

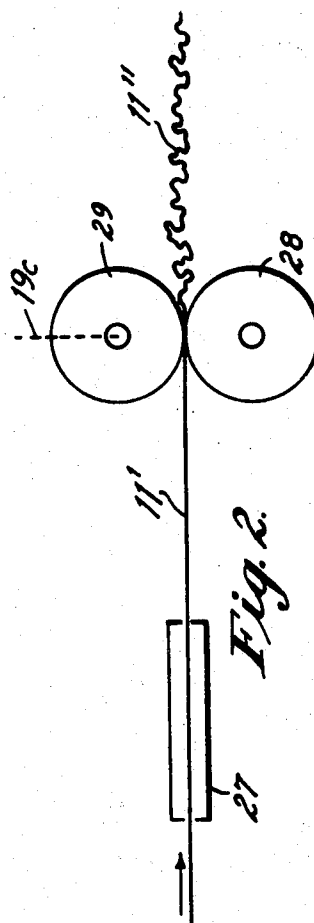
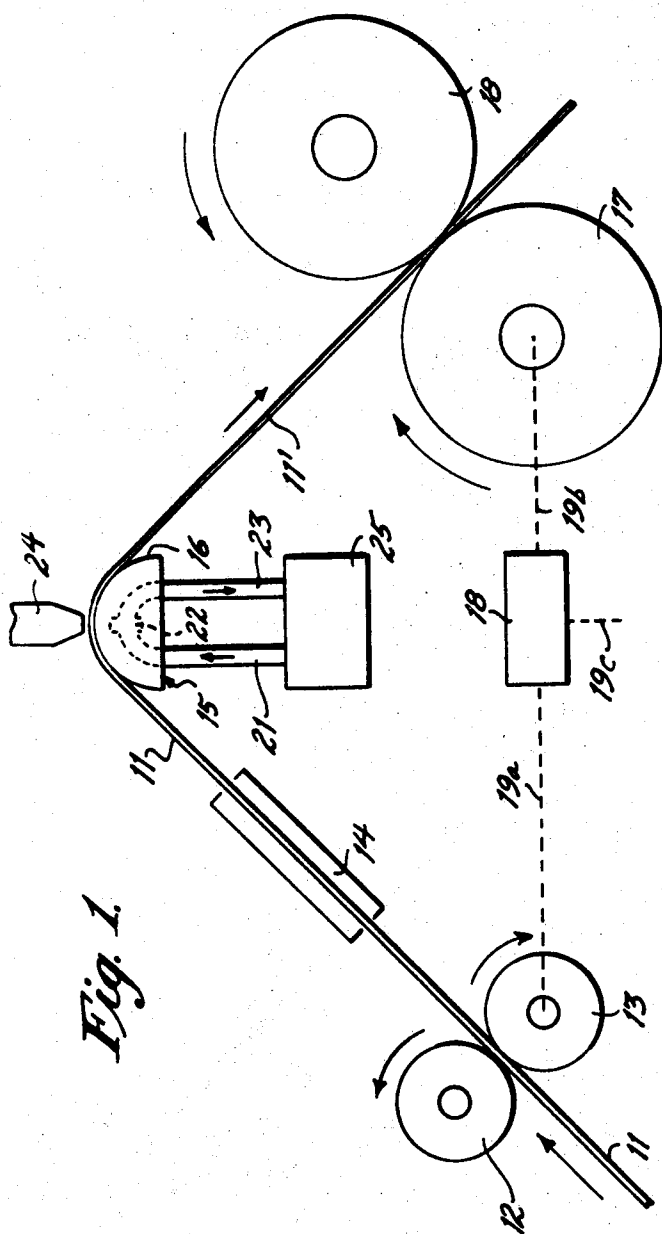
March 19, 1968

R. K. STANLEY
STRAND TREATMENT PROCESS

3,374,302

Filed Dec. 6, 1965

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

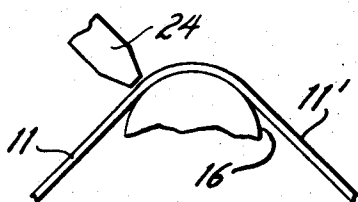


Fig. 3.

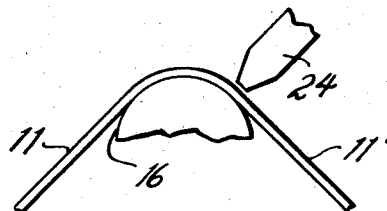


Fig. 4.

