Jan. 15, 1963 R. L. KROLL 3,073,001

APPARATUS FOR COLD-DRAWING YARN

Filed Oct. 21, 1958

FIG. 1

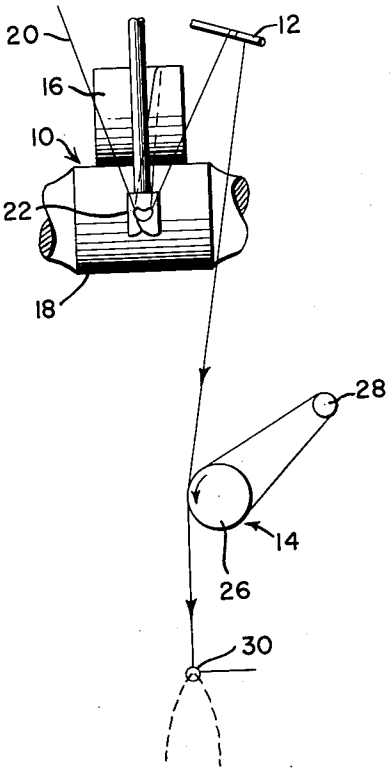


FIG. 3

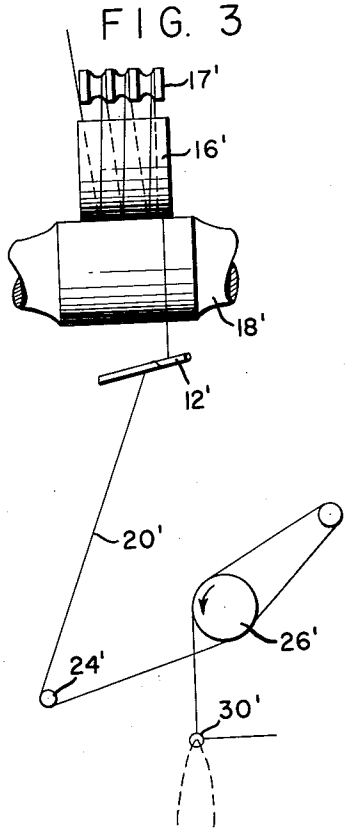
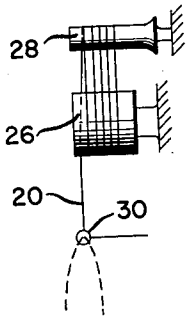


FIG. 2



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APPARATUS FOR COLD-DRAWING YARN

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This invention relates generally to the art of forming artificial filaments and, more particularly, to the cold-drawing of yarn consisting of one or more filaments, each composed of synthetic linear polymers.

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 at any temperature below the melting point, 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 of uniformity not possessed by undrawn filaments. Such physical characteristics generally can be obtained only through uniform drawing of the filaments. Inasmuch as the cold-drawing of synthetic linear 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 on the order of several hundred percent with an accompanying reduction in elongation to about 20%), it is important that variations in physical characteristics along the length of the filaments which occur during cold-drawing be maintained within small limits. A great improvement in the uniformity of drawn yarns followed the introduction of devices to localize the drawpoint, such as the draw pin disclosed in U.S. Patent No. 2,289,232.

Even the use of the draw pin does not prevent the occasional occurrence of a non-homogeneous section along the filament. These non-homogeneous sections of filament may have a length of about one-half to about twenty times the filament diameter. The non-homogeneity may be a nub having a diameter considerably larger than the average diameter of the yarn, a higher spinning birefringence, or an impurity. These non-homogeneities not only detract from the appearance of fabric made from the filaments, but also are the cause of broken filaments, draw roll wraps, and other instances of poor process operability which, in turn, result in loss of product and production time.

The most important object of this invention is the provision of a process and apparatus for producing uniformly cold-drawn synthetic linear polymer yarns and filaments.

Another important object of the invention is the provision of uniformly cold-drawn synthetic linear polyamide yarns and filaments.

A further object of the present invention is to provide a process and apparatus for continuously and uniformly cold-drawing synthetic linear polymer yarns and filaments with improved process operability.

