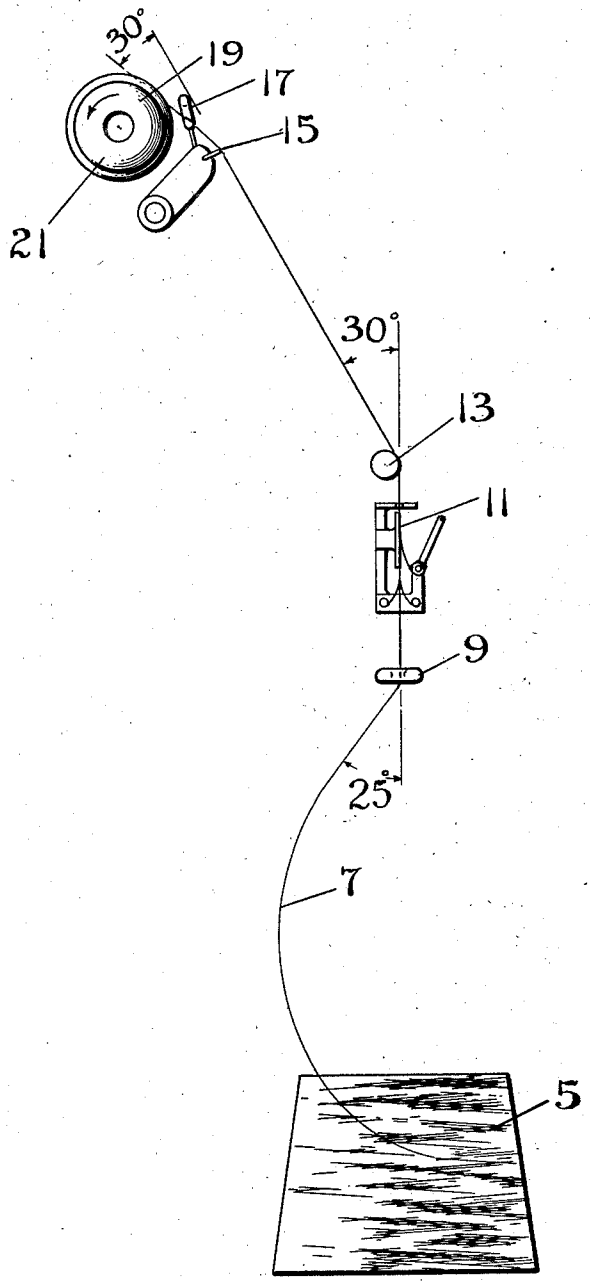
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THREAD PRODUCTION

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THREAD PRODUCTION

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This invention relates to an improved process for winding thread, yarn, or the like. More specifically, it relates to the direct precision winding on to cores of thread from packages that can be unwound only under widely varying tensions. The invention has particular applicability to the direct precision winding on to cores of rayon yarn from bucket cakes or similar packages which have been subjected to liquid treatment in a substantially unsupported state, as for example, without the use of a rigid internal support.

In the precision winding of thread on to a core, it is necessary to have, at all times, a substantial minimum tension on the thread, usually from 10 to 30 grams, or more, depending on the denier of the thread, so that an evenly wound, uniformly dense package may be obtained. There is also a maximum winding tension that must not be exceeded if thread free from "shiners" is to be produced. A "shiner" in a thread is evidenced by a luster which is higher than that present in the adjacent sections of the thread, and is formed by stretching the thread beyond its elastic limit. Threads containing shiners are unsatisfactory for use as the weft or filling yarn in the production of certain types of fabrics, since the shiners will be clearly visible in the finished product.

In the winding of thread from bucket cakes of rayon and similar processed packages, it has been found that there is a very considerable fluctuation in tension imparted to the thread as it is being drawn from the processed package because of deformation of the package arising from the liquid processing and drying procedures to which the package has been exposed. Even though the actual magnitude of the tensions necessary to draw the thread from the cake or package may be small, the wide fluctuations in tension are very undesirable because the tensions may be increased several-fold later in the winding operation.