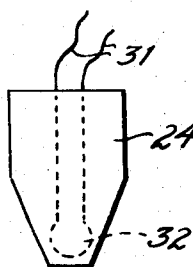


Fig. 5.

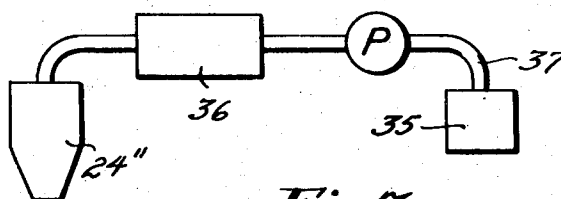


Fig. 7.

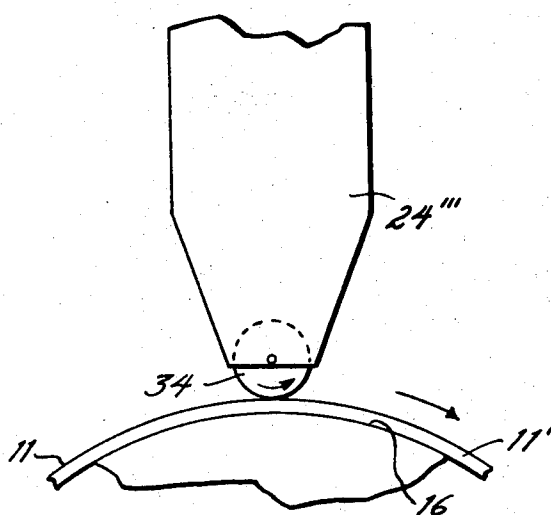


Fig. 8.

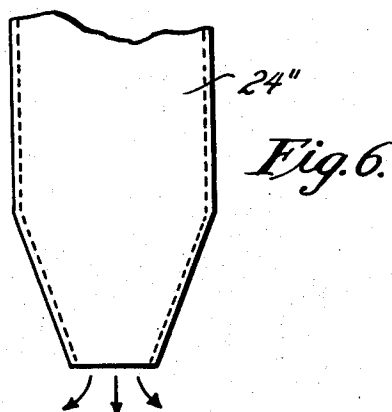


Fig. 6.

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3,374,302

STRAND TREATMENT PROCESS

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Continuation-in-part of application Ser. No. 476,933, Aug. 3, 1965. This application Dec. 6, 1965, Ser. No. 511,929

4 Claims. (Cl. 264—168)

ABSTRACT OF THE DISCLOSURE

A process of drawing and crimping textile strands is disclosed wherein the strand is pulled slidably over a snubbing surface, with cooling of the side of the strand in contact with the snubbing surface and simultaneous heating of the opposite side of the strand. The strand is withdrawn from the snubbing location and is subsequently relaxed, whereupon it obtains a bulky or crimped configuration. Optional features of the process include preheating the strand uniformly before reaching the snubbing location and withdrawing the strand from the snubbing location under reduced tension and heating it substantially uniformly. A form of the product is characterized by concavity on the side of the strand previously cooled in contact with the snubbing surface and by convexity on the opposite side previously heated.

This application is a continuation-in-part of my co-pending application Ser. No. 476,933, filed Aug. 3, 1965, for Strand Treatment.

This invention relates to drawing of molecularly orientable textile strands to increased length and thereby orienting them, and concerns also the crimping of such textile strands. Such a strand is pulled slidably over a snubbing surface, and the side in contact with the snubbing surface is cooled, while the opposite side is heated, whereupon the strand acquires an extended length and a bulky or crimped configuration.

Many textile strands, especially those composed of synthetic organic polymers of linear structure, are molecularly orientable by a procedure of extending the strand beyond its elastic limit or "drawing" it, whereupon the strand does not break but attains a stable extended length by virtue of longitudinal alignment and possibly slippage of the component polymeric molecules. Such procedure usually involves pulling the strand about a solid snubbing surface, most often cylindrical, and frequently involves heating the strand or the snubbing surface or both.

A primary object of the present invention is improvement in strand-drawing.

Another object is provision of crimped strands by way of a novel drawing technique.

A further object is provision of a draw-crimping process and apparatus for practicing it.

Other objects of this invention, together with means and methods for attaining the various objects, will be apparent from the following description and the accompanying diagrams.

