July 27, 1943. F. R. REDMAN 2,325,544

PROCESS FOR DETENSIONING FABRICS AND THE YARNS OR THREADS OF WHICH THE FABRIC IS COMPOSED

Filed Aug. 28, 1941 6 Sheets-Sheet 1

FIG. 2.

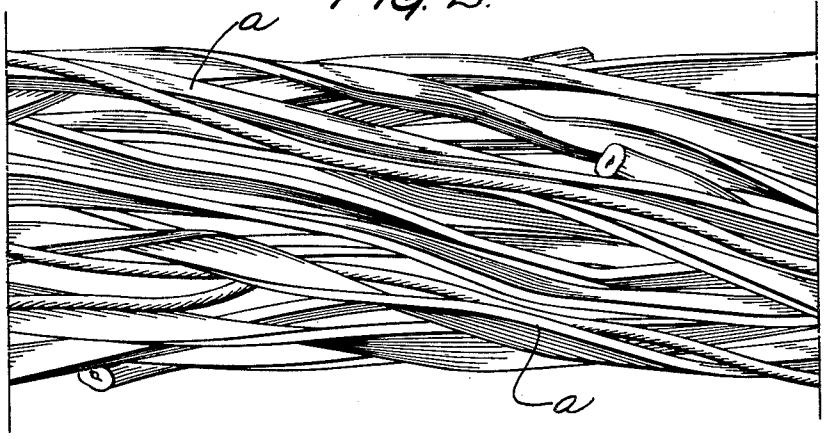


FIG. 3.

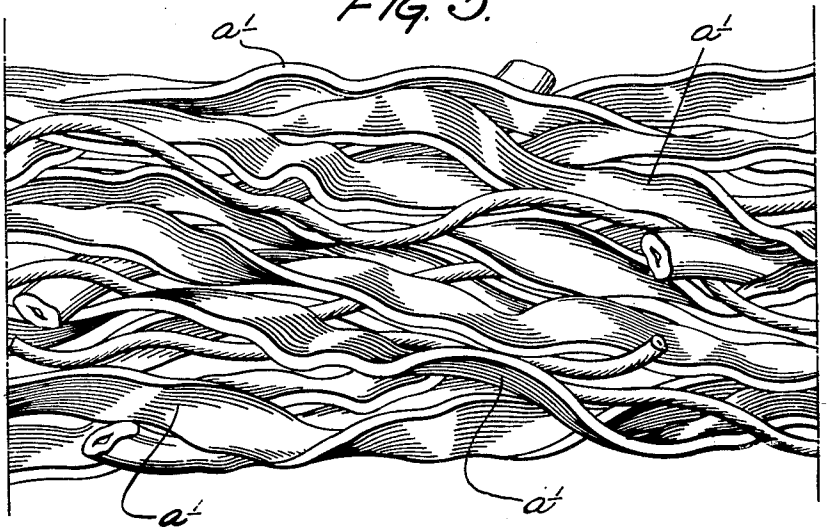


FIG. 1.



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Filed Aug. 28, 1941 6 Sheets-Sheet 2

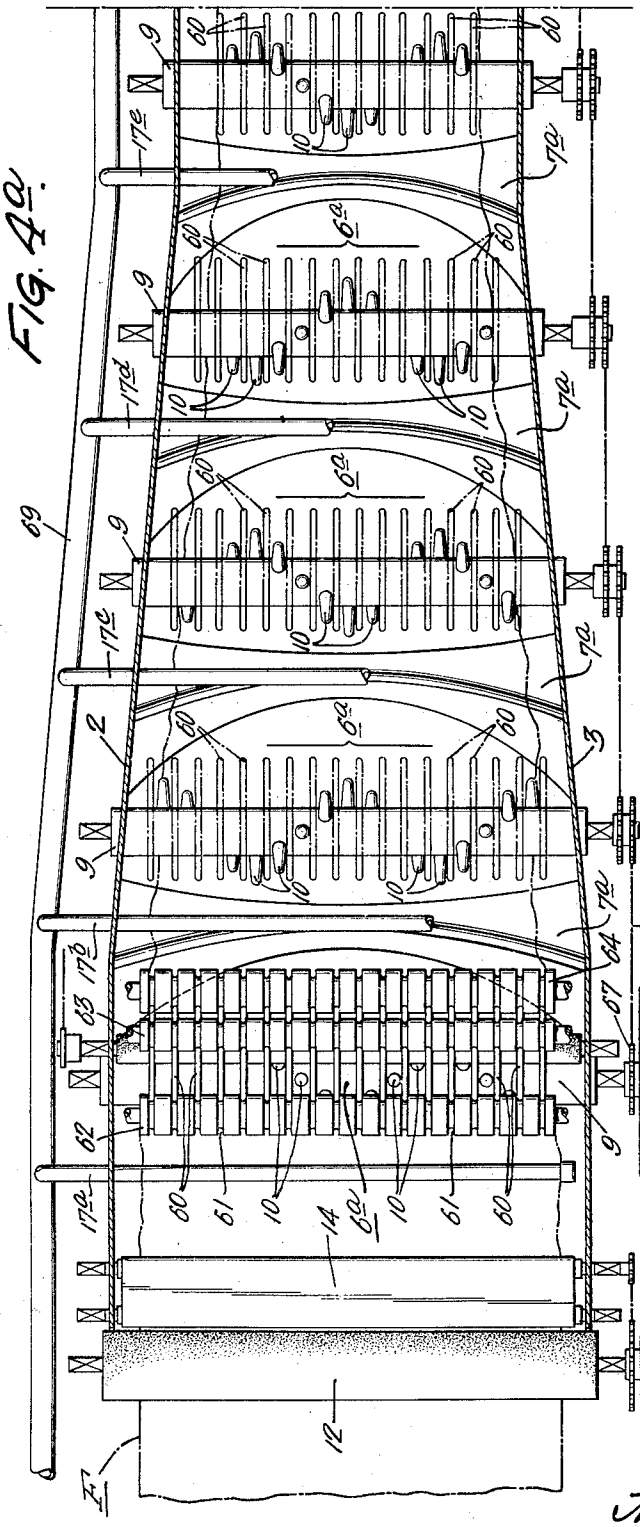


FIG. 4a.

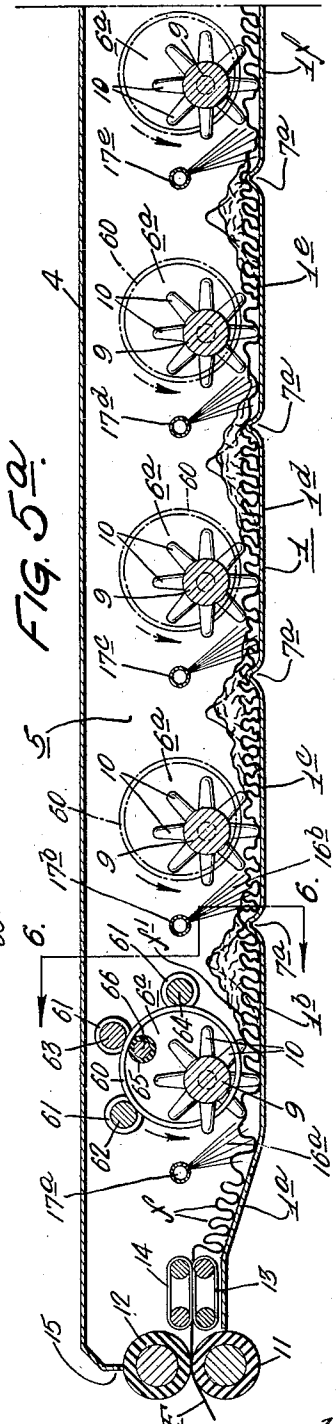


FIG. 5a.

