

May 30, 1944.

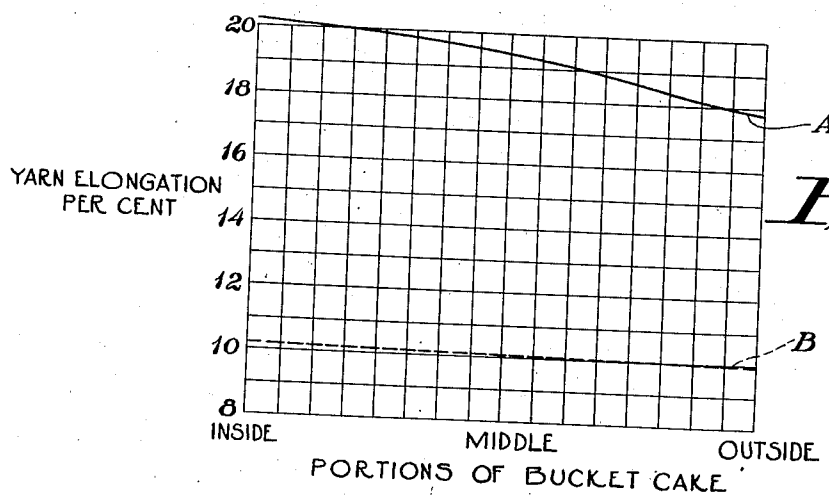
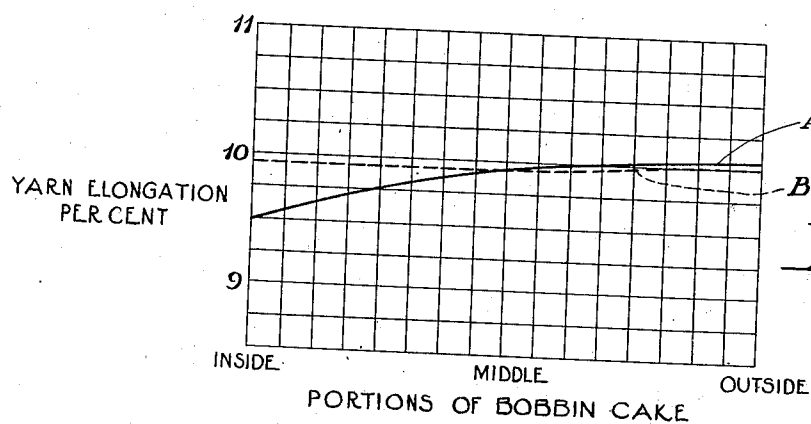
G. M. KARNS

2,350,168

PROCESSING YARN

Filed Jan. 4, 1941

2 Sheets-Sheet 1



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May 30, 1944.