FIG. 1 is a representation, partly in elevation and partly in schematic form, of apparatus according to the present invention;

FIG. 2 is a similar view on a reduced scale, of further apparatus according to this invention and of crimped strand produced thereby;

FIG. 3 is a representation, partly in elevation and partly in schematic form, of a portion of the apparatus of FIG. 1 with one of the component heaters displaced from its former position;

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FIG. 4 is a similar view with the same heater otherwise displaced from its former position;

FIG. 5 is a further view of the same heater partly in side elevation and partly in schematic form;

FIG. 6 is a similar view of the same heater modified somewhat;

FIG. 7 is a view, partly in side elevation and partly in schematic form, of a fluid supply system with the heater of FIG. 6; and

FIG. 8 is a view, partly in elevation and partly in schematic form, of another modification of such heater.

In general, the objects of the present invention are accomplished by pulling a molecularly orientable textile strand over a snubbing surface to draw it to increased length and thereby orient it, and simultaneously cooling the strand while in contact therewith and heating the opposite side of the strand. Upon subsequent relaxation from tension, with or without the aid of heat, the strand assumes a crimped configuration.

FIG. 1 shows strand 11, of molecularly orientable type, being fed by pair of feed rolls 12, 13 toward the upper right, past heater 14 and to snubbing member 15, which has semicylindrical snubbing surface 16. The strand is pulled over the snubbing surface by pair of draw rolls 17, 18 and past heater 24 juxtaposed to the opposite side of the strand and is thereby extended (after which it is denoted as 11'). Block 19 denotes drive means for the rolls by means of suitable drive linkages (indicated in broken lines): 19a to feed roll 13, 19b to draw roll 17, and 19c to a roll discussed hereinafter. The drive means comprises either an engine or an electric motor (not shown) together with suitable gearing (also not shown) so that the respective pairs of rolls can be driven at any desired angular speeds and any desired speed ratio. The second roll in each pair may be undriven except by contact with the driven roll and the strand passing through the roll nip, or both rolls in any pair may be driven alike (but in opposite directions). The draw rolls are driven at a greater surface speed than the feed rolls, preferably several times as great, the actual speed ratio depending upon the drawability of the strand composition and the desired degree of draw to be accomplished.

Snubbing member 15 is provided with conduits 21 and 23, shown with arrows leading respectively to and from the snubbing member, which is hollow (as indicated in broken lines) to interconnect them, and respectively from and to block 25, which represents circulation-inducing means and heat sink. Thus, where the circulating material is a refrigerant fluid, for example, the conduits and the interconnection thereof in the snubbing member comprise the cooling coil, the rest of a conventional refrigerator being represented by block 25, and enlarged portion 22 of the interconnection in the interior of the snubbing member representing a plenum chamber, preferably supplied with fins to the body of the member for ready heat-exchange therewith. Alternatively, conduits 21 and 23 may be simply electrical conductors (the arrows representing electrical current flow therein), in which event block 25 represents a D.C. generator, battery, or equivalent E.M.F. source, and enlarged portion 22 in the snubbing member represents a thermoelectric device (e.g., a Peltier junction or group thereof) adapted to produce a cooling effect upon current flow therethrough in the indicated direction, the selection of which is well within the capability of a person skilled in the art.

Heater 24 extends for substantially the entire width (i.e., perpendicular to the plane of FIG. 1 and the succeeding views) of snubbing surface 16 or so much thereof as is covered by the strand being drawn thereover. The tip of the heater is tapered to concentrate the heating effect

at a narrow line across the snubbing surface, as compared with the arcuate extent of the snubbing surface over which the strand travels, so as to provide substantially point heating of the strand. A differential or gradient in temperature is produced in the strand, extending transversely thereof, to the cool side of the strand in contact with snubbing surface 16, from the opposite side heated (momentarily) by heater 24.

This heater preferably does not actually come into contact with the strand unless modified for rolling contact therewith as described hereinafter. Various theoretical reasons (more apparent after the fact than before) may be advanced for the beneficial results of providing such a temperature gradient across the strand at or in the vicinity of the locus where the drawing to increased length occurs. Likewise, the effect upon the internal molecular arrangement is somewhat speculative, so this invention is not limited by any particular theoretical considerations or confined to any specific internal rearrangement, but rather is defined only by the claims appended hereto.

FIG. 2 shows (on a reduced scale) drawn strand 11' proceeding to the right past heater 27 to pair of strand-forwarding rolls 28, 29 driven through linkage 19c (indicated in broken lines) at reduced tension and a usually intermediate surface speed sufficient, however, to maintain in the strand at least some of the tension imparted by the strand-drawing rolls despite any change in length induced by heater 27 when on. This remaining tension, which may be only sufficient to prevent slack in the strand, is released as the roll nip releases the strand (then denoted as 11'') into relaxed crimped configuration, which is shown somewhat stylized. If desired, the strand-forwarding rolls may be omitted and the tension be released at the nip of the strand-drawing rolls. Also, if desired the strand-feeding rolls may be replaced by equivalent strand-restraining means effective to ensure adequate contact between the strand and the surface of the snubbing member as the stand-drawing rolls pull the strand thereover. The relaxation step, which induces stress relief in the strand, may be repeated, if desired, with or without variation therein.

