

June 11, 1940.

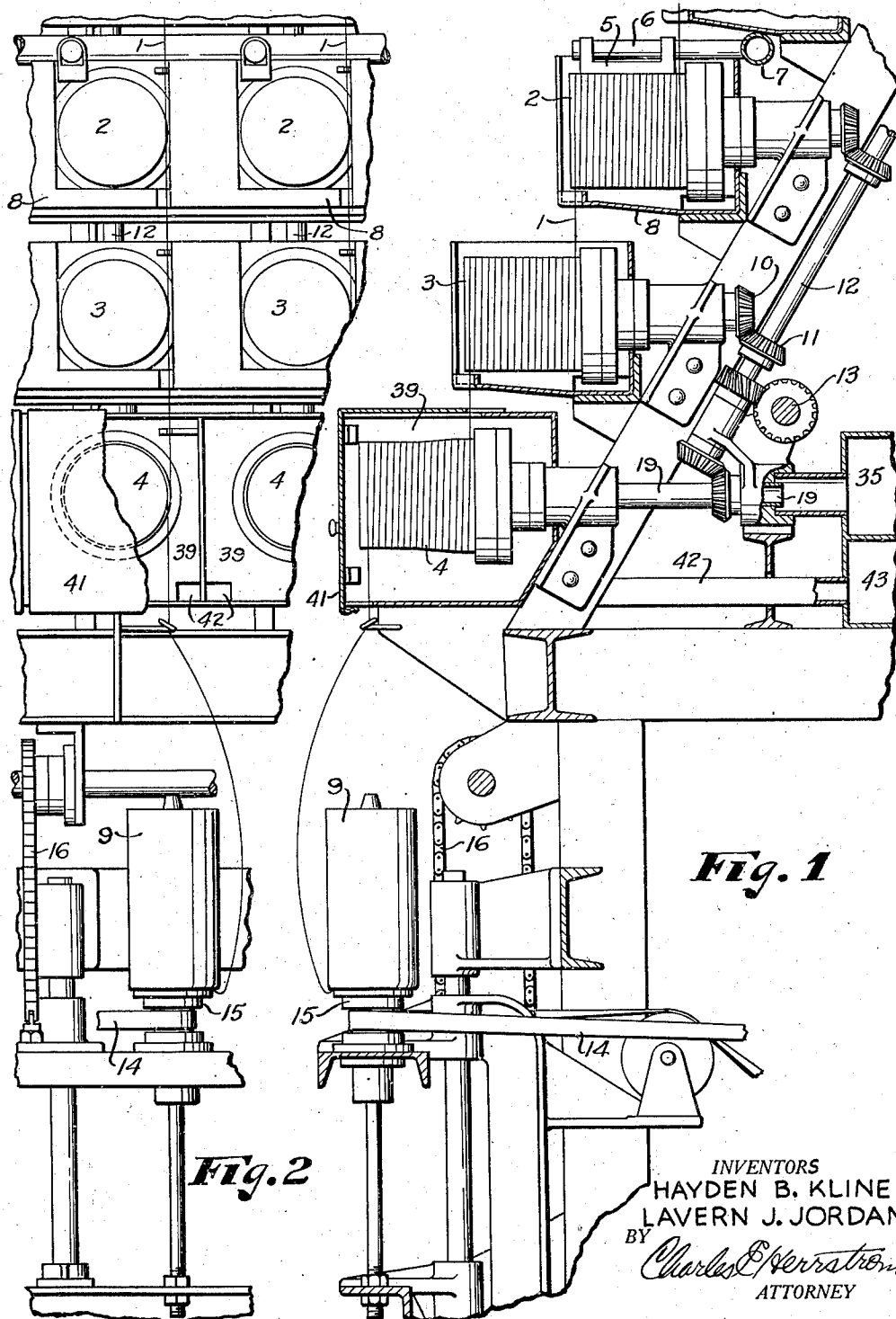
H. B. KLINE ET AL

2,203,686

THREAD-ADVANCING REEL

Filed Oct. 26, 1936

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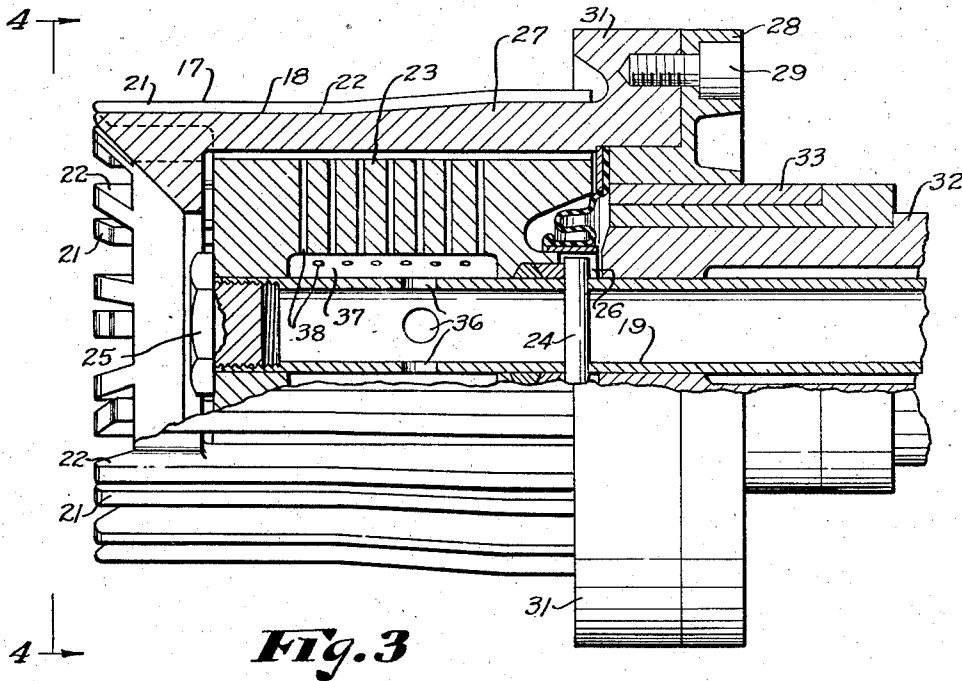


