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APPARATUS FOR ANNEALING FILAMENTARY TOW

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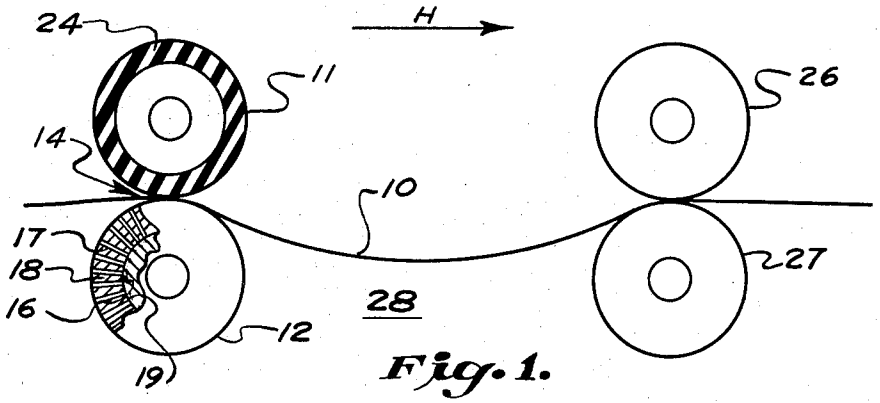

Fig. 1.

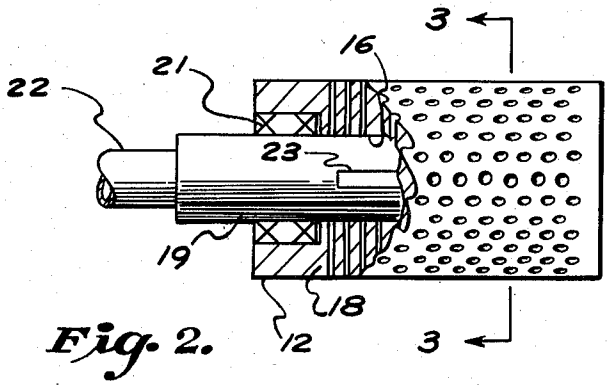

Fig. 2.

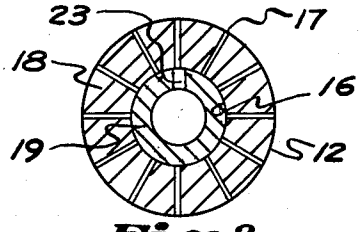

Fig. 3.

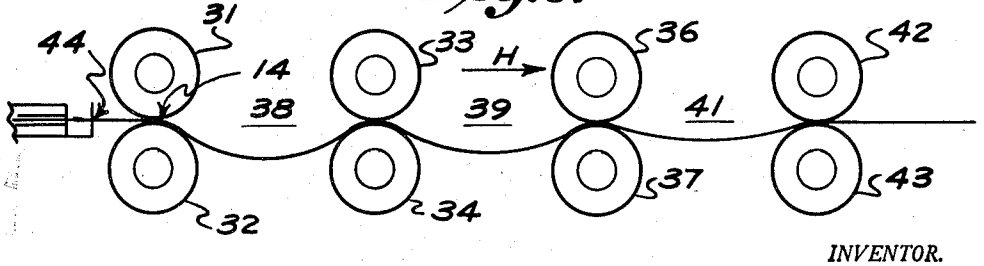

Fig. 4.

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APPARATUS FOR ANNEALING FILAMENTARY TOW

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1 Claim. (Cl. 18—1)

This invention relates to an apparatus for annealing filamentary material and more particularly to a method and apparatus for heat-relaxing or relieving the internal strains in filamentary material for instance, textile filaments or fibers formed from synthetic material, such as acrylonitrile polymers or the like.