The two cone winding devices now on the open market are provided with either a conventional washboard type or finger type tensioning device. Both these devices were found to be entirely unsuitable under the above-mentioned conditions, in view of their large angular contact with the thread. As an example, when winding cones from bucket cakes on one of these standard devices, the angular contact of the thread on the washboard device is approximately 260°, and the angular contact of the thread with other guides, over which it must pass in its travel from the cake to the windup package, is 240°, making a total of approximately 500°. The tension imparted to the thread by such a washboard tensioning device or finger tensioning device is due to angular snubbing; that is, the tension is developed by causing the thread to deviate from a straight line by interposing surfaces over which it must slide.

When a bucket cake of thread is rewound into a cone on such a machine, the tension on the thread at the cone is the product of the tension required to remove the thread from the cake and a factor which varies exponentially with the angularity of the snubbing in accordance with the following formula: $T_1=T_2(e^{Kr})$ in which T_1 is the tension on the thread after it leaves the last element of the tensioning or guiding devices; T_2 is the tension on the thread after it is drawn from the cake and as it approaches the first element of the tensioning or guiding devices; e is the base of natural logarithms; the constant K is the coefficient of friction of the thread on the surfaces over which the thread is being drawn (approximately 0.35 for viscose rayon on porcelain or steel for the range of speeds generally used); and r is the total snubbing angularity of the thread in radians as determined by adding together all the arcs of contact of the thread with the snubbing surfaces.

Since the tension necessary to draw the thread from bucket cakes of rayon, or the like varies from about 2 grams to 10 or 15 grams, or at times very much more, it will be readily apparent that the use of a washboard tensioning device which, in combination with the necessary directional guides, offers a total snubbing angularity in the neighborhood of 500°, will at times produce an extremely high tension on the thread at the point where it is being wound. For example, applying these data in the formula given above, we find that a change in tension from 2 grams to 10 grams at the cake will cause a change in tension, at the point where the thread is being wound, from 42 grams to about 210 grams. Since the application of this high tension is of extremely short duration (about 0.02 of a second), the thread is not broken but is stretched beyond its elastic limit over a short length and a shiner is produced in the thread. Obviously, if the pull were still greater, or were of a longer duration, the thread would be broken.

The washboard or finger type tensioner is quite satisfactory for use where the thread can be delivered at a substantially constant tension, as for instance in winding from a spool or bobbin. It is impossible, however, to wind from a bucket cake or other thread package that has been subjected to liquid treatment and drying in a substantially

unsupported state, without encountering tugs and jerks. Wrinkles and other disturbances of the thread windings occur most frequently in the 1,000 yards forming or adjacent the inner wall, herein referred to as the innermost portion, of the cake, and here it is common to find numerous plucks or tugs that amount to 5, 10, or even 15 grams, or more, tension in pulling the thread from the cake.

In spite of these bad wrinkles and other disturbances in processed bucket cakes of rayon, such cakes have been directly precision wound on machines equipped with the washboard or finger type tensioners. A cone of yarn so prepared is well formed but, obviously, it is full of shiners and can be used only in a limited way, such as for instance to produce knit goods where the shiners will not show up because of the fabric structure, even if they were not completely eliminated in the boil-off treatment of the knitted fabric. To produce rayon yarn free of objectionable shiners, that is satisfactory for use in producing woven fabrics of all kinds, it has been necessary heretofore to wind bucket cakes into skeins, process in that form, and then backwind the thread at low speed on to spools. This process is, of course, costly.

It is, therefore, an object of this invention to provide a method for directly precision winding a yarn or thread from a package necessitating a pull of greatly varying tension, without imparting an objectionable number of shiners to the thread.

Another object of this invention is to provide a thread tensioning and guiding arrangement for precision winding machines that will not impart an excessive tension to a thread being unwound from a package that has been liquid processed and dried without any rigid internal support.