Fig. 3

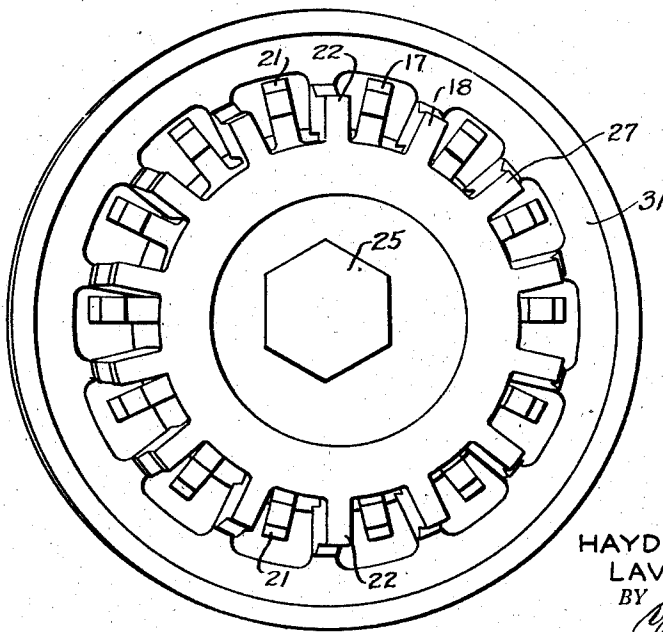


Fig. 4

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3 Sheets-Sheet 3

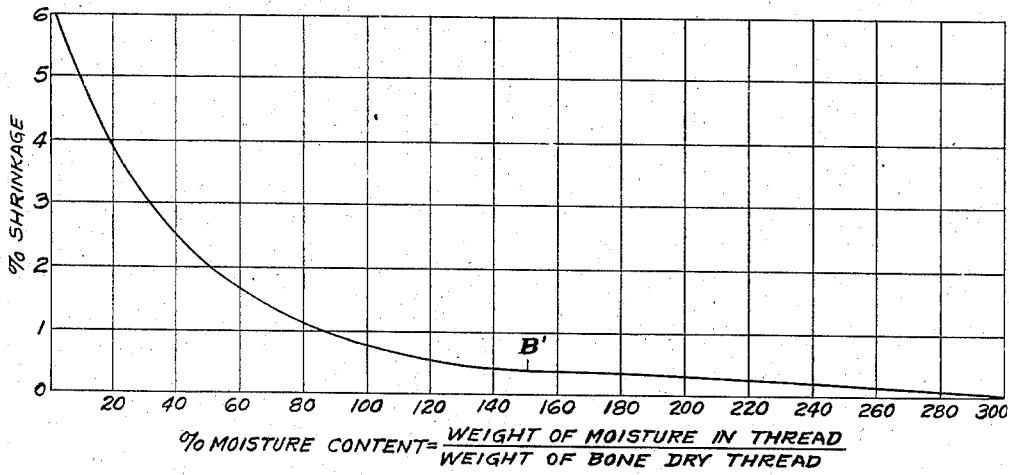


Fig. 5



Fig. 6

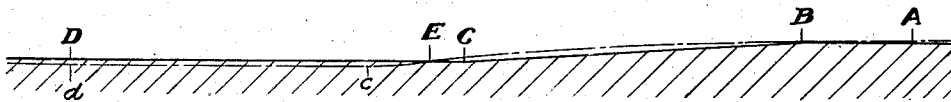


Fig. 7

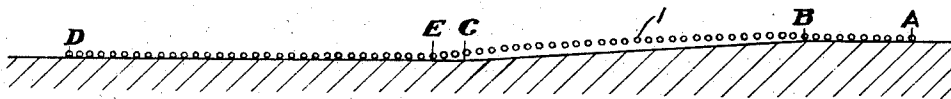


Fig. 8

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2,203,686

THREAD-ADVANCING REEL

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Application October 26, 1936, Serial No. 107,667

6 Claims. (Cl. 34—29)

This invention relates to the drying of substantially continuous lengths of materials, such as thread or the like, under circumstances in which provision is made for the shrinkage of such materials. More particularly, the invention relates to the drying of such material while stored in a plurality of generally helical turns on a winding reel permitting controlled shrinkage of the material being dried on the reel. While the invention may be employed to advantage in the drying of any kind of thread or the like which shrinks while being dried, it may be employed to particular advantage in the drying of artificial silk thread produced by any of the known wet-spinning processes, such, for example, as the viscose, nitrocellulose and cuprammonium processes.

While the invention is applicable to the drying of a wide variety of materials, generically referred to as thread or the like, for convenience it will be described hereinafter as applied to the drying of viscose artificial silk thread.

