United States Patent [19]

Yazawa

[11] **3,763,527**

[45] **Oct. 9, 1973**

[54] **PROCESS FOR PRODUCING CRIMPED FIBERS BY CONTINUOUS WET HEAT SETTING AND APPARATUS THEREFOR**

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[73] Assignee: **Polymer Processing Research Institute, Ltd.,** Tokyo, Japan

[22] Filed: **Nov. 24, 1971**

[21] Appl. No.: **201,944**

[30] **Foreign Application Priority Data**

Nov. 25, 1970 Japan 45/104328

[52] **U.S. Cl.** **28/1.6,** 28/72.14

[51] **Int. Cl.** **D02g 1/12**

[58] **Field of Search** 28/1.6, 1.7, 72.14

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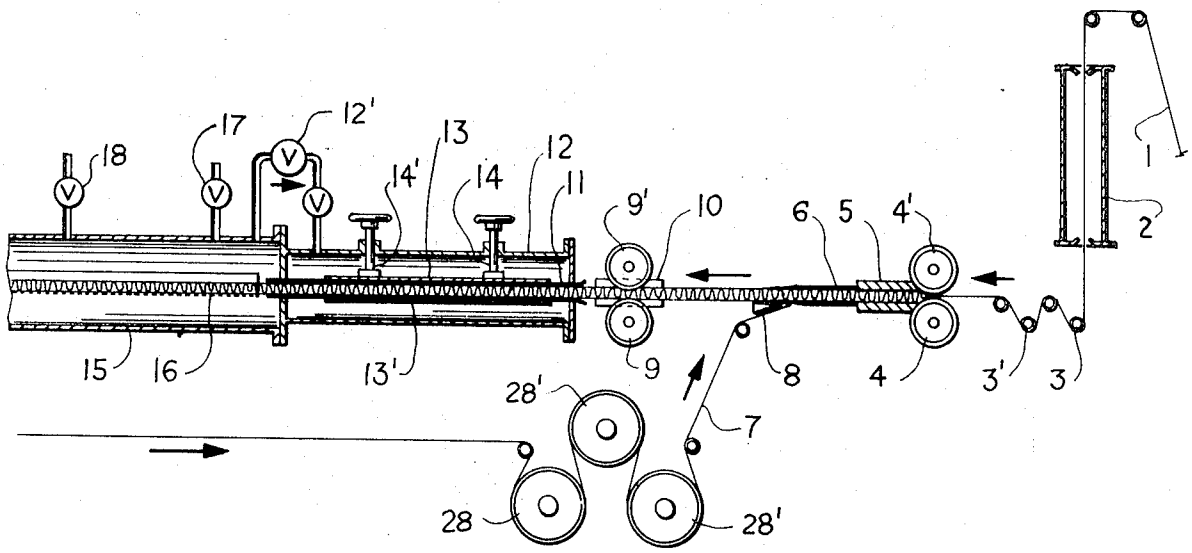
Primary Examiner—Louis K. Rimrodt

Attorney—James E. Armstrong et al.

[57] **ABSTRACT**

A process and an apparatus for setting fiber crimps by wet heat in which a crimped fiber cake having a rectangular cross section, discharged from the exit opening of a stuffing crimper, is wrapped with at least one cloth belt, and passed through a high temperature pressurized steam chamber above 100°C, while the fiber cake is maintained in substantially the same shape as it was discharged from the crimper exit opening.