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PROCESS FOR DETENSIONING FABRICS AND THE YARNS OR THREADS OF WHICH THE FABRIC IS COMPOSED

Filed Aug. 28, 1941 6 Sheets-Sheet 3

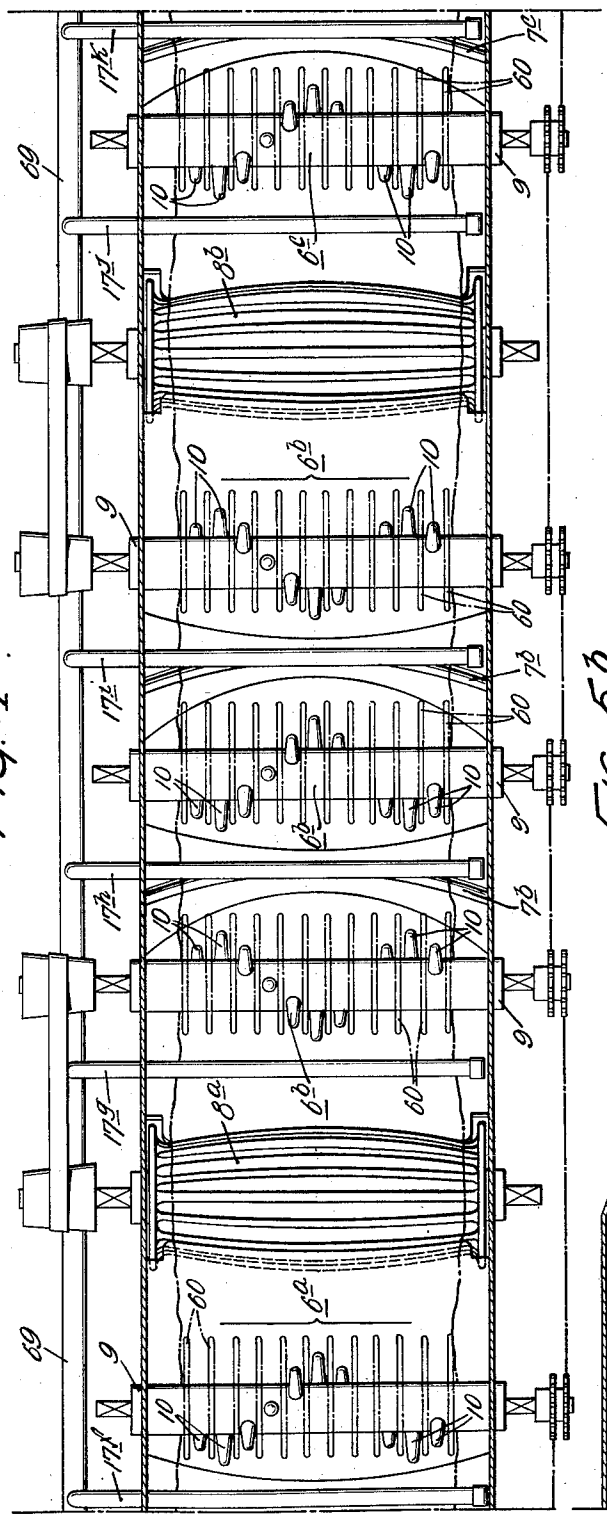


FIG. 4b.

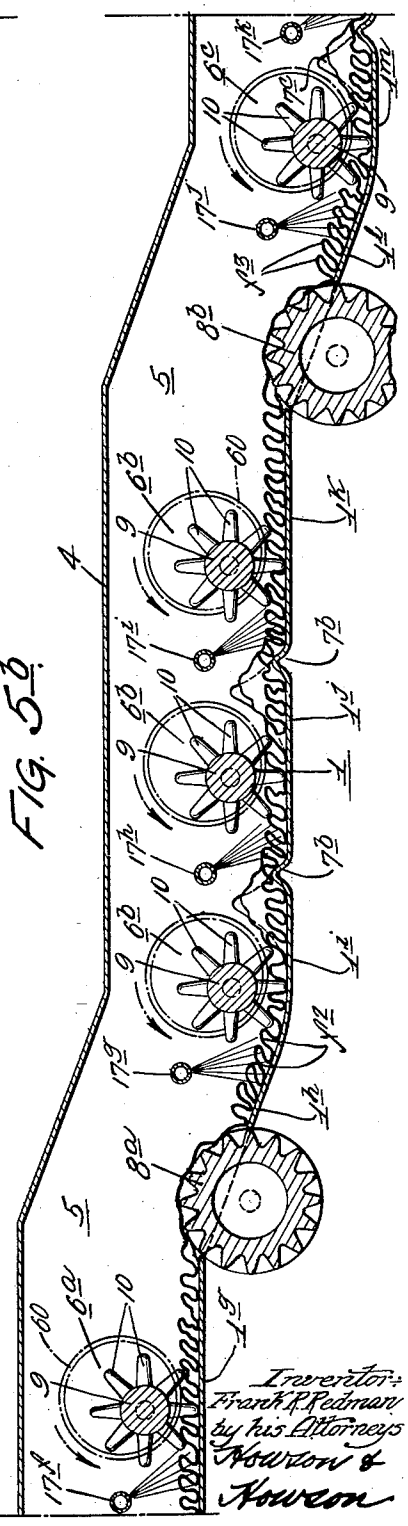


FIG. 5b.

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July 27, 1943. F. R. REDMAN 2,325,544

PROCESS FOR DETENSIONING FABRICS AND THE YARNS OR THREADS OF WHICH THE FABRIC IS COMPOSED

Filed Aug. 28, 1941 6 Sheets-Sheet 4

FIG. 4C

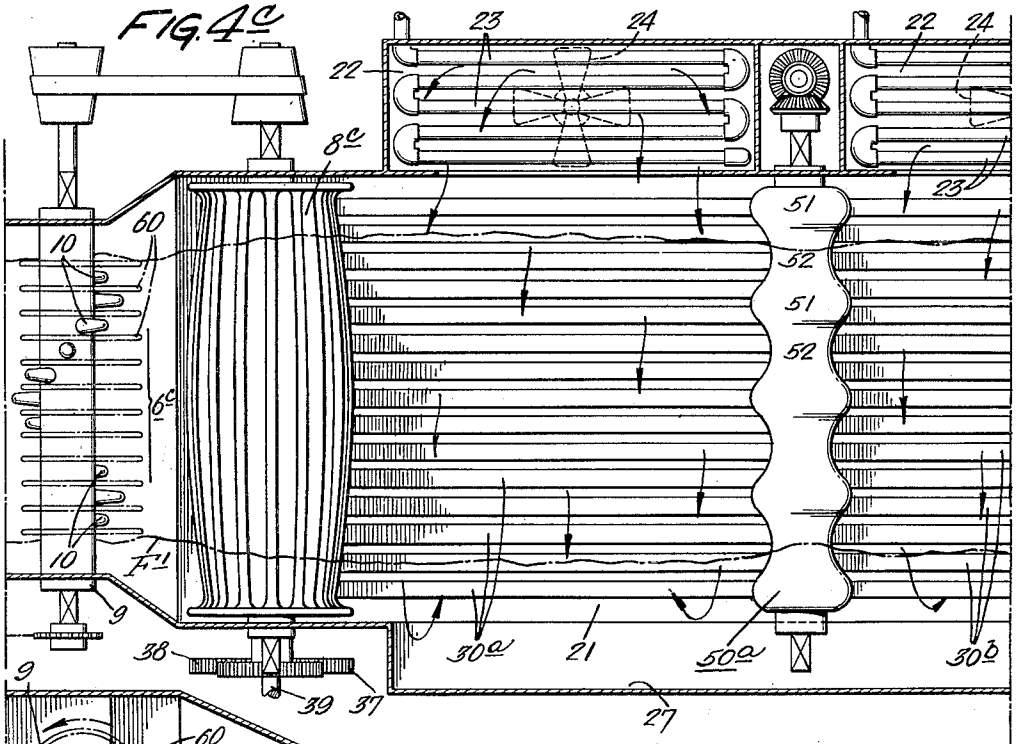
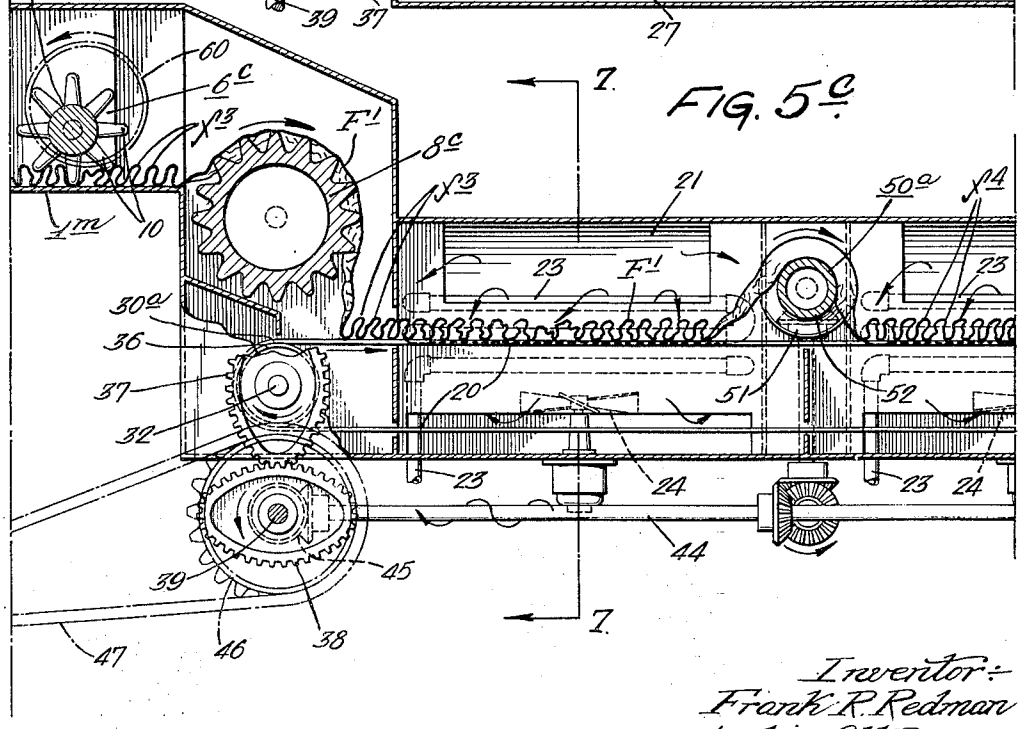