It is desirable that viscose artificial silk thread shall have along its length uniform physical and physico-chemical characteristics, this being particularly true in respect of what may be called its residual capacity to shrink. The term "residual capacity to shrink" may be defined as the amount, in proportion to its original dry length, a dry thread will, if unrestrained in any manner, shrink upon being re-wet and redried. Residual capacity to shrink is imparted to a thread which is prevented from completely shrinking as it is dried, the amount of shrinkage which the thread is permitted to experience before being prevented from further shrinking being determinative of its residual capacity to shrink. Uniformity of residual capacity to shrink is, however, extremely difficult to attain.

Uniformity of these physical and physico-chemical characteristics is particularly desirable in thread employed in the weaving of fabrics. In such fabrics, the cloth is initially woven to a width substantially equal to or slightly greater than the desired width of the finished fabric. In the finishing operations, the woven fabric, after being washed, dyed, etc., is dried in tentering frames which hold the fabric to the desired finished width. If the thread of which the fabric is formed has a high residual capacity to shrink, tearing of the fabric may result during the drying operation, due to stresses set up in the fabric as it shrinks while being thus held in the tentering frames. For this reason, it is desirable that the thread forming the fabric have a low residual capacity to shrink, particularly since the looms

used in the weaving industry, being of fixed widths, may not be adjusted to compensate for excessive shrinkage stresses.

Non-uniformity in such characteristics causes imperfections in the finished cloth, which imperfections are especially noticeable in dyed fabrics. Moreover, the manner of drying the thread, particularly in the case of viscose artificial silk thread, determines to a large extent the uniformity and amount of residual capacity to shrink imparted to the thread, as well as the uniformity of other physical and physico-chemical characteristics of the thread. For this reason, it is difficult to manufacture wholly satisfactory woven fabrics from artificial silk thread produced by a wet-spinning process in which the thread is dried on the spool on which it is collected. Such thread does not possess a satisfactory degree of uniformity, particularly in respect of the desired low residual capacity to shrink. This arises from the fact that the thread does not shrink evenly when dried on the spool.

As a result, thread which has been dried while wound on a spool has a residual capacity to shrink which varies widely at different points along its length. For instance, portions of the thread which are wound directly on the spool, being prevented thereby from shrinking on drying, have a high residual capacity to shrink, as do also portions on the outer surface of the cake which, due to their rapid drying, are prevented from shrinking by the inner layers of thread. Other portions of the thread which are permitted to shrink more or less freely, such as the portions of thread in the inner layers of the cake, have a relatively low residual capacity to shrink. If such thread is woven into a fabric which is dried on a tentering frame, the fabric will not shrink uniformly, due to such varying residual capacities to shrink, which adversely affect the uniformity with which the fabric may be dyed. The portions of thread of high residual capacity to shrink are subjected to higher tensions than other portions as the cloth is dried, thus giving rise to bright streaks known to the fabric trade as "shiners".

Heretofore, most of the wet-spun artificial silk thread manufactured for the weaving industry has therefore been produced by a process in which the yarn is unwound while wet from the package in which it is collected, such package being either a pot-spun cake or a cake of thread wound on a spool, after which it is reeled into skein form. In the latter form, the thread, after being subjected to various processing steps, is dried while hanging

loosely, thus permitting substantially free shrinkage of the thread. Since the weight of the thread as it hangs from the skein rods while drying tends to stretch certain portions of the thread and since all portions of the thread do not dry at the same rate, the thread inside of the skein winding dries more slowly than the outer portions of the thread, thus introducing variations in the physical and physico-chemical properties of the thread. It is therefore virtually impossible to obtain skein-dried thread which is of as high a degree of uniformity as might be desired. Furthermore, such methods entail a large amount of handling, with consequent disadvantages of excessive breakage of thread, high labor costs, large investment in machinery, plant space, etc., all of which factors tend to make weaving thread comparatively expensive.

By the present invention, it is possible to produce thread which is of uniform physical and physico-chemical characteristics along its entire length, having in particular a uniform, predetermined residual capacity to shrink which may be as low as desired. The thread, because of the control over the shrinkage made possible by the present invention, is of a higher quality than the best that it has heretofore been possible to manufacture on a commercial scale. It is particularly well suited to employment in the weaving of fabric. The thread is dried while temporarily stored on a winding reel in a plurality of spaced, advancing generally helical turns, the reel being adapted to permit either substantially complete shrinkage of the thread or unrestrained shrinkage of the thread to a point at which a desired residual capacity to shrink is imparted to the thread. Therefore, highly uniform artificial silk thread well suited for weaving may be produced at a much lower cost than has been heretofore possible.

Because of the improved means of drying the thread provided by the present invention, artificial silk thread may, as part of a continuous process, be unwound from the package in which it was collected, dried on a winding reel embodying the principles of this invention, and thereafter collected in suitable form. Such operations may be performed, for instance, by means of apparatus in which one or more winding reels are employed for processing thread supplied thereto directly from the spinning package. If desired, the thread may be dried according to this invention on apparatus of the general type shown, claimed and described in prior copending application Serial No. 7,114, filed February 18, 1935. For the purposes of convenience and illustration, but in no sense of limitation, the invention will be described in connection with the drying of viscose artificial silk thread on a reel forming part of a machine for the continuous manufacture of artificial silk thread, of the general type disclosed in the above-mentioned application Serial No. 7,114.