Use of either or both of heaters 14 and 27 may be dispensed with as may be desired. Heater 14, which is a preheater to facilitate drawing as is desirable with some strand compositions, may be replaced upon providing one or both of feed rolls 12, 13 with internal heating means, such as that shown and described for the feed rolls of a stuffer crimper in my Patent 3,111,740. Alternatively, with strands of readily drawable compositions, heater 14 may be removed without such modification of the feed rolls (or simply be left in place but not turned on), as the friction of the strand against snubbing surface 16 and the intermolecular friction engendered as the strand begins to draw will induce a heating of the strand. Of course, the cooled snubbing member acts to remove heat of whatever origin, including that provided by juxtaposed heater 24, from the drawing or drawn strand; however, unlike those other two heaters, it does not act uniformly on the strand but contacts it along one side only. Heater 27 is used to heat-relax the drawn strand wherever the latent crimp is not developed to the extent desired upon simply relaxing the strand by releasing it from tension. Where not required it can be removed or left in place turned off. A heat-relaxation aftertreatment may be employed instead of or in addition to heat-relaxation by heater 27. Both heaters 14 and 27 may be of any suitable design, such as an enclosure supplied with radiant energy, steam, or other means of heat-transfer, or simply a heated block over which the strand travels in heat-conductive contact.

Heater 24 may be similarly provided with heat energy for transmission to the strand by radiation, convection, conduction or combination thereof. It need not be located at the midpoint of snubbing surface 16 of the snubbing member (as viewed from the side) but may be displaced throughout the arcuate range within which the

strand is in contact with the snubbing surface. Thus, FIG. 3 shows heater 24 relocated at about the point of initial tangency, and FIG. 4 shows it at about the point of final tangency, of the strand with the snubbing surface (but at the opposite side of the strand therefrom, of course). While more than one such heater may be employed, at the illustrated locations or at points therebetween, that usually is not necessary. Regardless of whether one or more than one such juxtaposed heater is used, the location shown in FIG. 3 can be especially useful where no preheater 14 is used, and the location shown in FIG. 4 is helpful for strands that draw principally at or near that point.

Snubbing member 15, and particularly snubbing surface 16 thereof, is composed of any suitably hard material having suitably high heat-conductivity characteristics, usually a metal or alloy thereof. Conventional steel draw pins often are suitable for such member and may be cut in half longitudinally and hollowed if necessary. A semi-cylindrical snubbing surface is most convenient, as the strand does not wrap one or more turns about the member as is customary in conventional drawing operations with cylindrical draw pins but passes thereover through a preferred angle of about a radian of arc, or at least about a half radian and at most about two radians. Of course, a non-arcuate curved surface may be used, if desired. In either event the average radius of curvature of the snubbing member should be large with respect to the filamentary diameter of the strand, and for the purposes of this invention "large" means a minimum ratio of about one hundred times. For most purposes the snubbing member will be selected to have a radius of not less than about one centimeter nor more than about ten centimeters.

Suitable temperatures or ranges thereof for the snubbing member, the juxtaposed heater, and the preheater (if used) depend upon the strand composition, period of exposure thereto, and heat-transfer characteristics. An undrawn 6-nylon strand of forty four hundred total denier and sixty-eight filaments fed at two and one-half meters per minute (4× draw) without preheating, through slightly more than 30° of arc over the surface of a cylindrical snubbing member having a diameter of about ten centimeters and maintained at a temperature of 20° to 25° C., to which was juxtaposed a heater as in FIG. 1 having a temperature of about 200° C. at the tip, assumes upon release of tension therein a coiled or curly crimped configuration. The crimp is intensified by after-treatment of the entire strand at a temperature in the range of about 100° C. to a temperature approaching that of the juxtaposed heater. A similar strand subjected to treatment in identical manner except for omission (or inactivation) of the juxtaposed heater exhibits a considerably lesser degree of crimp, which although useful is either not as bulky or (even if as bulky) not as resilient and, therefore, not so well suited for hard usage applications.

