

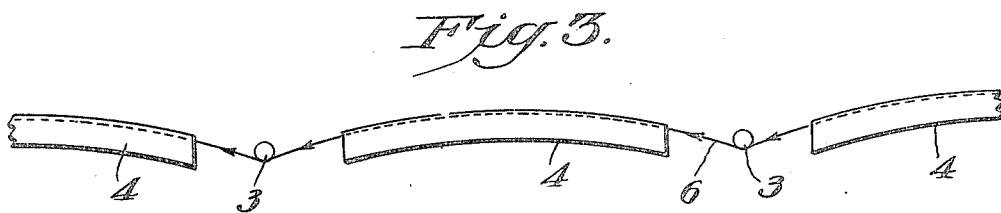
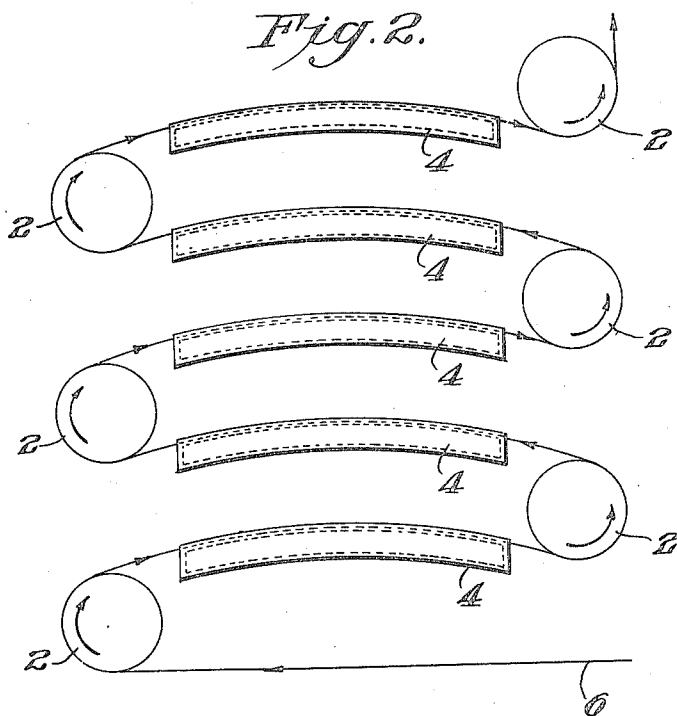
Jan. 17, 1950

R. F. CONAWAY ET AL
DRYING OF YARNS AND THE LIKE

2,495,053

Filed Jan. 3, 1947

3 Sheets-Sheet 1



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Fig. 4.

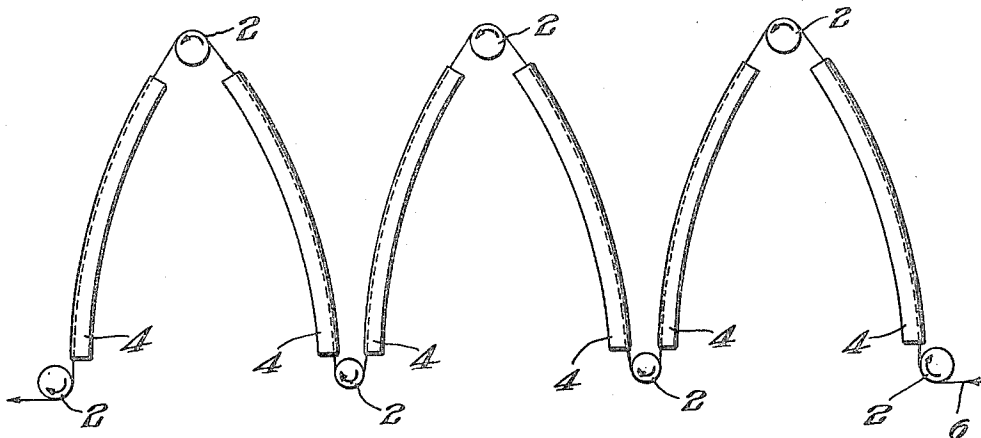
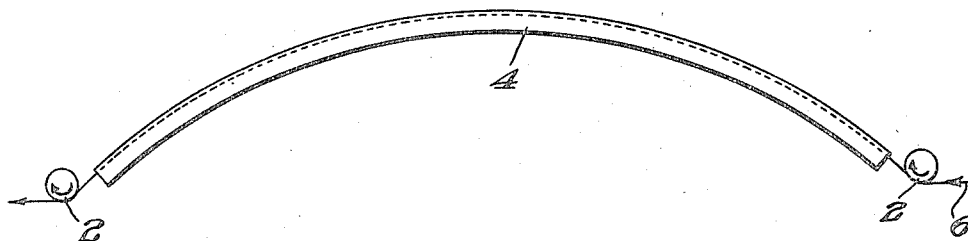