A still further object of this invention is to provide a thread tensioning and guiding arrangement for precision winding machines that will greatly reduce the percentage fluctuation in tension at the windup core as compared with the percentage fluctuation in tension at the cake.

Other objects of the invention will appear hereinafter.

The objects of this invention may be accomplished, in general, by passing the thread from the cake to the windup device through a tensioning system composed of an additive tension element and one or more directional guides which will impart a snubbing tension to the thread, the total snubbing angularity of the latter being maintained at such a low value as to substantially prevent the combined tension imparted by all of the tensioning elements from exceeding the elastic limit of the thread under the loading conditions encountered.

The present invention will be readily understood by reference to the following detailed description taken in connection with the accompanying diagrammatic illustration showing the path of the thread through the tensioning and guiding devices between the cake and the windup package.

Referring to the illustration, reference numeral 5 designates a bucket cake of purified and dried thread composed of artificial filaments. The thread 7 is drawn from the cake upwardly through a guide 9, making an angle therewith of about 25°, and through a pinching tension device 11, without any substantial change in direction. From the tensioning device 11, the thread is passed over a guide 13, taking an angular change in direction of about 30°. The thread then passes over the conventional bale wire 15 and traverse guide 17, and is wound on the conical core 19 which is securely positioned on the driven spindle 21. The thread, as shown, takes an angular change in direction of about 30° in passing over the bale wire and traverse guide, making a total snubbing angularity of the thread between the cake and the windup core of about 85°. Assuming that the pinching tension device adds 30 grams and that the tension on the thread as it is drawn from the cake (T_2) varies from 2 to 10 grams, in accordance with the process of the present invention the tension on the thread after it leaves the traverse guide and approaches the windup package (T_1) will vary from about 46.9 grams to about 60.4 grams. On the other hand, assuming that a washboard tensioning device or a finger tensioning device and other guiding elements were used in accordance with the processes of the prior art, which impart an angular change in direction to the path of the thread to the extent of about 500°, a variation of from 2 to 10 grams in the tension at the cake will result in a variation in tension at the windup device of from about 42 to about 210 grams. Consequently, an increase of 400% in tension at the cake will, in the first case, produce an increase in tension at the core of about 29%, and, in the second case, an increase in tension at the core of about 400%. Since the yield point, or elastic limit, of 150 denier regenerated cellulose thread with a load duration of 0.02 of a second is about 130 grams, it will be seen that a tension at the core of 210 grams, as above mentioned, will produce a shiner in the thread. It is preferred that the snubbing angularity be maintained sufficiently low, and a sufficient portion of the total tension be obtained by means of a device that applies tension additively, so that the percentage variation of tension at the windup core will not exceed one fourth of the percentage variation of tension at the cake.

Although it is not necessary to reduce the snubbing angularity of the thread to 85° as in the illustration, it is necessary to reduce the angularity to such an extent that the instantaneous tension peaks at the core will, in general, remain below 130 grams on 150 denier thread and proportionally lower for lighter denier yarn. Upon determining the variations in tension on the thread as it is unwound from the bucket cakes, the maximum permissible snubbing angularity of the thread to maintain the tension on the thread at the core below the elastic limit can be determined readily by means of the equation mentioned hereinbefore.

As described above, it is necessary, in accordance with the present invention, to reduce the total angular snubbing, to provide a tensioning device which will impart an additive tension, and to have a minimum tension of from 10 to 30 grams on the thread at all times in order to wind an acceptable precision-wound package.

When employing a winding spindle which is driven at a constant angular speed, the linear speed of the thread will increase several-fold from the beginning to the end of the winding operation. It is, therefore, also necessary to decrease the tension on the thread as the package builds up to prevent bulging of the thread at the ends of the cone package. In winding a 150 denier viscose rayon thread, the starting tension may, for instance, be about 45 grams, and as the

cone builds up the tension is progressively reduced until at the end of the winding operation the tension becomes about 27 grams.

