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CRIMPING APPARATUS AND METHOD

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Fig. 2

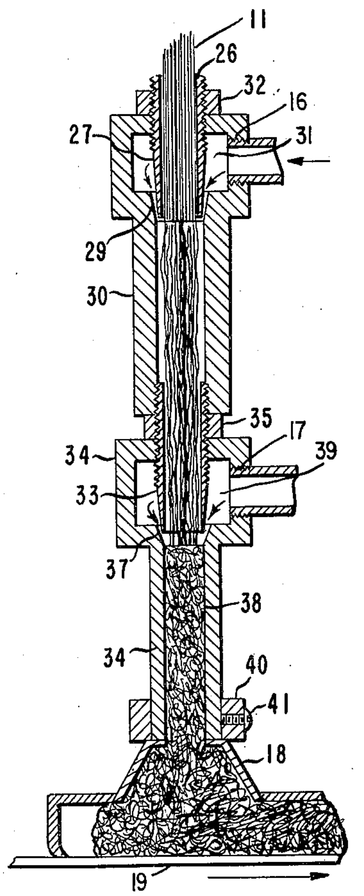


Fig. 1

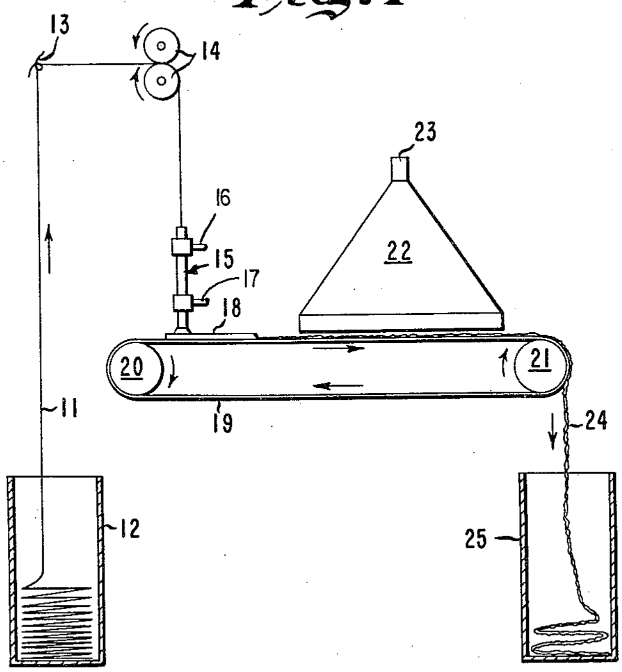
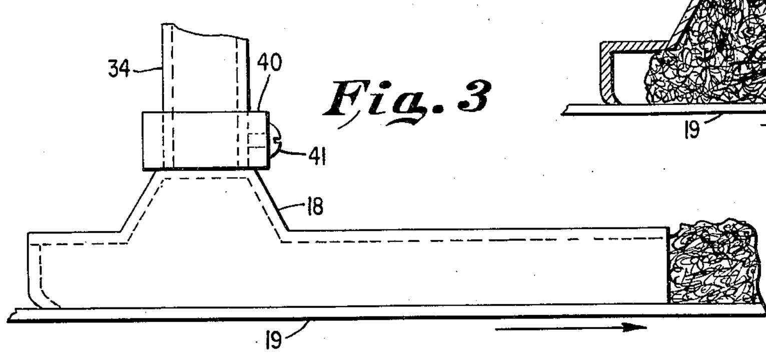


Fig. 3



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CRIMPING APPARATUS AND METHOD

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This invention relates to a method and apparatus for crimping heavy denier bundles of continuous filament synthetic fibers.

Synthetic staple fibers are prepared by cutting or breaking a continuous filament tow. In order that these staple fibers may be readily converted to spun yarns, they must exhibit a finite degree of crimp. This crimp is most advantageously applied to the fiber while it is still in the continuous filament tow form. The tow is crimped continuously and is then cut into staple of the desired length.

One common method used for imparting crimp to a tow of continuous filaments is to force the tow into a chamber in which the individual filaments are buckled against a mass of tow already present in the chamber and to remove the crimped product from the chamber when the pressure of the mass exceeds a certain limit. This method produces a very uniform crimp but has the disadvantage that the bends in an individual fiber lie in a single plane. A further disadvantage of this process is that it damages the fibers and reduces their tensile strength.

