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TOW-PROCESSING APPARATUS

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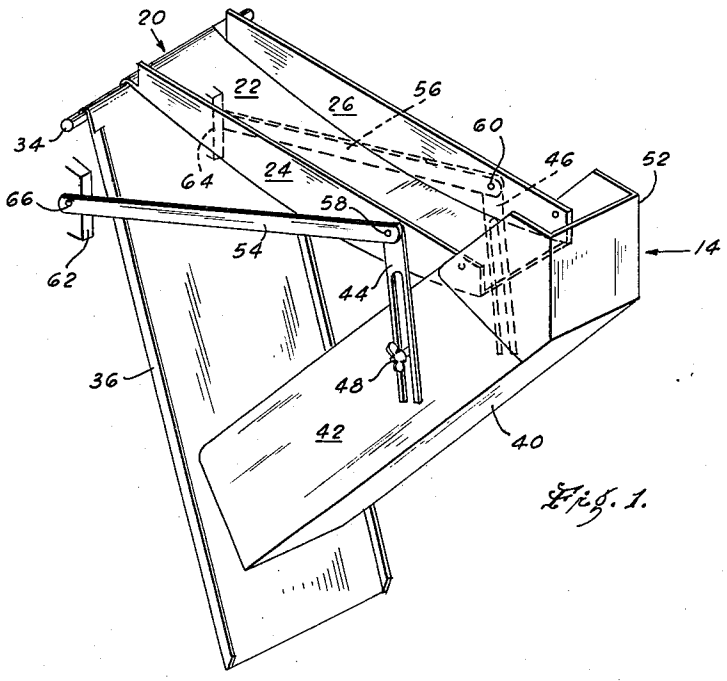


Fig. 1.

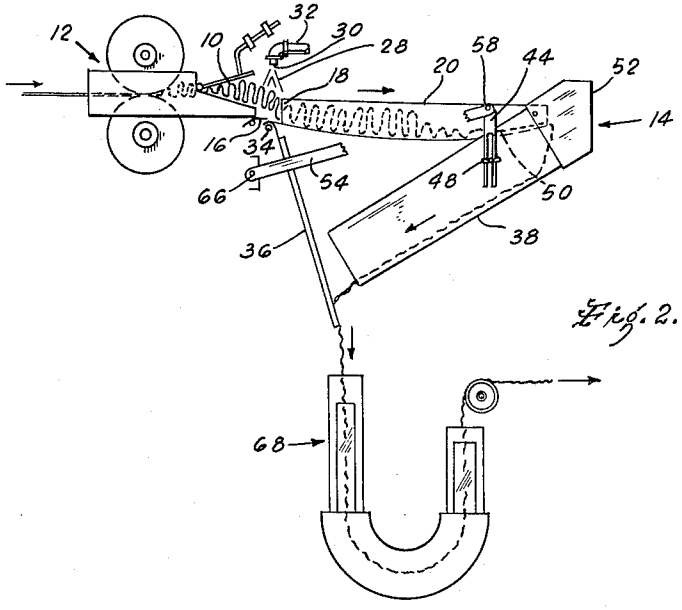


Fig. 2.

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TOW-PROCESSING APPARATUS

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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 apparatus for use in producing a tow of a 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 our 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 November 4, 1955, now Patent No. 2,960,752, dated November 22, 1960, and assigned to a common assignee. 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.

Another method of crimp-setting a tow of polyacrylonitrile filamentary material is described in Sellers U.S. Patent No. 2,874,446, dated February 24, 1959. This method comprises continuously passing a tow of such a 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 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 present invention has as its primary object an improvement in the crimp-setting apparatus described above. It makes it possible to improve the permanence of crimp of a tow of filamentary material that must be heated in order to be crimped, and to do this without materially affecting the operation of the tow crimper; that is, while preventing back pressure on the stuffing box of the tow crimper that would materially affect the uniformity of its operation.

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 when considered in connection with the accompanying drawing, which is illustrative of the invention, and in which:

FIG. 1 is a perspective view of the tow-quenching apparatus embodied in the present invention; and

FIG. 2 is a side elevation and somewhat schematic view showing the tow-quenching apparatus (i.e., tow quencher) of the invention in its relationship to a tow crimper of the stuffing-box type and to apparatus used in a next step of the operation, specifically a J-box.