FIG. 5C



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July 27, 1943. F. R. REDMAN 2,325,544

PROCESS FOR DETENSIONING FABRICS AND THE YARNS OR THREADS OF WHICH THE FABRIC IS COMPOSED

Filed Aug. 28, 1941 6 Sheets-Sheet 5

FIG. 4d.

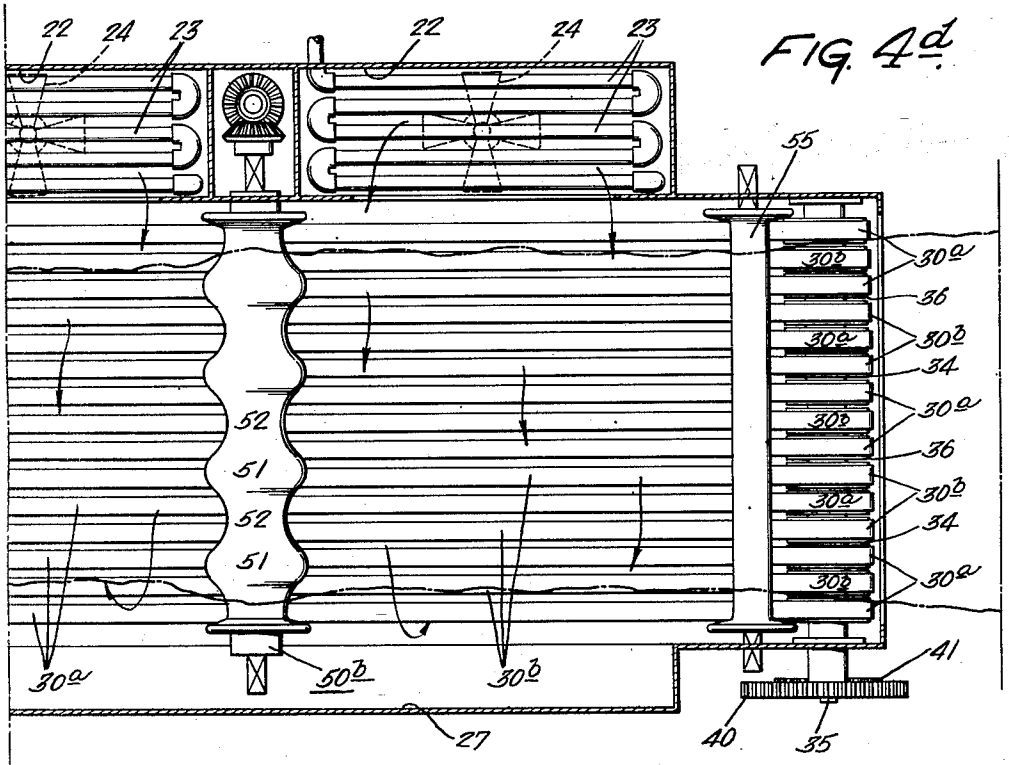
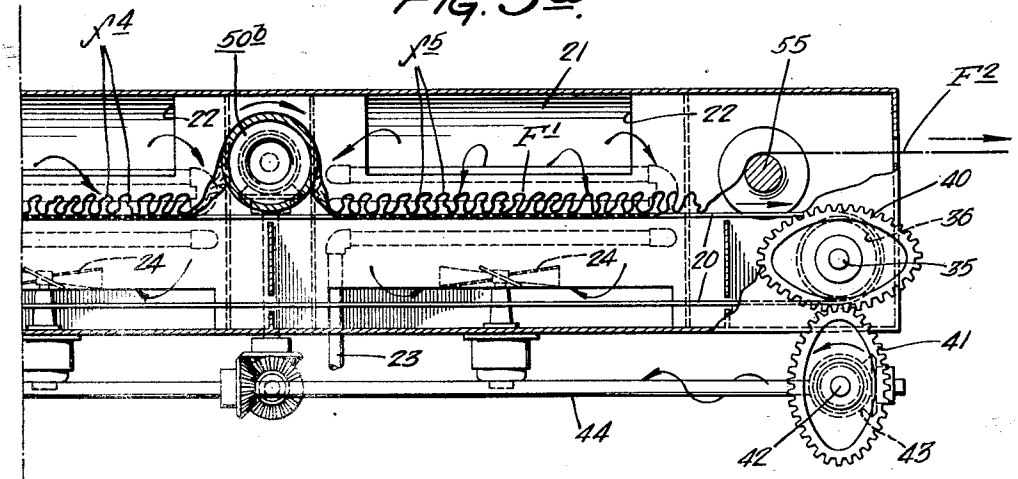


FIG. 5d.



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July 27, 1943. F. R. REDMAN 2,325,544

PROCESS FOR DETENSIONING FABRICS AND THE YARNS OR THREADS OF WHICH THE FABRIC IS COMPOSED

Filed Aug. 28, 1941 6 Sheets-Sheet 6

FIG. 6.

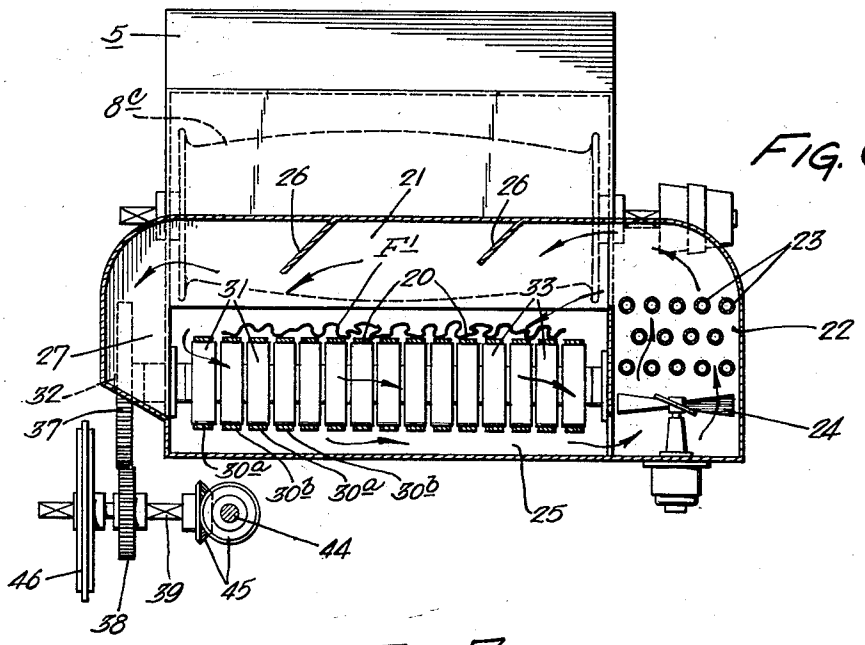


FIG. 7.

