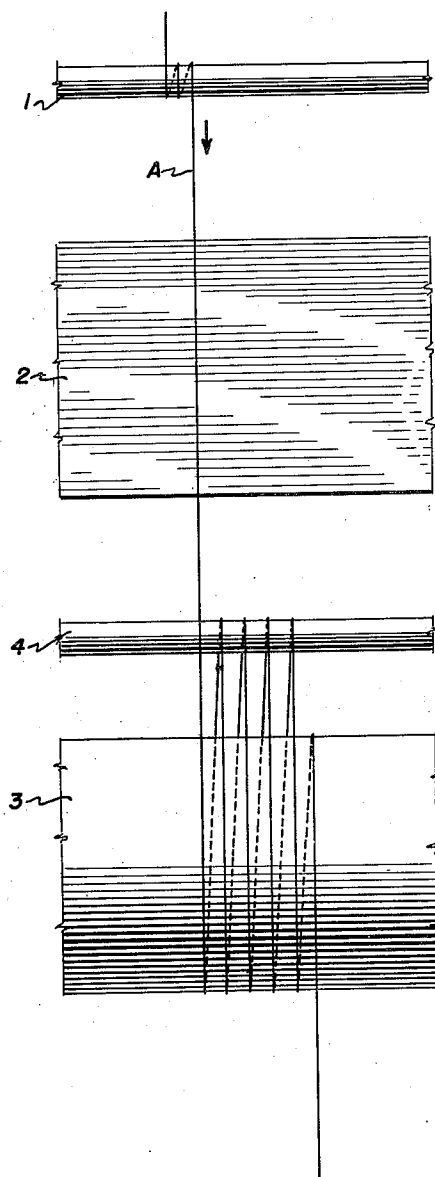


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METHOD AND APPARATUS FOR THE TWO-STAGE
DRAW OF SYNTHETIC FUNICULAR STRUCTURES
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METHOD AND APPARATUS FOR THE TWO-STAGE DRAW OF SYNTHETIC FUNICULAR STRUCTURES

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This invention relates to a new and improved method and apparatus for drawing funicular structures comprised of synthetic linear polymers.

Recently it has been determined that the physical and chemical characteristics of synthetic linear polyester yarns, such as yarns of polyethylene terephthalate disclosed in detail in Whinfield and Dickson U. S. P. 2,465,319, are greatly enhanced by thermal drawing of the yarn in two stages, cf., the application of Anderson Pace, Jr., Serial No. 763,088, filed July 23, 1947. The conventional means for drawing yarn between draw rolls when adapted to thermal drawing in two stages has obvious economic and mechanical disadvantages in that moving parts must be heated, and considerable space is required. Furthermore, when rolls are used to double-draw, an undesirable amount of quenching occurs between the first (primary) and second (secondary) draws. For example, in double-drawing between rolls, the yarn is drawn from a hot roll to a cold roll to effect the primary draw, and then, for the secondary draw, it is again drawn from a still hotter roll to another cold roll, the cold roll between the two hot rolls effecting an undesirable quenching, i. e., cooling, of the yarn. The reason for desiring a minimum degree of quenching lies in the fact that less work is needed to double-draw a yarn that is not quenched between the primary and the secondary stages. Moreover, with quenching kept at a minimum, a much greater part of the heat of drawing from the first stage is used to help raise the temperature of the yarn to that for the second stage of drawing. These factors coupled with the probability that an intermediate quench may well limit the degree of the second stage drawing show the desirability for limiting the degree of quenching.

An object of this invention, therefore, is to provide an improved method and means for the thermal drawing of yarns in two stages.

Another object is to provide compact means for the double-drawing of yarns, said means to comprise a minimum of moving parts.

Still another object is to provide apparatus for the thermal drawing of yarn in two stages, characterized by the advantage that quenching between the first and second draw is eliminated. These and other objects will more clearly appear hereinafter.

The figure illustrates schematically a specific arrangement of elements combined in accordance with the principles of this invention.

Referring to the drawing, the double-draw system of this invention, in a preferred specific em-

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bodiment comprises a heated, non-rotatable snubbing pin (Babcock U. S. P. 2,289,232) hereinafter called a hot pin 1, a hot plate 2, an unheated (i. e. cold) draw roll 3, and an unheated separator roll 4. The yarn A to be drawn, is fed at a uniform rate by means of a pinch or snubber feed roll (not shown) to the hot draw pin 1. One or more wraps are made about this hot pin depending on pin surface, pin diameter, temperature and yarn velocity. Primary draw occurs on this hot pin. The yarn then makes a single pass across the hot plate 2. This plate is maintained at a suitable temperature depending on the material being drawn. The exact temperature used in preferably considerably in excess of the temperature of the hot pin 1. At this point the secondary draw occurs. The yarn then passes to the unheated draw roll 3 the peripheral speed of which, is adjusted relative to the speed of delivery of the yarn from the pinch feed roll to provide the desired degree of stretch. Three or more wraps are made about this roll and the separator roll 4 to prevent slippage. The yarn is then taken up on a suitable wind-up device (not shown), such as a downtwister.