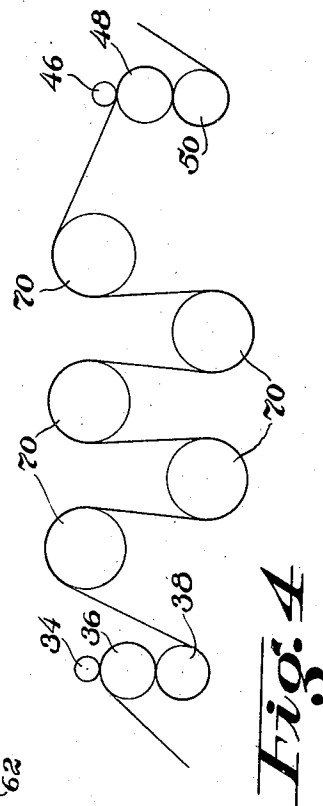
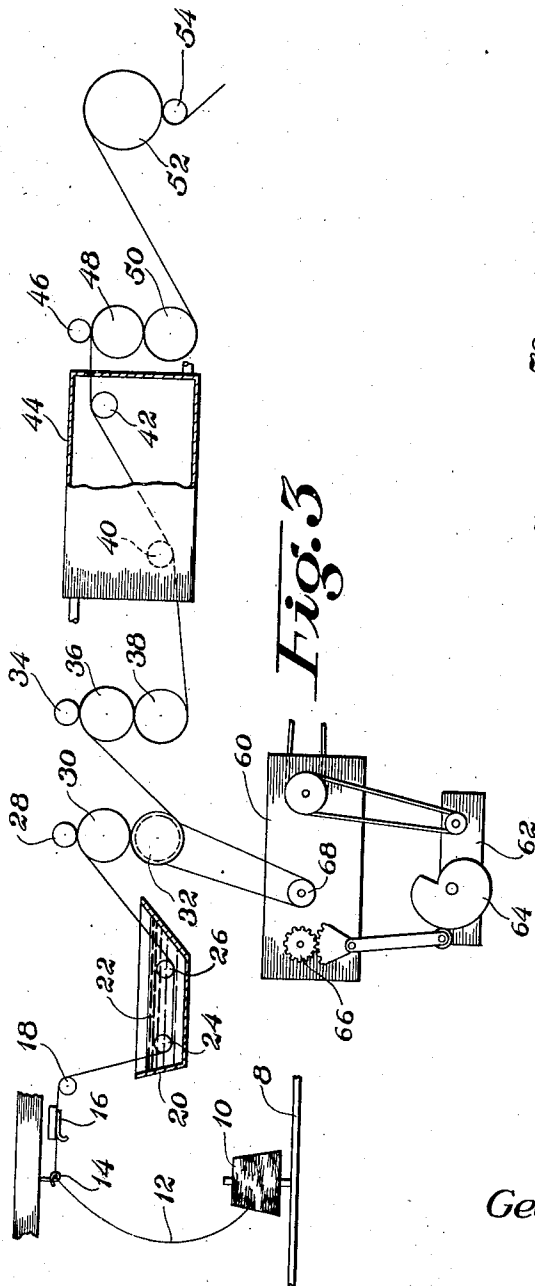
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PROCESSING YARN

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2 Sheets-Sheet 2



UNITED STATES PATENT OFFICE

2,350,168

PROCESSING YARN

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Application January 4, 1941, Serial No. 373,103

2 Claims. (Cl. 8—151)

This invention relates to the processing of gel regenerated cellulose yarn. It relates more particularly to the processing of the gel regenerated cellulose yarn which possesses non-uniform physical properties throughout its length. The process of this invention is especially useful for decreasing the elongation differential between the various portions of yarn in a package of gel regenerated cellulose yarn such as produced from viscose by either the bobbin or bucket spinning processes.

Viscose rayon yarns, i. e., regenerated cellulose yarns produced from viscose, are normally produced by either of two conventional processes, each of which operates in an intermittent rather than a continuous manner. According to each of them, a solution of viscose is extruded through a suitable nozzle or spinneret into a coagulating and regenerating bath from which the filaments of regenerated cellulose are withdrawn and wound in package form by a collecting device. According to the bobbin process, the yarn filaments leaving the bath are passed to a rotating spool or bobbin on which they are traversed and wound into a yarn cake. According to the bucket process, the yarn filaments leaving the bath are passed over a suitable feed wheel and guided into a rotating bucket, the filaments being laid down by centrifugal force along the inner periphery of the bucket while suitable traverse mechanism is provided to form the yarn mass into an annular cake. In each of these processes, layer upon layer of yarn is permitted to collect either on the bobbin or in the bucket until the accumulated mass forms a yarn cake of suitable size for doffing and subsequent washing, purification or finishing treatment.

Recently there have been developed methods for spinning viscose rayon yarns of high tenacity according to which the coagulating and regenerating filaments are subjected to considerable tension and consequent stretching between the spinneret and the collecting device. In the case of these high tenacity yarns spun by the bobbin process, this stretching occurs between the spinneret and the take-up bobbin and the yarn is wound on the bobbin under the same high tension at which it was spun. In the case of these high tenacity yarns spun by the bucket process, this stretching occurs between the spinneret and the feed wheel over which the yarn is passed before being introduced into the rotating bucket.

It has been found that these yarns are particularly useful for plying and twisting into strong cords which are especially valuable as reinforcing

members in rubber articles such as tires, beltings and the like.

Thus far, however, considerable difficulty has been encountered in the fabrication of rubber tires and similar articles from these high tenacity yarns because successive lengths of yarn taken from a single spinning cake show considerable non-uniformity in their physical properties and particularly in their elongation with a given load. In the case of bobbin spun yarn, purified and dried on the spinning bobbin, it is found that the elongation of the yarn at the outside of the bobbin cake is from 2½% to 3% greater than that of the yarn at the inside of the cake. In the case of bucket spun yarn, purified and dried in cake form, the spread in elongation between the inside and outside of the cake is usually much more and approaches 4% or even 5%. In the case of this latter yarn, however, it is found that the yarn at the inside rather than at the outside of the spun yarn cake possesses the higher elongation.