15 Claims, 7 Drawing Figures



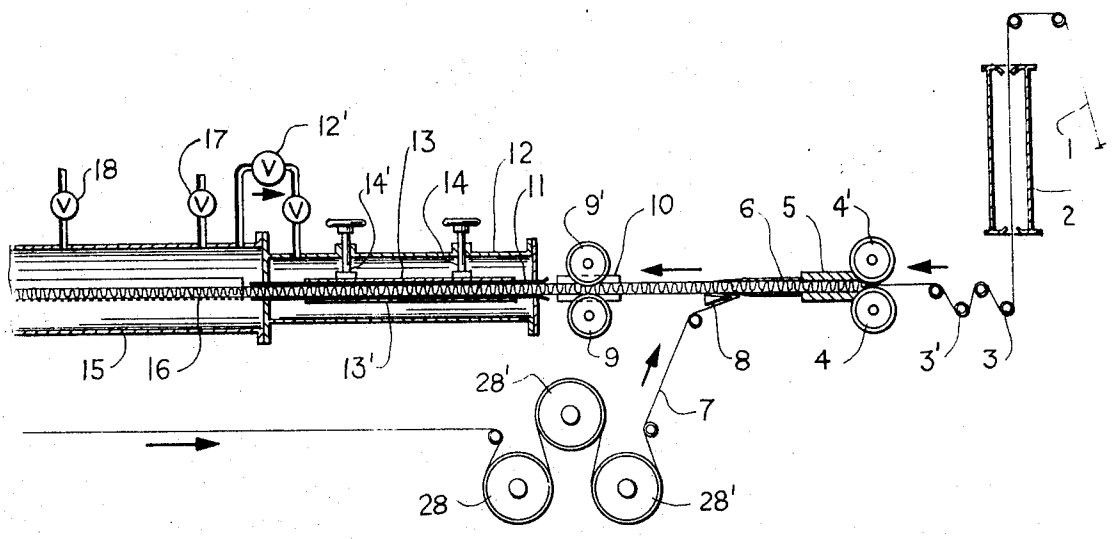

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FIG. 1

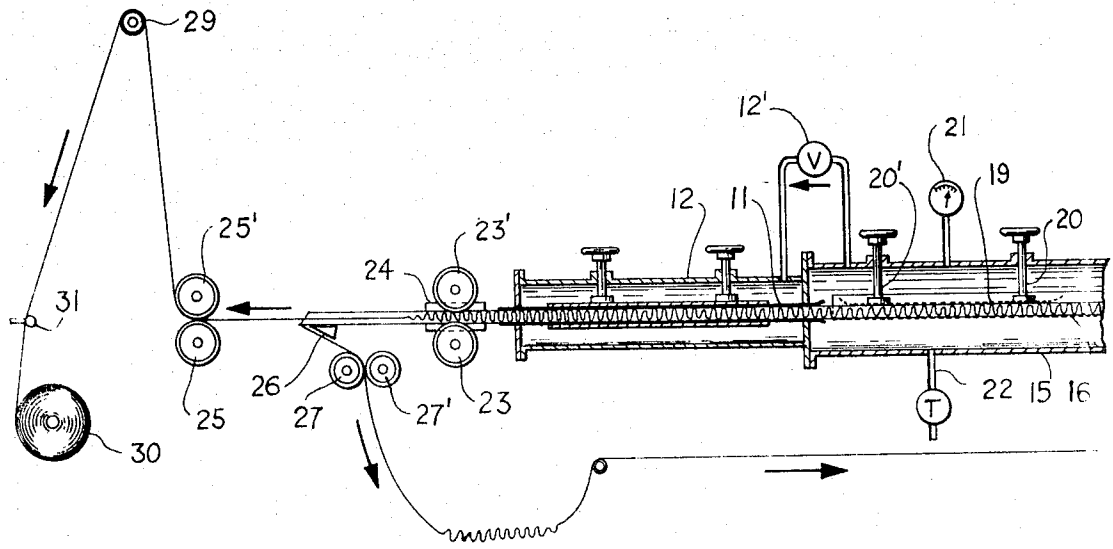
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FIG. 2