Referring to the drawing, a crimped tow **10** is led directly from a tow crimper **12**, wherein it has been hot-crimped mechanically, to the tow quencher **14** illustrated in more detail in FIG. 1. 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 160° F. to about 190° F. The hot, crimped tow which is quenched in accordance with the present invention can be any tow of filamentary material which is hot-crimped mechanically, including tows of natural and synthetic filamentary materials, numerous examples of which were given in the second paragraph of this specification. Thus, the tow of filamentary material can be a tow of a 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, also can be processed in accordance with the present invention in order to set the crimp.

The continuously moving tow **10** passes over the shelf **16** to the feed-in end **18** of the primary slide **20**. The hot tow, as it leaves 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 primary slide **20** is open at its feed-in end, and is comprised of bottom wall **22** (FIG. 1) and side walls **24** and **26** (FIG. 1). The primary slide is provided with a slight dip as indicated; that is, it has a concave bottom wall. This dip in the primary slide aids in keeping the slide wetted. The wetted primary slide facilitates preservation of the primary and secondary crimp without exerting excessive back pressure on the stuffing box of the crimper.

The hot, continuously moving tow **10** after it leaves the tow crimper **12** is quenched with a cooling liquid **28**, e.g.,

an aqueous cooling liquid at a temperature of from about 50° F. to about 100° F., and advantageously such an aqueous cooling liquid which contains an antistatic agent. Cooling liquids at a temperature lower or higher than those just mentioned by way of example may be used as desired or as conditions may require. However, the cooling liquid, as will be obvious to those skilled in the art, in all cases should be at a temperature materially below, e.g., at least about 30°–40° F. below, the temperature of the crimped tow leaving the exit end of the tow crimper. The cooling liquid is applied by any suitable means, for instance through the nozzle or spray **30** located at the exit end of the conduit **32** which is fed with the cooling liquid from a supply source (not shown).

The cooling liquid is advantageously applied to the continuously moving tow at a point after it leaves the exit end of the tow crimper **12** and at or just before it passes onto the primary slide **20**. Application of the cooling liquid to the continuously moving tow at a later stage of the process, e.g., while it is on the primary slide **20**, is not precluded and, with certain hot-crimping techniques and certain types of filamentary materials, even may be desirable.

Any suitable antistatic agent may be a component of the liquid cooling medium. Examples of antistatic agents which may be used are the guanylurea and guanidine salts of monoaliphatic hydrocarbon esters of sulfuric acid. more particularly such salts wherein the aliphatic hydrocarbon grouping contains from 12 to 18 carbon atoms, inclusive, e.g., guanylurea octadecyl hydrogen sulfate, guanidine octadecyl hydrogen sulfate, guanidine oleyl hydrogen sulfate, etc. Still other examples of antistatic agents which may be used are β-alkoxypropionitriles, e.g., octadecoxypropionitrile; reaction products of ethylene oxide and a long-chain alkyl guanamine, e.g., octadecyl guanamine; and reaction products of ethylene oxide and a long-chain alkyl guanidine, e.g., octadecyl guanidine.

The antistatic agent may be the sole effect agent that is present, along with the liquid (e.g., aqueous) component, in the quenching liquor; and such an agent may be one which is inherently capable of functioning both as a lubricating agent and as an antistatic agent. In other cases it may be desirable to use the antistatic agent in conjunction with other conditioning or effect agents which are commonly employed in treating synthetic fibers, more particularly fibers produced from acrylonitrile polymerization products. Such auxiliary conditioning agents include mineral, vegetable and animal oils, among which latter may be mentioned blown and unblown neat's-foot oil, sperm oil, olive oil, teaseed oil, peanut oil, soya bean oil and cottonseed oil, as well as the various sulfonated oils, e.g., sulfonated olive oil. Examples of other conditioning agents that may be employed in conjunction with the aforementioned guanylurea salt or guanidine salt or other antistatic agent are wetting and dispersing agents and textile lubricants of various kinds, for instance N-octadecyl disodium sulfosuccinamate, dioctyl sodium sulfosuccinate, lecithin, esters of long-chain fatty acids, e.g., alkyl stearates, palmitates and oleates, more particularly the ethyl, propyl, butyl and amyl stearates, palmitates and oleates.