The same disadvantages are found when the tow is crimped by passing it between a pair of meshing toothed wheels. The ease of processing staple fibers and the bulk of yarns prepared from those fibers are both improved when the fiber crimp is of a three-dimensional nature, that is when the bends or convolutions of the crimped fiber extend radially in all directions when viewed along the center line of the fiber.

A further advantage of fibers with crimp in the form of convolutions is that they produce fabrics of softer handle than those prepared from fibers with crimp in the form of sharp bends.

Apparatus which may be used to impart a crimp of the desired type to cellulosic tow is described in Mummery, U.S. Patent 2,379,824. Attempts to impart crimp to wholly synthetic fibers by the use of this apparatus have been unsuccessful regardless of the fluid medium used. Although crimp has been developed in the tow, it has been accompanied by such large loops and such a high degree of tangling that the resulting crimped tow has not yielded staple which can subsequently be processed by conventional or practical means.

It is therefore an object of this invention to provide a process for producing synthetic fiber tows with a three-dimensional convoluted crimp. A further object is to provide apparatus suitable for imparting a three-dimensional convoluted crimp to synthetic tows. Other objects will appear hereinafter.

The objects of the invention are attained by passing a tow of synthetic filaments at a regulated speed through a confining tube while simultaneously introducing into said tube a heated gas under pressure, maintaining the contact of heated gas and filaments through a path sufficiently long to raise the temperature of the filaments to a point at which crimping takes place above their second order transition temperature but below their melting or degradation temperature, and ejecting the filaments into a confined space, one side of which is made up by a moving surface.

The invention will be more fully comprehended by reference to the accompanying drawing in which: FIGURE 1 is a diagrammatic showing of a suitable arrangement for feeding, crimping and collecting continuous filament tow in accordance with the invention, FIGURE 2 is a cross-sectional elevation of a preferred form of crimper and FIGURE 3 is a side view of the restraining device or shoe which makes up part of the crimper.

Referring to FIGURE 1, a tow **11** of synthetic fibers is withdrawn from a container **12** through a guide **13** by means of positively driven feed rolls **14** rotating at a predetermined constant speed. The tow then passes into the upper end of the crimping device **15** which is provided with steam or other hot compressible fluid through inlets **16** and **17** and thence into the confined volume defined by the steaming shoe **18** and the moving belt **19**. The belt travels in the direction indicated between rolls **20** and **21**, one of which is driven at a surface speed less than that of roll **14**. The crimped tow issuing from the outlet of shoe **18** may be cooled or dried as desired by passing cool or hot air or other medium through the funnel-shaped device **22**, this air entering or being exhausted through opening **23** in said device. The crimped tow **24** falling from the end of the belt is collected by gravity in container **25**.

Referring to FIGURES 2 and 3, the nozzle **27** is adjustably mounted in supporting element **30** by a screw thread connection. The edges of the upper opening **26** of this nozzle are rounded to prevent damage to the tow. The lower end of the nozzle is beveled so that the position of the nozzle relative to the supporting member will vary the annular opening **29** between the two. A fluid, particularly steam, enters the supporting member through the threaded inlet **16**, filling the chamber **31** before passing through the annular opening **29**. The nozzle **27** is held in its desired position by means of the lock nut **32**. A second nozzle **33** is held in place in the tow exit end of the supporting element **30** by a threaded connection. Adjustably attached to nozzle **33** by means of screw threads is the member **34**. This member is equipped with a second threaded inlet **17** for the introduction of steam or other fluid. The fluid enters the chamber **39** before passing downward through the annular space **37** between the tapered lower end of nozzle **33** and the member **34**, this annular opening being adjustable because of the threaded connection between the two members and capable of being set in a given position with the aid of lock nut **35**. The fluid and tow pass downward through opening **38** in the tubular lower end of member **34**. The confining shoe **18** is attached to the lower end of member **34** by means of the cylindrical collar **40** provided with a set screw **41**.

The following specific examples describe a preferred mode of carrying out the process of the invention and the operation of the apparatus. They are intended to be illustrative, however, rather than limitative.