In the drawings, Figure 1 is a side elevation of a portion of the machine of the general type shown in said last-mentioned application. Figure 2 is a front elevation of the same machine. Figure 3 is a side elevation on an enlarged scale of a winding reel on which the thread may be dried according to this invention, parts being broken away more clearly to show the construction thereof. Figure 4 is an end elevation of the reel from line 4-4 of Figure 3. Figure 5 is a graph showing the amount of shrinkage of viscose artificial silk thread for various moisture

contents. Figures 6 and 7 show diagrammatic profile contours of reels on a larger scale than Figures 3 and 4. Figure 8 shows diagrammatically a preferred profile contour of a reel embodying the invention, revealing the relation of the thread to the reel during operation thereof.

In the drawings, like reference characters refer to like parts throughout.

In the apparatus illustrated in Figures 1 and 2, the thread 1 from a suitable source, such as a coagulating bath in which it has been formed, is passed in sequence to and over each of a series of suitable winding reels on each of which it is subjected to one or more desired processing treatments, three such reels, bearing reference numerals 2, 3 and 4, being shown in these figures. On reels on which processing liquid is applied to the thread, of which reel 2 is typical, the processing liquid, which in this case may be wash water, is applied by a suitable distributor 5 supplied by pipe 6 from a supply manifold 7 which may extend longitudinally of the machine and serve like reels in a horizontal series. The liquid is collected in a suitable trough 8 which may be disposed beneath the reel and likewise extend longitudinally of the machine. On reel 3 no processing liquid need be applied, the thread being simply stored on said reel to provide a period for allowing excess liquid to drip from the thread. The thread is then passed to reel 4 on which it is dried according to the present invention. It is collected by suitable means, such as cap-twister 9.

Winding reels 2, 3 and 4 may, as illustrated, be of cantilever form, having one end free and unobstructed as shown, in which case the reels may be disposed in a stepped arrangement as illustrated. Such an arrangement is advantageous in that it provides ready access to the reels for threading up, inspection, replacement, repair, etc. Each of the reels may be driven as illustrated through gears 10 and 11 from a drive shaft 12 driven from a main drive shaft 13 which extends longitudinally of the machine and drives each of the drive shafts 12 for a vertical series of reels. Cap-twister 9 may be actuated in the conventional manner whereby a belt 14, driven by suitable means, may rapidly rotate the bobbin-supporting whirl 15 while it is being vertically reciprocated by chain 16 which may be actuated by any suitable means.

The reel illustrated in Figures 3 and 4 as embodying the invention corresponds to drying reel 4 of the apparatus of Figures 1 and 2. This reel is of a type similar to the reel shown, described, and claimed in a copending application Serial No. 652,089, filed January 16, 1933. From these figures it can be seen that each reel comprises two rigid generally cylindrical members 17 and 18. Member 17, which may be termed the concentric member, is mounted concentrically upon and for rotation with drive shaft 19 and has its periphery comprised of a plurality of bar members 21. Member 18, which may be termed the eccentric member, may be rotatably mounted with its axis slightly offset from and askew to that of member 17 and has its periphery comprised of a plurality of bar members 22 equal in number to the bar members 21 and alternately disposed therewith.

Concentric member 17 may be formed as shown with the bar members 21 formed on the periphery of a cylindrical body 23, in which case great rigidity is obtained. While member 17 may be mounted on the drive shaft 19 in various man-

ners, in that shown the generally cylindrical body 23 thereof is provided with slots 26 at the rear end, in which slots are disposed the ends of pin 24 mounted in drive shaft 19 against which pin 24 generally cylindrical body 23 is held by a cap-nut 25 threaded into the end of drive shaft 19. Concentric member 17 is thus caused to rotate with shaft 19 by means of pin 24.

Eccentric member 18 is formed of a rigid cage-like member 27 mounted concentrically upon an annular supporting member 28 as by bolts 29. Rigid cage-like member 27 is formed of the aforesaid bar members 22 which are provided at their supported ends with an external supporting rib 31 by means of which the cage-like member 27 is mounted on annular supporting member 28. Annular supporting member 28 is rotatably supported in the desired offset and askew position with respect to the axis of concentric member 17 by being rotatably mounted on frame member 32, the shaft 19 being journaled in or otherwise supported in the desired relationship to frame member 32. A bushing 33 may, if desired, be provided in annular supporting member 28 to act as a bearing.

Rotation of reel drive shaft 19 causes concentric member 17 fixed thereto to rotate, whereupon contact of bar members 21 of concentric member 17 with bar member 22 of eccentric member 18 causes said eccentric member to rotate at the same angular speed. During such rotation, the offset rotation of the generally cylindrical members 17 and 18 causes the thread to transfer from the bar members of one generally cylindrical member to the bar members of the other generally cylindrical member. At the same time, the askew relationship of the generally cylindrical members causes the thread to advance in a plurality of spaced generally helical turns lengthwise of the reel.

The other reels 2 and 3 of the illustrated apparatus may be of the same general type and operate in the same general manner.