In accordance with the preferred procedure of the present invention, a pinch tensioning device of the type disclosed in the copending patent application, Serial No. 209,653, filed May 24, 1938, by Arthur E. Guenther is used, which adds a predetermined amount of tension, irrespective of the tension already on the thread as it approaches the device. This pinch tensioning device may be adjusted to any desirable starting tension, depending upon the density of the package to be wound and the thread denier, and may be reduced to any desired amount as the winding of a package is completed. Any other tensioning device which will impart to the thread an additive tension, as distinguished from an exponentially varying tension as produced by an angular snubbing type of tensioning device, may be used.

As I have previously indicated, the innermost 1000 yards of yarn in a liquid processed and dried bucket cake cause considerable difficulty in unwinding because of displaced threads, wrinkles, and the like. If there is a bad wrinkle on the inside of a cake caused by the shrinking and buckling of the cake on itself during drying, there is apt to be a pluck or tug every time a course of yarn is removed from that portion of the cake, that is, at intervals of about 15 inches of thread a tug will occur that will raise the tension on the thread momentarily as it is drawn from the cake from 2 to 5, 10, 15, or more grams. Winding at a speed of 400 yards per minute, which is about 240 inches per second, a tug or pluck may occur 10 or 15 times a second, and these plucks are sufficiently severe to require, with the prior art winding arrangements, a tension at the core of 300 grams or more to release the thread from the cake. As a result, this frequent recurrence of excessive tension causes an exceedingly large number of shiners in the thread. This is not a hypothetical or theoretical condition without basis in actual practice. Certain classes of woven goods produced from yarn wound under the conditions such as to give the tension fluctuation mentioned are very definitely full of shiners and of little or no commercial value.

On the other hand, by winding from cakes of exactly the same type, produced and processed in an identical manner, and using a winding arrangement in accordance with the present invention, it has been found that the same most critical portion of the cake, that is, the innermost 1000 yards, can be wound with practically no tension peaks, measured between the bale wire and the next preceding tensioning or guiding device, greater than about 85 grams. Since the snubbing angularity above the bale wire, as shown in the present illustration, is but 30°, the increased tension on the yarn passing therearound is only about 20% based on the original tension peak of 85 grams, which means that the tension at the core very seldom exceeds about 100 grams, and this is substantially below the elastic limit of 150 denier viscose rayon yarn when the load duration is 0.02 second or thereabouts.

While the invention has been described in terms of very low snubbing angularity, it should be understood that under normal operating conditions the snubbing angularity may be considerably more than 85°. For instance, in a well operated plant, bucket cakes are produced containing very few disturbances which cause plucks that necessitate a pull of more than 10 grams to remove the yarn from the cake. The yield point, or elastic limit, of 150 denier viscose rayon textile yarn, when the load duration is 0.02 of a second, is about 130 grams. When in accordance with this invention a pinch tensioning device such as referred to above is used in the set-up and adjusted to contribute 20 grams of additive tension on 150 denier viscose rayon textile yarn the maximum permissible snubbing angularity may be as much as 390°.

This is assuming that all the angular snubbing takes place before the additive tension is applied, and generally this is not the case. If half the total angular snubbing takes place before the additive tension is applied, and the balance afterwards, the maximum permissible snubbing angularity will be about 330°. If all the angular snubbing occurs after the application of the additive tension, the maximum permissible snubbing angularity will be only about 240°. In practice, from 10% to 50% of the total angular snubbing will occur before the additive tension is applied, which means the total snubbing angularity that can be tolerated in winding 150 denier viscose rayon textile yarn will be between about 250° and 330° when the additive tension amounts to 20 grams. If the amount of additive tension is less, the permissible snubbing angularity will be somewhat greater.

