July 7, 1942. D. F. BABCOCK 2,289,232

METHOD AND APPARATUS FOR PRODUCING FILAMENTARY STRUCTURES

Filed July 14, 1939 2 Sheets-Sheet 1

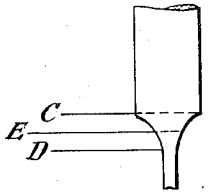

Fig. 1.

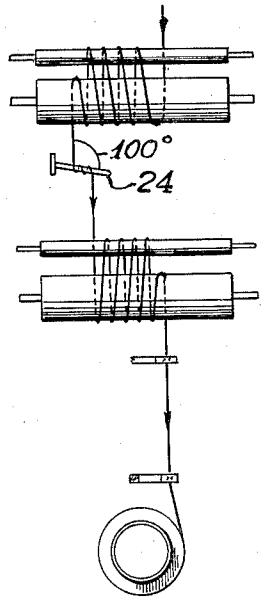

Fig. 3.

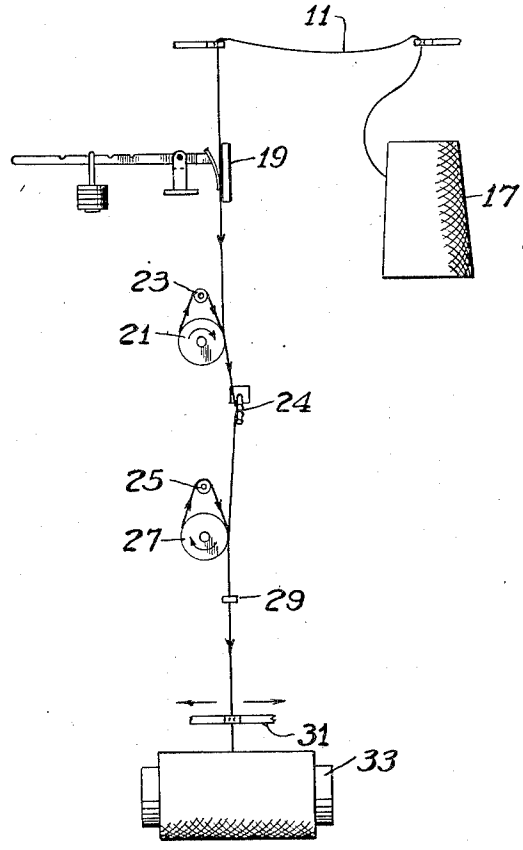

Fig. 2.

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METHOD AND APPARATUS FOR PRODUCING FILAMENTARY STRUCTURES

Filed July 14, 1939 2 Sheets-Sheet 2

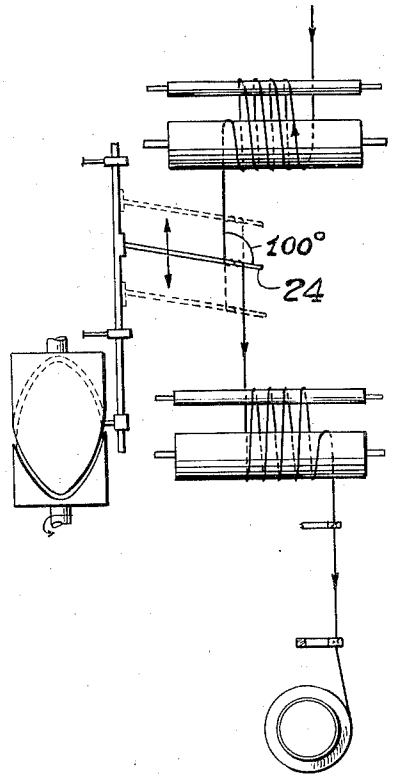

Fig. 5.