Example I

The starting material for this run was a 50,000 denier wet continuous filament tow of drawn filaments of about 6 denier per filament size prepared from a copolymer of 94% acrylonitrile and 6% methyl acrylate. This tow was drawn from the container **12** by the feed roll **14** at a linear speed of 180 feet per minute and fed into the crimping device **15**. The inner diameter of the two nozzles **27** and **33** of the crimping device was ¼ inch. The taper at the output end of each of these nozzles was 20° and the openings between these nozzles and the surrounding members was that given by raising each nozzle 1/20 inch from its closed position. Steam entered the apparatus through opening **16** at 20 pounds per square inch gauge and through opening **17** at 50 pounds per square inch gauge. The tubular exit end of member **30** was ⅜ inch in a diameter and 1½ inches in length while the tubular exit end of member **34** had an inner diameter of ⅜ inch and a length of 2¼ inches. The steaming shoe 18 had a height of ¾ inch, a width of ⅞ inch at the top and a width of 2⅜ inches at the bottom, it was 4 inches in length with the opening for the admission of the tow at a point 1 inch from the closed end. The belt on which the crimped tow impinged was traveling at a rate of 19 feet per minute. The length of belt from the exit end of the steaming shoe to the point of discharge of the crimped tow was 36 inches. No gaseous medium was passed through the funnel 22 in this run. The crimped tow falling from the belt 19 was collected in the receptacle 25. This tow was free of large loops and showed no tendency to tangle. At the end of the run the tow was removed from the receptacle 25 and cut to 2½-inch lengths using a yarn cutter of the type described in Cook, U.S.P. 2,747,663. This staple was dried in trays at 127° C. for 15 minutes. The staple was readily processed into jersey-knit fabric of desirable properties.

When a similar run was made under identical conditions to the above except that the restraining steaming shoe 18 was not present, the tow prepared was full of large loops and showed a strong tendency to tangle, making it very difficult to process this material through the yarn cutter. The frequency of crimp along the cut filaments and the stability of that crimp were both found to be undesirably low.

Example II

A second run was carried out under identical conditions to those of Example I except that the steam entering opening 17 of the crimping device was under a pressure of 150 pounds per square inch gauge and no steam was introduced through opening 16. The apparatus functioned satisfactorily and produced a crimped product free of large loops and with no tendency toward tangling. After cutting and drying the staple was readily processed into jersey-knit fabric of desirable aesthetic properties.

Example III

The crimping device used in this experiment was a single-stage device of the type shown in U.S. 2,379,824 except that a steaming shoe described in Example I was attached to the exit end of the device just above the collecting belt. Steam was fed into the device at a pressure of 100 pounds per square inch gauge. A tow of polyethylene terephthalate filaments having a total denier of 62,000 and an individual filament denier of 1.5 was fed into this device at a speed of 123 yards per minute. The belt on which the crimped tow impinged traveled at a rate of 53 feet per minute. The product obtained was readily processed through a staple cutter without tangling. After drying, the cut staple was readily converted into spun yarns which were used to make woven fabrics of desirable aesthetics.

In a similar test with no steaming shoe on the crimping device, large loops were formed and the tow showed a degree of tangling which made cutting impractically difficult.

The process of our invention is applicable not only to the fibers described in the examples but also to other synthetic fibers such as poly(epsilon caproamide), cellulose esters, polyethylene, polypropylene, polyvinyl chloride, poly(trans-para-hexahydroxylylene terephthalate), or polyethylene terephthalate/isophthalate.

The tow may be fed to the crimping apparatus from a container as indicated or it may be fed to the feed rolls directly from a spinning machine or a drawing machine. The size of the tow may be varied within wide limits depending upon production requirements. With tows of various sizes, it is necessary to alter the internal dimensions of the crimping apparatus. Thus, for an acrylic fiber tow of about 500,000 denier, nozzles having an internal diameter of $^{17}/_{32}$ inch have been found to be useful. With heavy denier tows it is sometimes desirable to use apparatus which is rectangular in internal cross-section in order to give the fluid which contacts the tow in the apparatus the greatest opportunity to penetrate to the fibers near the center of the tow.

When the tow entering the crimping apparatus comes directly from an operation in which it has been heated, for example, directly from a drawing operation carried out in water at a temperature near 100° C., it is sometimes found acceptable to use a single-stage aspirating jet of the type described in U.S.P. 2,379,824 instead of the two-stage jet of FIGURE 2. The single-stage jet must be used in conjunction with a steaming shoe of the type shown in FIGURE 3 in order to give a satisfactory product. In operation with either single-stage or double-stage type of jet, the annular space between the nozzle and its housing will depend on the tow denier, input speed and the steam pressure used as well as on the level of crimp frequency desired. In some instances it has been found that improved crimp frequency, crimp uniformity, and openness of the tow bundle may be obtained by utilizing apparatus in which the section immediately following the final jet increases in internal area in stepwise fashion in the direction of tow travel. The crimp frequency and the permanence of the crimp will depend also on the speed of the belt relative to the input speed and on the dimensions of the steaming shoe. Shoes of larger cross-sectional area and greater length are desirable for tow bundles of greater denier.