It is, of course, obvious that the total tension that can be imposed on a thread of less than 150 denier is correspondingly lower. Thus, in the case of 100 denier viscose rayon textile yarn which has a yield point of the order of 80 to 85 grams, when an additive tensioning device is used applying approximately 15 grams tension, the total snubbing angularity should not exceed about 250° when the angular snubbing is evenly divided on each side of the additive tensioning device. If only 10% of the angular snubbing occurs before the pinch tensioning device, the total snubbing angularity should be no greater than about 210°. So, too, with 75 denier viscose rayon textile yarn, the yield point being in the neighborhood of 65 grams, the total snubbing angularity, when used in combination with an additive tensioning device that applies 15 grams tension, should not exceed about 200° when the angular snubbing is distributed evenly on both sides of the additive tensioning device and should not exceed about 160° when only 10% of the angular snubbing is applied prior to the additive tension. As a general rule, a tension peak, arising when winding viscose rayon textile thread from bucket cakes which have been subjected to liquid treatment without a rigid internal support, should not exceed about 0.85 gram per denier. The winding of thread having a denier in excess of 200 usually does not involve the objectionable production of shiners and, therefore, the use of winding apparatus imparting low snubbing angularity is not essential.

Obviously, if the winding of viscose rayon textile yarn of different deniers (for example, from 75 denier to 200 denier) is to be carried out on the same winding equipment, the total snubbing angularity should not exceed about 200° in order to prevent the production of shiners in the low denier yarn. As above pointed out, however, when winding thread having a denier of 150, the total snubbing angularity on the thread may be as high as 330° or thereabouts, depending on the amount of additive tension applied, without imparting an excessive number of shiners to the thread. As a general rule, it has been found that the maximum allowable snubbing angularity in

degrees can be calculated for the winding of thread of any denier and with the application of any amount of additive tension, by a formula derived from the exponential equation hereinbefore mentioned. In the case of viscose rayon textile yarn, the maximum allowable tension peak which can be tolerated without producing a shiner is about 0.85 gram per denier and thus, when the value of T_2 is 10 grams and the coefficient of friction K is 0.35, the formula obtained is:

$$A = a + 375 \log_{10}\left[\frac{0.85d}{10(\text{antilog } 0.0027a)+x}\right]$$

where A is the total permissible snubbing angularity in degrees, a is the snubbing angularity in degrees between the cake and the additive tensioning device, d is the denier of the thread being wound, and x is the amount of additive tension, in grams, to be applied.

The formula given above is applicable to the precision winding of normal viscose rayon textile yarn which has an elastic limit of about 0.85 gram per denier under the conditions of loading encountered and which requires ignorably few tension pulls in excess of 10 grams for removal of the yarn from the cake. For winding this or other types of yarns, having different characteristics, however, the broader equation that follows may be used advantageously in calculating the maximum permissible snubbing angularity:

$$A = a + \frac{132}{K}\log_{10}\left[\frac{H}{T_2(\text{antilog } 0.0076aK)+x}\right]$$

wherein H is the elastic limit of the yarn, expressed in grams, under the conditions of loading encountered, T_2 is the tension pull, in grams, required to remove the yarn from the cake, K is the coefficient of kinetic friction of the yarn on the surfaces over which the yarn is drawn, and the other variables are the same as in the preceding specific formula. In using this formula, the value of T_2 is chosen sufficiently high to include all except inordinately high tension pulls which, because of their infrequency, can be ignored for practical purposes.

The formula

$$A = a + 375 \log_{10}\left[\frac{0.85d}{10(\text{antilog } 0.0027a)+x}\right]$$

is derived from the formula $T_1 = T_2(e^{Kr})$ in the following manner:

Starting with the formula $T_1 = T_2(e^{Kr})$ which formula relates to a device having only snubbing tension

T_1=tension on thread as it leaves last element of the tensioning and guiding devices

T_2=tension on thread as it approaches first element of the tensioning and guiding devices

e=base of natural logarithms

K=coefficient of friction (0.35 for viscose rayon)

r=total snubbing angularity in radians.