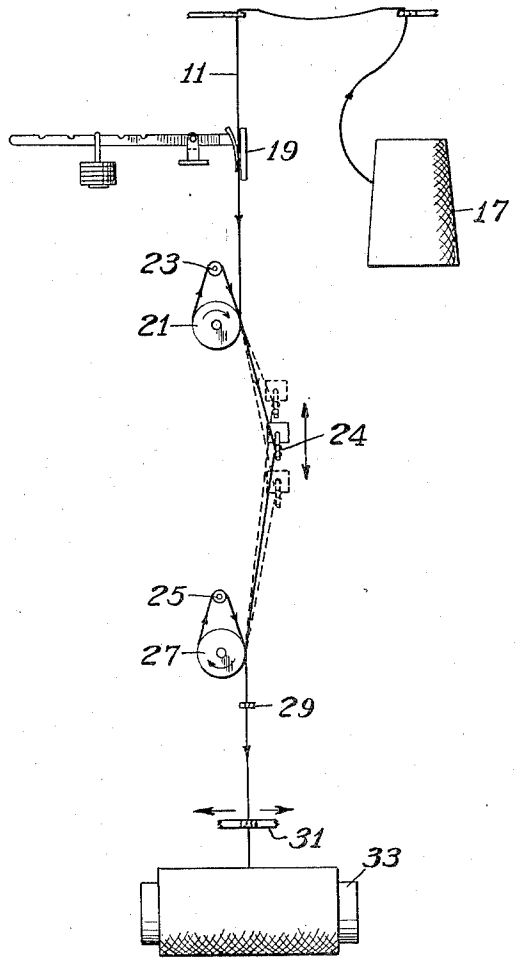

Fig. 4.

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2,289,232

UNITED STATES PATENT OFFICE

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METHOD AND APPARATUS FOR PRODUCING FILAMENTARY STRUCTURES

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Application July 14, 1939, Serial No. 284,569

13 Claims. (Cl. 18—8)

This invention relates to the art of forming artificial filaments, and is particularly concerned with improvements in the cold drawing of yarn, i. e., a bundle of filaments, composed of synthetic linear polymers.

Fiber-forming, synthetic linear polymers and methods and means for preparing the same are described in Wallace H. Carothers U. S. Patent No. 2,071,250, and the conversion of these polymers into fibers is disclosed in Wallace H. Carothers U. S. Patent No. 2,071,251. An important group of synthetic linear polymers, namely synthetic linear polyamides, is described in Wallace H. Carothers U. S. Patent Nos. 2,071,253 and 2,130,948. It is to be understood that the terms "linear polymer," "linear polyamide," and the like include not only linear polymers and linear polyamides produced by condensation polymerization, but also those produced by methods which do not involve condensation.

Inasmuch as this invention is most particularly concerned with improvements in the making of yarn from synthetic linear polyamides, the description of the invention will be largely directed to synthetic linear polyamides, although it will be understood that this will be illustrative of the preferred form of the invention and is not intended to exclude other fiber-forming polymers except as indicated.

Linear polymers can be formed directly into filaments from the molten state and the filaments so formed are capable of being cold drawn, i. e., permanently elongated, in the solid state, under the application of stress, into filaments and the like, exhibiting, upon X-ray examination crystallite orientation along the fiber axis. These cold drawn and oriented filaments possess certain characteristics not possessed by the filaments previous to the cold drawing, which adapt them to a wide range of utility in the textile field. The greatest utility is obtained when the filaments are so produced as to possess uniform physical characteristics, which, in turn, can be obtained only through uniform drawing of the filaments. Inasmuch as the cold drawing of linear polyamide filaments may effect an increase in length many times that of the undrawn filaments and a decrease in elongation to a small fraction of that possessed by the undrawn filaments (filaments of polyhexamethylene adipamide, a linear polyamide obtainable from the reaction of hexamethylene diamine and adipic acid, for example, being capable of being cold drawn approximately 400% with an accompanying reduction in elongation from about 400% to about 20%), it is most important that variations in physical characteristics along the length of the filaments which occur during cold drawing be maintained within very small limits.