Cords serving as reinforcing members in rubber articles, such as tires, are subjected to considerable loads that cause them to stretch. Naturally, if a cord is composed of yarns of widely varying elongation, the yarns with the higher elongation will not bear their full share of the load and the cord as a whole will not exhibit its maximum strength. Furthermore, the fact that such a cord does not stretch uniformly often causes one of the yarns in the cord to break. This materially reduces the life of the tire or other article of reinforced rubber in which the cord is used. It is, therefore, highly desirable that the yarns in a cord possess substantially uniform physical properties, and particularly elongation, throughout their length.

It is also desirable that the yarns possess a low elongation under breaking loads. Preferably, this elongation should be of the order of 10%. Those high tenacity viscose rayon yarns spun by the bobbin process possess an average elongation throughout the cake of approximately this figure and are satisfactory in this respect. The average elongation through the cake of those high tenacity viscose rayon yarns spun by the bucket process, however, is of the order of 18% to 20%. This fact, together with the non-uniform nature of the elongation mentioned above, has made it extremely difficult to use in this particular field those high tenacity yarns produced by the bucket process.

At first glance, it is difficult to understand why this difference in physical properties, as evi-

denced by the above-mentioned difference in elongation, should exist between successive lengths of yarn contained in a single spinning cake. However, it is undoubtedly due to the fact that the spun yarns are collected at the spinning machine in package form as on a bobbin or in a rotating bucket. In the case of the bobbin process, a yarn spun at the start of the spinning operation is wound directly on to the rigid surface of the bobbin and is afforded no opportunity to relax. As the spinning proceeds, however, the yarn is wound upon several layers of yarns and because of the resilience of these layers, this newly formed yarn is afforded an opportunity to relax. This relaxation of the yarn does not appreciably affect the yarn tenacity, but does increase the yarn elongation. In the case of a bobbin cake of yarn weighing 3 pounds, the yarn at the outside of the cake may possess an elongation $\frac{1}{2}\%$ greater than that at the interior of the cake or next to the bobbin. If now this bobbin package having been purified and treated with a finishing solution is dried in its original package form, it is found that because of shrinkage of the yarn on drying, this outside yarn is afforded a further opportunity to relax and in this case the elongation of the yarn at the outside of the cake may be from 2% to 3% greater than that at the inside of the cake.

In the case of those high tenacity viscose rayon yarns spun by the bucket process, the stretching of the coagulating and regenerating filaments occurs between the spinneret and the feed wheel and it is possible to accurately control all the phases of the spinning operation up to this point. After passing the feed wheel, however, the yarn is permitted to relax to a considerable extent on its way to the spinning bucket and therefore acquires a fairly high elongation, as, for example, upwards of 18% at the breaking load. If the yarn were relaxed at this point in a uniform manner throughout the spinning operation, it might be expected that a final yarn possessing uniform denier, elongation, tenacity and the like would be obtained. However, the very nature of the bucket spinning process and the after-treatment of the bucket cakes of yarn prevents such uniformity. For example, the yarn first spun into the spinning bucket is subjected to greater centrifugal force than that yarn which is later spun into the bucket. Furthermore, the yarn cake is subjected to numerous purification treatments, and, as in the case of the bobbin spun yarn, while these treatments are in process, those layers of yarn nearest the surface of the cake encounter different conditions than do those layers at the inside of the yarn cake. These different conditions include greater exposure to the air, and alternate wetting and partial drying conditions. Furthermore, the yarns at the inside of the cake may be subjected to pressure by the partial drying and consequent shrinking of the outer portion of the cake. Numerous other factors may also enter to affect the yarn properties.

As the result of these factors, a purified but undried bucket cake of high tenacity viscose rayon yarn will exhibit throughout its length a difference of 2% to 3% in elongation. If the yarn is now dried in cake form, this difference will be increased to 4% or even 5%.

It is therefore an object of this invention to produce a viscose rayon yarn which, although processed in package form, will exhibit substantially uniform physical properties.

It is a further object of this invention to produce a high tenacity viscose rayon yarn which, although processed in package form, will exhibit a substantially uniform and low elongation.