Then

$$\frac{T_1}{T_2} = e^{Kr}$$

In logarithmic form:

$$\log_n \frac{T_1}{T_2} = Kr$$

Converting to logarithms to base 10 and substituting for K and r:

$$2.3 \log \frac{T_1}{T_2} = 0.35\frac{a}{57}$$

Where a=total snubbing angularity in degrees

$$a = \frac{2.3 \times 57}{0.35}\log_{10}\frac{T_1}{T_2} = 375 \log_{10}\frac{T_1}{T_2}$$

The total permissible snubbing angularity in a tension device employing both snubbing tension and additive tension is $A = a_1 + a_2$ when a_1 is the angularity in degrees before an additive tension device and a_2 is the angularity in degrees after the additive tension. Since

$$a = 375 \log \frac{T_1}{T_2}$$

$$a_1 = 375 \log \frac{T_x}{T_y}$$

and

$$a_2 = 375 \log \frac{T_z}{T_w}$$

T_x=tension on thread approaching additive tension device

T_y=tension on thread at cake

T_z=tension on thread at wind-up cone

T_w=tension on thread just above additive tension device

If H is maximum allowable tension thread will stand without producing shiner:

$$a_2 = 375 \log \frac{H}{T_w}$$

$$a_2 = 375 \log \frac{H}{T_x + x}$$

(x=the additive tension transmitted by the additive tension device)

Substituting for a_2 in formula $A = a_1 + a_2$

$$A = a_1 + 375 \log\left(\frac{H}{T_x + x}\right)$$

If maximum pluck at cake=10

$$a_1 = 375 \log \frac{T_x}{10}$$

and

$$T_x = 10\left[\text{antilog } \frac{a_1}{375}\right]$$

$$T_x = 10 \text{ (antilog } 0.0027a_1)$$

Then

$$A = a_1 + 375 \log\left[\frac{H}{10 \text{ (antilog } 0.0027a_1)+x}\right]$$

$.85d$ can be substituted for H for viscose rayon.

From the above it will be clear that although A is expressed in terms of a_1 and x in the formulae, the formulae also take into consideration a_2 (the snubbing angularity, in degrees, after the additive tension device). The second term of the equation, namely,

$$375 \log\left[\frac{.85d}{10 \text{ (antilog } 0.0027a_1)+x}\right]$$

is really a_2 in terms of a_1, x and the denier of the thread.

In the practice of this invention the coefficient of kinetic friction rather than the coefficient of static friction is the useful figure. The coefficient of kinetic friction, K, of yarns on guide surfaces of metal, porcelain, etc., can be determined by means of the method described by Sellars, Textile World, December 1934, page 78. The value of K will vary depending on the type of yarn, the type of finish applied to the yarn, the type of guide surface and the speed at which the yarn passes over the guide surfaces. It is necessary

then to measure the value of K under conditions approximating those of the winding operation under consideration. In the winding of a cone or tube of yarn, the linear speed of the thread will increase as the package builds up unless provision is made to maintain the linear speed constant. Thus it may be necessary to select an average value for K over the range of speeds involved. In the case of viscose rayon textile yarn a value of K=0.35 has been found satisfactory for the purposes of this invention, as hereinbefore mentioned.

The yield point or elastic limit of the thread or yarn is the load point beyond which the thread or yarn retains its elongation permanently. When loads below the elastic limit are applied, the thread or yarn will elongate but when the load is removed, it will regain its original length. The elastic limit will differ in different types of yarn and even in the same yarn the elastic limit will be higher, when the load duration is very short, than it will be when the load is sustained. The elastic limit is usually measured under loading conditions of long duration as compared to the load duration encountered in the precision winding of yarns according to the present invention which is normally of the order of .02 second. It has been found that if the elastic limit, as measured by the conventional methods, as for example, by the method described by Hunter, Rayon Textile Monthly, November and December, 1936, is increased by about 20%, a value useful in the practice of this invention will be obtained. The value of H, as used in this specification and claims is estimated in accordance with this procedure to represent the elastic limit of the yarn under the conditions of loading encountered.