While it is important that the denier, elongation and elasticity of the cold drawn filaments be maintained as uniform as possible along the length of the filaments, it is still more important that the affinity of the filaments for dyestuffs be maintained extremely uniform. Even when cold drawing is so regulated that variations in denier, elongation and elasticity can be tolerated, it may still happen that variation in the dye affinity of the filaments is highly objectionable. The affinity of synthetic linear polyamide filaments for dyestuffs decreases upon orientation, and the changes in dye affinity are much more noticeable in small ranges of variation than changes of the same magnitude in many other physical characteristics of the filaments. Differences in dye affinity of synthetic linear polyamide threads arising from non-uniform cold drawing in many cases constitute a difference not only in shade, but even in color, and are not to be confused with the small differences in appearance attributable to changes in denier such as are experienced with other textile yarns. Inasmuch as synthetic linear polyamide filaments are particularly adaptable to the manufacture of fine, high quality fabrics such as full-fashioned hosiery and pile fabrics, it is highly desirable that the filaments exhibit substantially no variation in dye affinity.

It has been discovered, in accordance with this invention, that variations in the physical characteristics of cold-drawn linear polyamide filaments are caused by cyclical movements or periodic shiftings of the draw point. The term "draw point," as it is used throughout the specification and claims, is intended to designate that point which is the center of the zone or section of yarn within which the drawing takes place, the "draw point" of the yarn, mathematically stated, being that point at which the first derivative of the denier, with respect to yarn length, is a maximum (the second derivative being equal to zero).

It is an object of this invention to produce uniformly cold-drawn yarns and filaments.

It is another object of this invention to obtain uniformly cold-drawn synthetic linear polymer yarns and filaments.

It is a more specific object of this invention to obtain uniformly cold-drawn synthetic linear polyamide yarns and filaments.

It is a still further object of this invention to obtain oriented synthetic linear polyamide

yarns having a uniform dye affinity along the length thereof.

It is another object of this invention to provide a suitable process and apparatus for continuously and uniformly cold drawing synthetic linear polyamide yarns whereby to obtain oriented yarns which have a suitable dye affinity along the length thereof.

Other objects of this invention will appear hereinafter.

The details of the invention will be more clearly apparent by reference to the following description when taken in connection with the accompanying illustrations, in which:

Figure 1 is a greatly enlarged diagrammatic elevational view showing the manner in which a filament cold draws upon the application of a suitable tension.

Figure 2 is a diagrammatic side elevational view showing an apparatus for the cold drawing of linear polymer yarns and filaments, improved in accordance with the present invention.

Figure 3 is a diagrammatic front elevational view of a section of the apparatus shown in Figure 2 of the drawings.

Figure 4 is a diagrammatic side elevational view of another modification of an improved apparatus for the cold drawing of synthetic linear polymer yarns and filaments.

Figure 5 is a diagrammatic front elevational view of a part of the apparatus shown in Figure 4 of the drawings.

The objects of the invention are accomplished, in general, by cold drawing a bundle of continuous filaments of synthetic linear polymer, e. g. synthetic linear polyamide, which filaments are capable of being permanently elongated to at least 150% of their original length, under such conditions that the draw point of the filaments is maintained within a zone of ½ inch along that portion of the thread which is in contact with the surface of the element or member upon which the drawing down or "necking" of the filament or yarn occurs.

By way of illustrating the mechanism of drawing, reference may be had to Figure 1 wherein it is seen that the actual drawing occurs within a very small portion of the filament or yarn being drawn.

Referring to Figure 1 of the drawings, when yarns or filaments of synthetic linear polymers are cold drawn, the yarn 15 is fed to a positively driven feed roll 15 at a certain speed and is withdrawn at a greater speed, the actual drawing or "necking" of the thread occurring within a very small portion of the thread. The transition of an undrawn filament to a drawn filament is illustrated on a greatly enlarged scale, in Figure 1, C and D representing the limits of the zone within which the drawing of the filament takes place, the center of this zone, designated as E, being termed the draw point. Although Figure 1 represents a greatly magnified view of the drawing of a single filament, it will be understood that a yarn composed of a number of filaments will exhibit the same behavior as a single filament.

Synthetic linear polyamide yarn has, in the past, been cold drawn by passing several wraps of the yarn about a slowly rotating roll and then passing several wraps of the yarn about a rapidly rotating roll, the differential peripheral speed of the rolls determining the amount of drawing. According to this method of operation, yarn is produced having periodic variations in orientation, accompanied by variations in degrees of dye affinity. As stated above, these variations are due to a periodic shifting of the draw point.