The shelf **16** is held in place by any suitable means, for instance by being supported on a suitable support (not shown), and is positioned slightly above and even with (i.e., in approximately the same vertical plane), or slightly forward of, the rod **34** upon which are mounted, preferably detachably mounted, the primary slide **20** at its feed-in end and the discharge slide or guide **36**. The shelf **16** is preferably curved at its forward edge and is positioned sufficiently close to the bottom wall **22** of the feed-in end of the primary slide as to permit the continuous movement of the tow of filamentary material from the exit end of the tow crimper to the primary slide of the tow quencher. Since the forward edge of the shelf **16** is slightly above the rod **34**, and hence above the edge of the bottom wall of the feed-in end of the primary slide, there is a slight gap or opening therebetween.

By constructing and positioning both the shelf **16** and the primary slide **20** as described above, the possibility of back flow of quenching liquor (cooling liquid) into the stuffing box of the tow crimper is obviated, as a consequence of which uniformity of temperature control in the crimping operation is made possible. In other words the open, sloped, primary slide **20**, when positioned as described above with reference to the exit end of the tow crimper and especially the shelf **16**, prevents the flow of quench liquor into the crimping zone and thereby provides obvious advantages that will be readily appreciated by those skilled in the art.

The primary slide **20** is provided with arms **54** and **56** which are pivotally mounted as shown, that is, to the side walls of the primary slide, near the takeoff end thereof, through the pivots **58** and **60**, respectively; and are pivotally mounted at the other end on the supports **62** and **64**. The pivot mounting on the support **62** is shown at **66**. The arms **54** and **56** permit the lowering or raising of the primary slide **20** and thus make it possible to control the amount of liquid in the dip of the primary slide.

From the primary slide **20** the tow **10** passes continuously to an adjustable secondary slide **38** having a bottom wall **40** and side walls, one of which is shown at **42**. The secondary slide is pivotally mounted at the take-off end of the primary slide **20**, and is adjustably attached at the side walls thereof by means of the slotted arms **44** and **46** and corresponding set screws (one of which is shown at **48**) to the side walls **24** and **26** of the primary slide.

The adjustable secondary slide **38** permits adjustment of the frictional drag on the continuously moving tow **10** which, in turn, controls the point, shown at **50**, at which the tow changes from a folded form (so-called "block" form) to its normal or flat tow form.

From the foregoing it will be seen that the wetted, open, primary slide holds the tow in its crimped form while being quenched without exerting material (i.e., objectionable) back pressure on the stuffing box of the crimper. (Additional or excessive back pressure is undesirable since it can lead to too high a crimp and/or require an excessive force to feed the tow into the crimper.) In addition, the sloping, wetted slides, more particularly the dip in the bottom wall of the primary slide, allows the attainment of an appreciable residence time with advantages that will be readily appreciated by those skilled in the art. Furthermore, the construction and arrangement of the primary and secondary slides with respect to each other provides a residence time that can be easily adjusted as desired or as conditions may require.

The cap **52**, mounted as shown at the end of the primary slide and over the receiving end of the secondary slide, is advantageously employed to prevent the overflow of tow at the end of the primary slide.

The tow leaving the exit end of the adjustable secondary slide **38** is limited in its forward, and guided in its downward, motion by the lower portion of the discharge slide or guide **36**. From the secondary slide **38** and/or the discharge slide or guide **36** the tow passes to the next operating step of the process, e.g., through the J-box **68** wherein it may be suitably treated to improve its useful properties, e.g., with water at a temperature of 98° C. to 99.9° C.

Although not limited thereto, our invention is particularly applicable to the processing of a mechanically hot-crimped tow of filamentary material comprised of a polymer of acrylonitrile. The filamentary material may be formed of a homopolymer or of a copolymer of acrylonitrile. We may use, for example, a tow of filamentary

material comprised of, for instance, a copolymer of about 95% by weight of acrylonitrile and about 5% by weight of methyl acrylate; or 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

$$\begin{array}{l} | \quad | \\ CH_2-CH-CN \end{array}$$

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 $CH_2=C<$ 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 and other hydrocarbon-substituted acrylonitriles; unsaturated aliphatic hydrocarbons containing a single $CH_2=C<$ grouping, e.g., isobutylene, etc.; and numerous other vinyl, acrylic and other compounds containing a single $CH_2=C<$ 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, Sonnino Patent No. 2,849,751, dated September 2, 1958.