In the production of fibers or filaments and in particular continuous synthetic filaments of the type which may be formed from acrylonitrile polymers or the like, the freshly formed filaments produced by the spinning operation are subjected to an orientation treatment such as heat-stretching or the like. This orientation treatment aligns the filament molecules in the direction of the filament axis and alters the physical characteristics of the filaments in many ways including the vital feature of increasing the tensile strength of the filaments to the degree necessary to permit commercial use. However, this heat-stretching operation also leaves the filaments in an internally strained condition and if this strained condition is not relieved fibrillation will result, that is, the splitting off from the filaments of longitudinal sections or fibrils of material during the application of stress usually in the form of abrasion. In addition, the stretched filaments have a high residual shrinkage capacity and tend to shrink on subsequent heating at elevated temperatures. Furthermore, as a result of the stretching operation, the filament extensibility is decreased limiting its use in such textile operations as knitting and weaving where a high extensibility is desired.

It has been proposed in the past to overcome or reduce these undesirable physical characteristics inherent in stretched filaments by heating the internally strained filaments while in a relaxed condition so that the strains are relieved. By this heat-relaxing treatment, filament quality is materially improved as this operation reduces or substantially eliminates fibrillation and extensibility is increased. In the past, many arrangements have been proposed for subjecting filaments to this heat-relaxing or annealing treatment. For instance, it has been suggested that annealing of filamentary material can be accomplished by placing large batches of material in suitable containers. The containers can then be placed in autoclaves or similar chambers so that the material can be subjected to a heating medium such as steam. Thus, the material is elevated to the desired annealing temperature while in a relaxed state in the container.

While this method of annealing filamentary material gives generally satisfactory results, it may be desirable to produce an end product which is devoid of coloration or what may be classified as a substantially white material. It is well known that filaments formed from acrylic material such as acrylonitrile polymers tend to take on a yellow hue when subjected to elevated temperatures over an extended period of time. This so-called "batch type" of annealing process is not therefore well adapted for producing such an end product as the large mass of filaments cools slowly and therefore remains in a heated state for longer periods than necessary for annealing

purposes. As a result of such prolonged heating, the filaments tend to discolor to such an extent that the white end product is difficult to obtain.

Furthermore, it is well known that in the production of synthetic filamentary material, modern day requirements of economy dictate a smooth continuous flow in the preparation and processing of materials so that the end product can be obtained with a minimum of operations involved and time expended. Interruption of the smooth flow in a production line, by operations where the handling of material and the expenditure of time is considerable, is costly and reduces the output below that which could otherwise be obtained.

In textile operations such as "batch type" annealing, stacking and removal of filamentary material from the container involves additional steps which are time consuming. Also, in many cases an additional step in the annealing operation is desirable which involves crimping a tow of filamentary material prior to placing it in the annealing containers as the stacking of uncrimped tow in the container often results in considerable filament entanglement which renders removal of the annealed tow in a continuous separated form from the container a difficult operation.

Accordingly, a primary object of this invention is to provide a new and novel apparatus for heat-relaxing or annealing internally strained filamentary material.

Another object of this invention is to provide a new and novel apparatus for annealing filamentary material such as textile filaments formed from acrylonitrile polymers and the like which reduces or substantially eliminates the tendency of the filaments to discolor and consequenlty produces a relatively white, annealed textile product.

A further object of this invention is to provide a new and novel apparatus for annealing filamentary material such as a tow of synthetic filaments formed from acrylonitrile polymers and the like which operates in a highly efficient continuous manner on a tow of indefinite length.

Still another object of this invention is to provide apparatus for annealing synthetic filamentary material such as that formed from acrylonitrile polymers and the like which is simple and inexpensive in operation, which permits the rapid annealing of uncrimped filamentary tow, and which permits the tow to be packaged directly in tow form with virtually no filament entanglement.

Another object of this invention is to provide a new and improved apparatus for heat-relaxing or annealing of heat-stretched filamentary material.

A still further object of this invention is to provide a new and improved apparatus for annealing filamentary material which momentarily subjects successive portions of the material to a heating medium in accurately controlled quantities and which permits a predetermined degree of annealing to be easily carried out.