With these and other objects in view, the apparatus of the present invention includes structure for carrying out the feeding, snubbing, and drawing steps of a cold-drawing process, which apparatus has been modified either by the addition of yarn diverting means, by the relocation of the draw pin, or by a combination of these features. Such modifications and the advantages inherent therein will be described herein, with reference to the accompanying drawing, wherein:

FIGURE 1 is a schematic representation of a preferred embodiment of the drawing apparatus of the present invention;

FIG. 2 is a detailed view of the draw rolls shown in FIG. 1; and

FIG. 3 is a schematic representation of an alternate form of apparatus useful in the practice of the invention.

The expression "process operability" refers to the frequency with which the thread line breaks down and, in the drawing of multi-filament yarns, to the number of broken filaments which form so-called draw roll wraps and result in bobbin rejects.

According to the teaching of the present invention, when the distance from the draw pin to the point of tangency between the filament and the draw roll, i.e., the draw zone, is materially increased, a more uniform yarn is obtained and substantially better process operability is achieved. This distance, which is about 4½ inches in conventional cold-drawing processes, is increased to a distance ranging from 8 to 40 inches, and preferable from 12 to 35 inches.

Referring now to FIG. 1, a cold-drawing apparatus has been illustrated which includes a feed section **10**, a draw pin **12**, a draw section **14**, and a balloon guide **30** through which the yarn passes to a windup bobbin.

The feed section **10** includes a rubber-covered pinch roll **16** and a feed roll **18**. Yarn **20** from a creel (not shown) passes through one throat of a double throat guide **22**, over pinch roll **16**, onto feed roll **18**, and is diverted upwardly by its passage through the second throat of guide **22** to the draw pin **12**. The yarn **20** is passed about the draw pin several turns, so as to localize the draw point at the pin. The pin **12** is mounted at an angle, as shown, so that successive turns thereabout will remain separated.

The draw section **14** includes a draw roll **26** and a separator roll **28**, over which the yarn is trained before passing to the guide **30**. In FIG. 2, it is seen that yarn **20** makes several passes over the rolls **26** and **28**, the peripheral speed of which may be anywhere from 1½ to 10 times that of the feed roll, depending on the draw ratio that is desired.

In operation, the yarn **20** is fed at a uniform rate by the feed roll **18** to the draw pin **12**, via the second throat of guide **22** which functions to divert the yarn away from the roll **18** so that the draw pin **12** may be located at a substantially greater distance from the draw roll **26**, resulting in a draw zone within the desired range.

In FIG. 3, an alternate embodiment of the apparatus is illustrated in which the yarn **20'** from a creel makes several wraps about roll **16'** and a multiple grooved guide **17'** before passing over feed roll **18'** to a conventionally located draw pin **12'**. The multiple grooved guide **17'** facilitates more than one wrap around the pinch roll **16'**; such multiple pinching is preferred where heavy denier yarn is being handled. A roller guide **24'** is positioned on the apparatus beneath the roll **18'** and away from the normal path of travel of the yarn between draw pin **12'** and draw roll **26'**. In this manner, substantially the same results are achieved, i.e., the draw zone is extended to a length that is within the desired range of the present invention.

The efficiency of these arrangements is independent of the distance between the feed section and the draw pin, so long as a sufficient number of turns is taken about the draw pin and no appreciable tension exists in the yarn upstream therefrom, as compared to the section between the draw pin and the draw roll.

In actual operation, under various operating conditions, several examples of the improvements to be expected from the application of this invention have been recorded.

Example I

15 denier monofilament yarn of polyhexamethylene adipamide (66 nylon) was drawn at 500 yards per minute as the surface speed of the draw roll. At the standard 4½ inch distance between pin and draw roll there was approximately one nub for every 1300 yards. When the draw pin was moved very close to the draw roll (½ inch distance), the average spacing between nubs became about 25 yards, but if the distance between pin and roll was increased to 9 inches, no nubs were encountered in 75,000 yards.

Example II

When drawing filaments of polyhexamethylene adipamide (66 nylon) to a draw ratio of 3.1 at 400 yards per minute to yield a 40 denier, 13 filament yarn on a conventional draw-twisting machine, a more uniform yarn was obtained with a thread line whose draw pin to draw roll distance was 15 inches than with the standard 4½ inches. In the former case only 3% of the positions showed draw roll wraps as compared to 7% in the latter case.