A still further object of this invention is to provide a process of decreasing the elongation differential between the various portions of yarn in a package of gel regenerated cellulose yarn.

Other objects of the invention will appear hereinafter.

The objects of this invention are accomplished, in general, by unwinding a high tenacity regenerated cellulose rayon yarn from the bobbin or bucket cake in which it was spun, washed and purified, but not dried, and subjecting it while still in a gel and highly swollen state to a stretch corresponding approximately to the actual percentage elongation of the yarn. The yarn is then dried under uniform tension conditions whereby the finished yarn will retain its newly acquired uniform character.

The term "stretch" as used throughout the specification and claims is meant to include not only positive stretch, but negative stretch, i. e., a shortening or shrinking of the yarn. For example, the several parts of a yarn in a yarn cake may measure 5%, 10% and 15% elongation. By following the process of the present invention, the elongation characteristics of this yarn may be made uniform at 10% elongation by stretching the yarn having a 15% elongation, 5%, and stretching the yarn having 5% elongation a negative 5%, i. e., permitting it to shrink 5%.

This invention is based on the discovery that when a high tenacity regenerated cellulose yarn in the gel state is stretched a certain percentage of its original length and is then dried in that stretched condition, the dry elongation of the yarn is reduced by approximately the same percent. That is, when such a yarn is stretched 10% and dried in this stretched condition, the dry elongation of the yarn is reduced about 10%, for instance from 20% to 10%. Similarly, by permitting the yarn to shrink by a definite amount (applying a negative stretch) and then drying it in this condition, it is possible to increase the elongation of the yarn over its former value.

In the case of bobbin-spun, high tenacity viscose rayon yarn in the gel state as mentioned above, the elongation of the yarn contained at the outside of the bobbin cake (last spun yarn) is higher by $\frac{1}{2}\%$ or more than that of the yarn contained at the inside of the cake (first spun yarn). Therefore, in processing this yarn in accordance with the principles of this invention, it will be necessary to progressively decrease the stretching tension applied to the yarn as the cake is unwound.

In the case of high tenacity viscose rayon yarn spun according to the bucket process, the elongation of the gel yarn contained at the outside of the package (first spun yarn) is lower than that of the yarn contained at the inside of the package (last spun yarn). Therefore, in this case it will be necessary to increase the stretching tension applied to the yarn as it is unwound from the outside of the package.

The amount of and rate at which this stretch tension is applied to the gel yarn, as it is unwound from the package, will depend on the exact manner in which the elongation of the yarn varies throughout the cake. For some types of production, this change in stretch can be linear in nature. For other types, it may be necessary to deviate from a linear rate of change. In any

case, however, the stretch applied to the yarn contained in the outside layers of the spun yarn cake will differ from the inside layers of the cake and the difference in the stretch applied to these respective portions of yarn will be approximately equal to the difference in elongation that originally existed in the yarn cakes.

To determine the nature and extent of this change for a given cake of yarn, it is only necessary to determine the elongation of the yarn contained in the various portions of the cake. This can be done by taking lengths of yarn from the various portions of the gel cake of yarn, drying them at constant length and determining their elongation. Or, it can be done more conveniently by unwinding the yarn from the cake, and drying it in a continuous manner and at constant length without subjecting it to the changeable stretching tension that forms the basis for this invention as described above. Then the elongation of the various portions of this dried yarn can be determined. The changeable stretching tension necessary to eliminate the difference in elongation in accordance with the principles of this invention can then be readily ascertained by an inspection of the data so obtained.

The present invention will be more readily understood by reference to the following detailed description when taken in connection with the accompanying illustrations, in which:

Figure 1 illustrates graphically the manner in which the elongation of a high tenacity viscose rayon yarn in the gel state varies throughout a typical cake of such a yarn spun according to the bobbin process.

Figure 2 illustrates graphically the manner in which the elongation of a high tenacity viscose rayon yarn in the gel state varies throughout a typical cake of such a yarn spun according to the bucket process.

Figure 3 illustrates diagrammatically one form of apparatus suitable for carrying out the process of the present invention on a cake of high tenacity viscose rayon yarn spun by either the bobbin or bucket process.

Figure 4 illustrates a modified form of a portion of the apparatus shown in Figure 3.

