

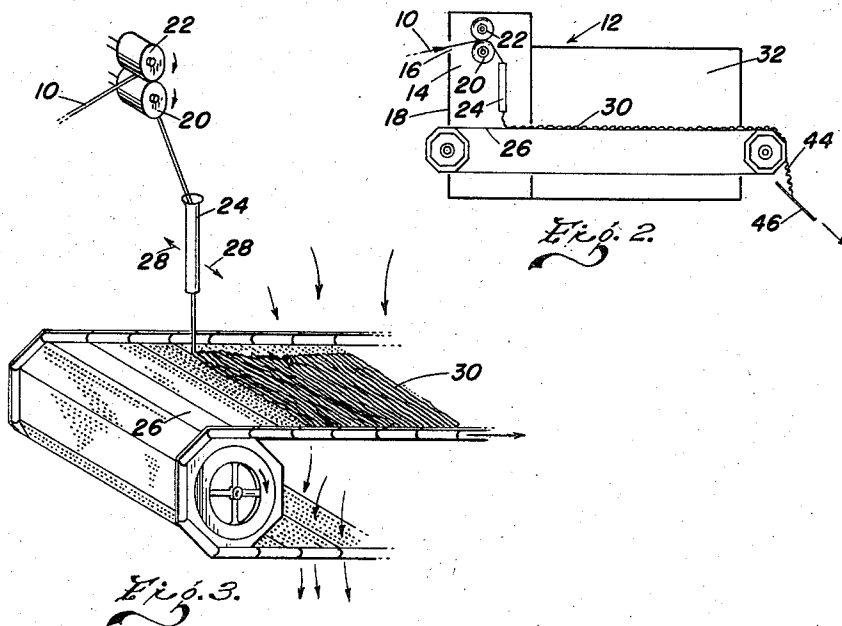
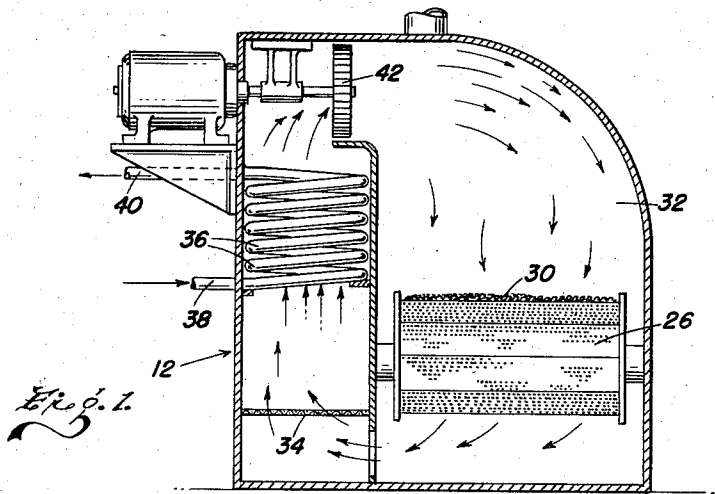
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METHOD OF PRODUCING A TOW OF FILAMENTARY MATERIAL

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METHOD OF PRODUCING A TOW OF FILAMENTARY MATERIAL

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8 Claims. (Cl. 28—72)

This invention relates broadly to the production of a tow or strand of filamentary material, more particularly a synthetic filamentary material, and specifically a polyacrylonitrile filamentary material, that is, one which is comprised of a polymer (fiber-forming polymer) of acrylonitrile. The invention is especially concerned with certain new and useful improvements in a continuous method of producing a tow of polyacrylonitrile filamentary material, advantageously one comprised of a polymer of acrylonitrile containing a major proportion (preferably at least 75%) by weight of acrylonitrile combined in the polymer molecule.

