Other objects and advantages of the instant invention will become apparent during the following discussion of the drawings.

FIG. 1 is a chematic elevation view of the apparatus for bulking yarns, showing the yarn input and output packages, acoustic treating means, resin bath, drying and curing means, and driving means.

FIG. 2 is a schematic elevation view adding to the components of FIG. 1 a falsetwisting means in order to add stretch to the finished, bulked yarn physically.

FIG. 3 is a schematic elevation view adding to the components of FIG. 1 a second chemical bath in order to add stretch to the finished, bulked yarn chemically.

Referring now to the drawings, FIG. 1 is an embodiment showing an acoustic generator **10**, capable of, for example, **10** to 100 watts power output at 60 hertz/second to 1 megahertz/second frequency, connected by leads **11**, to a ceramic-type transducer **12**, which is hermetically sealed in tank **13**. Other methods of generating acoustic energy may be used, such as magnetostrictive or barium titanate transducers coupled to an electronic variable or fixed frequency oscillator, or an acoustic horn. The transducers may have a flat surface, or may have a curved surface designed to focus the energy on the yarn. Obviously, either type surface may be large enough to enable processing multiple yarns, or even fabrics.

Tank **13** represents a vessel to contain a cross-linking agent, such as a 5 to 20 percent dimethylol ethyleneurea, and is maintained at relatively constant temperature and volume by conventional means, not shown. Under some conditions, however, it may be preferable to put the solution under vacuum or under pressure, or to heat or cool the solution to expedite treating the yarns. The yarn **15** from package **16** is pulled over rotatable guide roll **17** mounted on bearings, not shown, by coacting rolls **18**, **18'** mounted on bearings, not shown. Preferably, rolls **18**, **18'** are positively driven by V-belt **19** from DC electric motor **20** whose rotational speed is controlled by rheostat **21**. Rolls **18**, **18'** can also serve as squeeze rolls to remove excess liquid from the yarn.

During passage of the yarn through the liquid bath, the action of the acoustic transducer imparts bulk to the yarn. The exact reason for this phenomenon is not known, but it is believed that the acoustic energy causes vaporous cavitation which puts tremendous pressures on the yarn and this in turn results in an increase in crimp, curl, and matting of the individual fibers. The fibers contract and tend to separate from each other, resulting in increased bulk and diameter of the yarn. This bulking phenomenon can be achieved by a wide range of frequencies and intensities of acoustic energy. For example, it has been determined that 20 to 800 kHz. frequency at 1 to 10 watts/cm^2 will cause vaporous cavitation with associated powerful shock waves that will bulk single or multiple yarns. A 3-inch diameter ceramic transducer at 800 kHz. and 10 watts/cm.^{2} will concentrate about 80 percent of its energy in a solid cone of 6° apex angle around its main axis. Yarn or yarns passed through this energy zone will bulk rapidly.

Returning to FIG. 1, rolls **18**, **18'** pull the yarn **15** from supply package **16** with a minimum of tension so that the yarn can contract at will under the influence of the acoustic energy. The acoustic energy also serves to thoroughly impregnate the yarn and fibers with the resin formulation. The treated yarn

passes through a conventional hot air or steam heated drier **22** wherein the resin treated bulked yarn is dried and the resin is cured. This curing of the resin permanently sets the bulked yarn so that it can be woven, knitted, and otherwise handled without losing its bulked properties. The bulked yarn is wound on a rotatable package **23** mounted on bearings, not shown, by a conventional friction roll **24** driven by belt **25** from motor **20**. Bearings for this roll are now shown. This form of friction takeup eliminates the need for synchronizing package **23** with rolls **18, 18''**. However, other driving methods can be used. In fact, coacting rolls **18, 18'** need not be positively driven, in which case friction drive **24** can be replaced by a positive drive system.

Other modifications of the apparatus of the invention will be obvious to those skilled in the art. A tensioning device can be applied to the yarn between supply package **16** and rolls **18, 18'** so that constant tension is exerted on to yarn **15** regardless of type of yarn or apparatus speed. Dielectric heating as a means of drying and curing the yarn can be substituted for drier **22**. In fact, drying and curing resin treated yarn has been successfully carried out using a 1 kw., 8.0 MHz. radiofrequency generator in combination with the electrodes disclosed in U.S. Pat. No. 2,492,187. A superior product is produced, but the dielectric drier is expensive.