Since it is obvious also that the values of elastic limit and coefficient of friction will be somewhat dependent on humidity conditions encountered, it should be understood that these will be determined, for each particular yarn, under conditions approximating those of the actual winding operations in which the present invention will be practiced.

Although this invention has been described in its application to the precision winding of viscose rayon textile yarn from processed bucket cakes, it is not so limited, but is applicable to the precision winding of any textile yarn from packages necessitating a pull of greatly varying tension where excessive tension peaks may cause shiner formation. Obviously, the invention is of primary importance in the precision winding of yarn for use in the making of woven fabrics where more than an occasional shiner will not be tolerated.

Since it is obvious that many changes and modifications can be made in the above described procedure without departing from the nature and spirit of the invention, it is to be understood that such obvious changes and modifications are intended to be included within the scope of the claims.

I claim:

1. In a process for the direct precision winding of viscose rayon yarn from bucket cakes thereof which have been purified and dried in a substantially unsupported state, and necessitating a pull fluctuating from normal up to about 10 grams for the removal of the yarn therefrom, the step which comprises passing the yarn from the cake to the winding core with the application of an additive tension and with a total snubbing angularity, in degrees, not in excess of that corresponding to the formula,

$$A = a + 375 \log \left[\frac{0.85d}{10(\text{antilog } 0.0027a) + x} \right]$$

in which A designates the total permissible snubbing angularity in degrees, a designates the snubbing angularity in degrees between the package being unwound and the point of application of said additive tension and is sufficiently low that the quantity in the brackets of said formula is not less than unity, d designates the denier of the yarn, and x designates the additive tension in grams.

2. In a process for the direct precision winding of viscose rayon yarn from bucket cakes thereof which have been purified and dried in a substantially unsupported state and necessitating a pull fluctuating from normal up to about 10 grams for the removal of the yarn therefrom, the step which comprises passing the yarn from the cake to the winding core with the application of a predetermined minimum additive tension and with a total snubbing angularity, in degrees, not in excess of that corresponding to the formula,

$$A = a + 375 \log \left[\frac{0.85d}{10(\text{antilog } 0.0027a) + x} \right]$$

in which A designates the total permissible snubbing angularity in degrees, a designates the snubbing angularity, in degrees between the package being unwound and the point of application of said additive tension and is sufficiently low that the quantity in the brackets of said formula is not less than unity, d designates the denier of the yarn, and x designates the additive tension, in grams.

3. In a process for the direct precision winding of viscose rayon yarn from bucket cakes thereof which have been purified and dried in a substantially unsupported state and necessitating a pull fluctuating from normal up to about 10 grams for the removal of the yarn therefrom, the step which comprises passing the yarn from the cake to the winding core with the application of a minimum additive tension of 10 grams and with a total snubbing angularity, in degrees, not in excess of that corresponding to the formula,

$$A = a + 375 \log \left[\frac{0.85d}{10(\text{antilog } 0.0027a) + x} \right]$$

in which A designates the total permissible snubbing angularity in degrees, a designates the snubbing angularity in degrees between the package being unwound and the point of application of said additive tension and is sufficiently low that the quantity in the brackets of said formula is not less than unity, d designates the denier of the yarn, and x designates the additive tension in grams.

4. In a process for the direct precision winding of viscose rayon yarn from bucket cakes thereof which have been purified and dried in a substantially unsupported state, necessitating a pull of fluctuating tension for the removal of the yarn therefrom, the step which comprises passing the yarn from the cake to the windup core with the application of such additive tension and through a snubbing tensioning system having such low total snubbing angularity that the percentage variation of tension on the yarn at the windup core is not in excess of one-fourth of the percentage variation of tension on the yarn at the cake whereby shiner formation in the yarn is reduced.

5. In a process for the direct precision winding of viscose rayon yarn from bucket cakes thereof which have been purified and dried in a substantially unsupported state, necessitating a pull of fluctuating tension for the removal of the yarn therefrom, the step which comprises passing the yarn from the cake to the windup core with the application of such additive tension and through a snubbing tensioning system having such low total snubbing angularity that a transmitted tension of 10 grams on the yarn at the cake will not necessitate a pull of more than 0.85 gram per denier on the yarn at the windup core whereby shiner formation in the yarn is reduced.