Fig. 5.



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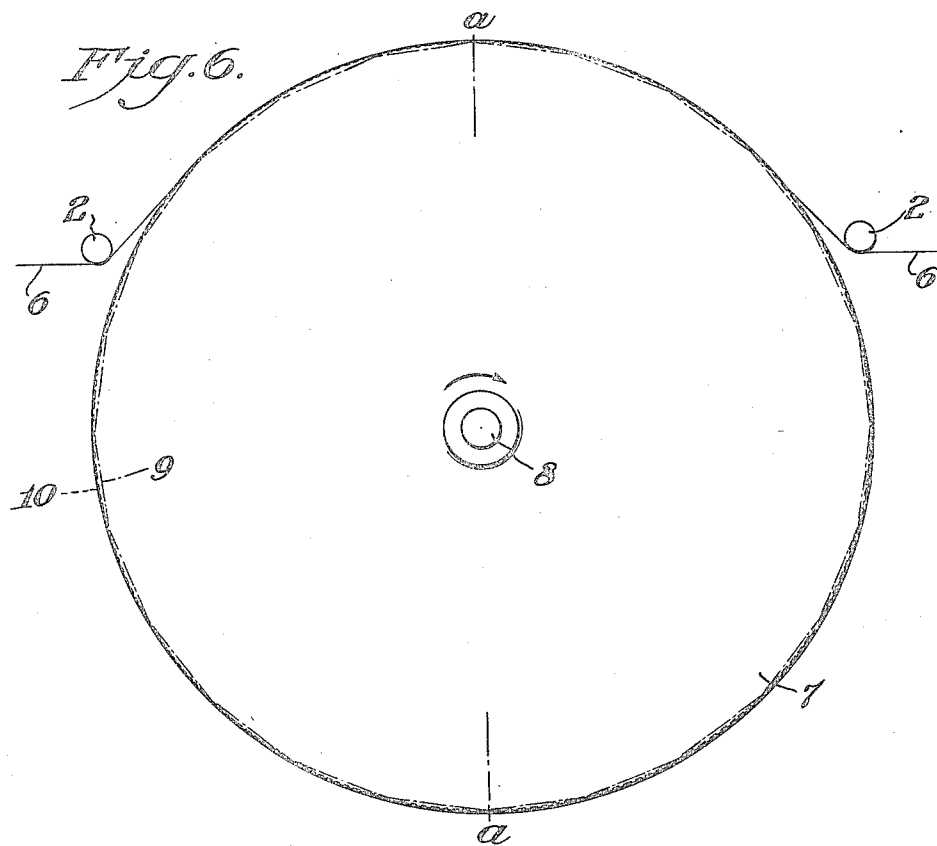
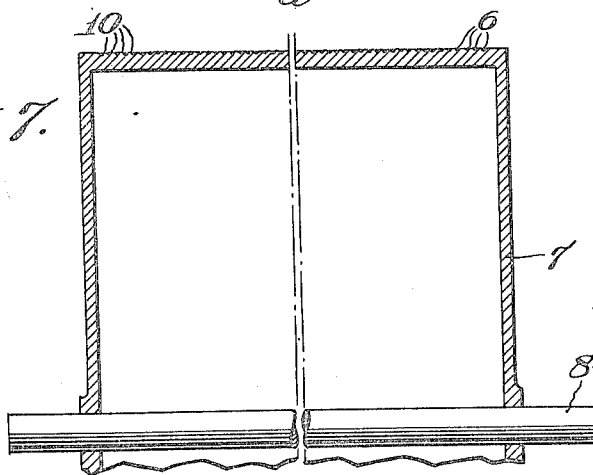