As the thread is continuously stored on the drying reel 4 (Figures 1 and 2), it is dried by suitable means. In the apparatus illustrated, the drying is accomplished by means of heated air supplied from a supply manifold 35 through the shaft 19 of the reel 4 which may be made hollow for this purpose. The heated air passes through the holes 36 in shaft 19 to a chamber 37 in the interior of the cylindrical body 23 of concentric member 17. It reaches the thread stored on the reel through the holes 38 which may extend toward the spaces between the bars 21 of concentric member 17. In order to intensify the drying action, provide better control over the drying operation, and conserve the heated air, a suitable housing 39 may be provided, the same being supplied, if desired, with a door 41 by means of which access may be obtained to the reel 4. The air may pass through return duct 42 to an exhaust manifold 43 whence it may pass to suitable reconditioning and reheating means, not shown, after which it may be recirculated back through supply manifold 35.

If the reel is made of metal having good heat conductivity, an aluminum, drying of the thread may be caused to a material extent by condition of heat through the reel members to the thread, as well as by convection of the air.

According to the present invention, provision is made for allowing substantially unrestrained shrinkage of the thread 1 as it is dried while be-

ing progressed lengthwise of the drying reel 4 in a plurality of spaced generally helical turns. In the illustrated embodiment of the invention, as shown in Figures 3 and 4, this is accomplished by making the thread-bearing periphery of the reel of such form that substantially unrestrained shrinkage of the thread occurs thereon for at least a portion of the length of the periphery of the reel. Particularly, the periphery of the reel is so designed as in part to permit the thread to dry out of actual contact with the reel.

To aid in better understanding the function of the reel in permitting substantially unrestrained shrinkage of the thread, a typical free shrinkage curve has been reproduced in Figure 5. The curve of Figure 5 represents the percentages of free shrinkage of the thread based on the length in the original wet condition for various percentages of moisture in the thread. The moisture content, plotted as the abscissa, is the proportion that the weight of the moisture in the thread bears to the weight of the bone dry thread at any given time, while the percentage of shrinkage, plotted as the ordinate, is the proportion that the reduction in length of the thread due to shrinkage bears to the original wet length of the thread for a given moisture content. As can be seen from this curve, as the moisture content of the thread is reduced by drying, as from 300% to approximately 150%, very little shrinkage of the thread occurs. However, at a moisture content of approximately 150%, noted as point B' on the curve, pronounced shrinkage of the thread begins, which shrinkage increases as the moisture content of the thread is reduced. When the moisture content of the thread is reduced to zero, the thread for which the curve of Figure 5 was determined shrinks somewhat more than 6% of its original length.

The occurrence of but slight shrinkage of the thread while its moisture content is being reduced from 300% to 150% may be due to the fact that substantially all of the moisture removed from the thread during this drying phase may be surface moisture, while the high percentage of shrinkage which occurs while the moisture content of the thread is reduced from 150% is probably due to a change in the structure of the thread during the removal of internal moisture from the thread. It has been found that moisture is rapidly removed from the thread until its moisture content is reduced to the point of pronounced shrinkage, whereas the remaining moisture is removed from the thread more slowly. This is probably due to the fact that the surface moisture is rapidly removed by evaporation, while the remaining moisture in the thread is removed more slowly by diffusion.

As drying of the thread occurs when it is stored on the reel in a plurality of spaced generally helical turns, the diameter of the generally helical turns of thread will tend to decrease due to shrinkage of the thread. For a given set of drying conditions, a given set of operating conditions of the reel, including a given spacing of the thread turns, and a given kind and size of thread, the generally helical turns of thread will, if shrinkage is unrestrained, define a surface having diameters decreasing from the initial diameter of the generally helical turns in which the wet thread was wound to a smaller diameter determined by the amount of shrinkage of the thread, the curvature of the portion of the surface of revolution between the two portions of

different diameters being determined by the shrinkage characteristics of the thread. It has been found possible to determine a peripheral form of a winding reel the profile contour of which corresponds to the theoretical profile contour which would be defined by the thread as it shrinks under the above circumstances. For a given set of conditions, this contour of the reel will permit unrestrained shrinkage of the thread.

A typical theoretical profile contour of a reel for free shrinkage of thread which is dried under certain drying conditions on a winding reel of the general type and construction shown in Figures 3 and 4 is diagrammatically shown in Figure 6. It will be noted that, from the point *a* at which the thread starts on the reel to the point *b*, the reel is substantially cylindrical; from point *b* to point *c* the diameter of the reel diminishes, the profile contour between point *b* and point *c* being a curve from the larger diameter of portion *a—b* of the reel to a smaller diameter; while from point *c*, at which shrinkage of the thread ceases, to the point *d*, at which the thread leaves the reel, the reel is substantially cylindrical.

When the thread is stored in a plurality of spaced generally helical turns and advanced from point *a* to point *b* while being dried, it loses excess moisture, being in the condition corresponding to the portion of the curve of Figure 5 to the right of point *B'* thereof. By the time it reaches point *b* on the reel, it has had its moisture content reduced to the point corresponding to point *B'* of Figure 5, at which pronounced shrinkage of the thread begins. Since moisture removed while the thread is advancing between points *a* and *b* is probably largely free surface moisture on the thread, which may be evaporated quickly, the relatively short length of travel represented by *a—b* is sufficient. As the thread is advanced from point *b* to point *c*, the thread, as shown by the diminishing diameters of this portion of the theoretical contour, shrinks relatively rapidly as the moisture content is reduced, the thread being meanwhile in the condition corresponding to the portion of the curve of Figure 5 to the left of point *B'* thereof. The moisture removed while the thread is advancing between points *b* and *c* is probably largely internal moisture. Since it must be removed by diffusion, which requires a relatively longer time, the relatively longer portion *b—c* of the reel is required. After the thread has shrunk to the point corresponding to the moisture content remaining in the thread after the drying operation, no further appreciable shrinkage thereof takes place, as is evidenced by the generally cylindrical portion extending from *c* to the end of the reel.