6. In a process for the direct precision winding of viscose rayon yarn from bucket cakes thereof which have been purified and dried in a substantially unsupported state, necessitating a pull of fluctuating tension for the removal of the yarn therefrom, the step which comprises passing the yarn from the cake to the windup core with the application of such additive tension and through a snubbing tensioning system having such low total snubbing angularity that the minimum tension on the yarn at the windup core is 10 grams and the maximum tension is below the elastic limit of the yarn under the conditions of loading encountered.

7. In a process for the direct precision winding of viscose rayon yarn from bucket cakes thereof which have been purified and dried in a substantially unsupported state, necessitating a pull of fluctuating tension for the removal of the yarn therefrom, the step which comprises passing the yarn from the cake to the windup core with the application of such additive tension and through a snubbing tensioning system having such low total snubbing angularity that the minimum tension on the yarn at the windup core is 10 grams and the maximum tension is below the elastic limit of the yarn for pulls up to 20 grams at the cake for the removal of yarn therefrom.

8. In a process for the direct precision winding of viscose rayon yarn from bucket cakes thereof which have been purified and dried in a substantially unsupported state, necessitating a pull fluctuating up to about 10 grams for the removal of the yarn therefrom, the step which comprises passing the yarn from the cake to the windup core with the application of an additive tension and with a total snubbing angularity in degrees, not in excess of that corresponding to the formula,

$$A=a+\frac{132}{K}\log\left[\frac{H}{10(\text{antilog } 0.0076aK)+x}\right]$$

in which A designates the total permissible snubbing angularity in degrees, a designates the snubbing angularity in degrees between the package being unwound and the point of application of said additive tension and is sufficiently low that the quantity in the brackets of said formula is not less than unity, H designates the elastic limit of the yarn in grams under the conditions of loading encountered, K designates the coefficient of kinetic friction of the yarn on the surfaces over which it is drawn, and x designates the additive tension in grams.

9. In a process for the direct precision winding of viscose rayon yarn from bucket cakes thereof which have been purified and dried in a substantially unsupported state, necessitating a pull fluctuating up to about 10 grams for the removal of the yarn therefrom, the step which comprises passing the yarn from the cake to the windup core with the application of a predetermined minimum additive tension and with a total snubbing angularity in degrees, not in excess of that corresponding to the formula,

$$A=a+\frac{132}{K}\log\left[\frac{H}{10(\text{antilog } 0.0076aK)+x}\right]$$

in which A designates the total permissible snubbing angularity in degrees, a designates the snubbing angularity in degrees between the package being unwound and the point of application of said additive tension and is sufficiently low that the quantity in the brackets of said formula is not less than unity, H designates the elastic limit of the yarn in grams under the conditions of loading encountered, K designates the coefficient of kinetic friction of the yarn on the surfaces over which it is drawn, and x designates the additive tension in grams.

10. In a process for the direct precision winding of viscose rayon yarn from bucket cakes thereof which have been purified and dried in a substantially unsupported state, necessitating a pull fluctuating up to about 10 grams for the removal of the yarn therefrom, the step which comprises passing the yarn from the cake to the windup core with the application of a minimum additive tension of 10 grams and with a total snubbing angularity in degrees, not in excess of that corresponding to the formula,

$$A=a+\frac{132}{K}\log\left[\frac{H}{10(\text{antilog } 0.0076aK)+x}\right]$$

in which A designates the total permissible snubbing angularity in degrees, a designates the snubbing angularity in degrees between the package being unwound and the point of application of said additive tension and is sufficiently low that the quantity in the brackets of said formula is not less than unity, H designates the elastic limit of the yarn in grams under the conditions of loading encountered, K designates the coefficient of kinetic friction of the yarn on the surfaces over which it is drawn, and x designates the additive tension in grams.

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