Fig. 7.



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2,495,053

DRYING OF YARNS AND THE LIKE

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Application January 3, 1947, Serial No. 720,030

8 Claims. (Cl. 34-41)

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This invention relates to the drying of yarns, threads, ribbons or filaments and more particularly to the provision of improved apparatus for the rapid drying of yarns, threads, ribbons or filaments.

Previously, drying of yarns and the like has been effected by passing them through heated chambers, or over drying rollers, or by placing bobbins holding the wet yarn in heated chambers. These methods have not been incorporated in continuous spinning processes with complete success. Difficulties encountered have arisen from non-uniformity of drying, non-uniformity of shrinkage, or slow drying rates. These obstacles have led to yarn of inferior quality and have hindered processing yarn and the like successfully at the high speeds essential to an economically feasible commercial process. Another difficulty frequently encountered has been breakage and snagging of the wet yarns due to tension built up on the yarn during drying.

This invention has as an objective the provision of apparatus for the rapid, uniform drying of yarns, threads, ribbons or filaments. A further object has been the provision of a drying process whereby yarns and the like could be dried to a uniform moisture content at high speeds and at exceedingly high temperatures. A still further object has been the rapid, uniform drying of yarns and the like under low tension conditions, thereby minimizing yarn breakage. Other objects will appear hereinafter.

These objects are accomplished by the following invention, in which, broadly stated, individual ends of yarn and the like to be processed, are rapidly dried as they are drawn at high speeds and under low tension over curved, dryer plates heated at temperatures which are substantially above the boiling point of water. The curvature of the dryer plates is adjusted to obtain maximum efficiency, the drying rate and yarn tensions being so balanced to give optimum drying conditions. The yarns and the like are guided over the dryer plates by means of yarn directing pins. These may be stationary or they can be either idling rollers or gear driven rollers. The guiding means may also include the use of grooves arranged arcuately in the surface of the curved plates, the grooves being adapted to receive yarn or the like traveling across the plate.

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In the drawings, in which like numerals refer to like parts, Figure 1 represents an end view of a typical dryer plate 4, showing at 1 a rectangular shaped groove and yarn 6 therein. Ordinarily these grooves are about $\frac{1}{8}$ of an inch wide and about $\frac{1}{8}$ to $\frac{1}{4}$ of an inch deep. However, the dimensions are not limited to these and the grooves may be larger or smaller depending upon the size of the yarn or the like being processed. Generally, the grooves must be so designed to receive the yarn or the like in such a way that there is sufficient clearance at the sides and top for rapid evolution of moisture and steam. The dryer plates can be stacked in tier arrangement as is shown in Figure 2 or they may be placed end-to-end (or straight way arrangement) as is shown in Figure 3, allowing for a straight pass of yarn. Further, a back-to-back arrangement as is shown in Figure 4, may be used. Instead of using a plurality of dryer plates a single long dryer plate, as is shown in Figure 5, may be employed. The plates used in any of these arrangements are preferably bent on a radius from about 5 feet to about 32 feet. The arc of any plate used in these arrangements may be as much as 180° or several plates of smaller arc may be placed end to end to simulate a single plate dryer of larger arc. In the tier arrangement, the yarn is passed over roller 2 which is preferably gear driven (not shown). In the other arrangements, a stationary pin 3 is used in directing the yarn and the like over the plates and through successive grooves if grooves are employed. The pin may be replaced by an idling roller or a gear driven roller.