This invention further contemplates the provision of a new and novel apparatus for producing filaments formed from acrylonitrile polymers and the like which have a controlled residual shrinkage capacity and improved textile processing characteristics.

Other objects and advantages of the invention will become apparent from the following description taken in connection with the accompanying drawing.

In general, the objects of the invention are accomplished by providing a continuous rope or tow of filamentary material such as material formed from acrylonitrile polymers and the like. The tow is directed into means for advancing the tow such as a pair of cooperating processing rolls, one of which continuously subjects the tow to a heating medium as it passes between the nip of the rolls and thereby raises the tow to a predetermined annealing temperautre. A second pair of rolls, which

may be conventional take-up rolls, is arranged in spaced relationship with the first pair of processing rolls so that the heated tow moves into the take-up rolls and is discharged therefrom. The take-up rolls are preferably rotated at a somewhat slower speed than the processing rolls so that the tow is suspended therebetween in a drooping or relaxed condition within what may be defined as a relaxing area. Thus, the tow moving through the pairs of rolls is successively heated and then permitted to relax, relieving the strained filaments and producing an annealed tow. Although one pair of processing rolls and one pair of take-up rolls may be sufficient for annealing the tow to the required degree, additional processing rolls may be provided through which the tow passes successively so that additional relaxing areas are provided between adjacent pairs of rolls in order to obtain the degree of annealing desired.

The novel features which are believed to be characteristic of the invention are set forth with particularity in the appended claim. The invention itself, however, both as to its organization and method of operation may be best understood by reference to the following description taken in conjunction with the accompanying drawing in which:

Figure 1 is a diagrammatic side view of the annealing apparatus of the invention;

Figure 2 is a longitudinal view partially in section of the heating roll of the apparatus of Figure 1;

Figure 3 is a sectional view taken substantially along line 3—3 of Figure 2 in the direction of the arrows; and

Figure 4 is a diagrammatic side view of a modification of the invention.

Referring now to the drawing, there is shown in Figure 1 an embodiment of the invention for heat-relaxing or "annealing" a strip or tow of material. In the specific embodiment illustrated, the material comprises an elongated bundle or tow **10** containing a plurality of fibers or continuous filaments. It should be understood, however, that although the tow may be of any fibrous or filamentary material it preferably consists of continuous filaments formed from a synthetic material such as acrylonitrile polymers or the like.

As is well known, synthetic filaments of the acrylic type are usually oriented following their formation, such as by stretching, to impart certain desirable qualities to the filaments, such as increasing their tensile strength. This stretching leaves the filaments in an internally strained condition with such undesirable qualities as a high residual shrinkage capacity and increased fibrillation. The stretched filaments therefore must be heat-relaxed or annealed to relieve these internal strains or stresses and novel means have been provided in this invention for performing a heat-relaxing operation on a filamentary tow of such acrylic material.

As specifically illustrative of the invention, advancing means are provided as shown in Figure 1, such as a pair of processing rolls designated generally by the numerals **11, 12,** which are arranged in cooperating relationship to move filamentary material such as the tow **10** in the direction of arrow H. The tow preferably comprises a bundle of continuous filaments formed from acrylic material by any conventional spinning operation. The rolls **11, 12** are driven in opposite directions by any suitable means (not shown) so as to move the tow **10** continuously at a uniform rate of speed.

In order to raise the tow **10** to a predetermined annealing temperature, means have been provided in the lower roll **12** for directing a heating medium into the tow as it moves through the nip of the rolls designated generally by the numeral **14**. More specifically, the lower roll **12** contains a central bore **16**, as shown best in Figures 2, 3, and a plurality of radial ports or passages **17** in its peripheral wall **18**. The ports **17** are preferably arranged in a plurality of circumferentially spaced rows in the roll wall **18** and adjacent rows are positioned in staggered relationship as shown in Figure 2.