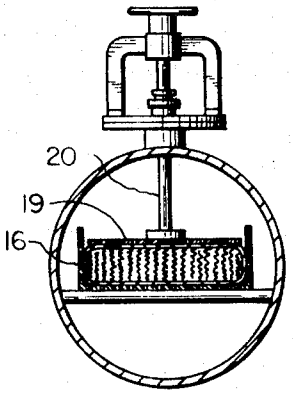

FIG. 3

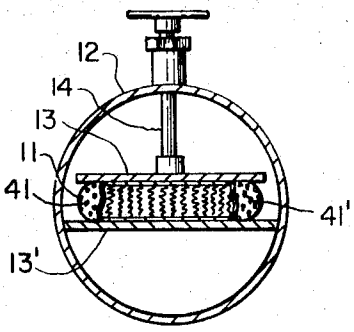

FIG. 4

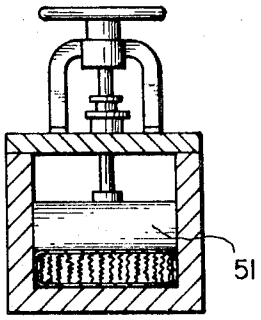

FIG. 5

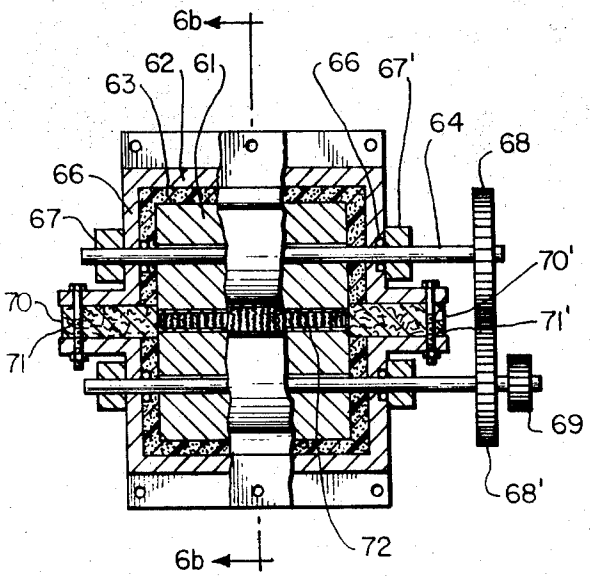

FIG. 6a

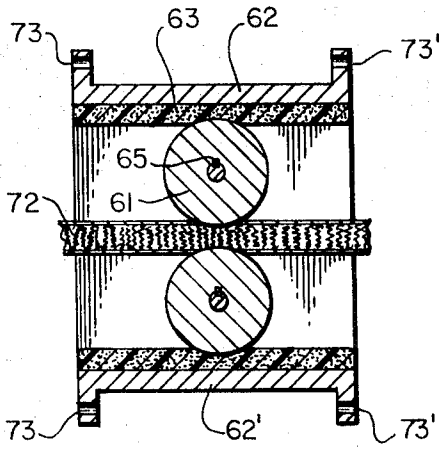

FIG. 6b

PROCESS FOR PRODUCING CRIMPED FIBERS BY CONTINUOUS WET HEAT SETTING AND APPARATUS THEREFOR

CROSS-REFERENCE TO RELATED APPLICATION

The present invention represents an improvement on the process described in U.S. Pat. No. 3,667,094.

BACKGROUND OF THE INVENTION

Conventionally, in crimping filament yarn by the stuffing method, a dry heat setting method of a single, individual filament has been used. By this method, however, those defects such as unevenness in yarn quality and in dyeing have not been avoided. Further, the wet heat treatment for crimping a filament tow by stuffing is carried out at a temperature up to 100°C, and therefore the crimps are not stabilized sufficiently; the crimps, when straightened mechanically, do not appreciably recover even by heating. Thus, saturated pressurized steam heat setting has been required. However, there has not been a proper method of continuously passing the crimped tow through a pressurized steam chamber while maintaining the tow in a crimped state. Accordingly, at present, the pressurized steam setting is acutally performed in a batch operation by repeated processing steps of evacuation and introduction of pressurized steam.

SUMMARY

This invention provides a process and an apparatus for producing crimped fibers by continuous wet heat setting in which parallel fibers, such as a filament tow, slivers in a spinning process or filament yarns in the form of a crimped fiber cake discharged from a stuffing crimper exit opening or a joint tube joined thereto and having nearly the same cross sectional opening as that of the crimper exit are wrapped with a cloth belt traveling at a speed substantially equal to or slightly faster than that of the cake pushed out of the said exit, to the extent of more than one time. The fiber cake thus wrapped is passed through a passage and pinch rollers while maintaining the cake in a constant width. Under the tension of the cloth belt the cake is then introduced through an inlet side pressure sealing means into a high temperature pressurized chamber and is passed through an easily steam-permeable straight guide passage provided in the chamber; if necessary after being heated therein the wrapped cake is pressed in the direction of its thickness to set the crimps at acute angles. Thereafter the cake is drawn out successively through an outlet side pressure-sealing means and a passage provided in the open air to maintain the cake in a constant width and thickness by pinch rollers; immediately after passing through the pinch rollers the fibers are taken up at a high speed sufficient to straighten the folds of the cake, while at the same time the cloth belt is peeled off and returned to the inlet side for recycling and reuse.