The plates may be fixed and immovable or they may be so arranged to simulate large diameter rotatable drums moving at speeds substantially different than yarn speed and in the same or opposite direction of yarn travel. Figure 6 shows an end view of such a rotatable drum 7, supported and rotating on shaft 8 which is driven by an outside power source not shown. This drum may be cylindrical and continuous or it may be segmented, as shown by lines 9, each segment being supported on an arm (not shown) extending radially and in turn supported on shaft 8. Further, the segments may be arranged so that there are gaps between successive dryer plates. The plates may be smooth surfaced or they may con-

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tain grooves, as shown by line 10 and in Figure 7, a sectional view of the rotating drum taken on line aa. The yarn 6 travels over the plate in a manner similar to that described above using rollers 2 or stationary pins 3. The yarn may travel in the same or in the opposite direction of cylinder travel. It is preferred, because of the exceedingly high temperatures used, to employ yarn speeds and drum speeds which are substantially different.

The drying members employed in such a manner may be heated in ways similar to those employed for stationary plates, as is described below.

The dryer plates are generally metallic and are heated electrically, numeral 5 representing the heating element. However, the plates may be composed of other materials such as glass or plastics, which may be appropriately jacketed and heated with usual media such as oil or superheated steam. High boiling organic liquids, such as Dowtherm, and high melting inorganic salt mixtures may also be employed as heating media. While Figure 1 has shown only one groove per plate, the plates may be multi-grooved, permitting the rapid drying of several yarns at one time.

For rapid drying the radius upon which the plates are curved is critical. It has been found that a radius of about 7 feet produces the desired rapid drying. The curvature at this radius is correctly adjusted for most yarns. However, if the curvature is reduced, i. e., a larger radius of curvature, greater drying times are needed to produce the same end condition of the yarn under identical drying conditions. This is shown in Table I. The viscose type, regenerated cellulose yarn used had the following characteristics: 100-denier, 40-filament and 0-twist (100-40-0); 145% initial moisture; dryer travel was 144 inches.

TABLE I

Effect of curvature of dryer plates on drying

7' Radius			32' Radius		
Yarn Speed, I. P. M.	Plate Temp., °C.	Per Cent Residual H ₂ O BD Basis	Yarn Speed, I. P. M.	Plate Temp., °C.	Per Cent Residual H ₂ O BD Basis
10,000	189	10.0	10,000	213	19+
			10,000	221	16+
			8,000	190	19.7
			6,000	190	10.0

Thus, yarn containing 145% moisture could be dried to 10% moisture (calculated on a bone dry basis) at a speed of 10,000 inches per minute on a plate bent on a radius of 7 feet, the plate temperature being 189° C. At the same speed but at the higher temperature of 221° C. and on a plate constructed on a 32 foot radius, the same yarn could be dried to only 16% residual moisture. At comparable temperatures, it was necessary to reduce the speed to 6,000 inches per minute to obtain yarn having 10% residual water. By reducing the curvature from a 7 foot radius to a 32 foot radius the drying time required to produce the same end yarn was almost doubled. Plates constructed on a radius of 5 feet or on a radius of 9 feet have been found to give satisfactory results similar to those obtained using plates bent on a radius of 7 feet.

This invention is readily adaptable to both low denier yarns and the like (50 to 150 denier) and higher denier yarns (1100 to 2200 denier or

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more), high speed drying being accomplished with either type of yarn. While Table I and Table III refer to the drying of low denier yarn, Table II gives examples of the drying of high denier yarn. This yarn had finish applied to it. A multi-plate dryer was used, the tier arrangement shown in Figure 2 being employed.