Referring to Figure 1 of the accompanying drawings the solid line A shows the difference in elongation between the various sections of yarn throughout a typical cake of high tenacity viscose rayon gel yarn produced by the bobbin spinning process. The dotted line designated by B shows the approximate elongation characteristics of the yarn after being treated in accordance with the present invention.

Figure 2 of the drawings illustrates similarly the elongation characteristics of a cake of gel yarn produced by the bucket spinning process. The solid line A illustrates the percentage elongation of the various sections of the yarn throughout the bucket cake, and the dotted line B illustrates the elongation characteristics of the various sections of yarn throughout the bucket cake after treatment in accordance with the present invention.

In a well-operated spinning plant, the cake-to-cake variation in elongation characteristics of the yarns contained in the various portions of the cakes spun under the same conditions will be so slight that a separate determination for each and every yarn cake will not be necessary. Thus, the conditions under which the yarn of a cake must be stretched may be determined by the analysis of a sample cake, and this determi-

nation will serve for all cakes spun under similar conditions.

Referring to Figure 3 of the drawings, reference numeral 8 designates a support for a yarn cake 10. The yarn cake 10 which may be a bucket cake is positioned on the support and the yarn 12 is pulled from the top of the cake, as illustrated. The yarn 12 is passed through a guide 14, thence through a tensioning device 16 over a roller guide 18 and into a trough 20 which contains an aqueous liquid 22. The yarn is treated with the liquid primarily to insure a uniformity of moisture content in the gel yarn. The liquid 22 may contain finishing materials or sizes which it is desired to apply to the yarn since such materials will not interfere with the processing of the yarn in accordance with the present invention.

The trough 20 is provided with a pair of roller guides 24 and 26 around which the yarn is passed. The yarn is then passed between nip rolls 28 and 30, and then between nip rolls 30 and 32. From nip roll 32 the yarn is led between a second set of three nip rolls 34, 36, and 38. The nip rolls 28, 30, and 32 are coaxing and are adapted to be driven at a variable speed by connection to a variable speed device 60. The variable speed device 60 is preferably a cam-controlled P. I. V. drive of the type shown and described in U. S. Patent No. 2,147,514. The cam 64 is driven through the gear reduction box 62 to slowly move the P. I. V. control gear 66 so as to gradually increase, or decrease, the speed of driving wheel 68. The nip rolls 34, 36 and 38 are also coaxing and are driven at the same peripheral speed. The peripheral speed of this second set of nip rolls is preferably maintained constant throughout the treatment of the yarn in a yarn cake. After passing from nip roll 38, the yarn is passed over rolls 40 and 42 in a drying chamber 44. Hot drying medium, such as heated air, is passed through the drying chamber 44 in such quantity as is necessary to remove the moisture from the yarn 12. The yarn is then passed between the rolls of a third set of nip rolls 46, 48, and 50. This latter set of nip rolls are also rotated at identical peripheral speeds, and the speeds of these rolls are maintained constant throughout the yarn processing operation. The yarn is then passed to a wind-up roll 52 which may, if desired, be driven by a surface drive roll 54 to maintain the peripheral speed thereof constant and substantially equal to the peripheral speed of nip rolls 46, 48, and 50.

The process of the present invention may be practiced by the use of the apparatus shown in Figure 3 in the following manner. A high tenacity viscose rayon yarn 12 which is still in the gel state (a yarn in the gel state is one which has never been dried) is withdrawn from the cake 10, and is passed through guide 14, tensioning device 16, and roller guides 18, 24, and 26. The latter two guides are contained in a trough 20 containing an aqueous treating liquid 22. Although the yarn is still in the gel state, it is desirable to pass the same through a treating liquid to thoroughly wet and swell the gel yarn so that it will be uniformly responsive to the subsequent stretching treatment. The wet yarn is then passed about nip rolls 28, 30, and 32 which, in the case of a bucket cake yarn, are driven at a gradually decreasing speed throughout the treatment of the yarn on a bucket cake. The variable speed device 60 together with the gear reduction box 62 and the cam 64 are so adjusted that the cam

will make substantially one revolution during the treatment of the yarn on one bucket cake. The second set of nip rolls 34, 36, and 38 are driven at a constant speed. In this manner, the outer layers of yarn from the bucket cake are stretched to a lesser degree than the inner layers of yarn from the said cake. This variation in stretching of the bucket cake yarn compensates for the higher percentage elongation on the inside of the yarn cake and the lower percentage elongation on the outside of the yarn cake. The yarn is then passed through the heating chamber 44 and thence about a third set of nip rolls 46, 48, and 50 and from these nip rolls to a take-up roll 52. The third set of nip rolls 46, 48, and 50 and the take-up roll 52 are preferably rotated at the same peripheral speed as the second set of nip rolls 34, 36, and 38. In this manner, the yarn will be dried while maintaining the same at a constant length during the drying thereof.