The pin and plate temperatures may be any two temperatures that are convenient and suitable to the character of the yarn being so drawn. However, since in most cases the secondary draw requires a higher temperature to permit the necessary internal rearrangement of the molecular structure of the filaments of the yarn the plate will normally be maintained at a temperature somewhat higher than that of the pin. Then again, this second drawing step, in the case of crystalline materials, is generally the step at which a major portion of the crystallization occurs. Therefore, it is desirable within the limits of the individual material, to hasten this crystallization step by using as high a temperature as possible, keeping in mind, of course, the physical properties of the material and the high degree of operability desired.

The total draw ratio (the ratio of the length of the yarn in its drawn state to the original length of the yarn) may obviously be varied over a considerable range by varying the respective speeds of the feed and draw rolls. In general, it will be found that of this total draw, 80-90% occurs at the draw pin and the remainder occurs at the draw plate.

The following examples are illustrative of the practice of this invention.

A 1200-denier, 70-filament polyethylene terephthalate yarn (birefringence 0.0008) is passed

over a snubber feed roll to a hot pin (100° C.). Two wraps are made about this pin, and then the yarn passes immediately over a 3" hot plate (180° C.) to the draw roll which has a peripheral speed (corresponding to the desired draw ratio) faster than the feed roll. Three or more wraps are made around the draw roll to prevent slippage and also to cool the yarn before reducing the tension on it, after which the yarn passes to an appropriate yarn take-up device. The table below shows the exact conditions at each step in the process for this apparatus as well as the properties of the resultant yarn:

TABLE I

Example.....	I	II
Yarn Temp. at Pin Draw Point (° C.).....	90	80
Draw Ratio at Pin.....	5.31:1	6.2:1
Yarn Temp. at Plate (° C.).....	180	180
Draw Ratio at Plate.....	1.1:1	1.1:1
Total Draw Ratio.....	5.89:1	6.85:1
Drawn Denier.....	204	173
Tenacity (grams per denier (g./d.)).....	6.3	7.3
Elongation.....percent	9.2	6.0

Example III

As an example of the use of the apparatus of this invention with a different yarn construction, a 460-denier, 34-filament polyethylene terephthalate yarn (birefringence 0.0019) is drawn at a pin temperature of 92° C. and a plate temperature of 180° C. The apparatus and method of string-up are as described in Examples I and II. The draw ratio at the pin is 5.46:1 followed by a draw ratio of 1.1:1 across the plate for a total draw ratio of 6.07:1. The yarn drawn by this process exhibits a tenacity of 8.4 grams per denier at 5.4% elongation.

Example IV

To illustrate the use of this invention for drawing other synthetic polymers, a 1080-denier, 34-filament polyhexamethylene adipamide yarn (birefringence 0.0023) is drawn with a pin temperature of 92° C. and a plate temperature of 180° C. by the process described in Examples I and II. The draw ratio observed at the pin is 5.46:1 followed by a ratio of 1.1:1 across the plate for a total draw ratio of 6.07:1. The yarn is found to have a tenacity of 9.1 grams per denier at 11.7% elongation.

While the apparatus of this invention has been specifically described herein as a hot pin-hot plate apparatus, it will be realized that for an individual polymeric material certain modifications can be made. In place of the hot plate, there are many obvious substitutions that come to mind such as the periphery of a tube, a plate flat or curved, use of radiant heat, a bath (high boiling liquid, molten salt or metal) and many others, which like the hot plate and in contrast with the hot pin, imposes no substantial resistance or snubbing action to the travel of the yarn.

The adaptability of the apparatus of this invention for the drawing of funicular structures composed of polymeric materials other than those disclosed by the aforementioned application of Pace is readily apparent. In general, all synthetic linear fiber-forming polymeric materials capable of exhibiting improved properties when subjected to a drawing process are operable using the apparatus described herein. As suitable examples of several such classes may be mentioned condensation polymers such as polyesters, poly-

amides and addition polymers such as the poly-vinyl compounds.