TABLE II

Drying of high tenacity 2200-denier, 960 filament, viscose type regenerated cellulose yarn at 6,000 I. P. M. to 11% water

Yarn	Per Cent Initial Moisture	Plate Temp., °C.	No. of 48" Plates	Time, Sec.
A-----	115-120	303	6	4.5
		223	8	6.0
		175	10	7.5
B-----	130-140	340	6	4.5
		251	8	6.0
		197	10	7.5

In these examples, the total travel per pass was 75.4 inches. This total represents a summation of the travel of the yarn on the plate, in air and around the rolls. As can be seen from a comparison of the above two sets of figures, the higher the initial moisture content of the yarn the higher is the temperature required to dry yarn to the same end condition for a given drying time.

The effect of temperature distribution over the plates is apparently negligible. On several runs for 2200-denier yarn, the plate temperatures were graduated to give temperatures as high as 371° C. on the first few plates and as low as 177° C. on the last few. No significant difference could be found in the drying rate for these runs and for other runs in which all the plates were maintained at a temperature equivalent to the average plate temperatures of the graduated series.

The drying of low denier yarns was accomplished readily, Table III indicating appropriate conditions. A multi-plate dryer of the end-to-end arrangement shown in Figure 3 was employed in these examples, the total plate travel being 144 inches.

TABLE III

Drying of low denier untwisted viscose type regenerated cellulose yarns

Denier and filament count	Initial H ₂ O per cent	Speed, I. P. M.	Time, Secs.	Plate Temp., °C.	Residual H ₂ O (B. D. Basis)
150-60	145	8,000	1.08	210	11.2
100-40	145	10,000	.884	189	10.0
75-30	145	10,000	.884	160	9.0
75-30	145	13,000	.665	175	7.7
50-20	145	13,000	.665	135	10.3
100-40	156	10,000	.884	175	6.7
100-40	156	8,000	1.08	160	11.6

An outstanding feature of this invention is the surprisingly small tension build-ups which occur as the yarn is drawn over the dryer plates. For example, when 2200-denier yarn was passed at 6000 I. P. M. over dryer plates in the tier arrangement, a build-up from 20 to 100 grams per end per pass occurred. Since the yarn was driven by rollers 4, the build-up was not cumulative. When low denier yarns were drawn over

three dryer plates laid end to end the tension build-up was as follows:

TABLE IV

Tension build-up for 100-denier yarn

Yarn Speed, I. P. M.	Tension, Grams
13,000	3.0
10,000	2.25
8,000	1-1.5
6,000	Less than 1.0

Thus, the apparatus and process of this invention permit the drying of yarns under relatively low tensions, being generally in the range of 0.01 to 0.5 gram per denier.

The plates used in the examples given in Table IV were constructed on the basis of a 7 foot radius. Reduction of the curvature of the plates to a radius of 32 feet resulted in a decrease in the tension build-up, the tension build-up in each example of Table IV being then less than 1 gram. However, the drying time needed to dry the yarn and the like to an acceptable residual moisture content was materially increased.

If wet yarn or the like is drawn over cold dryer plates, an extremely large tension build-up results. This tension exceeds the breaking tension of the wet yarn and probably is due to the surface tension of the water in the yarn. As pointed out above this effect disappears when the yarn is drawn over hot dryer plates. It is postulated that the yarn actually rides on a blanket of steam. Intimate contact with the surfaces of the plates, whether grooved or not, is avoided. The temperatures required to obtain satisfactory drying rates frequently are above the softening points or charring points of the material of which the various yarns are composed. Plate temperatures may be varied from 100° C. to 500° C. Higher or lower temperatures may be employed depending upon the moisture content of the yarn, speed of yarn thread, position of the plate in the drying cycle and composition of the yarn. Temperatures in the range of 115° C. to 450° C. are preferred for most operations. Care must be taken to avoid charring and burning. In this connection, the yarn speeds must be adjusted so that burning is avoided. Speeds of yarn which have been used successfully have been as low as 800 and as high as 26,000 inches per minute. Higher or lower speeds might be employed, however, if desired. Yarn speeds and plate temperatures are adjusted for each yarn dried to avoid scorching, melting or burning of the yarn. If the residual moisture content of the yarn is reduced too much, charring may occur. The combined features of this invention, namely the curve of the plate, the guiding means and the use of low tensions allow for the drying of yarn and the like with minimum contact with hot stationary surfaces. Hence, the yarn may be dried rapidly yet under very low tensions and with infrequent snagging and breakage of the yarn.