The strand may be a monofilament or multifilament and may range in size from as small as one or two to fifteen or more denier per filament. In the instance of multifilament strands the total denier may be in the hundreds or even the thousands. In the instance of multifilament each component filament of the strand should have a diameter of at most about one one-hundredth of the radius of curvature of the snubbing surface. In the processing of large bundles of filaments it is preferred to spread them laterally by any suitable means to ensure that the individual filaments are gripped securely by the rolls and are brought into relatively good heat-exchanging relation to the heaters (when used) and the snubbing member. The removal of heat from each filament of the strand by means of the snubbing member during drawing induces a transverse non-uniformity therein, which although only imperfectly understood induces a most satisfactory crimp, the full extent of which may become

apparent only upon subsequent relaxation of the strand, performed one or more times.

Articles made by knitting, weaving, or otherwise fabricating such strands, with or without addition of other strands or materials, exhibit desirable characteristics of cling, cover, elasticity, and the like. The invention provides such strands by a rapid, readily controlled, and inexpensive technique. It may be incorporated in the manufacturing line of a plant in which synthetic strands of molecularly orientable compositions are extruded from melts or solutions thereof.

FIG. 5 shows, partly in side elevation and partly in schematic form, an embodiment of heater, designated as 24', for juxtaposition to the strand and designed principally for radiant heating of the side thereof opposite the side in contact with the snubbing surface. This heater is furnished with a pair of electrical leads 31 and with interconnected internal resistance heating element (indicated in broken lines). If desired, the heater (suitably hollowed) may be supplied with heated fluid through pipelines substituted for the electrical leads. In either event heat radiating from the tip of the heater raises the temperature of the side of the strand to which it is juxtaposed as in the preceding views.

FIG. 6 shows similarly, but on an enlarged scale, another embodiment of such heater, designated as 24'', designed principally for convective heating of the side of strand to which it is juxtaposed. This heater is hollow inside (as indicated by broken lines) and open at the tip for flow of fluid therefrom (as indicated by arrows). FIG. 7 shows, largely schematically, heater 24'' interconnected into a fluid supply system. The system comprises source 35 of fluid, heater 36 therefor, and interconnecting piping 37 (to heater 24'') containing pump P between the fluid source and heater 36. Flow of the fluid out the tip of heater 24'' raises the temperature of the adjacent side of the strand. The fluid may be gas or vapor, such as hot air or steam, or may be liquid, preferably non-wetting for the strand (e.g., a molten metal). If desired, heater 24'' may be modified to accommodate combustible gas and to jet the resulting flame or hot combustion product onto the strand, although care must be taken not to degrade the strand by excessive heating or chemical action.

FIG. 8 shows, also partly in side elevation and partly in schematic form, a further embodiment of such heater, designated as 24''', designed principally for conductive heating of the strand upon juxtaposition to the side of the strand opposite the snubbing surface. Here the tip of the heater housing is spaced from the strand much as in the previous embodiments, but the intervening space is occupied by a sector of the roller protruding from the tip. As the strand slides over the cool snubbing surface, the roller rotates in essentially non-slipping contact with the opposite side of the strand and raises the temperature thereof by exchange of heat therewith. The roller nor-

mally is free-running, being rotated only by contact with the strand, although it may be driven by appropriate means if desired, either more slowly or preferably more rapidly than the rate of travel of the strand over the snubbing surface. The major part of the roller being inside the heater tip is heated there by any of the means utilized in the previously described and illustrated heaters for juxtaposition to the strand, providing good heat transfer thereto via the minor exposed part of the roller as it rotates out from the tip and into contact with the strand. Also, if desired, when fluid heating is employed, some of the fluid may be permitted to escape therefrom over or past the roller and onto the strand.

Although particular apparatus embodiments have been illustrated and described and certain modifications suggested, other modifications may be made therein while retaining at least some of the benefits of the present invention, which itself is defined only in the following claims.

The claimed invention is:

1. Process of drawing and crimping a textile strand including at least one continuous filament drawable to increased length, comprising pulling the strand slidably over a snubbing surface at a snubbing location and thereby localizing the drawing of the strand to increased length at the snubbing location, cooling the side of the strand in contact with the snubbing surface, simultaneously heating the opposite side of the strand at the snubbing location, withdrawing the strand from the snubbing location, and subsequently relaxing the strand.

2. The process of claim 1 wherein the strand is preheated substantially uniformly before reaching the snubbing location.

3. The process of claim 1 wherein the strand is forwarded under reduced tension after being withdrawn from the snubbing location and is heated substantially uniformly while under reduced tension.

4. The process of claim 1 wherein the snubbing surface is convex, the side of the strand cooled in contact therewith is by such contact rendered concave, the heated opposite side of the strand is by such contact rendered convex, and the respective sides remain concave and convex after subsequent relaxation of the strand.

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