While, as indicated, on a reel having this theoretical contour substantially unrestrained shrinkage of the thread is possible for a given set of operating conditions and for a given kind of thread, any marked variation in the drying conditions, the speed of the reel, the kind of thread being dried, etc., will necessitate a change in this contour. It has been found, however, that, by modifying the contour of the reel from the theoretical contour in a manner provided by the present invention, satisfactory results may be obtained, even over widely varying operating conditions and with threads of widely varying sizes and physical characteristics. To more clearly explain the form and operation of a reel having a preferred peripheral contour, in Figure 7 the theoretical profile contour of Figure 6 has been superposed in broken lines on the preferred profile

contour, shown in full lines, of a winding reel embodying the invention, which reel for the purposes of correlation is of the same general construction and which is designed to operate over a range of conditions which include the operating conditions for the reel embodying the theoretical profile contour of Figure 6.

The preferred contour of a reel embodying the invention is substantially similar to the theoretical contour, as shown in Figure 7. As before, the reel may comprise two generally cylindrical portions *A—B* and *C—D* having between them an intermediate portion *B—C* so formed that it varies somewhat from the portion *b—c* of the ideal contour, the diameters of portion *B—C* of the preferred reel being less than the corresponding diameters of a reel having the ideal contour, as shown in Figure 7. In other words, at least a portion of the periphery of the reel over which pronounced shrinkage of the thread takes place decreases in diameter at a greater rate, as the turns of thread are advanced along said portion, than the diameter of each turn of thread tends to decrease due to shrinkage of the thread. As a result, substantially unrestrained shrinkage of the thread is allowed to take place over such a portion of the reel.

The diameters of the portion *C—D* of the reel may be such as to determine the amount of residual capacity to shrink imparted to the thread; that is, the generally cylindrical portion *C—D* may be of such diameter that the thread leaves the tapered portion *B—D* and starts on the portion *C—D*, as at point *E*, before it is completely shrunk. In such case, drying of the thread is completed on the generally cylindrical portion *C—D* and a definite, uniform, controlled residual capacity to shrink is imparted to the thread. If desired, the diameters of portion *C—D* may be such as to allow the thread to shrink completely, in which case the thread may have no residual capacity to shrink. As shown in Figure 7, however, the diameter of portion *C—D* of a reel of the preferred contour is slightly larger than the corresponding portion of a reel of the theoretical contour shown, thus providing a certain small amount of residual capacity to shrink in the thread. However, if desired, a reel having a theoretical contour may also be similarly made larger at the corresponding portion to provide a desired amount of residual capacity to shrink in thread which may be dried on a reel having such contour. By varying the diameter of generally cylindrical portion *C—D* within reasonable limits, it is possible to vary the residual capacity to shrink imparted to the thread. Thus, by increasing the diameter of portion *C—D*, the residual capacity to shrink imparted to the thread may be increased; while by decreasing such diameters, the residual capacity to shrink imparted to the thread may be decreased.

Furthermore, if desired, the generally cylindrical portion *C—D* of a reel of the preferred contour may, as illustrated, be somewhat longer than is necessary to dry the thread to the desired moisture content, since such longer portion may provide an additional setting period for the thread to reach equilibrium drying conditions before it leaves the reel. As previously indicated, the thread may not be dried to a bone-dry condition, but to a condition in which the thread has a moisture content of around 10% of the bone-dry weight of the thread, corresponding to the ordinary "regain moisture content" of thread produced by ordinary methods. This moisture is ad-

vantageous if, as in the illustrated embodiment, the thread is twisted after leaving the drying reel since a moisture content of this amount aids in the twisting operation.

The position of the thread on the reel while being dried is shown to advantage in the diagrammatic view of Figure 8, which shows in profile the preferred contour of the reel and the cross-section of the threads thereon. In this figure the first helical winding of the wet thread started on the reel comes into contact with the reel at A. The thread may be very wet, having a moisture content which may be in the neighborhood of 300%. As the thread is advanced axially of the reel it is dried, as by convection of the heated air supplied from the interior of the reel and by the conduction of the heat through metallic bars of the reel. The moisture content of the thread is reduced as the thread is advanced along portions A—B of the reel at such a rate that, as the thread reaches the vicinity of point B, it is in the condition corresponding to point B' on the moisture content-shrinkage curve of Figure 5, at which point pronounced shrinkage of the thread begins. The portion A—B of the reel may be substantially cylindrical, since the amount of shrinkage of the thread as its moisture content is reduced to the point to which pronounced shrinkage of the thread commences is so small as to be almost negligible. The contour of the portion A—B of the reel may, if desired, be of such shape as to conform to even such slight amount of shrinkage of the thread.

While the thread has been quite firmly supported on portion A—B of the reel, it is loosely supported when it is advanced over the portion of the diminishing diameters B—C of the reel, due to the previously mentioned fact that the reductions of the diameters of the reel, as the thread advances along this portion, are greater than the reductions in diameters of the corresponding turns of thread occurring from shrinkage of the thread. This is illustrated by the fact that, during operation of the reel the thread turns on portion B—C of the reel actually leave the reel during rotation thereof, as shown in Figure 8, only occasionally touching the reel. The action of the reel as the thread turns advance along the portion B—D thereof is not so much that of supporting the thread turns, but that of guiding and advancing the thread turns. The thread is thus allowed substantially unrestrained shrinkage until it comes into contact with the portion C—D of the reel, on which portion, if desired, the shrinkage of the thread may be halted and the drying of the thread allowed to proceed to completion. Thus, by suitably designing the reel, there may be imparted to the thread a definite uniform residual capacity to shrink which may within reason, be of any desired magnitude.