Also, a special feature of this invention consists in that, particularly in processing a large number of filament yarns arranged in parallel at one time, the division of the filament yarns into single, separate yarns in the final processing step of this invention is markedly facilitated because no disorder of the yarns due to the deformation of the side ends of the cake takes place. This results from the above-mentioned process in which the crimped cake pushed out of the stuffing crimper exit opening is wrapped with cloth and the width of the cake is maintained substantially the same throughout the whole process under the tension of the cloth.

DETAILED DESCRIPTION OF THE INVENTION

According to the process of my copending application, Ser. No. 40,795, now U.S. Patent 3,667,094, when a crimped tow is passed through a pressure-sealing means with the tow being wrapped to the extent of more than one time by one or two sheets, upside and downside, of cloth, the tow can be passed through the pressurized steam chamber with the remaining crimps unstraightened. However, even by this method, the crimped tow pushed out of the stuffing crimper exit opening drops intermittently at irregular speeds, and the wrapping of the tow in a substantially uniform thickness remains a problem. As a solution for this, I have discovered a method in which the crimped tow (for example 700,000 to 800,000 deniers in thickness after crimping an original tow of 500,000 deniers) falling from the stuffing tube is raised up and swung down in the middle part of the cloth, and after being wrapped by the cloth it is passed through a pressurized steam chamber in which the wrapped tow is passed over curved surfaces; at this time a lateral pressure is exerted toward the center axis of the curvature, which is developed by an excess tension of the outside cloth due to the difference of the lengths of travel between the part moving in contact with the curved surface and the part moving at the outside of the curved surface. By this pressure the angles of the crimps are made acute and the crimps are set. My further study showed that such intermittent, uneven falling of the crimped tow takes place when the crimped tow pushed out of the crimper exit opening is allowed to fall spontaneously, and this is caused by uneven fiber density in the direction of the width of the supplied tow; the higher density part has larger frictional resistance when moving through the stuffing crimper and this results in uneven drawing speed upon the spontaneous falling. On the other hand, by using a stuffing box longer than that generally used or by using a joint guide conduit, joined thereto and having a rectangular cross section, the conduit being 30 to 50 cm in length and having nearly the same opening cross-section or one 5 to 15 percent greater in thickness, the speed of the cake pushed out of the outlet is substantially constant. The reason for this is as follows: The fibers pressed in the stuffing box tend to move in the direction of parts having lower density in the course of longer passage through the box and thus the density is made uniform. Since the supply of the fibers per unit time is constant and the volume of the stuffing box and the joint guide conduit are constant, if the volume of the stuffing box is large enough with a constant width and height of the box, the length of which is selected to be sufficiently long, the crimped cake should naturally be discharged at a substantially constant speed. Thus, it was found that the unstabilized pushing out or extrusion speed of the cake is caused by a force exerted on the outlet to draw out the cake, for example by the force of spontaneous falling of the cake. Accordingly, it was confirmed by experiment that if the cake is received in the middle part of the wrapping cloth as it is pushed out, and wrapped for example with cloth to the extent of one and a half times by using a guide device, the cake can be wrapped in a constant thickness. Although the cake is in a compressed state

in the stuffing box, at the same time as it is pushed out, it expands to some extent by the resilience of the crimps and therefore the discharge speed of the cake is increased to a slight degree. If the cloth travels at a faster speed than that speed, the cake will be stretched, and for the above-mentioned reason, difference will take place in the ratio of being stretched every moment, thus forming a cake of uneven thickness. This will give rise to a disadvantage upon passing the cake through the pressure-sealing means of the pressurized steam chamber. It is, therefore, an important feature of this invention that the running speed of the wrapping cloth is substantially equal to the speed of the cake which is pushed out of the stuffing box or the succeeding rectangular joint guide having nearly the same cross-sectional area of the opening, or slightly faster than that speed taking into consideration the natural expansion of the bends of crimp.