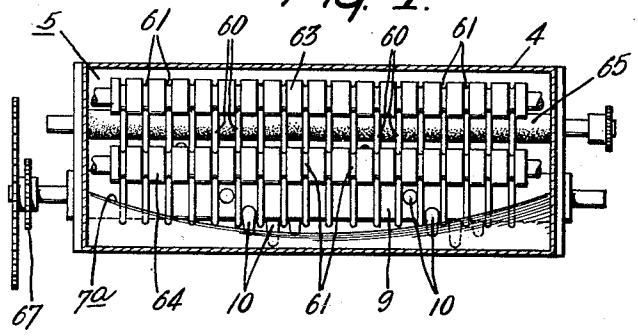
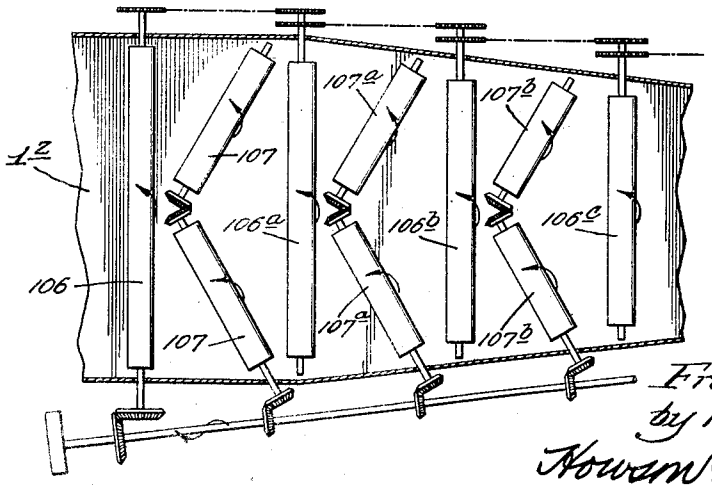


FIG. 8.



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Patented July 27, 1943 2,325,544

UNITED STATES PATENT OFFICE

2,325,544

PROCESS FOR DETENSIONING FABRICS AND THE YARNS OR THREADS OF WHICH THE FABRIC IS COMPOSED

Frank R. Redman, Yardley, Pa.

Application August 28, 1941, Serial No. 408,676

17 Claims. (Cl. 26—19)

This invention primarily relates to a process for treating textile fabrics, to control the amount of shrinkage in a finished fabric, or at a predetermined stage in the finishing of the goods, in order that the fabric, or articles made therefrom, may be accurately described as being "non-shrinkable" or having "less than 2% shrinkage" etc., according to the demand made upon the commercial finisher.

The process is adapted for use with woven, knitted, braided, netted, twist-lace and other varieties of textile fabrics, made of cotton, wool, artificial silk, etc., or combinations thereof, in flat-sheet, tubular, or strip form.

Most natural textile fibres, prior to being formed into yarns or threads, have at least some inherent irregularities, such as spiral twists, wavy edges, sharp bends, easy curves, kinks, etc., throughout the length of each individual fibre.

In the case of synthetic fibres, such as artificial silk and other substitutes for natural silk, commercially known as "Rayon," "Nylon," etc., the filaments, as formed, are substantially straight. In some instances these filaments are cut into staple lengths, corresponding to cotton or wool, for use alone or for mixing with other fibres. During the formation of these synthetic filaments or fibres into yarns they are twisted together and thereby assume spiral twists, curves or other deviations from the purely straight character of the original filament. These assumed irregularities, after the fibres have been twisted together in a yarn or thread and processed, take on a permanent "set" which closely approaches the permanent "set" of the inherent irregularities of natural fibres, insofar as the fibres, if tensioned and then released, will reassume their irregular form rather than return to the purely straight line character of the original filament.

During the formation of the natural fibres into yarns or threads, the permanent or set irregularities of the individual fibres are temporarily reduced to some extent, as a result of tension under which the fibres are placed and maintained.

During the fabrication of the yarns, composed of natural or synthetic fibres, into a fabric, and as a result of the more or less tight interengaging relationship of the yarns or parts of yarns with each other in a finished fabric, the degree of tightness depending upon the character of the fabric and the mode of fabrication, the extent of the permanent irregularities of the individual fibres of which the interengaging yarn parts are composed are further reduced and held in that abnormal condition, with the permanent twists, kinks, bends, curves, etc., of a large percentage of the fibres practically straightened out.

In the course of bleaching, dyeing, and other processing, a fabric frequently gains a considerable amount in length, as a result of the tension under which the fabric is maintained. This further reduces the extent of the set irregularities of the individual fibres.

I have found, by extensive research, that the above noted conditions are responsible for subsequent shrinkage of the fabric each time the fabric is laundered, in bulk or after having been made up into garments and/or other articles of various kinds, such as men's and boys' shirts, underwear, sweaters, tablecloths, mattress and furniture covers, etc., for several washings. I have found that such shrinkage will continue until the set irregularities of the natural or synthetic fibres return to the individual fibres.

I have also found, as a result of further extensive research, that all or any predetermined part of the manufacturing and processing gain, resulting from the above noted condition of the fibres, can be removed from the fabric at one time, and subsequent shrinkage eliminated, by treating the fabric in a manner to permit the twists, kinks, bends and curves to return to the individual fibres.

Taking cotton as an example, the raw fibres, when examined under a microscope, are found in some instances to be in the form of spirally twisted bands and of substantially flat, rectangular cross-section with irregular wavy edges. In other instances, the fibres appear to be in the form of hollow tubes of various cross-sectional shapes and of an irregular, wavy formation throughout the length of the fibre.

When the fibres are in their original form, as harvested, the twists, bends and curves, etc., of the fibres are "set" therein, and while such irregularities may be temporarily decreased or entirely removed when the fibre is placed under tension, such irregularities will return instantly upon release of such tension from the fibre. Wool fibres, like cotton, include irregular undulations throughout the length of each fibre.

In preparing cotton, for example, for use in weaving, knitting, etc., the fibres, after ginning and willowing to remove seeds and dirt, are put through a number of operations known generally as "cotton spinning," which includes mixing, opening and picking, carding, drawing, slubbing, roving, spinning, doubling, slashing, etc.

In the carding, drawing, slubbing and roving operations, particularly, the fibres are constantly placed and held under longitudinal tension, for the purpose of drawing the fibres out as straight as possible preparatory to twisting the sliver or roving, as the case may be, into a thread or yarn ready for singeing, or slashing.

During the slashing operation, the yarn or thread is held under longitudinal tension while the sizing is applied to the outer surface thereof and dried. The drying of the sizing on the tensioned yarn keeps the fibres under tension, after the tension on the yarn as a whole has been released. During the slashing operation, a yarn frequently gains in length from 2% to 7%, due to the tension under which the yarn is held.

In weaving a fabric, the yarns are divided into warps and wefts (filling). The warps are under high tension at all times during the weaving operation. The warps are divided into at least two series, which are raised and lowered alternately to provide open sheds for receiving the filling, which latter is carried across the warp under some degree of tension by shuttles or needles, hooks, etc., depending upon the type of loom employed. The tension on the filling is increased when the warp shed changes to bind in each newly inserted weft. Thus, all the threads or yarns are placed and held under tension in the woven fabric.

In knitting, the thread is maintained under tension when fed to the needles of the knitting machine, and although this tension may be reduced to some extent as the newly formed stitches are cast from the needles, there still remains a certain amount of tension in the yarn when the fabric is removed from the knitting machine.

In braided fabrics, the interlacing of the various threads is effected with the threads under relatively high tension and, due to this tension, the interengaging relationship of the yarn parts holds the fibres in an unnatural condition, in the same general manner as in woven or knitted fabrics.

After a fabric is completed on a loom, knitting machine, braiding machine, etc., it is subjected to a finishing process in which it may gain 10% or more in length. Cotton shirtings, for example, are bleached, dyed and finished. In the bleachery, the fabric is singed, while held under tension in a flat open form. The fabric is then wetted and reduced to a rope form. From the singeing house, which is more or less remotely situated with respect to the bleaching as a matter of precaution against spread of fire, the rope of fabric may be pulled through "pot eyes" a distance of from 50 to 300 feet, to a keir in the bleach house, under tension. In the keir the fabric is packed and boiled. From the keir the fabric rope is pulled, under tension, to a washing machine, through which the fabric passes at least five times while held under extremely high tension. The fabric is then opened up again into a flat form and passed through a mangle, while being held under high tension.

From the mangle the fabric is passed, under tension, about a series of drying cylinders, known as a can drier. From the drier, the flattened fabric may pass to and through a mercerizing solution, after which it is again reduced to a rope form for passage three or more times through the washing machine, under high tension. From the washing machine the fabric again returns to the keir for another boiling. After this treatment in the keir, the fabric is again run in rope form, under high tension, through the washing machine at least five times. From the washing machine the fabric rope may be run through a bleaching solution and subsequently given at least two more washings, under high tension. The fabric is then spread out and run through a mangle from which it passes to and through a loop drier or around the cylinders of a cam drier preparatory to dyeing or starching, under high tension constantly.

If the fabric is to be dyed, it is held out flat, under high tension, in order that the dye will enter it evenly, without streaking. If the cloth is to be starched, it is likewise held out flat, under high tension, to permit the starch to spread uniformly.

After dyeing or starching, etc., the cloth is applied to a tenter frame to pull it out to uniform predetermined width, under heavy tension, for final drying.

From the foregoing, it will be clear that from the time the treatment of the fibres begins until the fabric is finished, the fibres are held, constantly, under longitudinal strain.