The drying conditions in drying chamber 44 are maintained so that the yarn upon leaving the chamber is sufficiently dry to retain the physical properties imparted to it by the variable stretching operation. Each increment of yarn passing between the coating sets of nip rolls 34, 36, and 38, and 46, 48, and 50 will have been given the same drying treatment. If the second and third sets of nip rolls are driven at the same peripheral speed, the yarn will be dried with the properties characteristic of it as it left the second set of nip rolls. If, on the other hand, the third set of nip rolls 46, 48, and 50 are driven at a greater speed than that of the second set of nip rolls 34, 36, and 38, the yarn will be uniformly stretched during the drying, and a dried yarn will be produced which will have a lower elongation than if dried without this additional stretching. Similarly, if the third set of nip rolls is driven at a lower speed than that of the second set of nip rolls, the yarn will be permitted to relax and will possess a higher elongation than if dried without this additional relaxation.

From the third set of nip rolls the yarn passes to any suitable take-up device 52 such as a bobbin, spool, pirn, beam or the like which may be equipped with suitable traversing mechanism to collect the yarn into a satisfactory dry package for further use.

The treating liquid 22 may be composed of any desired constituents which will thoroughly wet and swell the yarn. The liquid may be water, an aqueous alcohol solution, which will dry more readily, an aqueous finishing, dressing or adhesive composition, or an aqueous desulfuring, bleaching or other rayon processing bath. If desired, a series of baths may be employed by providing several troughs in series such as trough 20.

If desired, the drying chamber 44 may be replaced by a series of rotatable drying drums 70 as illustrated in Figure 4 of the drawings. As illustrated in this figure, the drying rolls 70 are positioned between the second and third set of nip rolls. These rolls are preferably heated internally by means of hot water, steam, or other hot fluids or by means of electrical heating units. If desired, warm dry air may also be blown over or through the drying rolls so as to aid in the drying of the yarn. These rolls may be driven by the yarn passing over them or they may be positively driven at a peripheral speed equal to that of the second and third set of nip rolls. If the rolls are positively driven at a constant speed, the contact of the yarn on the roll surfaces will serve to maintain the yarn at constant length, 75

i. e., without stretching or shrinking, during the drying operation, and in this event the second and third sets of nip rolls may be completely dispensed with.

As a further alternative, if a set of drying rolls is employed without a second and third set of nip rolls, the final elongation of the yarn may be varied by increasing, or decreasing, one or more of the drying rolls positioned beyond the first or second drying rolls. In other words, the final drying roll may be made to rotate at a higher, or lower, peripheral speed than the remainder of the drying rolls. In all cases, however, the peripheral speed of the take-up roll 52 should be equal to that of the final drying drum or last set of nip rolls so that the completely dried yarn will not be subjected to a stretching, or shrinking condition.

The apparatus disclosed in Figure 3 may be operated in still another method in accordance with the present invention. As above outlined, the preferred embodiment of the invention accomplishes the stretching by driving the second set of nip rolls 34, 36, and 38 at a constant peripheral speed while the peripheral speed of the first set of nip rolls 28, 30, and 32 is varied in a predetermined manner whereby the yarn passing through the apparatus is stretched, or shrunk, to the desired amount. However, if desired, the first set of nip rolls can be driven at a constant peripheral speed and the yarn stretched the desired amount by varying the peripheral speed of the second set of nip rolls or drying drums as shown in Figure 4. In this event, however, it would be necessary to vary the speed of the third set of nip rolls as well as the take-up roll, or the various drying rolls together with the take-up roll, in substantially the same manner as the speed of the second set of nip rolls is varied.

While the above description has been made in terms of the processing of a single yarn, it is obvious that a multiplicity or warp of yarns may be processed simultaneously. When a warp of yarns is processed, the take-up device may advantageously be in the form of a warp beam on which all of the yarns can be collected. A single beam is then conveniently available for further conversion of the yarns into cords or the like. When processing such a warp of yarns in this manner, however, it is obvious that the yarns must be processed in a batch manner rather than in a continuous manner such as one involving the use of a magazine creel.