It was suggested prior to my invention that certain vegetable fibers (specifically cotton, hemp, jute, ramie and flax) and certain uncrosslinked thermoplastic synthetic fibers (specifically viscose and acetate rayons, nylon, fibers made from condensation products of terephthalic acid and glycol, and fibers made from polyvinylidene chloride) be mechanically crimped while hot and then immediately crimp-set by cooling, while compacted under a substantially constant pressure, in a cooling zone of the same apparatus. Such a method and apparatus for practicing the same are described in, for example, Rainard U. S. Patent No. 2,575,839.

A method of crimping and crimp-setting a tow of a polyacrylonitrile filamentary material is disclosed and claimed in the copending application of Mario Sonnino, Serial No. 545,043, filed concurrently with the present application. In the specific crimp-setting technique therein described by way of example, the crimp is fixed by passing the tow of synthetic filamentary material through a so-called "j-box" or other suitable receptacle containing cold water. The cold water that is taken up by the tow (thereby forming a saturated tow) must subsequently be removed by a squeeze roll or other suitable device; and the removal of this entrained water may, under certain conditions, cause fiber entanglement and reduction of crimp amplitude. If no consideration be given to the tow as a final product, the squeeze roll or equivalent device may be by-passed and the crimp-set tow may be cut into staple while it contains approximately 400% by weight of moisture. It is then necessary to form the cut staple into a blanket which must be squeezed, separated or re-opened, and then conveyed to a staple dryer for drying the cut staple.

The present invention has as its primary object an improvement upon the crimp-setting methods described above. Briefly described, the improvement comprises continuously passing a tow of a polyacrylonitrile filamentary material, and more particularly one comprised of a polymer of acrylonitrile containing a major proportion by weight of acrylonitrile combined in the polymer molecule, at a temperature of from about 150° F. to about 200° F. directly from a tow crimper, wherein it has been hot-crimped mechanically, to a quenching zone in which cooled gas (e. g., cooled air, nitrogen, flue gas, etc.) is circulated. The tow-quenching apparatus or so-called "tow quencher" is separate and distinct from the

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crimping apparatus, as a consequence of which the hot-crimped tow is readily available for inspection prior to setting of the crimp therein and the practical advantages of which will be immediately apparent to those skilled in the art. The hot tow in relaxed state is supported on a moving support, e. g., a continuously moving apron or screen formed of metal or other suitable material. This support is preferably porous, e. g., by being provided with orifices or slots, or by the use of wire screening, so as to facilitate the passage of the cooled gas through the thusly supported tow. The supported, relaxed tow is passed continuously through the quenching zone. The temperature of the quenching zone and the time the tow is present therein are correlated so that the tow is at a temperature below 120° F., and preferably not higher than about 100° F., when it leaves the said zone.

The crimp-set tow, after it leaves the tow quencher, can be cut into staples, e. g., by means of centrifugal cutters, and thence dried, opened and baled for shipment; or, alternatively, it can be dried in the form of tow, and the dried tow then plaited into a suitable container for shipment as tow.

By quenching the hot-crimped tow in a separate cooling zone while in a relaxed state in accordance with my invention, there is greater assurance of obtaining a more uniform product since there is less chance for physical damage to the crimped tow. A uniform product is a matter of considerable practical importance, not only from the standpoint of dye uniformity but also from the standpoint of uniformity in mill processing and in end uses. Still another reason for the improvement in the quality of the tow is due to the fact that it is subjected to less handling (as will be apparent from the following paragraph) while it is in a condition or state when it is relatively sensitive to damage.

As compared with processes that involve passage through water or other cooling fluid, or spraying with such fluids, the method of this invention eliminates such a step. As a result, the number of subsequent process steps is thereby reduced and substantial savings in operating and equipment costs are attained; furthermore, drying costs also are reduced since the moisture content of the tow is reduced during its passage through the tow quencher.

Another advantage of the invention is the fact that it requires no large floor areas, or expensive or specially constructed apparatus. In marked contrast, the equipment required to practice the method of the invention is compact, relatively inexpensive and readily available.