The disadvantages of prior methods of cold drawing linear polyamide filaments and yarn are overcome by following the principle of the present invention, and the following discussion will describe various ways of applying the principle of this invention.

Cold drawing by restricting the draw point to a fixed zone of limited extent

(a) Figures 2 and 5 illustrate the cold drawing of synthetic linear polyamide filaments and yarn by controlling the drawing to prevent the draw point from shifting beyond a narrow, fixed zone along the length of the filaments or yarn being drawn. It has been found by experience that if the draw point is maintained within a zone not in excess of ½ inch along the length of the thread, substantial elimination of variations in physical characteristics of the filaments and yarn will be effected.

Referring to Figures 2 and 5, the undrawn yarn 11 is passed from package 17 through a tensioning device 19, around a positively driven feed roller 21, a very slight tension being imparted by tensioning device 19 in order to permit an even wrap around roller 21. The yarn is then passed about separating roller 23 and back around feed roller 21 a number of times (the last yarn wrap being around roller 21 alone, as shown). Separating roller 23 serves to prevent successive windings of yarn from wrapping over each other. The yarn is then passed about a non-rotatable snubbing pin 24, and the yarn is then passed around positively driven drawing roller 27 which rotates at a greater peripheral speed than roller 21. The thread is passed several times around roller 27 and its adjoining separating roller 25 (the last wrap being around roller 27 alone, as shown). The yarn is then passed through guide 29 and traverse guide 31 on to bobbin 33. The yarn is passed about rollers 21 and 23, and also around rollers 25 and 27, a sufficient number of times to prevent undesirable slippage of the yarn on the rollers.

The snubbing pin 24 has a diameter up to ½ inch, and preferably has a diameter of from ⅛ inch to ¼ inch. The yarn is passed about this snubbing pin one or several turns so that the tension developed in the yarn by its passage around the pin will preferably be at least one half the tension required in the drawing operation. It is preferred that the snubbing pin be mounted with a slight downward tilt, as shown in Figure 3, so that successive turns of the yarn about the snubbing pin will remain separated.

By the use of the drawing apparatus of Figures 2 and 3, it is found that the draw point of the yarn is located on the surface of the snubbing pin and that comparatively little shifting of the draw point occurs. Any shifting of the draw point is maintained within an arc of ½ inch on the surface of the snubbing pin.

Cold drawing accompanied by slow displacement of the zone in which drawing occurs

Although it is preferred that the draw point be localized within a fixed zone, it has been found that sustained, or comparatively long movements of this zone can be tolerated in yarn intended for use in high grade fabric such as hosiery if the speed of movement of the zone does not exceed 2% of the linear velocity of the undrawn yarn. It is understood however that in this form of the

invention the movement of the draw point is confined to a zone of ½ inch, e. g., on the surface of the snubbing pin **24**.

By the term "sustained shift" is meant a shifting of the zone in the same direction for a length of time during which a substantial amount of yarn is drawn, e. g., 3 inches to 6 inches of drawn yarn. Motion of the zone may be accomplished by moving the snubbing pin (of Figures 2 and 3) or other form of tension device, according to any type of motion, e. g., rectilinear, circular, elliptical or reciprocal motion. If the speed of movement of the snubbing pin or other tension device does not exceed 2% of the linear speed of the undrawn yarn, and the movement of the draw point on the surface of the drawing member is limited to a ½ inch zone, the irregularities in dye affinity, denier and other physical characteristics are minor and are not objectionable.

That form of the invention which involves slow movement of the tension device on which drawing occurs is illustrated in Figures 4 and 5, which show an apparatus similar to that shown in Figures 2 and 3 (like numerals designating similar parts) with the exception that the snubbing pin **24** is slowly shifted or reciprocated according to the manner indicated by the dotted lines shown in those figures. Any desired mechanism can be used for effecting the shifting of pin **24**, it being only necessary that the rate at which the snubbing pin is shifted does not exceed 2% of the linear velocity of the yarn prior to being drawn. This form of the invention has the advantage that the snubbing pin **24** can be shifted in such a way as to prevent wear on any particular portion of the pin as would occur in the form of device shown in Figures 2 and 3 wherein a stationary snubbing pin is used.