The invention contemplates the employment of reel contours of various kinds in the portion of the periphery over which unrestrained shrinkage of the thread is permitted to occur, but in general a straight line contour such as that of portion B—C of the reel shown and described is preferred.

The conditions affecting the operation of the reel, such as the kind of thread being dried, the temperature and humidity of the heated air, speed of rotation of the reel, etc., may be varied with reasonable limits without an appreciable variation in the physical properties of the thread or of the residual capacity to shrink thereof. This arises from the fact that the thread is loose-

ly supported while shrinkage thereof occurs, and, while such variations vary the rate of drying of the thread, they merely change the position longitudinally of portions C—D of the point E at which the thread leaving the tapered portion B—C of the reel comes into contact with the generally cylindrical portion C—D thereof. Thus, if the operating conditions are so varied that the thread dries somewhat more rapidly, and consequently shrinks more rapidly, the point E at which the thread contacts the generally cylindrical portion C—D moves nearer point C, while, if the thread is dried more slowly, the point E moves away from point C.

The amount the thread shrinks and the residual capacity to shrink imparted to the thread are thus not affected by such variations in drying conditions, since the thread is in each case permitted unrestrained shrinkage until it reaches portion C—D. This advantage is not obtained on a reel having a tapered portion which decreases in diameter more gradually than the thread turns tend to decrease due to shrinkage. In such case, the thread is under an appreciable amount of tension as it passes over the tapered portion of the reel, since any variation in the drying conditions causes the thread to complete its drying at different portions on the tapered portion of the reel, thus varying the amount of shrinkage occurring in the thread as well as the residual capacity to shrink imparted to the thread.

Because of the fact that reels of the type embodying the preferred form of the invention may operate under varying conditions without appreciable variations in the final physical properties of the thread, it is therefore possible to dry a plurality of threads, as on apparatus of the type illustrated in Figures 1 and 2, without appreciable variations from thread to thread in the residual capacities to shrink of the thread or in other physical and chemical properties which may be affected by variations in drying conditions. This is particularly advantageous, since in the operation of machines in which large numbers of threads are dried, it is not commercially practicable to maintain exactly uniform and identical drying conditions for all of the threads; yet by means of reels embodying the present invention it is possible to have all threads produced on such apparatus of substantially identical physical properties.

As an illustrative example of the operation of a reel having a contour of the type shown in Figure 8, it has been found in actual practice that desirable results are obtained in drying 150 denier filament viscose artificial silk thread on an aluminum drying reel of the type illustrated in Figures 3 and 4. In such reel the diameters of the reel members at the portions A—B thereof may be 4.950"; the diameters of the portions of the reel members at portions C—D thereof, 4.700"; the distance from the point A at which the thread starts on the reel to point B, $2\frac{3}{32}$ "; and the distance from point B to C, $1\frac{3}{4}$ ". The reel is preferably rotated at approximately 165 R. P. M., the thread being supplied from a preceding reel rotating at the same speed and having reel members of 5" diameters at their discharge ends. Due to the construction of the reel, the thread is advanced in a plurality of generally helical turns which are spaced approximately $\frac{1}{16}$ " apart. It is dried by heated air supplied at 185° F. at a static pressure of about 6" of water. The finished thread has along its entire length a

very uniform low residual capacity to shrink very closely approximating 0.6%, all other physical and chemical characteristics of the thread being also of a high degree of uniformity.

5 It has been found, further, that the amount of tension in the wet thread at the commencement of the drying operation determines to an appreciable extent the amount of residual capacity to shrink imparted to the thread when it is dried on the reels of the present invention. Thus if the thread is under substantial tension at the beginning of the drying operation, the residual capacity to shrink imparted to the thread will be higher than if the thread is under little or no tension at the commencement of the drying operation. For this reason, it is desirable that, at the commencement of the drying operation, the thread be under as little tension as practicable for satisfactory operation of the reel.

20 Where the thread is dried on an individual drying reel, as in the illustrated embodiment of the invention, this may be accomplished by providing a peripheral speed of that portion of the drying reel on which the thread first starts on the reel; i. e., portion A—B of the reel, which is less by a suitable amount than the linear speed at which the thread is supplied to the reel from the source of thread. Thus, in the illustrated apparatus in which the thread passes from a preceding reel to the drying reel, the peripheral speed of portion A—B of the drying reel may be less than the peripheral speed of the discharge end of the preceding reel. This may be accomplished, for instance, by making the portion A—B of the drying reel and the discharge end of the preceding reel of the same diameters and rotating both reels at different angular speeds, or by making the diameter of portion A—B of the drying reel less than that of the discharge end of the preceding reel and driving both reels at the same speed, or by a combination of these methods. As a result, any tension in the thread will be released, the thread, if it is at all stretched, being allowed to contract as it starts on the drying reel.