In order to prevent the fabric from shrinking after it has been made up into garments, etc., it is essential that the gain which the yarns and the fabric attain during manufacture be eradicated, and that the tense, abnormal condition of the fibres of the yarns be nullified.

Briefly, the process by which such eradication and nullification are accomplished, according to the present invention in its broadest aspect, consists in intermittently placing the fabric under longitudinal and transverse compression, in the plane of the fabric, and then permitting it to relax, while applying moist heat to the fabric.

The invention also relates to apparatus by which the method may be put into practical use. It will be readily conceivable that many different forms of apparatus may be utilized within the scope of the invention, insofar as the method is concerned.

The method and one or more forms of apparatus will be more fully disclosed, in detail, hereinafter, reference being had to the accompanying drawings, of which:

Fig. 1 illustrates a yarn or thread composed of textile fibres having set irregularities by which the individual fibres when relieved of tension will inherently deviate from a purely rectilinear form;

Fig. 2 illustrates a greatly magnified fragmentary portion of the yarn or thread of Fig. 1, showing the component fibres under longitudinal tension comparable to that of the fibres in a fabric prior to undergoing treatment in accordance with the principles of the present invention, i. e., with set irregularities of the fibres materially reduced in extent;

Fig. 3 illustrates the yarn or thread of Fig. 2 after treatment of the fabric according to the present invention, i. e. with the set irregularities returned to the individual fibres;

Figs. 4*a*, 4*b*, 4*c* and 4*d* collectively constitute a sectional plan view of one form of apparatus adapted for use under the method of the present invention;

Figs. 5*a*, 5*b*, 5*c* and 5*d* collectively constitute a vertical longitudinal sectional elevation through the portions of the structure shown in Figs. 4*a*, 4*b*, 4*c* and 4*d* respectively;

Fig. 6 is a transverse section on the line 6—6, Fig. 5*a*;

Fig. 7 is a transverse section on the line 7—7, Fig. 5*c*; and

Fig. 8 is a diagrammatic plan view of a modified form of apparatus.

The yarn or thread A, shown in Fig. 1, is composed of a multiplicity of intertwisted individual fibres *a*, *a*, of long, short, or intermediate length, depending upon the use to which the yarn or thread is to be put and the class and quality of the fabric in which the yarn or thread is to be incorporated.

As shown in Fig. 2, the individual fibres *a*, *a*, when the yarn or thread is under tension, are relatively straight and in general parallel relation to each other.

As shown in Fig. 3, the fibres a^1, a^1, when the yarn is relieved of tension, return to their set irregularly wavy, twisted, kinked, sharply bent, or easy curved condition.

When the fibres are in the strained, abnormal condition illustrated in Fig. 2, the fabric will have a tight, relatively harsh feel or "hand" as it is commonly termed in the art; whereas, when the fibres return to their set irregular condition, illustrated in Fig. 3, the fabric will have a softer, fuller feeling.

The transition of the fibres from the condition illustrated in Fig. 2 to the condition illustrated in Fig. 3, is attained by working the fabric, and consequently the individual fibres, constantly, in the presence of moist heat, with the fabric in a fully relaxed state. This working is preferably carried on in such a manner that the fabric, in relatively small spaced local areas thereof, is bunched up and then released, repeatedly, by which the fibres are placed under more or less longitudinal compression, intermittently, and are then permitted to relax. These localized areas are distributed over the length and breadth of the fabric and their relative positions are changed constantly so that the entire area of the fabric receives the treatment repeatedly. The loose, free, relaxed condition of the fabric, as a whole, permits the bunching up of the fabric in adjacent local areas without placing the fabric lying intermediate spaced local areas under any tension whatsoever, at any time.

In order to work over the entire length of a continuous strip or web of fabric, I prefer to advance the fabric lengthwise along an elongated table, by pushing the fabric, at all times, which produces the above noted bunching of the fabric and the consequent intermittent longitudinal compression of the individual fibres.

As the fabric is pushed in the direction of its length along the work table, it is also pushed inwardly from both of its marginal edges, simultaneously or alternately, which contributes to the bunching action above referred to and places the fibres of any threads which extend transversely of the fabric (filling for example) under lengthwise compression at the same time as the fibres of the longitudinal threads (warps for example) are placed under lengthwise compression.

The above noted lateral inward pushing and bunching of the fabric is repeated a number of times as the fabric is pushed longitudinally along the work table, and, intermediate these inward pushings, the fabric may be spread laterally, outwardly, without being tensioned.

In Figs. 5*a*, 5*b*, and 5*c*, the elongated work table, referred to above, is illustrated at **1**. As illustrated in Figs. 4*a*, 4*b*, and 4*c*, the work table **1** is provided with veritical side walls **2** and **3**, respectively, which extend from said table upwardly to a roof structure **4**, spaced above the table **1**, and which therewith form a closed processing chamber **5**.

At spaced intervals throughout the length of the processing chamber **5**, and extending transversely thereof, are three series of rotary buncher units **6***a*, **6***b*, **6***c*, in the present instance, of which there may be as many or as few individual units in each series as desired or necessary for any particular job.

Associated with the three series of rotary buncher units **6***a*, **6***b*, **6***c*, are three series of stationary buncher units **7***a*, **7***b* and **7***c*, respectively.

Following each series of bunchers **6***a*, **7***a*; **6***b*, **7***b*; **6***c*, **7***c*; is a transfer roll **8***a*, **8***b* or **8***c*, as the case may be.

Each rotary buncher **6***a*, **6***b* or **6***c*, as the case may be, comprises a central axially elongated hub section **9** which preferably extends completely across the chamber **5**, between and, if desired, beyond the side walls **2** and **3**. Projecting radially from and arranged in a spiral course around and along each hub section **9** is a series of resilient fingers **10**, the tips of which, as the buncher revolves about its horizontal axis, makes light but firm contact with the work table **1** or any piece of fabric spread out or lying thereon.

At the feed end **15** of the chamber **5**, is a pair of resilient faced rolls **11** and **12** which receive a fabric F in full width and in a substantially smooth, flat condition. The rolls **11** and **12** pass the fabric F into the bite of a pair of parallel conveyor belts **13** and **14**. These belts **13—14** deliver the fabric onto the upper end of a downwardly inclined portion **1***a* of the stationary work table **1**. As the belts **13—14** continue to feed the fabric F onto the incline **1***a*, the fabric slides down said incline, by gravity, and builds up in folds *f* along said incline.

As the number of folds *f* increases, the weight of the fabric lying on the incline **1***a* forces the folds *f* along a contiguous horizontal portion **1***b* of the work table **1**, until the folded fabric comes under the rotating fingers **10** of the first rotary buncher **6***a*.

The fabric F, in entering the chamber **5**, may be in a dry or moist state. A moisture content amounting to not more than 80% of the dry weight per square yard of the fabric is preferred. As the folds *f* of the fabric F slide down the incline **1***a*, onto and along the flat part **1***b* of the table **1**, they come under the influence of moist heat in the form of steam sprays **16***a* impinging thereon from a transversely extending steam pipe **17***a*. The steam sprays **16***a* warm and moisten the fabric as it comes under the influence of the first rotary buncher **6***a*. As the folds *f* advance downwardly along the incline **1***a*, the longitudinally extending fibres, i. e. the fibres of the threads which extend longitudinally of the fabric, are placed under a longitudinal compression which is provided by the weight of the fabric pushing the folds *f* down the incline **1***a*.

As the folds *f* advance toward the fingers **10** of the rotary buncher **6***a*, these fingers, one after another, press into the folds *f* and advance the fabric further along the horizontal portion **1***b* of the work table **1**. As shown in Fig. 4*a*, the fingers **10** are arranged spirally about the hub **9** and in successively contacting the transversely extending folds *f*, the fingers **10** break up such transverse folds into local relatively spaced, irregularly distributed bunches of fabric, indicated at f^1.

The frictional effect caused by the fabric being pushed along the horizontal portion **1***b* of the

work table 1, by the fingers 10 of the first rotary buncher 6a, places the longitudinal fibres in the local bunches f^1 under increased longitudinal compression. As the fingers 10 successively move out of contact with the fabric F, and the forward movement of the fabric bunches f^1 by the respective fingers 10, 10 ceases, the bunches f^1 produced by the fingers are permitted to relax. Thus, the intermittent compressions and relaxations in the local areas of the fabric are effected.

The forward progression of the fabric as a whole is retarded by the fabric coming in contact with the forwardly inclined face of the first stationary buncher 7a. The buncher 7a is in the form of a transversely extending inverted V-shaped ridge formed in or on the work table 1. The upper edge of the stationary buncher 7a is low at the central portion of the work table 1 and is inclined upwardly and rearwardly, with respect to the direction of progress of the fabric, from the center of the work table 1 toward each of the side walls 2 and 3. The stationary buncher 7a presents a vertical concave dam or barricade to the progress of the fabric passing along the work table 1.