In the form of device shown in Figures 4 and 5, it is preferred that the diameter of the snubbing pin have the dimensions specified in the form shown in Figures 2 and 3.

The following example illustrates a specific method for cold-drawing synthetic linear polymer yarns whereby to obtain yarns which have been cold-drawn with such uniformity as to exhibit improved uniformity of physical characteristics, and particularly to exhibit substantially uniform dyeing affinity along the length of the yarn.

Example

A 150-denier, 15-filament, 4-turn Z twist, unoriented polyhexamethylene adipamide yarn is cold drawn on apparatus of the type illustrated in Figures 4 and 5 of the drawings.

The pin **24**, preferably made of agate, is $\frac{3}{16}$ inch in diameter and 1½ inches long, and is rigidly fixed between rolls **21** and **27**. The pin **24** is mounted as shown, so as to divert the yarn away from a line tangential both to rolls **21** and **27**, with the outer end of the pin inclined downwardly from the horizontal so that the yarn coming from the feed roll **21** will make an angle with the axis of the pin of approximately 100°. The yarn passing from the feed roll **21** is wrapped about the snubbing pin two turns and is then passed to the draw roll **27** and thence to the wind-up mechanism as previously described. Feed roll **21**, of the same diameter as draw roll **27**, is positively driven at a speed of 12.5 R. P. M. and draw roll **27** is positively driven at a speed of 50 R. P. M.

The denier of consecutive 9 cm. lengths of the yarn so drawn is determined and it is found that the denier of these consecutive sections does not deviate from the average by more than ½ denier. This drawn yarn is knit into a fabric and dyed as previously described. In this case the fabric is of very uniform appearance.

While the invention has been described specifically in terms of a snubbing pin, it is obvious that use may be made of any means which localizes the draw point within the desired limits. Various known tension devices placed in relation to the other parts of the drawing set-up as described in the invention may be substituted for the snubbing pin; for example, instead of pins, sheets or plates shaped to present a suitable curved surface convex to the yarn being drawn may be used with advantage. The interposed tension device will preferably impart to the yarn or filament a tension of at least 50% of the total tension required to cold draw the said yarn or filament in order to localize the draw point at the tension device. As indicated above, the preferred species of snubbing pin is an agate pin $\frac{3}{16}$ inch in diameter and having a moderately smooth surface. However, smooth pins of other materials having a diameter up to ½ inch will also prove satisfactory, e. g., stainless steel, chromium plated steel, Isolantite, alsimag, illium, porcelain, Bakelite, methyl methacrylate resin, etc. If the diameter greatly exceeds ½ inch, the length over which tension is applied becomes increasingly greater. Similarly, the snubbing pin may be rotated in a direction opposite to the direction of travel of the yarn since it is the snubbing, sliding action which is desired. In general, agate pins are preferred since surfaces having the desired degree of smoothness can be obtained more readily and the yarn is not as likely to become damaged. For example, when snubbing pins of Isolantite or illium are used, the yarn tends to break much more frequently during the operation. The resistance of agate pins to abrasion by the passage of the yarn is very remarkable. Using them, yarn has been drawn at a rate of 50 feet per minute for periods up to several months without showing any apparent wear of the pin as observed by a low power microscope. Likewise, the use of snubbing pins and other tension devices showed that there was no greater tendency to form broken filaments than without them.

Instead of using feed and draw rollers, e. g., rollers **21** and **27**, of the same diameter operated at different rotational speeds to effect drawing of the yarn, these rollers may be of different diameters so long as the peripheral speeds of the rollers are sufficiently different to give the proper drawing ratio. In this latter form of drawing device, the feed and drawing rollers may be keyed to the same shaft, in axial alignment, and rotate at the same rotational speed, the drawing ratio being controlled by the relative diameters of the rollers. Where the rollers are on the same shaft, the separating rollers, e. g., rollers **23** and **25**, can be disposed above the rollers with which they cooperate, the yarn being led from feed roller about a pin according to this invention, to roller **27**.