While it is not essential to use grooved plates, it is frequently advantageous to do so. The grooves may be of any shape, those rectangular or U-shaped being generally preferred. The depth of the groove does not appear to be critical. The use of grooved drying plates results in a drying apparatus which is easier to string-up and which involves a minimum of entanglement of the separate threads being dried. The grooves

function as additional guiding means and further force the yarn into very intimate contact with the heat radiating from the sides of the groove. Even so, contact with the hot metal grooved surfaces is avoided just as effectively as when plates without grooves are used, the surrounding steam again acting as a protecting blanket.

The efficiency of the dryer is dependent in part upon the area of the yarn exposed as the yarn passes over the heated plate. A flattening or spreading out of the filaments in each yarn permits faster heating and more rapid drying. This spreading out may be accomplished, for example, by passing the yarn over a crowned roller at such points as 2 or 3 in the drawings. Convergence of the filaments into a single thread after drying may be done readily by means of a grooved roller, for example.

In general no adverse effects on the physical properties of the yarn processed on the dryer plates of this invention at the exceedingly high temperatures occur. This is true in all instances in which the final moisture content is in the range of 5% to 15%. If this content is reduced to below 3.5% or 4%, danger of degradation becomes appreciable. But even yarns drastically dried to 3.5% to 4% moisture show little reduction in quality. For example, when 2200-denier yarns were dried to moisture contents to about 3.5% to 4.0% regain, only one physical property, oven-dry cord tenacity, was affected. Oven-dry cord tenacities are obtained by drying the sample substantially to bone dryness and then testing rapidly prior to appreciable moisture regain. The oven-dry cord tenacities of yarns dried this drastically by the process of this invention were on the average only 0.1 gram per denier lower than similar tenacities measured on control yarns. All other properties were unaffected. When textile yarns, that is, yarns of low denier, were dried by the process of this invention to 6% to 7% residual moisture, no degradation at all occurred.

Another outstanding advantage of the dryer of this invention is the uniformity of shrinkage that can be attained. Shrinkage tests run on textile yarns demonstrate that the process of this invention is superior in respect to other methods, such as drying on a bobbin. Examples of shrinkages obtained upon drying 100-denier yarn on 3 plates equivalent to 144 inches of travel are given in Table V below.

TABLE V

Shrinkage of 100-40-0 viscose type regenerated cellulose yarn

Drying Speed	Tension	Shrinkages
I. P. M.	Grams	Per cent
13,000	3.0	5.0±0.5
10,000	2.25	4.5±0.25
8,000	1-1.5	4.0±0.25
6,000	Less than 1.0	3.8±0.1

The thermal efficiency of the dryer of this invention is remarkably high. On high denier yarn a dryer thermal efficiency of 70% to 75% is obtained. On lower denier yarns a comparable efficiency of 70% attains. This high efficiency is an important advantage for it permits operation at lower costs.

The apparatus and process of this invention may be used with either finished or unfinished yarn. In the former instance the build-up of finish on the plates occurs very slowly and no

difficulties are encountered. When unfinished viscose rayon yarns, containing 80% water, were dried at 6,000 I. P. M., residual carbon disulfide flashed and burned with a blue flame in the first 24 to 36 inches of travel. However, no visible bad effects were noted and the physical properties, such as tensile strength and elongation were unaffected.