A stationary cylindrical tube or tank **19** is centrally positioned within the roll bore **16** by means such as bearings **21** and is arranged to be supplied with a heating medium such as steam through a pipe or conduit **22** connected to a suitable source (not shown). A longitudinal slot **23** is provided within the wall of the tank **19** in a plane defined by the axes of the rolls **11** and **12** and is arranged to communicate with the spaced ports **17** in each row or rows successively as the roll **12** is rotated. The tank **19** is preferably constructed so as to provide a relatively close fit between its outer peripheral wall and the bore **16** of the roll **12**. Thus the heating medium will flow substantially through only the ports presented to the slot **23**. It will be noted that in the specific embodiment illustrated the tank **19** is positioned so that the slot **23** communicates with a single row of ports **17** only when the outer or outlet end of the ports are in substantial alignment with the nip **14** of the rolls **11, 12** and the remaining ports are closed by the peripheral wall of the tank **19**. Furthermore, it should be understood that slots or the like may be employed instead of ports or the ports may be arranged in any desired pattern without departing from the spirit of the invention.

Although any desired spacing may be employed for the ports **17**, it has been found in practice that a spacing of approximately 0.25 inch between ports in each row and approximately 2 degrees between rows has given satisfactory performance.

In order to confine the heating medium in the tow, the upper roll **11**, which is preferably formed of steel or the like, is provided with the layer **24** of resilient material such as neoprene rubber or the like secured in any suitable manner to its outer periphery (Figure 1). The resilient layer **24** is arranged to resiliently engage the tow **10** as it moves through the nip **14** and confine the heating medium flowing out of ports **17** into the tow. This assists in raising the tow to the desired annealing temperature rapidly as successive portions of the tow are exposed to the heating medium for only a relatively short period of time.

In order to take up the tow **10** moving out of rolls **11, 12,** means such as a pair of take-up rolls **26, 27** are positioned in spaced relationship with the processing rolls **11, 12** and engage the tow **10** in the conventional manner as shown so as to continuously take up the tow as it advances in the direction of the arrow H. The rolls **26, 27** may be of any suitable construction.

Means have also been provided to relax the tow **10** heated in the rolls **11, 12.** More specifically, the reach of the tow **10** between the processing rolls **11, 12** and the take-up rolls **26, 27** is of such length as to provide a relaxing area designated generally by the numeral **28** which permits the internal strains within the tow to be substantially relieved. It can be seen by reference to Figure 1 that the tow is suspended between the processing and take-up rolls in a sagging or drooping condition so that successive portions of the tow heated within the processing rolls **11, 12** may relax freely in the area **28**. In one example of the operation of the apparatus of Figure 1, it has been found that satisfactory annealing is obtained when successive portions of the tow are subjected to steam for approximately 0.1 of a second at a temperature within the range of 130° to 150° C. The take-up rolls **26, 27** are consequently driven at a relatively slower speed than the processing rolls **11, 12** in order to compensate for the shrinkage in the tow **10** occurring in the relaxing area **28**.

In the practice of the invention with the novel apparatus shown in Figure 1, the filamentary tow **10** which has been previously placed in a strained condition such as by a stretching operation moves into the processing rolls **11, 12.** As steam is constantly fed from the tank slot **23** to successive rows or ports **17** in the lower roll

12 as the ports move into alignment therewith, steam is continuously ejected into the tow from the outlet end of the ports at substantially the nip 14 of the rolls. The resilient layer 24 on the upper roll 11 assists in sealing or confining this ejected steam in the tow and successive portions of tow, as it moves in the direction of arrow H, are brought to a temperature (130° to 150° C.) at which they assume a plastic or drawable consistency. The heated tow then moves into the relaxing area 28 between the processing rolls 11, 12 and the take-up rolls 26, 27 wherein it is permitted to relax in a suspended condition and substantially eliminate the internal strain induced in the tow filaments during the previous stretching operation. Some shrinkage of the tow will occur in the relaxing area and the take-up rolls should therefore be rotated at a relatively slower speed than the processing rolls. The annealed tow then moves through the take-up rolls 26, 27 to a suitable collection point at which it may be baled or otherwise treated.