In addition to providing the resin formulation for permanently fixing the bulked yarn, tank **13** can contain other chemicals to impart other desirable properties. For example, bath **14** can be formulated to contain dimethylol ethyleneurea for bulking, carboxymethyl cellulose for antisoiling, copper naphthanate for mildewproofing, tetrakis(hydroxymethyl)phosphonium chloride for flame resistance, and any dye that is compatible with the resin formulations and the fiber. Other possibilities for multipurpose treatments will be obvious to those skilled in the art of textile finishing.

Under proper conditions, the liquid bath method of treatment can be replaced by a method of applying the resins in vapor phase. Under this condition the efficiency of transfer of acoustic energy to the yarn is reduced somewhat, and processing speeds tend to be lowered.

While the invention has been discussed in terms of yarn bulking, it is also feasible to bulk fabrics. The degree of bulking will not be as great as with yarns, but a substantial increase in fabric bulk can be achieved.

FIG. **2** discloses an embodiment of the invention whereby a bulked yarn with stretch properties is produced. Referring to FIG. **2**, yarn **30** with two or more plies from supply package **31** is passed through resin treating bath **14**. The yarn is subjected to acoustic energy by transducer **12** which is coupled to acoustic generator **10** by leads **11**. Roll **70** guides the yarn into bath **14**. Roll **70** is a device that puts constant tension on the yarn as it is pulled forward by windup package **37**. Package **37** is driven by a conventional friction drive **24** which is connected by V-belt **25** to DC electric motor **20**. The motor is controlled by a standard rheostat **21** in line with a source of DC power, not shown. Drier **22** is a conventional hot air or steam drier.

In operation, the yarn is bulked and resin impregnated as heretofore described in connection with FIG. **1**. Before the yarn is dried and cured, however, it is falsetwisted by a conventional falsetwister head **43** which imparts a high degree of falsetwist to the yarn between tension device **70** and package **37**. The yarn is dried and set while in this twisted configuration. The result is a bulked yarn capable of 100 percent or more stretch from the relaxed state. The degree of stretch is determined by the number of turns of falsetwist in the yarn; this can be varied at will be changing the relationship of the rotational speed of the falsetwister and the delivery rate of the yarn. The treated yarn is wound into a conventional package.

As a practical example, 20/2 yarn made with 12 turns per inch of "S" ply twist is treated with 20 kHz., 10 watts/cm.^{2} acoustic energy in a bath of dimethylol ethyleneurea crosslinking resin. The yarn is falsetwisted with 40 turns per inch in the "Z" twist direction. The falsetwisted yarn is dried and cured and wound on a package.

In some instances it has been found advantageous to make roll **70** a freely rotating tensionless roll and to make roll **44** a tension control device. This procedure reduces the length of yarn being falsetwisted and thereby improves the uniformity of stretch properties. On the other hand, a falsetwist inserted in the longer length of yarn between roll **70** and package **37** results in wringing out more moisture from the yarn and thus allows an increase in processing speed in those cases where processing speed is handicapped by lack of drying capacity.

Low-twist yarns have been found to bulk more rapidly and to a larger degree than high-twist yarns.

Another embodiment for producing bulked, stretch yarns is disclosed in FIG. **3**. This embodiment is essentially a two-stage continuous yarn system. Yarn **50** from package **51** is pulled through resin bath **14** wherein the yarn is bulked by acoustic irradiation from transducer **12** coupled by leads **11** to acoustic generator **10**. After bulking and resin treatment, yarn **50** is dried and cured in hot air drier **56**. The yarn is pulled through drier **56** by rolls **57, 57'** which are positively driven by any conventional means (not shown), and the said yarn thereafter passed through a bath **58** containing an appropriate catalyst to break a number of cross-links between the resin and the fiber. The yarn is falsetwisted by a conventional falsetwisting head **43**, and is dried and cured in hot air drier **60**. Those cross-links which were broken by catalyst in the bath are reformed in the falsetwisted position and are cured in this position, thereby imparting permanent stretch to the yarn. The yarn is wound onto package **61** by friction drive **24**, which is driven by DC electric motor **20** through V-belt **25**. Motor **20** is controlled by a rheostat **21** to provide any desired speed. Any conventional source of DC power may be used, and is not shown.