45 As an example of the effect of the initial tension of the thread on the residual capacity to shrink imparted to the thread the following is illustrative:

50 Viscose artificial silk thread is dried according to the above-outlined method on an aluminum reel, of the type above described. The reel is 5" long and has reel members 5" in diameter at the end at which the thread is started on the reel. The difference in the diameters of portions A—B and C—D of the reel is $4\frac{1}{2}\%$, the reel being rotated at 165 R. P. M. The thread is dried by heated air supplied from the interior of the reel at 185° F. The diameter of portion A—B of the reel is the same as that of the discharge end of the preceding reel and both reels are driven at the same speed. Consequently, no attempt is made to release any tension existing in the thread. The residual capacity to shrink of the thread so dried is in the neighborhood of 1.6%.

65 Thread of the same kind is dried on a reel of the same general dimensions as the reel of the preceding example, the only difference being that the diameter of portion A—B of the reel is 1% less than the diameter of the discharge end of the reel immediately preceding it. In this case, as in the preceding case, there is a difference of $4\frac{1}{2}\%$ between the diameters of portions A—B and C—D of the reel. Both the reel in question and the reel immediately preceding it are rotated at 165 R. P. M., the thread being dried by

heated air at 185° F. supplied from the interior of the drying reel. The residual capacity to shrink is in the neighborhood of .5%.

Thus it is apparent that the amount of tension existing in the thread at the commencement of the drying operation appreciably affects the residual capacity to shrink imparted to the thread.

It is apparent that the type of reel in connection with which this invention has been described is purely illustrative and that the invention may be applied to reels operating on various other principles. It may be applied to reels on which the thread is dried by other means than heated air, as in the examples herein given. Furthermore, reels embodying the invention may be employed for other uses and in other arrangements than those herein illustrated without in any way departing from the spirit of the invention. In the appended claims, the term "thread" is intended to include, besides thread, all articles of the nature of thread or the like which may be wound and dried on reels according to the teachings of the present invention.

It is intended that the patent shall cover, by suitable expression in the appended claims, whatever features of patentable novelty reside in the invention.

What is claimed is:

1. In apparatus for handling thread, a thread-advancing reel made up of a plurality of interdigitating cage members, means for rotating said cage members, means providing relative movement between the thread-bearing surfaces of said cage members to advance the thread lengthwise of the reel in a series of generally helical turns, and means for subjecting the thread as it is being advanced on the reel to conditions which cause it to shrink, the reel being substantially circular in transverse cross section from one end thereof to the other but having a periphery comprising a first substantially cylindrical portion on which the thread is advanced in firmly supported turns, an intermediate substantially frusto-conical portion on which successive perimeters of the reel in the direction of travel of the thread are sufficiently shorter than the lengths of the corresponding thread turns to permit the thread to advance in loosely supported turns, and a second substantially cylindrical portion of smaller diameter than said first substantially cylindrical portion on which the thread is advanced in firmly supported turns.

2. In apparatus for handling thread, a thread-advancing reel made up of a plurality of interdigitating cage members, means for rotating said cage members, means providing relative movement between the thread-bearing surfaces of said cage members to advance the thread lengthwise of the reel in a series of generally helical turns, and means for subjecting the thread as it is being advanced on the reel to conditions which cause it to shrink, the reel being substantially circular in transverse cross section from one end thereof to the other but having a periphery comprising a substantially cylindrical portion on which the thread is advanced in firmly supported turns and, associated therewith, a substantially frusto-conical portion on which successive perimeters of the reel in the direction of travel of the thread are sufficiently shorter than the lengths of the corresponding thread turns to permit the thread to advance in loosely supported turns.

3. Apparatus of the character described in claim 2 in which the substantially cylindrical portion on which the thread is advanced in firmly

supported turns constitutes the portion on which the thread starts on the reel.

4. Apparatus of the character described in claim 2 in which the means for subjecting the thread to conditions which cause it to shrink includes means for passing a gaseous medium outward through the periphery of the reel whereby the turns of thread on said substantially frusto-conical portion are urged away from the reel by said gaseous medium.

5. In apparatus for handling thread, a thread-advancing reel made up of a plurality of interdigitating cage members, means for rotating said cage members, means providing relative movement between the thread-bearing surfaces of said cage members to advance the thread lengthwise of the periphery of the reel in a series of generally helical turns, and means for subjecting the thread as it is being advanced to processing conditions which cause it to shrink, the periphery of the reel including an initial generally cylindrical portion on which the thread is firmly supported and, associated therewith, a succeeding generally tapered portion so correlated to the processing conditions to which the thread is thus subjected that in spite of the tendency of the thread to shrink as it is advanced successive perimeters of the reel taken in the direction of travel of the

thread are small enough as compared with the lengths of the corresponding thread turns to enable the thread to advance loosely over said generally tapered portion.

6. In apparatus for handling thread, a thread-advancing reel made up of a plurality of interdigitating cage members, means for rotating said cage members, means providing relative movement between the thread-bearing surfaces of said cage members to advance the thread lengthwise of the periphery of the reel in a series of generally helical turns, and means for subjecting the thread as it is being advanced to processing conditions which cause it to shrink, the periphery of the reel including two spaced, generally cylindrical portions on each of which the thread is firmly supported and an intermediate generally tapered portion so correlated to the processing conditions to which the thread is thus subjected that in spite of the tendency of the thread to shrink as it is advanced successive perimeters of the reel taken in the direction of travel of the thread are small enough as compared with the lengths of the corresponding thread turns to enable the thread to advance loosely over said generally tapered portion.

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