As the fabric builds up against the stationary buncher 7a, it is pushed up the forwardly inclined face thereof and over the top edge of the barricade, by the advancing action produced in the fabric by the first rotary buncher 6a. As the fabric slides over the concave upper edge of the barricade 7a, the marginal edges of the fabric, those portions intermediate the marginal edges, and the central part of the fabric, tend to slide down the lateral inclines of the upper edge of the barricade lying adjacent the opposite sides respectively of the work table 1, toward the center thereof as a result of the downwardly converging inclinations of the vertical concave upper edge of the stationary barricade 7a.

The inward transverse movement of the fabric, as afforded by the concave surface of the stationary buncher 7a, tends to produce local bunching of the fabric transversely thereof, in conjunction with the local bunching produced by the longitudinal advancement of the fabric by the rotary buncher 6a. This action places the transverse fibres, or the fibres of the transversely extending threads of the fabric, under longitudinal compression. At the same time, the transverse bunching reduces the overall width of the forwardly advancing fabric.

As the fabric is advanced over the first stationary buncher 7a, it slides down the forward inclined face thereof toward the secondary rotary buncher 6a. Intermediate the second rotary buncher 6a and the first stationary buncher 7a, the bunched fabric is subjected to moist heat in the form of steam sprays 16b impinging upon the fabric from a transversely extending pipe 17b.

The weight of the fabric sliding down the forward face of the stationary buncher 7a under the impetus of the advancing movement of the fabric afforded by the first rotary buncher 6a, advances the fabric along the next horizontal portion 1c of the work table 1, until it comes under the influence of the fingers 10 of the second rotary buncher 6a.

The fingers 10 of the second rotary buncher 6a are in offset or staggered relation, or in some other predetermined irregular relationship with respect to the fingers 10 of the first rotary buncher, so that the fingers of the second rotary buncher engage the fabric in different spots from those engaged by the fingers of the first rotary buncher, thus, some of the bunches created by the first rotary buncher are upset by the fingers of the second rotary buncher, which, as a matter of fact, were previously modified by the movement of the fabric over the first stationary buncher 7a.

The above noted operations are repeated any desired number of times as the fabric advances along succeeding flat portions 1c, 1d, 1e, 1f and 1g, for example, with the fabric, in each instance, first coming under the influence of a rotary buncher and being pushed thereby over a stationary buncher in the presence of moist heat admitted from the pipes 17c, 17d, 17e, 17f.

As the fabric passes over the stationary bunchers 7a, one after another, the marginal edges thereof are worked inwardly toward the central portion of the fabric, by sliding down the inwardly and downwardly inclined surfaces of the stationary bunchers. After leaving the last rotary buncher of the series 6a, the fabric is pushed thereby onto the upper surface of the first rotary spreader 8a, which, as shown in Fig. 4b, is of a convex construction, being of larger diameter at the central vertical plane of the work table 1 than it is adjacent the side walls 2 and 3 of the chamber 5, thus, as the convex roll 8a is rotated, the fabric is pushed onto its rotating surface and has a tendency to fall of its own weight from the central portion of the surface of the roll toward the opposite ends respectively thereof, thereby spreading the fabric laterally without placing it under any tension.

As shown in Fig. 5b, the axis of rotation of the convex roll 8a is below the cloth-carrying surface of the work table 1. Thus, the roll is not required to lift the fabric and place it under longitudinal tension. Preferably, the convex roll 8a is longitudinally fluted to provide looseness in the fabric as it passes over the surface of the roll, thus preventing tensioning of the fabric.

The spreading roll 8a delivers the fabric onto a downwardly inclined section 1h of the work table 1, in the form of a newly arranged series of folds f2 which then come under the influence of the first rotary buncher of the second series of units 6b, 6b.

Intermediate the individual units of the second series of rotary bunchers, 6b, the work table 1 is provided with a second series of stationary bunchers 7b and with flat sections 1i, 1j and 1k of the table 1 between said stationary bunchers. These flat sections provide for horizontal movement of the bunched fabric along the table 1. The fabric receives substantially the same treatment by the rotary bunchers of the second series 6b and the associated stationary bunchers 7b as it had received from the rotary buncher 6a and stationary buncher 7a of the first series thereof. Moist heat is provided from the transverse pipes 17g, 17h and 17i impinging steam against the fabric in the manner previously described.

The last of the rotary bunchers of the series 6b pushes the fabric longitudinally onto a second convex spreader roll 8b, which, like the spreader roll 8a, rotates about an axis disposed preferably below the work table 1.

The spreader roll 8b delivers the fabric in the form of rearranged folds f3 onto a downwardly inclined portion 1l of the work table 1, said folds being subjected to moist heat from the transverse pipe 17j, Fig. 5b. At the bottom of the incline 1l, the fabric passes along a horizontal portion 1m of the work table 1 and comes under the influence

of the first unit of a third series of rotary bunchers 6c. The section 1m of the work table 1 may or may not be provided with stationary bunchers, one of which is shown at 7c. The last buncher of the series 6c, Fig. 5c, delivers the fabric onto a convex spreader roll 8c. The fabric again receives moist heat from the steam pipes 17k, while passing along the table section 1m under the influence of the series of rotary bunchers 6c.

Intermediate the feeding aprons 13 and 14, and the spreader roll 8c, the fabric, assuming it to have been dry or substantially dry when fed into the chamber 5 by the rolls 11 and 12, will have preferably absorbed not more than 80% of the dry weight per square yard of the fabric in moisture. While in this moist condition, the fabric is continuously maintained under longitudinal and transverse compression in the plane of the fabric, and is continuously worked over in a multiplicity of ever-changing local areas by the rotary and stationary bunchers. Such continuous working of the fabric in the presence of the moist heat, with the fabric in a damp condition, causes a relative loosening of the individual fibres in the component yarns or threads of the fabric and affords a complete relaxation of the fibres from the tension under which the fibres had been placed during the manufacture of the yarn, and the subsequent manufacture of the fabric from a multiplicity of such yarns. This relaxation from tension, and the loosening of the fibres with respect to each other, permits the fibres of each component yarn or thread to change from the relatively straight form of Fig. 2, in which the fibres are deformed, to their normal or set state illustrated in Fig. 3, where the set irregularities, including curves, bends, kinks, etc., are returned to the fibres.

The return of the set irregularities of the fibres is further assisted as the fabric is dried, after leaving the spreading roll 8c. For this purpose, the fabric is delivered by the spreading roll 8c onto a carrying run of a horizontal belt conveyor 20, Figs. 5c and 5d. The conveyor 20 travels in a horizontal plane through a drying chamber 21, in which dry heat is circulated in the manner shown in Fig. 6.

As shown in Fig. 6, the drying chamber 21 is provided with a circulating chamber 22 in which are installed air-heating pipes, or the equivalent, 23, and a fan 24 by which air is drawn from the lower portion 25 of the chamber 21, below the carrying run of the conveyor 20, and passed upwardly through the air heater 23 into the upper portion of the chamber 21, where the air travels transversely across the worked over fabric F1, suitable deflectors 26, 26 being provided to cause the air moving transversely of the chamber 21 to descend into contact with the fabric F1, thereby effecting a drying of the fabric. After passing across the conveyor 20 with the fabric F1 thereon, the air passes through a second circulating chamber 27, by which it is directed into the lower portion 25 of the drying chamber 21 for a repeat of the circulating cycle. Obviously, any suitable form of air-circulating means or air-heating means may be provided.

Instead of permitting the fabric to lie in a quiescent state on the conveyor 20 as it is being dried, I prefer to work the fabric continuously during the drying thereof in a multiplicity of local areas thereof, and for this purpose, the conveyor 20 is preferably composed of two series of relatively narrow bands 30a, 30a and 30b, 30b, arranged in parallel alternating succession across the width of the drying chamber 21, as shown in Figs. 4c, 4d, and 7.

At the end of the drying chamber 21, adjacent the spreading roll 8c, the bands 30a pass around wheels 31, which are secured to a transverse shaft 32. The shaft 32 is suitably mounted for rotation in the drier. Intermediate the tight wheels 31 on the shaft 32, the bands 30b extend around wheels 33, which are loosely mounted on the shaft 32.

At the opposite end of the dryer, the bands 30b pass around wheels 34, which are secured to the transverse shaft 35, mounted for rotation in the dryer, while the bands 30a pass around intermediate wheels 36, which are loosely mounted on the shaft 35.