The use of a friction drive on takeup package **61** obviates the need for synchronizing the yarn takeup with the yarn input or with any other part of the system. If desired, however, any of the well-known synchronous drive systems can be used to control speeds throughout the apparatus.

Restating the embodiment of the invention represented by FIG. **3**, a chemical-physical step is added to the idea of bulking with ultrasonic irradiation while the yarn is submerged in a cross-linking formulation. The chemical-physical step consists of (1) reimmersing the yarn, this time in a solution containing a catalyst generally used in resin curing, such as, for example, a 2 percent solution of magnesium chloride or zinc nitrate, or a mixed catalyst solution containing about 0.5 percent each of magnesium chloride and citric acid, thereby breaking some of the cross-links established earlier, (2) falsetwisting the wet yarn, and (3) while the yarn is being moved with a minimum of tension to the repackaging step, heat curing the yarn again to reestablish the cross-links in a twisted configuration thereby producing a bulked yarn with stretch properties.

I claim:

1. A method of imparting a stretchable bulked configuration to cellulosic and other textile yarns which comprises:

a. immersing a textile yarn in a solution containing a cross-linking agent;

b. subjecting the yarn, while so immersed, to acoustic energy irradiation to cause said yarn to acquire a bulked configuration;

c. transporting the wet bulked yarn with a minimum of tension to a heating zone;

d. applying a falsetwist to the yarn while being transported and before said yarn reaches the curing zone; and

e. heating the falsetwisted yarn to cure the cross-linking agent thereby producing a cross-linked stretchable, bulked yarn.

2. A method of imparting a stretchable bulked configuration to cellulosic and other textile yarns which comprises:

a. immersing a textile yarn in a solution containing a cross-linking agent;

b. subjecting the yarn, while so immersed, to acoustic energy irradiation to cause said yarn to acquire a bulked configuration;

c. heating the wet bulked yarn, while under a minimum of tension, to cure the cross-linking agent, thereby cross-linking the yarn and setting the bulked configuration;

d. passing said cross-linked yarn through a catalyst solution to partially break the cross-links while applying a falsetwist to the wet yarn; and

e. then heating the wet, falsetwisted yarn to recure the cross-linking agent to set the falsetwist, thereby producing a cross-linked stretchable bulked yarn.

3. Apparatus for imparting a stretchable, bulked configuration to cellulosic and other textile yarns comprising:

a. a source of supply of said yarn;

b. a tank for containing a solution of chemical cross-linking agent to react with the yarn, said tank having a yarn inlet point and a yarn exit point;

c. transducer means mounted within said tank;

d. means for generating an electrical signal having at least a sonic frequency connected to said transducer;

e. heating means disposed outside and beyond the yarn exit point of the tank;

f. transporting means for passing yarn from the source of supply in proximity to the transducer and then through the heating means, said transporting means including first guide means for guiding yarn from said source of supply to the entrance point of the tank, second guide means to maintain yarn immersed in the tank in proximity to the transducer, first driven means for withdrawing yarn through the exit point of the tank while applying a minimum of tension to the yearn, and second driven means beyond the heating means for drawing yarn from the first driven means through said heating means; and

g. means disposed between said first and second driven means for applying a falsetwist to the yarn prior to its passage into the heating means.

4. Apparatus for imparting a stretchable, bulked configuration to cellulosic and other textile yarns comprising:

a. a source of supply of said yarn;

b. a first tank for containing a solution of a chemical cross-linking agent to react with the yarn;

c. transducer means mounted within said first tank;

d. means for generating an electrical signal having at least a sonic frequency connected to said transducer;

e. a second tank for containing a cross-link breaking catalyst solution;

f. first heating means located between said first and second tanks;

g. driven windup means for winding up finished, treated yarn;

h. yarn transporting means for passing yarn, serially, from the source of supply through the first tank, the first heating means, through the second tank, and finally to said windup means, said transporting means including means for guiding yarn into and out of said first tank while passing said yarn in proximity to the transducer, means for guiding said yarn from the first tank through the first heating means to the second tank, and means for guiding said yarn from said second tank to the yarn windup means;

i. means for driving said windup means while applying a minimum of tension to the yarn;

j. second heating means disposed between the second tank and windup means for heating yarn withdrawn from said second tank; and

k. means disposed between the windup means and the second tank for applying a falsetwist to the yarn prior to its passage through the second heating means.

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