Still another advantage of the invention is the fact that it obviates or minimizes filament entanglement, knotting, etc., that occur or tend to occur if a continuously moving, hot-crimped, polyacrylonitrile tow or strand, while still hot, is exposed to blasts of cold air or other gas sufficient to cool the tow quickly and to set the crimp.

The novel features of the invention are set forth in the appended claims. The invention itself, however, will be understood most readily from the following detailed description thereof when considered in connection with the accompanying drawing, which is illustrative of the invention, and in which:

Fig. 1 is a cross sectional end view of one form of apparatus that can be used in practicing the method of the invention, and showing the tow on a moving support that carries it through the apparatus;

Fig. 2 is a side elevation and somewhat schematic view of the apparatus illustrated in Fig. 1 and showing the tow being carried through, and leaving, the apparatus; and

Fig. 3 is a perspective view of a portion of the moving support shown in Figs. 1 and 2, and of one means for

laying the tow upon the support end of a preferred manner in which the tow is laid or plaited upon the support.

Referring to the drawing, a crimped tow 10 is led directly from a tow crimper (not shown), wherein it has been hot-crimped mechanically, to a tow quencher 12. The tow is hot when it leaves the tow crimper, e. g., at a temperature of from about 150° F. to about 200° F. and, more particularly, about 165° F. to about 195° F. The hot, crimped tow which is quenched in accordance with the present invention is a tow of synthetic filamentary material, and more particularly a tow of polyacrylonitrile filamentary material, e. g., one comprised of a polymer of acrylonitrile containing a major proportion (advantageously at least 75%) by weight of acrylonitrile combined in the polymer molecule. Crimped tows of a polyacrylonitrile filamentary material containing 50%, or less than 50% (e. g., as little as 35 or 40%), by weight of acrylonitrile combined in the polymer molecule are not precluded from treatment as herein described in order to set the crimp with the same attendant advantages previously stated earlier in this specification.

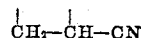
The tow 10 enters the feed-in section 14 of the tow quencher 12 through an opening 16 in the side wall 18 of the said section. The hot tow, as received from the tow crimper, is generally wet with water and may contain, for example, from about 50% to about 150% by weight of water, based on the weight of the bone-dry tow. The tow passes between a pair of feed rolls comprising a lower roll 20 and an upper roll 22 which lightly presses the tow upon the lower roll. From the pair of feed rolls the tow passes through the plaiting tube 24, which is positioned above the continuously moving support 26 as shown. This plaiting tube lays the hot tow, while it is in a relaxed state, in a transverse, zigzag pattern upon the said moving support, and is moved back and forth, as indicated by the arrows 28, by means of conventional traverse mechanism (not shown). A plaiter chute (not shown) may be provided, if desired, in order to facilitate the plaiting of the tow upon the support 26, which latter may be, for example, a continuously moving perforated apron. The support 26 may be formed of metal or of any other suitable material.

The plaited tow 30, while resting in a relaxed state upon the continuously moving support, is passed through the quenching zone 32 of the tow quencher 12. In this zone a cooled gas, specifically cooled air, is circulated as indicated by the arrows in Fig. 1. One or more openings (not shown), as desired or as may be required, may be provided for the intake of outside air or other gas into the quenching zone. The air filter 34 provides means for filtration of impurities from the air or other gas which is circulated through the zone. After passage through this filter the gas passes over the cooling coils 36 through which a cold fluid medium, e. g., refrigerated brine solution or other suitable coolant, is circulated. This cold fluid medium enters the coils 36 at inlet end 38 and leaves through outlet end 40. A suitable fan 42, e. g., a multi-blade fan wheel or equivalent device, facilitates the circulation of the cooling gas through the quenching zone, and over and through the tow during its passage through said zone while resting on the support. The heat of the tow is imparted to the cooled gas, specifically cooled air, which is circulated through the perforated or porous moving support. The circulated, cooled gas sets the crimp in the tow and also reduces the moisture content of the tow, with the economical and practical advantages mentioned hereinbefore.