On one end of the shaft 32 is secured an elliptical gear 37, which meshes with a corresponding elliptical gear 38 secured to a transverse shaft 39, mounted for rotation outside the dryer chamber. The shaft 35 is provided with an elliptical gear 40, rigidly secured thereto, which meshes with a corresponding elliptical gear 41, secured to a transverse shaft 42, mounted for rotation outside the dryer chamber. The shaft 42 is coupled by miter gearing 43 to a longitudinal shaft 44, which is also coupled by miter gearing 45 with the shaft 39. The shaft 39 is provided with a drive wheel 46, which is rotated by a belt or chain, etc., 47, from any suitable source of power, such as an electric motor, etc., (not shown).

As shown in Figs. 5c and 5d, the longer diameters of the elliptical gears 37 and 40 on the shafts 32 and 35, respectively, are set at 90° with respect to each other, i. e. when the elliptical gear 37 is in a position with its longer diameter vertically disposed; the elliptical gear 40 is in a position with its longer diameter horizontally disposed, as shown in Figs. 5c and 5d, respectively. The corresponding elliptical gears 38 and 41 are likewise set at 90° apart.

The gears 38 and 41 are driven at constant, uniform speeds, and transmit, through the elliptical gears, variable speeds to the shafts 32 and 35, which, while rotating in the same direction, are each accelerated in one portion of each cycle of rotation and decelerated in another portion of the cycle.

As a result of the two series of conveyor bands 30a and 30b being driven by the shafts 32 and 35, respectively, the carrying runs of these bands, while they move continuously in one direction through the drying chamber 21, are alternately accelerated and decelerated, i. e. the alternate bands will move under increased speed for a relatively short period while the intermediate bands are moving at a slower speed, after which the intermediate bands will increase in speed while the alternate bands decrease in speed, thus, these portions of the width of the fabric lying on the respective bands are constantly being moved with respect to immediately adjacent portions of the width of the fabric.

The surface speed of the spreading roll 8c is greater than the linear speed of the carrying run of the conveyor 20, thus, the roll 8c delivers the fabric F1 to the conveyor 20 in the form of transverse folds f3. These folds provide sufficient looseness in the fabric lying on the conveyor 20 to prevent any tensioning between adjacent parts of the fabric, during the differential movements of the adjacent bands 30a and 30b of which the conveyor 20 is composed.

Intermediate the opposite ends of the drying chamber 21, said chamber is provided with trans-

versely extending rolls 50*a* and 50*b*, Figs. 5*c* and 5*d*, respectively, which, as shown in Figs. 4*c* and 4*d*, respectively, are corrugated throughout their length, said corrugations comprising circumferentially extending high portions 51 alternating with circumferentially extending low portions 52. The high portions 51, 51 of the rolls 50*a* and 50*b* are disposed in alignment, longitudinally of the chamber 21, with the low circumferential portions 52, of each other.

As the fabric F1 is advanced through the drying chamber 21, it passes first over the roll 50*a* and then over the roll 50*b*. The corrugations of the roll 50*a* upset or disturb the positions of the folds or bunchings *f*3 of the fabric F1 and redeposit the fabric F1 on the bands 30*a*, 30*b* of the conveyor 20 in a new arrangement illustrated at *f*4 in Figs. 5*c* and 5*d*. The corrugated roll 50*b* then lifts the fabric off the conveyor and upsets the bunchings *f*4 and redeposits the fabric in a new arrangement of folds *f*5. In other words, the high and low parts of the rolls 50*a* and 50*b* tumble the fabric about transversely as it is advanced by the bands 30*a* and 30*b*, thus, the entire area of the fabric is undergoing a working action, both longitudinally and transversely, while the fabric is being dried.

The constant overall working of the fabric permits the kinks, bends, etc., of the fibres to return to their "set" condition. The fabric F1 is finally passed over a delivery roll 55 adjacent the shaft 35 and passes from the drying chamber in a dry, normalized state, as indicated at F2, Fig. 5*d*. The peripheral speed of the delivery roll 55 would substantially correspond to the peripheral speed of the feed rolls 11 and 12 and the feed aprons 13 and 14 located at the opposite end of the apparatus less the reduction per yard effected by the process according to the invention. The fabric F2, as delivered from the dryer 21, may be passed through any further finishing or additional processing that may be desired without departing from the spirit of the present invention.

In some instances, due to processing of the fabric prior to its entrance into the chamber 5, the moisture content of the fabric may be in excess of 100% of the weight of the fabric per square yard. Under such circumstances, the weight of the water itself prevents the return of the fibres to their set condition, should an attempt be made to normalize the fibres under the process of the present invention. Under such circumstances, I prefer to reduce the moisture content to not more than 80% of the dry weight of the fabric per square yard, prior to feeding the fabric between the rolls 11 and 12 for entrance into the normalizing chamber 5. When such conditions are encountered, the fabric can be run through any suitable dryer, for example, an ordinary loop dryer or over drying cans, etc., to reduce the moisture content. If desired, a dryer similar to that illustrated in the present case, comprising the drying chamber 21 with the differentially movable bands 30 and 30*a*, may be employed ahead of the working or reducing chamber 5. The working of the wet fabric in the presence of hot circulating air will tend to lower the moisture content rapidly, preparatory to the entrance of the fabric into the working or reducing chamber 5. Such predrying and constant working of the fabric prior to its entrance into the main working chamber 5 takes some shrinkage out of the fabric.

In order to operate the fabric working apparatus within the chamber 5 at a high rate of speed, for example, with the fabric passing into and out of the apparatus at the rate of 45 to 100 yards per minute, I provide suitable means for preventing the fabric from clinging to the fingers 10 of the rotary bunching units. In the present instance, this means comprises a series of stripper rings 60 for each of the rotary bunching units, as shown clearly in Figs. 4*a* and 5*a*.

As shown in Figs. 4*a*, 4*b*, 5*a*, 5*b* and 6, the fingers 10 are spaced apart along the length of the hub section 9, in addition to being spaced apart circumferentially of said hub section. Preferably, there is a stripper ring 60 placed between each adjacent pair of fingers 10. Each stripper ring 60 is eccentrically disposed with respect to the axis of rotation of the hub 9. Each ring 60 passes under the hub section 9, and its axis of rotation is disposed above and forward of the axis of rotation of the hub section.

Each ring 60 is maintained in alignment with the space between the two fingers 10, 10, with which the ring cooperates by fitting into grooves 61 formed in guide rolls 62, 63 and 64, the axes of which are spaced apart circumferentially of the stripper ring 60 and extend parallel to the axis of the hub 9.

Located in a plane parallel to and intersecting the axis of the hub 9, the common axis of each set of rings 60, and the axis of the grooved roller 63, and engaging the inside surfaces of the rings 60 of each set thereof is a driving roller 65, which extends transversely of the chamber 5, parallel to and adjacent the guide roller 63.

The rings 60, associated with each of the rotary bunching units, are driven at equal peripheral speeds which are in excess of the tip speeds of the fingers 10 of the rotary buncher with which the set of stripper rings is associated. The directions of rotation of the fingers 10 and the set of rings 60 associated therewith are the same in each instance. Any fabric which may tend to adhere to the tips of the fingers will be stripped therefrom as the fingers rotate and recede between adjacent stripper rings 60. The circular paths traveled by the rings intersect the circular paths traveled by the tips of the fingers 10. By this arrangement the fabric is at all times cleared from the fingers.

The friction drive roller 65 for the rings 60 is preferably composed of natural or synthetic rubber, in order to provide a resilient friction contact with the inner surface of the rings 60. The driving rollers 65 are formed about a transversely extending shaft 66.

It will be understood that the apparatus may include any suitable form of framework having suitably bearings for rotatably supporting the various feed rolls, rotary bunchers, spreader rolls, etc., and any suitable means may be provided for driving these rotary elements at the relative speeds necessary for accomplishing the result desired, without departing from the spirit of the invention. In the present instance, sprocket wheels 67 and sprocket chains 68 are provided in lieu of belts, gears, or equivalent power-transmitting mechanism.

As shown in Figs. 4*a*, 4*b* and 4*c*, the steam pipes 17*a*, 17*b*, etc., are connected to a manifold 69, which, in turn, may be connected to any suitable source of steam.

The humidity and temperature within the chamber 5 may be automatically maintained and controlled by the usual form of dry and wet bulb thermometers commonly used for such purposes.

I prefer to maintain a temperature of about 215° F. within the processing chamber **5**; and a dry temperature of about 240° F. upwardly in the drying chamber **21**. However, these temperatures may be varied if and when conditions require. For example, compact woven or braided fabrics may require higher humidity and/or temperature than the more open knitted, netted or lace-twist fabrics.