In the case of high fiber density in the stuffing tube, for example when the bottom doctor plate of the stuffing box having a rectangular section is raised by pressurized air to cause high lateral pressure, the crimps will be made acute and dense. In such a case the fiber density of the cake will reach in excess of 0.4, and therefore when the fibers are wrapped with cloth while being maintained in that density and introduced into the pressurized steam chamber, a considerable length of time will be required for steam penetration. However, even in that case, by using a rectangular joint guide conduit having a little larger sectional area than that of the stuffing tube, the cake supplied to the joint guide conduit will expand and the cake will be discharged from its terminal end with a lower fiber density and at a constant speed. With too wide an opening in section, however, the discharge speed tends to be unstabilized. Accordingly, it is necessary to lower the bottom doctor plate pressure to prevent excessive crimping when a longer stuffing tube is used for facilitating the wrapping procedure of the cake, or to lower the fiber density by joining a joint guide conduit having an opening of a little larger cross sectional area after a stuffing box of strong bottom pressure in consideration of the natural expansion of the bends of crimp. Of course, so far as the cake is pushed out at a constant speed, the lower the fiber density of the cake is, the faster and the more uniformly the pressurized steam penetrates. This means is adopted as required.

When an acrylic fiber tow of, for example 500,000 denier is introduced into a stuffing crimper equipped with rollers having a diameter of 150 mm and a width of 110 mm, and a stuffing box having a width of 110 mm and a height of about 20 mm, a cake of an apparent thickness of 10,000,000 d. (denier) will be pushed out in the usual way of operation. When this cake is introduced into a joint guide conduit with the same width and a height of 24 mm, a 8,000,000 denier cake will be pushed out at a constant speed. In any event, the pushing-out speed of the cake is from one fifteenth to one twentieth of the supply speed of the tow. Also, when 300 parallel yarns of each 100 d. are supplied to a crimper having rollers, 80 mm in width and 150 mm in diameter, and a stuffing box 80 mm wide and 8 mm high, the thickness of the pushed out cake will be from 2,400,000 to 3,000,000 d. In this case, the pushing-out speed of the cake is from 1/80 to 1/100 with respect to the supply speed of the yarns. In the case of a larger feed supply of yarns with respect to the unit width of the crimper, or in the case of lower height of the rectangular-sectional stuffing tube, the pushing-out speed of the cake, of course, becomes faster. Also, if the thrusting pressure of the bottom doctor plate is high enough, the crimps will become a compact structure with acute angles, thus slowing down the pushing-out speed of the cake; on the other hand, if the thrusting pressure is lower, the crimps will become coarser with obtuse angles, thus increasing the pushing-out speed. The thrusting pressure is regulated according to the desired properties of the crimps. Although cotton sheeting, rayon cloth (100–150 g/m²), porous oxford cloth, knitted fabric, net, etc. are used as the wrapping cloth because of their good steam permeability, canvas is undesirable for use because of the difficulty in wrapping and its poor steam permeability. For the fiber composing the wrapping cloth, synthetic fibers are not desirable because of their thermoplasticity and tendency to wrinkle; cloth composed of cellulosic fibers having high heat resistance is suitable.

In any event, the fact that the pushing-out speed of the cake from the stuffing box is considerably less than that of the original fiber tow, permits a lower speed of the wrapping cloth relative to the high speed of the feed supply of the fiber, and therefore allows a larger amount of processed fibers relative to the consumed amount of the cloth belt, thus offering economical operational advantages. In the case of a thick cake, however, when the method of my previous invention is used, the cake tends to become thin because the difference between the speed of the part passing in contact with the curved surface and that of the part traveling over the outside in the pressurized chamber tends to become decreased. This causes deformation in the side ends of the cake. Particularly, in the case of yarn, disorder and entanglement of the yarns take place. This makes the operation of dividing into single, separate yarns difficult. Thus, my previous invention was not perfect as a method of producing crimped yarns because in case of applying said method such disadvantages could not be eliminated. In the present invention, however, the rectangular-sectional cake is passed through the whole apparatus including rollers, pressure-sealing means and all the guide passages which are placed substantially in straight or linear arrangement, while the cake is maintained in the width as it was when pushed out of the stuffing box. Thus, neither deformation at the side ends of the cake nor the disorder of the fibers takes place. Accordingly, the method of this invention has much higher practical value in comparison with the previous invention. Since the bent parts of the crimps are in a strained state, if the crimped fibers are allowed to stand completely free when introduced into the pressurized chamber, the crimps will be relieved to recover to the original uncrimped state. In this method, however, since the cake is wrapped in a cloth under tension, there is no danger of the crimps vanishing. The crimps of the wrapped cake can be effectively set at acute angles, particularly when the wrapped cake, while being passed through a guide passage (for example a perforated guide conduit composed of perforated plates or a number of short (-) -shaped walls arranged in series in a close spaced relationship) and heated therein to an elevated temperature, is pressed between the bottom plate of the guide passage and a perforated plate placed on the cake, and the distance between these plates is externally regulated by a regulating