Fluids other than steam such as air, vapors of inert liquids and the like are sometimes of advantage in the crimping process. However, the cheapness and availability of steam make it most desirable for most applications. The temperature of these gases should be sufficiently high to bring the temperature of the filament bundle above the second-order transition of the polymer from which the filaments are made within the short time it takes for them to be delivered to the belt.

The contact of the fibers with the heated fluid in the apparatus brings about a certain degree of fiber relaxation which would otherwise have to be developed by a separate operation or by use of increased drier temperature. As compared to processes in which the crimping has been carried out by other crimping devices and the relaxation has been accomplished during the drying of the tow, the present crimping process produces a tow which can be dried with much less critical control of the drier temperature.

The length of the belt used to collect and discharge the crimped tow will depend on the properties of the individual tow. For different starting materials it may be desirable to use additional cooling or heating by auxiliary means while the tow is on the belt in order to reduce the length of belt travel. The belt may discharge the product into a receptable as previously shown or may desirably discharge the material onto the moving belt of a drying apparatus.

By the practice of this invention it is possible to produce a crimped tow of synthetic fibers of desirable processing characteristics. The tow may be cut directly into staple fibers which have desirable properties for conversion into spun yarns by the usual cotton system and wool system operations. The tow may likewise be used directly in those operations which convert it to silver through breaking or staggered cutting operations. These slivers are in turn converted into spun yarns through commonly used textile processing operations. In either case the spun yarns may be converted into knit fabrics or woven fabrics in the usual way and these fabrics are found to possess desirable softness of a degree not attainable with yarns prepared from fibers of the same filament denier which have been crimped by the mechanical crimping devices of the prior art.

It will be apparent that many widely different embodiments of this invention may be made without departing from the spirit and scope thereof, and therefore it is not intended to be limited except as indicated in the appended claims.

We claim:

1. The process of crimping a compact bundle of continuous linear synthetic filaments which comprises feeding the said bundle through a tube onto a moving belt introducing a hot gas under pressure into the said tube and imparting a crimp to the said bundle and confining the same as it meets the moving belt.

2. The process of claim 1 in which the bundle of filaments is withdrawn on top of the belt at a rate lower than the rate at which it is fed to the confined space.

3. The process of claim 1 in which the hot gas is steam.

4. The process of claim 1 in which the temperature of the compact bundle is above the second-order transition temperature of the filaments and below their melting point.

5. The process which comprises feeding a wet bundle of filaments through a nozzle, aspirating the said bundle by means of a hot gas against a moving belt at a rate faster than it is withdrawn, confining the wet bundle as it moves with the belt and subjecting the confined moving bundle to a hot gas under pressure.

6. The process of claim 5 in which the gas is steam.

7. The process of claim 5 in which the temperature of the gas is above the second-order transition point of the polymer from which the filaments are made and below its melting point.

8. Apparatus for crimping continuous synthetic linear filaments which comprises a nozzle, means for passing a bundle of filaments through the nozzle, a housing around the nozzle, means for supplying steam to the said housing, a tube below the said nozzle, an annular space between the nozzle and the said tube, connecting means between the housing and the said annular space for delivering steam through the annular space into the tube, a moving belt at the exit end of the said tube, and a shoe having an inlet through which the exit end of the said tube passes and delivers the yarn passing therethrough onto the said moving belt.

9. Apparatus for crimping a bundle of continuous linear synthetic filaments which comprises a tube, means for introducing the said bundle into the tube at a controlled rate, means for introducing a compressible fluid under pressure into the tube, a moving belt at the exit end of the said tube and a housing surrounding the immediate space above the said moving belt, and means for feeding the said bundle through the tube at a rate greater than that of the moving belt.

10. The apparatus of claim 8 which includes two nozzles in tandem.

References Cited in the file of this patent

UNITED STATES PATENTS

2,379,824	Mummery	July 3, 1945
2,435,891	Lodge	Feb. 10, 1948
2,622,306	Anderson	Dec. 23, 1952
2,852,906	Breen	Sept. 23, 1958