Insofar as the fundamental principles of the present invention are concerned, the process may be efficiently worked by relieving a piece of fabric of all tension in all directions, steaming the fabric until it absorbs moisture to the extent of from 25% to 80% of its own dry weight, a range from 40% to 50% being the most desirable, constantly working the fabric by spreading the tips of the fingers of one or both hands over spaced local areas, respectively, of the fabric and drawing the fingers of each hand toward a common focal point to bunch the fabric up under each hand, then relaxing the fingers to release the fabric, spreading the fingers again over different local areas and repeating the bunching and relaxing operation until the entire area of the fabric has been worked over many times as steam is being applied.

Such constant working of the fabric in ever-changing localized areas thereof, in the presence of the heat and moisture absorbed from the steam by the fabric, effectively releases the fibres so that the set irregularities of the fibres return thereto.

Where the working is continued during the drying, the time of working in the presence of the moist heat can be reduced and the return of the fibres to normalcy quickened.

Any apparatus which would simulate the massage-like working of the fabric, or which would work the fabric in an equivalent manner to intermittently compress the fibres lengthwise thereof, could be used to put the process into commercial use without departing from the spirit of the invention.

Fig. 8 illustrates one modified form of apparatus for practicing the method. In this instance the fabric is fed to a stationary work table *1z* in the same general manner as described with respect to the work table **1**. Operating over the work table *1z* is a series of longitudinal bunchers alternating with transverse bunchers in the same general manner as heretofore described, except that in this instance the bunchers are in the form of rollers, preferably of the soft face type, which bear against the cloth and push it along the work table *1z*. For example, the one longitudinal buncher **106** pushes the full-width cloth into bunches and passes it in this form along the work table to a pair of divergently arranged transverse rollers **107**, **107**, which, due to the angles of their respective axes with respect to the longitudinal center line of the work table, work the fabric into rearranged bunches and pass these along to the next right angle transverse buncher roller **106***a*. This roller works and passes the fabric to another pair of divergent buncher rolls **107***a*, **107***a*. By and from the rolls **107***a*, **107***a*, the fabric is pushed to a right angle buncher roll **106***b*, thence to divergent rolls **107***b*, **107***b*, etc.

The right angle bunchers **106**, **106***a*, etc., alternating with the divergent bunchers **107**, **107***a*, etc., work the fabric continuously in a longitudinal direction and in a transverse direction.

There may be a number of series of the above noted rollers, arranged in tandem, with spreader rolls between the successive series, the same as previously noted with regard to the preferred form of apparatus previously described.

It will be understood that steam is applied to the cloth in this case also as the fabric is advanced along the work table *1z* by the rollers **106**, **107**, and that a drying unit may be used behind and/or in front of this shrinking unit, the same as previously noted.

Any suitable means may be employed to drive the various rollers **106**, etc., **107**, etc., without departing from the spirit of the invention.

From the foregoing descriptions, it will be clear that any apparatus which will rumple the fabric repeatedly over its length and breadth, or work or push the fabric inwardly or together in the direction of its length and width repeatedly to cover substantially the entire area of the fabric, without placing any portion of the fabric under tension, and which will apply heat to initially wet fabrics or heat and moisture to substantially dry fabrics undergoing treatment in accordance with the present invention, will effect either a complete return of the set irregularities to the fibres, or partial return, depending upon the length of time over which the treatment is continued, and will consequently reduce shrinkage of the fabric to zero or to any percentage it may be desired to leave in the fabric.

I claim:

1. A process for shrinking textile fabrics, characterized by compressively rumpling a fabric lengthwise and widthwise over its entire area repeatedly in the presence of moisture and heat and constantly maintaining the fabric free from tension during and intermediate the repeated rumplings thereof.

2. A process for shrinking textile fabrics, characterized by alternately bunching up and relaxing the fabric lengthwise and widthwise in spaced local areas over the length and breadth of the fabric repeatedly in the presence of moisture and heat and constantly maintaining the fabric free from tension during and intermediate the repeated bunchings thereof.

3. A process for shrinking textile fabrics, characterized by compressively working a fabric together lengthwise and widthwise repeatedly in the presence of moisture and heat and constantly maintaining the fabric free from tension during and intermediate the repeated workings thereof.

4. A process for shrinking textile fabrics, characterized by compressively pushing a fabric lengthwise and widthwise repeatedly in the presence of moisture and heat and constantly maintaining the fabric free from tension during and intermediate the repeated pushings thereof.

5. A process for shrinking textile fabrics, characterized by compressively pushing a fabric lengthwise at spaced intervals along a supporting surface and widthwise at intermediate intervals in the presence of moisture and heat and constantly maintaining the fabric free from tension during and intermediate the repeated pushings thereof.

6. A process for shrinking textile fabrics, characterized by compressively pushing a fabric lengthwise at spaced intervals along a supporting surface and widthwise at intermediate intervals in the presence of moisture and heat, periodically spreading the fabric as it is pushed lengthwise along the support and constantly maintaining the fabric free from tension during and intermediate said pushings and spreadings.

7. A process for shrinking textile fabrics, characterized by repeatedly compressively rumpling a fabric lengthwise and widthwise over its length and width in the presence of moisture and heat and subsequently in the presence of circulating dry heat and constantly maintaining the fabric free from tension during and intermediate the repeated rumplings thereof.

8. A process for treating textile fabrics, characterized by repeatedly rumpling a fabric compressively over its length and width in the presence of dry heat and constantly maintaining the fabric free from tension during and intermediate the repeated rumplings thereof.

9. A process for shrinking textile fabrics, characterized by repeatedly rumpling a fabric compressively over its length and width in the presence of dry circulating heat, then in the presence of moist heat, and finally in the presence of dry circulating heat and constantly maintaining the fabric free from tension during and intermediate the repeated rumplings thereof.

10. A process for shrinking textile fabrics formed of threads composed of longitudinally tensioned fibres, characterized by working the threads repeatedly in the direction of their respective lengths over the length and breadth of the fabric in the presence of moisture and heat with the fabric in a non-saturated condition to reduce the tension on the fibres and constantly maintaining the fabric free from tension during and intermediate said workings.

11. A process for shrinking textile fabrics formed of threads composed of longitudinally tensioned fibres, characterized by placing the threads under longitudinal compression repeatedly over the length and breadth of the fabric in the presence of moisture and heat to reduce the tension on the fibres and constantly maintaining the fabric free from tension to afford said longitudinal compression of said fibres.

12. A process for shrinking textile fabrics formed of threads composed of longitudinally tensioned fibres, characterized by intermittently placing the individual fibres under lengthwise compression lengthwise and widthwise of the fabric in the presence of moisture and heat to reduce the tension on the individual fibres and constantly maintaining the fabric free from tension to afford said longitudinal compression of said fibres.

13. A process for shrinking and drying textile fabrics, characterized by compressively rumpling a fabric over and in the direction of its length and breadth repeatedly in the presence of moisture and heat, feeding the rumpled fabric onto a forwardly moving belt at a linear speed greater than the linear speed of the belt, applying dry heat to the fabric on the belt and constantly maintaining the fabric free from tension during and intermediate the repeated rumplings thereof.

14. A process for shrinking and drying textile fabrics, characterized by rumpling a fabric over its length and breadth repeatedly in the presence of moisture and heat, feeding the rumpled fabric onto a forwardly moving belt at a linear speed greater than the linear speed of the belt, accelerating the forward motion of adjacent parallel sections of the fabric on the belt alternately, and applying dry heat to the fabric on the belt.

15. A process for shrinking and drying textile fabrics, characterized by rumpling a fabric over its length and breadth repeatedly in the presence of moisture and heat, feeding the rumpled fabric onto a forwardly moving belt at a linear speed greater than the linear speed of the belt, accelerating the forward motion of adjacent parallel sections of the fabric on the belt alternately, tumbling the rumpled fabric laterally in opposite directions at intervals along the path traveled by the belt, and applying dry heat to the fabric on the belt.

16. A process for drying textile fabrics, characterized by feeding a fabric tensionless lengthwise and widthwise onto a forwardly moving belt at a linear speed in excess of the linear speed of the belt, accelerating the forward motion of adjacent parallel sections of the fabric on the belt alternately, and applying dry heat to the fabric on the belt.

17. A process for drying textile fabrics, characterized by feeding a fabric tensionless lengthwise and widthwise onto a forwardly moving belt at a linear speed in excess of the linear speed of the belt, accelerating the forward motion of adjacent parallel sections of the fabric on the belt alternately, tumbling the rumpled fabric laterally in opposite directions at intervals along the path traveled by the belt, and applying dry heat to the fabric on the belt.

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