means provided in the air. The same object can be achieved by using, instead of such a conduit, a perforated rectangular-sectional tube having a constant width, but having a backward portion of a suitably lower height when compared with that of the forward portion. Another type of guide passage which can be used contains a number of driving rollers having the same width as that of the initial wrapped cake and horizontally arranged in series in the pressurized steam chamber, free rollers mounted above the driving rollers so as to nip and to press the wrapped cake by their own weight, and sides plates at both side surfaces of each pair of said rollers to prevent the cake from being forced out. This type of guide passage is preferably used when some amount of air is contained in the wrapped cake, since it is effective in replacing air with steam and introducing acute angles to the crimps.

In the previous invention such a compressive force was given to the cake by changing its travelling direction over curved surfaces while in this invention compressive force is applied to the cake by decreasing height of the straight passage of a constant width to introduce acute angles to the crimps and set them. Therefore, this is another feature of this invention. Further, the thin cake in the previous invention was capable of being folded zigzag in parallel longitudinally, while on the other hand the thick cake in this invention does not permit folding after being wrapped in cloth, which folding is unfavorable because it tends to cause disorder in the fibers. This invention is thus improved from the previous invention in that the rectangular-sectional wrapped cake is processed without causing disorder of fibers by maintaining its initial width to the extent possible, and it is a further characteristic of this invention that a pressure-sealing means having a passage of substantially the same width as that of the cake pushed out of the stuffing box is used to achieve the above improvement.

In another previous invention, I have proposed a pressure-sealing means to be provided at the inlet and outlet parts of the pressurized steam chamber, which comprises a flat, thin-walled tube and packing material inserted in the tube along its both sides. When the wrapped cake is passed through the tube, the cross section of the tube is decreased by applying an external pressure or by diminishing the distance between two pinch plates which can be provided as required. At this time irregular vacant spaces which may be developed between the side walls of the tube and the side ends of the wrapped cake are conveniently filled up with packing material which is easily deformed so as to seal the pressure. This sealing means can be used for the pressure-sealing in this invention.

In Japanese Patent No. 420851 (U.S. Pat. No. 3,213,470), I have proposed a method of sealing of high pressure, in which multi-step valves capable of regulating the cross section of the opening thereof are used and between each valve a part of leaked steam is directly released in the air at a constant pressure. The invention described in this patent has been made applicable to the present invention by particularly designing the width of the opening to be the same as that of the wrapped cake. Thus, this is a still further characteristic of this invention.

The wrapped cake, as soon as it is drawn out in the air by pinch rollers after passing through the pressurized steam chamber, is taken up from backward at a speed at which the folds of the crimped fiber cake and a part or the whole of the crimps are straightened by subjecting the fibers to tension. When the wrapping cloth is peeled off under tension, it can be easily taken up separately from the fibers. The wrapping cloth is removed from wrinkles by roller-irons in the course of circulation and is returned to the inlet side for reuse.

It is an important characteristic of this invention that, in applying this invention to the production of a number of crimped textured yarns at one time from several hundred filament yarns arranged in parallel, the crimped cake pushed out of the stuffing box of the crimper is wrapped with cloth and passed through the whole process of the present invention while its width remains intact. If wrapped cake is not maintained in a constant width so that deformation at the side ends of the cake does not occur even under compression in the processing steps including the step of being compressed between the pinch rollers at the inlet side, the step of being compressed in the passage of a decreased height to set the crimps into acute angles (after being passed through the inlet and outlet pressure-sealing means and the rectangular-sectional guide passage in the pressurized tube in which it is heated to an elevated temperature) and the step of being pressed between the pinch rollers at the outlet side, the side ends of the cake will be deformed, which will cause disorder of the traversed fibers. This makes the dividing operation of the yarns into single, separate yarns extremely difficult because of entanglement of the fibers.