In many cases it is sufficient to provide only a single relaxing area 28 in order to obtain the desired amount of strain relief. However, in some cases it may be desirable to provide more than one relaxing area. In these cases, additional processing rolls may therefore be provided between which relaxing areas are located. With this arrangement, the tow 10 is heated successively by a plurality of processing rolls shown in the embodiment of Figure 4 as three pairs of processing rolls 31, 32; 33, 34; 36, 37 each substantially identical in construction and operation to the processing rolls 11, 12 of Figure 1.

Three successive relaxing areas 38, 39 and 41 are therefore provided each of which are operatively identified with a pair of processing rolls and when the tow leaves the last relaxing area 41 it is taken up by a pair of take-up rolls 42, 43 as shown in the embodiment of Figure 1. It should be understood that in each of the relaxing areas 38, 39, 41 strain relief of the tow 10 is obtained and as many pairs of processing rolls may be employed as desired to provide the necessary number of relaxing areas for bringing the tow to the desired final state. It will be noted in the modification of Figure 4 that the amount of sag in the tow reach in each of the relaxing areas 38, 39, 41 decreases as the tow is processed. The droop of the tow can be reduced in the later stages by reducing the speed differential between adjacent pairs of rolls as the amount of relaxation required for each subsequent annealing step decreases during the progress of the tow through the apparatus of Figure 1.

It can be seen that the apparatus disclosed in Figures 1–4 is particularly adaptable to a continuous type of tow processing operation which constitutes one of the desirable features of the invention. In a textile filament producing operation the apparatus of the invention would be located directly after the filament stretching devices to give a smooth flow of work. Often, however, it may be desirable to raise the temperature of the tow 10 prior to the annealing operation or prior to its movement into the processing rolls of Figures 1 and 4 in order to insure that the tow reaches the proper annealing temperature. Means, therefore, may be provided for preliminary heating of the tow such as a steam conditioner designated generally by the numeral 44 and shown diagrammatically by Figure 4. In the arrangement shown the tow is carried through the steam conditioner after leaving the stretching devices (not shown) and before entering the processing rolls so that the temperature of the tow is initially raised with the addition of moisture thereto by means of the steam.

One of the outstanding features of this invention is the relatively short period of time at which the tow is held at the annealing temperature. Heat is applied to the tow only momentarily at the nip of the processing rolls and is permitted to cool rapidly in the relaxing area. As is well known, this means that a whiter product is obtained, considerably enhancing its value as the filaments are not permitted to acquire the characteristic yellow hue common to acrylic material when it has been subjected to sustained periods of heat application. Another outstanding feature of the invention is its simplicity of construction and operation which enables uncrimped tow to be processed at a high speed without interrupting the flow of work in a production line. No complicated or expensive apparatus is required and the directing of steam into the tow is accomplished in a simple manner. Furthermore, by means of the novel construction of the invention, the annealing operation may be accomplished in a plurality of successive annealing steps so that complete strain relief of the filaments may be obtained and the residual shrinkage capacity of the fibers is thereby reduced to an absolute minimum.

While there has been described what at present is considered to be the preferred embodiment of the invention, it will be understood by those skilled in the art that various changes and modifications may be made therein without departing from the invention and therefore it is the aim of the appended claim to cover all such changes and modifications as fall within the true spirit and scope of the invention.

Having thus described the invention, what is claimed is:

An apparatus for annealing a tow of filamentary material, comprising a first roll having a central bore and a plurality of longitudinal rows of ports extending radially from the bore outward through the roll, a second roll engaging the first roll, said rolls being adapted for rotation to advance a tow therebetween, and a stationary cylindrical tank positioned in the bore in the first roll for containing a heating medium and having a longitudinal slot lying in a plane defined by the axes of the rolls so as to direct said heating medium into the longitudinal row of ports leading to the nip of the rolls for heating the tow, said second roll having therearound a layer of resilient material adapted to cooperate with the first roll to prevent escape of the heating medium from the tow.

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