Example III

The installation of raised draw pins so as to give a 15-inch draw zone (instead of 4½ inches) allowed increasing the spinning speed (and hence machine productivity) for 15 denier monofilament yarn by 25% while maintaining the same quality standards as were kept at the slower speed.

Example IV

High tenacity yarn consisting of 140 filaments of 66 nylon was drawn at a draw ratio of 4.8 to a drawn denier of 840 at 269 yards per minute, using a 24-inch draw zone. Compared to drawing the same yarn with a standard 4½ inches draw zone, the number of draw roll wraps was decreased from 73% to 17%, the number of draw twister breaks from 7 per 1000 pounds to 6 per 1000 pounds, and the number of bobbins rejected for broken filaments was decreased from 5.7 to 3.4%.

Example V

In the drawing of 15 denier monofilament nylon yarn spun at 450 yards per minute and then drawn at a draw ratio of 4.5 nub frequencies were reduced from a range of 60 to 80 nubs per 1000 yards to a range of 1.8 to 3.5 nubs per 1000 yards when changing the length of the draw zone from the standard 4½ inches to various distances between 15 and 30. Optimum results were obtained with the draw pin 21 inches from the point of tangency to the draw roll which resulted in 1.8 nubs per 1000 yards.

Example VI

In an extended test using 1872 draw twister positions operating at a drawing speed of 269 yards per minute in which a 24-inch draw zone was employed between draw pin and draw roll as compared to the conventional 4½ inches, the quality of 840 denier 140 filament industrial high tenacity nylon yarn was improved while a 50% reduction in draw roll wraps, 40% reduction in broken filament inspection rejects, and a 30% reduction in quality stops per beam were achieved.

A theoretical explanation of the striking improvements in yarn uniformity and process operability achieved by extending the draw zone is as follows: if a filament section of length y contains a non-homogeneous draw-resistant section of length r and a draw ratio x is applied to this section, the total length of the section of filament after drawing will be $z=yx$. Since the non-homogeneous segment is resistant to drawing (draw ratio $=1$), the average draw ratio x is obtained by drawing the homogeneous section to a ratio of x_r greater than x. The difference between x_r and x should be kept to a minimum. Increases in this difference (x_r-x) will increase the probability of a filament breakdown. The term (x_r-x) has a high value when the draw zone is short and the non-homogeneous segment r occupies a relatively large fraction of this zone. By extending the draw zone, the fraction of this zone occupied by the non-homogeneous segment is relatively small and the term (x_r-x) has a low value. However, when the draw zone is extended beyond about 40 inches the yarn and cord properties are poor, probably due to the fact that in the part of the draw zone beyond about 40 inches the filaments have cooled to a point that the drawing tension causes damage to the internal structure of the yarn.

Inasmuch as this invention is principally concerned with improvements in the making of yarn from synthetic linear polyamides, the description of the invention has largely been directed to polyhexamethylene adipamide, although it will be understood that the invention is equally applicable to other fiber-forming polyamides and other fiber-forming polymers such as synthetic linear polyesters.

I claim:

1. Apparatus for cold-drawing yarn, said apparatus comprising: a source of yarn, a feed roll receiving yarn from the source, a draw roll for receiving yarn from the feed roll, a fixed draw pin for snubbing the yarn as it passes from the feed roll to the draw roll, the length of the yarn path of travel between the draw pin and the draw roll defining a draw zone, and fixed guide means for diverting the path of travel of the yarn intermediate the rolls whereby to permit an extension of the draw zone, said zone being from 12–35 inches in length.

2. An apparatus as set forth in claim 1 wherein said diverting means is situated in the yarn path of travel between the feed roll and the draw pin to alter the direction of movement of the yarn away from the draw roll and wherein the shortest distance from the feed roll to the draw roll is less than the distance from the draw pin to the draw roll.

3. An apparatus as set forth in claim 1 wherein said diverting means is a frictionless guide positioned downstream from the pin and away from a line tangential to the pin and draw roll.

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