The invention is not limited to the use of feed and/or draw rolls of the type shown in the figures since their sole function is to feed the undrawn or partially drawn yarn and to draw away the drawn yarn at a uniform rate. The use of any conventional mechanism for accomplishing these functions when used in accordance with this invention falls within its scope.

Although the invention has been described

particularly in terms of continuous filament yarn, it is also applicable to the drawing of staple length filaments and yarn containing the same where great uniformity in the extent of drawing is desired. Furthermore, although the invention has been described in terms of the orientation of yarn composed of synthetic linear polymers, and particularly synthetic linear polyamides, it is particularly applicable to the cold drawing of yarn composed of any material which is capable of being permanently elongated to at least 150% of its original length. For convenience the invention has been described in terms of the drawing of undrawn yarn, but it is understood that it is equally applicable to the drawing of partially drawn yarn, it being only necessary that the yarn be capable of being drawn at least 150%. It may in many instances be desirable to effect the drawing in two or more stages. Similarly, while the invention has been described particularly for the purpose of obtaining dye uniformity, it is obvious that it is of great value for obtaining improvements in the uniformity of properties other than dye affinity.

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

I claim:

1. A process for cold-drawing yarn capable of being permanently elongated at least 150% which comprises feeding the yarn at a uniform rate, snubbing the yarn around a pin not greater than ½ inch in diameter and thereby, localizing, in the yarn in contact with said pin, at least 50% of the tension required to draw said yarn and drawing said yarn away at a predetermined rate sufficiently in excess of the rate of feeding to accomplish the desired drawing.

2. The process which comprises cold-drawing a cold-drawable yarn, which is subject to necking in a draw-point and shifting of the draw-point as a result of a cold-drawing tension applied thereto, by subjecting the yarn to a cold-drawing tension between two spaced tensioning members, and fixing the said draw-point to a given zone between said spaced tensioning members by passing the yarn over a convex snubbing surface which has sufficient snubbing contact with the yarn to localize, in the yarn in contact with said surface, at least 50% of the tension required to draw said yarn.

3. The process which comprises cold-drawing a cold-drawable yarn, which is subject to necking in a draw-point and shifting of the draw-point as a result of a cold-drawing tension applied thereto, by subjecting the yarn to a cold-drawing tension between two spaced tensioning members, and fixing the said draw-point to a zone not in excess of ½ inch between said spaced points by passing the yarn over a convex snubbing surface which has sufficient snubbing contact with the yarn to localize, in the yarn in contact with said surface, at least 50% of the tension required to draw said yarn, said convex snubbing surface having a sufficiently small radius of curvature to maintain said draw-point within a zone of ½ inch on said surface.

4. The process which comprises cold-drawing a cold-drawable synthetic linear polymer yarn, which is subject to necking in a draw-point and shifting of the draw-point as a result of a cold-drawing tension applied thereto, by subjecting the yarn to a cold-drawing tension between two spaced tensioning members, and fixing the said draw-point to a zone not in excess of ½ inch between said spaced points by passing the yarn over a convex snubbing surface which has sufficient snubbing contact with the yarn to localize, in the yarn in contact with said surface, at least 50% of the tension required to draw said yarn, said convex snubbing surface having a sufficiently small radius of curvature to maintain said draw-point within a zone of ½ inch on said surface.

5. The process which comprises cold-drawing a cold-drawable synthetic linear polyamide yarn, which is subject to necking in a draw-point and shifting of the draw-point as a result of a cold-drawing tension applied thereto, by subjecting the yarn to a cold-drawing tension between two spaced tensioning members, and fixing the said draw-point to a zone not in excess of ½ inch between said spaced points by passing the yarn over a convex snubbing surface which has sufficient snubbing contact with the yarn to localize, in the yarn in contact with said surface, at least 50% of the tension required to draw said yarn, said convex snubbing surface having a sufficiently small radius of curvature to maintain said draw-point within a zone of ½ inch on said surface.