The temperature of the quenching zone 32 and the time the tow is present therein are correlated so that the tow is at a temperature below 120° F., preferably not higher than about 100° F., e. g., about 80–90° F. when it leaves the quenching zone and the end of the moving support, as indicated at 44, and from which it falls into a suitable chute 46. It is then ready for further processing as has been described hereinbefore.

In a typical example air is cooled to a temperature of about 35°–45° F. by passage over the cooling coils 36, and is then circulated as illustrated in Fig. 1. The hot tow of polyacrylonitrile filamentary material is comprised of a polymer of acrylonitrile containing, by weight, about 95% acrylonitrile and 5% methyl acrylate; and is at a temperature of about 175° F. when it is plaited upon the support 26. It contains about 100% by weight of water and about 0.8% by weight of an antistatic finish. The quenching zone 32 is about 9 feet long. The hot, plaited tow 30 is carried through this zone, while resting on the continuously moving support 26, at an average rate of between about 800 and about 2000 pounds per hour, based on the bone-dry weight of the tow. The quenched tow is at an average temperature of between about 80° F. and about 90° F. when it leaves the exit end of the quenching zone 32 and is at approximately this same temperature when it leaves the support 26 at the point 44.

It will be understood, of course, by those skilled in the art that my invention is not limited to the processing of a mechanically hot-crimped tow of filamentary material comprised of a copolymer of about 95% by weight of acrylonitrile and about 5% by weight of methyl acrylate as set forth in the foregoing example. Thus, instead of using such a tow of filamentary material comprised of the aforesaid copolymer, I may use a tow of filamentary material comprised of, for example, a homopolymer of acrylonitrile or of a ternary polymer of, by weight, about 88% acrylonitrile, about 6% of vinyl acetate and about 6% of a vinylpyridine, e. g., 2-methyl-5-vinylpyridine. Other acrylonitrile copolymers (thermoplastic acrylonitrile copolymers) of which the tow may be composed or comprised, and after being hot-crimped mechanically then used in practicing the present invention, are acrylonitrile copolymers containing in the polymer molecules an average of, for example, at least about 35%, preferably at least about 75%, by weight of combined acrylonitrile. Taking as an example the expression "an acrylonitrile polymer containing in the polymer molecules an average of at least about 35% by weight of combined acrylonitrile," this means herein a polymerization product (homopolymer, copolymer or graft polymer or mixtures thereof) containing in the molecules thereof an average of at least about 35% by weight of the acrylonitrile unit, which is considered to be present in the individual polymer molecule as the group

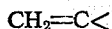


or, otherwise stated, at least about 35% by weight of the reactant substance converted into and forming the polymerization product is acrylonitrile. The expression "an acrylonitrile polymer containing in the polymer molecules an average of at least about 75% by weight of combined acrylonitrile" has a similar meaning herein.

Illustrative examples of monomers which may be copolymerized with acrylonitrile to yield a polymerization product containing in the polymer molecules an average of at least about 35%, preferably at least about 75%, by weight of combined acrylonitrile are compounds containing a single $\text{CH}_2=\text{C}<$ grouping, for instance, the vinyl esters and especially the vinyl esters of saturated aliphatic monocarboxylic acids, e. g., vinyl acetate, vinyl propionate, vinyl butyrate, etc.; vinyl halides, e. g., the vinyl chlorides, bromides and fluorides; allyl-type alcohols, e. g., allyl alcohol, methallyl alcohol, ethallyl alcohol, etc.; allyl, methallyl and other unsaturated monohydric alcohol esters of monobasic acids, e. g., allyl and methallyl acetates, laurates, cyanides, etc.; acrylic and alkacrylic acids (e. g., methacrylic, ethacrylic, etc.) and esters and amides of such acids (e. g., methyl, ethyl, propyl, butyl, etc., acrylates and methacrylates, acrylamide, methacrylamide, N-methyl, -ethyl, -propyl, -butyl, etc., acrylamides and methacrylamides, etc.); methacrylonitrile, ethacrylonitrile

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and other hydrocarbon-substituted acrylonitriles; unsaturated aliphatic hydrocarbons containing a single



grouping, e. g., isobutylene, etc.; and numerous other vinyl, acrylic and other compounds containing a single $\text{CH}_2=\text{C}<$ grouping which are copolymerizable with acrylonitrile to yield thermoplastic copolymers. Alkyl esters of alpha, beta-unsaturated polycarboxylic acids also may be copolymerized with acrylonitrile to form copolymers, e. g., the dimethyl, -ethyl, -propyl, -butyl, etc., esters of maleic, fumaric, citraconic, etc., acids.