The following example is submitted to illustrate the detailed process as applied to a plurality of high tenacity viscose rayon yarns spun in a bucket cake. This example is not to be considered as limitative of the present invention.

Example

Three hundred and fifty-two ends of 300-denier, high tenacity viscose rayon yarn spun in round buckets at constant pump delivery and constant feed wheel speed are taken off the same number of washed undried yarn cakes and passed through an aqueous bath in which the threads are thoroughly wet out. The yarns are then passed in the wet state to suitable nip rolls of a slasher. The speed of these nip rolls varies in a linear manner from 162.5 feet per minute when the threads from the outside of the spin cake are passing over them to 159.5 feet per minute when the threads from the inside of the spin cake are passing over them. Between the cakes and the nip rolls, the threads

are under an average tension of 25 grams and are stretched 2.4%. From the nip rolls the threads pass to the drying drums running at a constant peripheral speed of 170 feet per minute with a temperature of 96° C. at the surfaces of the drums. The stretch imparted to the threads between the nip rolls and the drying drums varies linearly from 4.6% for threads from the outside of the spin cake to 6.6% for threads from the inside of the spin cake. The threads pass over drying drums for a total travel of 23.5 feet and are dried thereby to a moisture content of 11% whereupon the dried lengths are essentially maintained. There is no slippage of the threads on the nip rolls or drums. From the drums the threads pass over calender rolls running at a peripheral speed of 170 feet per minute to a beam on which they are wound. When successive measurements of elongation are made on yarn from the inside to the outside of a bucket cake processed in the above manner, we find that the elongation varies less than 1% with an average elongation of 10%, an average tenacity of 3.00 grams per denier, and an average denier of 275.

The invention provides a means whereby high tenacity viscose rayon yarns produced by the bobbin or bucket processes may be converted into yarns possessing substantially uniform elongation as well as other physical properties throughout their entire length.

The invention also provides a method for the processing of a plurality of viscose rayon yarns of high tenacity, whereby a highly desirable yarn package in the form of a warp beam of substantially uniform yarn is readily available.

As a still further advantage of this invention, regenerated cellulose yarn produced by the bobbin or bucket spinning process and which heretofore has been generally unsuitable for use in tire cords can now be made eminently suitable for this purpose. For the first time, a high tenacity viscose rayon yarn of uniformly low elongation has been produced by an intermittent spinning process, which yarn is not only ad-

mirably suitable for use in reinforcing all types of rubber structures including tires, steam hose and beltings and the like, but is also desirable for use in many industrial fabrics, such as, conveyor belts, belt driers, zinc oxide bags and the like.

Since it is obvious that many changes and modifications can be made in the details above-described without departing from the nature and spirit of the invention, it is to be understood that the invention is not to be limited to the detailed description except as set forth in the appended claims.

I claim:

1. The process of decreasing the elongation differential between the various portions of yarn in a package of gel regenerated cellulose yarn having different elongation characteristics along the length thereof which comprises unwinding the yarn from said package and stretching the successive portions of yarn an amount approximately equal to the difference between the actual elongation and a predetermined given elongation of the yarn thereof to produce a yarn having said predetermined given elongation throughout the length thereof, and then drying said yarn while maintaining the tension on said successive yarn portions substantially constant.
2. The process of decreasing the elongation differential between the various portions of yarn in a package of gel regenerated cellulose yarn having different elongation characteristics along the length thereof which comprises unwinding the yarn from said package, wetting said yarn, and stretching the successive portions of yarn an amount approximately equal to the difference between the actual elongation of the yarn and a predetermined given elongation thereof to produce a yarn having said predetermined given elongation throughout the length thereof, and then drying said yarn while maintaining substantially constant the successive equal lengths of yarn.

GEORGE M. KARNS.

CERTIFICATE OF CORRECTION.

Patent No. 2,350,168.

May 30, 1944.

GEORGE M. KARNS.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 1, second column, line 35, for "highely" read --highly--; page 5, second column, line 24, before the word "thereof" strike out "of the yarn" and insert the same after "elongation" in line 23, same column; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 5th day of September, A. D. 1944.

Leslie Frazer

Acting Commissioner of Patents.

(Seal)