While the invention has been described in reference to viscose type regenerated cellulose yarns, it is understood that the apparatus and process of this invention are applicable to other yarns and the like, whether composed of synthetic or natural occurring materials. Thus, yarns and the like composed of cellulose derivatives, such as cellulose acetate, cellulose acetate-propionate, ethyl cellulose, etc., polyesters and polyamides, polyacrylonitrile, other polyvinyl compounds, proteins, etc. may be processed efficiently in the apparatus described herein.

As a further example, 450 denier "Acele" yarn was dried from approximately 100% moisture to essentially bone dryness at a dryer temperature of 186° C., the dryer travel being 49 inches and the yarn speed being 816 inches per minute. The dryer plates used in this particular experiment contained grooves which were $\frac{1}{8}$ of an inch wide and $\frac{1}{8}$ of an inch deep, the grooves being spaced on $\frac{1}{2}$ of an inch center to 1 inch centers. Since the apparatus and process of this invention are generally applicable, the examples which have been given are accordingly illustrative only and are not to be considered as limitative.

Any departure from the above description which conforms to the present invention is intended to be included within the scope of the claims.

We claim:

1. Yarn treating apparatus comprising members having arcuated surfaces bent on a radius between about 5 feet and about 32 feet; means for directing yarn over the said surfaces under a tension between about 0.01 and about 0.5 gram per denier; means for avoiding direct contact of said yarn with said surfaces; means for heating said surfaces.
2. Yarn treating apparatus comprising members having arcuated surfaces bent on a radius between about 5 feet and about 32 feet; means for directing yarn over the said surfaces under a tension between about 0.01 and about 0.5 gram per denier, said members being in an end-to-end arrangement; means for avoiding direct contact of said yarn with said surfaces; means for heating said surfaces.
3. Yarn treating apparatus comprising members having arcuated surfaces bent on a radius between about 5 feet and about 32 feet; means for directing yarn and the like over the said surfaces under a tension between about 0.01 and about 0.5 gram per denier, said members being in a tier arrangement; means for avoiding direct contact of said yarn with said surfaces; means for heating said surfaces.
4. Yarn treating apparatus comprising members having surfaces curved on a radius between

about 5 feet and about 32 feet; means for directing yarn over said surfaces, the said means including grooves arranged arcuately in the said surfaces; means for avoiding direct contact of said yarn with said surfaces; means for heating said surfaces.

5. A process for treating yarn which comprises passing the yarn over members having surfaces curved on a radius between about 5 feet and about 32 feet, the said surfaces being heated at temperatures between 115° C. and 450° C. and the said yarn being passed over the said surfaces in a manner whereby direct contact of said yarn with said surfaces is avoided and at a rate of speed sufficient to prevent scorching.

6. A process for treating regenerated cellulosic yarn which comprises heating members having surfaces curved on a radius between about 5 feet and about 32 feet at temperatures between 115° C. and 450° C.; passing the said yarn over the said surfaces under a tension of about 0.01 to about 0.5 gram per denier in a manner whereby direct contact of said yarn with said surfaces is avoided and at a speed of at least 800 inches per minute.

7. A process for treating yarn which comprises passing the yarn over members having surfaces curved on a radius between about 5 feet and about 32 feet, the said surfaces being heated at temperatures between 115° C. and 450° C.; avoiding direct contact of said yarn with said members; and rotating the said members at a speed substantially different than the speed of the said yarn.

8. A process for treating yarn which comprises passing yarn over members having surfaces containing grooves and curved on a radius between about 5 feet and about 12 feet, the said surfaces being heated at temperatures between 115° C. and 450° C. and the said yarn being passed arcuately through said grooves in a manner whereby direct contact of said yarn with said surfaces is avoided and at a rate of speed sufficient to prevent scorching.

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