6. The process which comprises cold-drawing a cold-drawable yarn, which is subject to necking in a draw-point and shifting of the draw-point as a result of a cold-drawing tension applied thereto, by subjecting the yarn to a cold-drawing tension between two spaced tensioning members, contacting the yarn, between said members, with a snubbing pin having sufficient snubbing contact with the yarn to localize, in the yarn in contact with said pin, at least 50% of the tension required to draw said yarn, said pin having a sufficiently small diameter to maintain said draw-point within a zone of ½ inch on the surface of said pin.

7. The process which comprises cold-drawing a cold-drawable synthetic linear polymer yarn, which is subject to necking in a draw-point and shifting of the draw-point as a result of a cold-drawing tension applied thereto by subjecting the yarn to a cold-drawing tension between two spaced tensioning members, contacting the yarn, between said members, with a snubbing pin having sufficient snubbing contact with the yarn to localize, in the yarn in contact with said pin, at least 50% of the tension required to draw said yarn, said pin having a sufficiently small diameter to maintain said draw-point within a zone of ½ inch on the surface of said pin.

8. The process which comprises cold-drawing a cold-drawable synthetic linear polyamide yarn, which is subject to necking in a draw-point and shifting of the draw-point as a result of a cold-drawing tension applied thereto, by subjecting the yarn to a cold-drawing tension between two spaced tensioning members, contacting the yarn, between said members, with a snubbing pin having sufficient snubbing contact with the yarn to localize, in the yarn in contact with said pin, at least 50% of the tension required to draw said yarn, said pin having a sufficiently small diameter to maintain said draw-point within a zone of ½ inch on the surface of said pin.

9. The process which comprises cold-drawing a cold-drawable synthetic linear polyamide yarn, which is subject to necking in a draw-point and shifting of the draw-point as a result of a cold-drawing tension applied thereto, by subjecting the yarn to a cold-drawing tension between two

spaced tensioning members, and maintaining any shifting of the draw-point to a rate of speed not in excess of 2% of the linear speed of the undrawn yarn by passing the yarn over a convex snubbing surface which has sufficient snubbing contact with the yarn to localize, in the yarn in contact with said surface, at least 50% of the tension required to draw said yarn, and moving said surface, between said tensioning members, at a speed not to exceed 2% of the linear speed of the undrawn yarn.

10. The process which comprises cold-drawing a cold-drawable synthetic linear polyamide yarn, which is subject to necking in a draw-point and shifting of the draw-point as a result of a cold-drawing tension applied thereto, by subjecting the yarn to a cold-drawing tension between two spaced tensioning members, contacting the yarn, between said members, with a convex snubbing surface having a sufficient snubbing contact with the yarn to localize, in the yarn in contact with said surface, at least 50% of the tension required to draw said yarn, said convex snubbing surface having a sufficiently small radius of curvature to maintain said draw-point within a zone of ½ inch on said surface, and moving said surface, between said tensioning members, at a speed not to exceed 2% of the linear speed of the undrawn yarn.

11. Apparatus for cold-drawing yarn which comprises a pair of cooperating yarn tensioning rolls, and a snubbing pin between said rolls, said snubbing pin positioned obliquely to the path of the yarn between the tensioning rolls, whereby to prevent contact between successive turns of yarn about said pin.

12. Apparatus for cold-drawing yarn which comprises a pair of cooperating yarn tensioning rolls, and a snubbing pin between said rolls, and means for moving said pin to different positions between said rolls.

13. Apparatus for cold-drawing yarn which comprises a pair of cooperating yarn tensioning rolls, and a snubbing pin between said rolls, and means for continuously moving said pin to different positions between said rolls.

DALE FRIEND BABCOCK.

CERTIFICATE OF CORRECTION.

Patent No. 2,289,232. July 7, 1942.

DALE FRIEND BABCOCK.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 2, first column, lines 52 and 53, strike out the reference numeral "15"; second column, lines 11 and 22, for "Figures 2 and 5" read --Figures 2 and 3--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 18th day of August, A. D. 1942.

(Seal)

Henry Van Arsdale,
Acting Commissioner of Patents.