From the foregoing it will be seen that the present invention involves certain new and useful apparatus features constituting improvements in apparatus for producing a tow of filamentary material wherein the said tow has been hot-crimped mechanically. The method features comprise causing the crimped tow, after it leaves the exit end of the tow crimper, to move continuously over a wetted surface; maintaining said surface in a wetted condition while the aforesaid tow is continuously passing over it; and controlling the frictional drag on the continuously moving tow thereby to control the point at which the said tow changes from a folded or so-called "block" form to its normal tow form. In the preferred embodiment the hot, continuously moving tow is quenched with a cooling liquid, e.g., an aqueous cooling liquid such as one that contains an antistatic agent, shortly after it leaves the exit end of the tow crimper.

Specifically, the invention makes feasible a method wherein the tow of filamentary material is maintained, while being quenched, in the form of folds of crimped tow without exerting material back pressure on the stuffing box of the tow crimper. In other words, the invention makes it possible to prevent back pressure, while the tow is being quenched, on the stuffing box of the tow crimper that would materially affect the uniformity of operation of the tow crimper.

The invention also provides compact (i.e., requires no large floor areas), relatively inexpensive apparatus that is simple to construct and whereby the foregoing method improvements in the processing of a hot-crimped tow of filamentary material can be effected.

Another advantage of the invention is the fact that its use obviates or minimizes filament entanglement, knotting, etc., that occur or tend to occur if a continuously moving, hot-crimped 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 method features of the invention are claimed in our divisional application Serial No. 72,243, filed November 28, 1960.

We claim:

1. Tow-quenching apparatus comprising means for applying a quenching liquid to a tow of filamentary material; a primary slide provided with side walls and having in the bottom wall thereof a dip into which excess liquid from the wetted tow falls and drains, thereby, in conjunction with the wetness of the tow, keeping the slide wetted as the tow passes over the said slide; means for controlling the amount of quenching liquid in the said dip in the said bottom wall of the said primary slide; and an adjustable secondary slide having a receiving end and a discharge end, which slide, in operation, is contacted by the said wetted tow of filamentary material and which is in operative relationship with the said primary slide and whereby the frictional drag on the tow in the primary slide can be adjusted to control the point in the primary slide at which, during operation of the apparatus, the tow changes from a folded form to its normal tow form.

2. Apparatus as in claim 1 which additionally includes a cap for preventing overflow of tow at the end of the primary slide, the said cap and the primary and secondary slides being so arranged with respect to each other that the tow is permitted, during operation, to move from the primary slide to the secondary slide.

3. Tow-quenching apparatus adjacent a tow crimper having a stuffing box, said apparatus comprising means adjacent said tow crimper for applying a quenching liquid to the tow of filamentary material leaving the exit end of the said crimper during operation of the apparatus; a shelf adjacent the exit end of the said tow crimper for conveying tow from the tow crimper to the forward end of a primary slide, said shelf being so constructed and positioned that said quenching liquid is prevented from entering the stuffing box of the tow crimper and said

primary slide being provided with side walls and having in the bottom wall thereof a dip into which excess liquid from the wetted tow falls and drains, thereby, in conjunction with the wetness of the tow, keeping the slide wetted as the tow passes over the said slide; adjustable means including arms attached to the side walls of said primary slide for controlling the amount of quenching liquid in the said dip in the said bottom wall of the said primary slide, said arms permitting the lowering or raising of the said primary slide and thus making it possible to control the amount of liquid in the dip of the primary slide; and an adjustable secondary slide having a receiving end and a discharge end, which slide, in operation, is contacted by the said wetted tow of filamentary material and which is in operative relationship with the said primary slide and whereby the frictional drag on the tow in the primary slide can be adjusted to control the point in the primary slide at which, during operation of the apparatus, the tow changes from a folded form to its normal tow form.

4. Apparatus as in claim 3 which additionally includes a cap for preventing overflow of tow at the end of the primary slide, the said cap and the primary and secondary slides being so arranged with respect to each other that the tow is permitted, during operation, to move from the primary slide to the secondary slide.

5. Apparatus as in claim 3 which additionally includes

a discharge slide beneath the said shelf and which is adapted to direct the passage of the tow leaving the discharge end of the said secondary slide to the next step of the operation.

6. Apparatus as in claim 3 which additionally includes a cap for preventing overflow of tow at the end of the primary slide, the said cap and the primary and secondary slides being so arranged with respect to each other that the tow is permitted, during operation, to move from the primary slide to the secondary slide; and, also, a discharge slide beneath the said shelf and which is adapted to direct the passage of the tow leaving the take-off end of the said secondary slide to the next step of the operation.

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