The apparatus of this invention is capable of securing an increased draw ratio accompanied by a very appreciable tenacity increase over that obtained by the conventional hot pin drawing procedure of the prior art. An example of these improved results is shown in the following table. A representative polymer, in this case polyethylene terephthalate, having an intrinsic viscosity of 0.7 is used. The single-stage drawing, i. e. the hot pin part of the tandem hot pin, hot plate process was carried out at 80° C.

TABLE II

Yarn (Birefringence 0.0008).....	B	C
Optimum Single-draw ratio.....	5.99:1	5.99:1
Optimum Double-draw ratio.....	6.85:1	6.85:1
Single-draw Dry Tenacity (g./d.), Hot Pin.....	6.1	5.8
Double-draw Dry Tenacity (g./d.), Tandem, Hot Pin, Hot Plate.....	7.2	7.4

A similar improvement is obtained when another type of yarn, polyhexamethylene adipamide (birefringence 0.0023) is drawn by the tandem process. The table below shows the compound results obtained. For comparative purpose, the values for a single-stage draw are included:

TABLE III

Optimum single-draw ratio.....	5.34:1
Optimum double-draw ratio.....	6.07:1
Single-draw dry tenacity (g./d.).....	7.2
Double-draw dry tenacity (g./d.).....	9.1
Tandem hot pin, hot plate	

The improvement to be realized by this invention as demonstrated by thread breaks per pound of yarn drawn is shown by a comparison of a hot pin single-stage draw and two-stage apparatus as described herein. The following table shows comparatively the improvement in operability in the case of polyethylene terephthalate yarn (birefringence 0.0019) as well as the improved yarn properties.

TABLE IV

Drawing Method	Draw Ratio	Denier	Thread Breaks per lb.	Tenacity, g./d.	Elongation, Per Cent
Hot Pin.....	5.56:1	71.7	7.8	6.50	8.1
Two Stage Hot Roll.....	5.85:1	69.0	8.0	6.90	7.2
Hot Pin, Hot Plate Tandem.....	5.56:1	72.6	1.6	7.02	11.4

This table as well as the previous one shows the improved physical properties, such as tenacity and elongation, obtained by using the apparatus of this invention as compared to the results obtained when the same material is drawn by the more conventional pin drawing process. The tenacity is improved normally from 5-15% with a corresponding increase in elongation. Since this improvement in physical properties is accompanied by a very appreciable increase in operability as shown by thread breaks per pound of yarn drawn, the advantage of the subject apparatus over the prior art is obvious.

Additionally, when using the apparatus of this invention to secure the preferred higher draw ratios, a further improvement is realized in lower boil-off shrinkage of the drawn yarn. This shrinkage for tandem versus hot pin drawn yarns is of the order of 6-7% as against 12-14%.

Other general advantages that may be mentioned for tandem drawn yarn are the fewer broken filaments observed and further, because of the lower draw forces, the pin surfaces and temperature need not be held under such close control as for hot pin drawing alone.

I claim:

1. Apparatus for drawing heat-stretchable yarns and like structures of synthetic filament-forming material in two stages comprising in combination a heated, non-rotatable snubbing pin in the path of the yarn to be stretched, additional stationary means to heat the yarn as it comes from said pin, and means to impose a stretching tension on yarn heated by said pin and by said additional means.

2. Apparatus for drawing heat-stretchable yarns and like structures of synthetic filament-forming material in two stages comprising in combination means for continuously advancing yarn, a heated, non-rotatable snubbing pin in the path of the yarn from said advancing means, a heated stationary surface positioned to contact and further heat the yarn as it comes from said pin, and means for imposing a stretching tension on the yarn in its travel about said pin and over said heated surface.

3. Apparatus for drawing heat-stretchable yarns and like structures of synthetic filament-forming material in two stages comprising in combination a heated, non-rotatable snubbing pin in the path of the yarn to be stretched, a heated plate positioned to contact and further heat the yarn as it comes from said pin, and a

stretching roll positioned to impose a stretching tension on the yarn in its travel around said pin and over said plate.

4. In the process of drawing heat-stretchable yarns and like structures of synthetic filament-forming material wherein the yarn is heated and stretched in two stages, the improved steps which comprise passing the yarn maintained at stretching tension around a heated, non-rotatable snubbing pin whereby the yarn is heated-softened and the major proportion of the total draw is effected, and thereafter passing the yarn directly from said pin in contact with a heated stationary surface while maintaining the yarn under stretching tension whereby the drawing thereof is completed.

5. The process of claim 4 wherein the yarn is polyethylene terephthalate and the heated stationary surface is maintained at a temperature higher than that of the heated snubbing pin.

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