Ordinarily, the molecular weight (average molecular weight) of the polyacrylonitriles (homopolymeric or copolymeric acrylonitriles) used in making the tow of filaments is within the range of 25,000 or 30,000 to 200,000 or 300,000 or higher, and advantageously is of the order of 50,000 to 100,000, e. g., about 70,000-80,000, as calculated from a viscosity measurement of the said polymerization product in dimethyl formamide using the Staudinger equation (reference: U. S. Patent No. 2,404,713).

The tow of polyacrylonitrile filamentary material may be produced from an acrylonitrile polymerization product by any suitable method and using any suitable apparatus, but advantageously is produced as is described in, for example, the copending application of Mario Sonnino, Serial No. 536,479, filed September 26, 1955, now Patent No. 2,849,751, dated September 2, 1958.

I claim:

1. In a continuous method of producing a tow of polyacrylonitrile filamentary material wherein the said tow has been hot-crimped mechanically by a tow crimper and is then continuously passed directly from said tow crimper to a separate quenching zone while the crimped tow is at a temperature of from about 150° F. to about 200° F., the improvement which consists in circulating cooled gas through said quenching zone; laying the hot tow in a transverse, zigzag pattern and while it is in a relaxed state on a moving support; and passing the thusly supported, relaxed tow through said quenching zone, the temperature of said zone and the time the tow is present therein being correlated so that the tow is at a temperature below 120° F. when it leaves said zone.

2. The improvement as in claim 1 wherein the cooled gas which is circulated in the quenching zone is cooled air.

3. The improvement as in claim 1 wherein the tow which is processed is a tow of filamentary material com-

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prised of a polymer of acrylonitrile containing a major proportion by weight of acrylonitrile combined in the polymer molecule.

4. The improvement as in claim 3 wherein the polymer of acrylonitrile of which the tow is comprised contains at least 75% by weight of acrylonitrile combined in the polymer molecule.

5. The improvement as in claim 1 in a method wherein the tow which is passed directly from the tow crimper to the separate quenching zone contains from about 50% to about 150% by weight of water, based on the weight of the bone-dry tow.

6. The improvement as in claim 1 wherein the temperature of the quenching zone and the time the tow is present therein are correlated so that the tow is at a temperature not higher than about 100° F. when it leaves said zone.

7. In a continuous method of producing a tow of filamentary material comprised of a polymer of acrylonitrile containing at least 75% by weight of acrylonitrile combined in the polymer molecule and wherein the said tow has been hot-crimped mechanically by a tow crimper and then continuously passed directly from said tow crimper to a separate quenching zone while the crimped tow is at a temperature of from about 165° F. to about 190° F., the improvement which consists in circulating cooled air through said quenching zone; laying the hot tow in a transverse, zigzag pattern and while it is in a relaxed state on a moving support; and passing the thusly supported, relaxed tow through said quenching zone, the temperature of said zone and the time the tow is present therein being correlated so that the tow is at a temperature not higher than about 100° F. when it leaves said zone.

8. The improvement as in claim 7 wherein the cooled air is circulated both over and through the tow during its passage through said zone on said moving support.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

February 24, 1959

Patent No. 2,874,446

William N. Sellers

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 1, for "end" read -- and --.

Signed and sealed this 30th day of June 1959.

(SEAL)

Attest:

KARL H. AXLINE

Attesting Officer

ROBERT C. WATSON
Commissioner of Patents