It is a characteristic of this invention that, for processing the wrapped cake in a constant width, the widths of all the processing elements throughout the whole process, for example the pinch rollers, pressure-sealing means and their forward and backward adjoining guide passages, and the guide passage in the pressurized steam chamber, must be maintained constant. For example the pinch rollers should have the same width as that of the crimper and should be provided with side plates on both sides so that the cake is pinched over the full width of the rollers to prevent the deformation of the side portions of the cake. In the case of a filament tow or a number of parallel slivers of staple fibers, it is of course desirable that the width of the wrapped cake is maintained constant so that the disorder of the fibers does not occur. However, in the case of the filament tow and slivers, they are not subjected to the dividing operation, or even if divided, the operation is easy. Therefore, the constant-width processing is not an essential condition in this case.

Once a temperature of saturated steam in a pressurized tube is selected at a certain degree, the pressure of said steam is solely fixed at the value shown in a well-known steam table.

Usually, for obtaining excellent products of crimp setting, that is, those of highly stabilized crimps and of good crimp recovery, treatment at the highest possible temperature is desirable up to the point where a permissible decrease in the strength of the fibers resulting from relaxation of the molecular orientation occurs. In practice, however, in consideration of the dyeing and ironing temperature, wet heat treatment at a temperature above 125°C (1.34 kg/cm^2 gauge) brings about satisfactory results of crimp setting for a major part of synthetic fibers. On the other hand, in the case of regenerated cellulose fibers, the crimp setting is not sufficiently stabilized without effecting saturated steam

treatment at a temperature above 180°C, (9.19 kg/cm² gauge) that is at a pressure of about 10 atmospheres.

Suitable temperature ranges of saturated steam heat treatment for crimp-setting of ordinary, commercially available fibers are: 125°–160°C (1.34 – 5.27 kg/cm² gauge) for polyester, 125°–135°C (1.34 –2.09 kg/cm² gauge) for acrylic coplymer, 145°–155°C (3.21 – 4.51 kg/cm² gauge) for acrylonitirile homopolymer, 125–140°C (1.34 – 2.65 kg/cm² gauge) for nylon 6 and nylon 66, 180°C (9.19 kg/cm² gauge) or above for regenerated cellulose, 125°–135°C (1.34 –2.09 kg/cm² gauge) for cellulose acetate, and 105°–115°C (0.20 – 0.70 kg/cm² gauge) for polyvinyl chloride. The higher the treatment temperature is, the higher the stability of crimps is, and at a high temperature the relax-annealing effect of the fibers also can be expected.

In the practice of this invention, if fibers are padded with dyeing solution beforehand and treated with saturated steam at a temperature as high as permissible, crimp-setting and dyeing can be simultaneously accomplished in a short period of time of from one to five minutes; the required time depending on the thickness of the cake. For example, in the case of filament yarns, a number of yarns arranged in parallel and in spaced relationship are uniformly padded with dyeing solution and then dried. They are regularly converged, and are passed through a stuffing crimper. Thereafter, by applying the method of this invention, yarn dyeing and crimp-setting are simultaneously achieved, which therefore offers a considerable advantage.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows the first half of the process of this invention which is carried out in a horizontal, straight-line route.

FIG. **2** shows the second half of the process.

FIG. **3** is a section of the rear part of a steam-permeable, straight guide passage conduit, provided in the saturated steam pressurized chamber, in which a wrapped fiber cake is compressed.

FIG. **4** is a cross section of a pressure-sealing means, provided at both the inlet and outlet ends of the saturated steam pressurized chamber, through which the wrapped cake is passed, comprising a flat, thin-walled tube, two (upper and lower) pinch plates to adjust the opening section of the tube by regulating the distance between them, and packing material consisting of elongated parallel fibers inserted in the tube along its sides.

FIG. **5** is a cross section of a pressure-sealing means of the gate valve type having an opening of the same width as the wrapped cake.

FIGS. ***6a*** and ***6b*** shows cross and longitudinal sections of a pressure-sealing means comprising two (upper and lower) rollers driven at an equal speed which pinch and press the wrapped cake in their entire width, and hermetical sealing walls surrounding the outside of the rollers.

DETAILED DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a sectional view of the apparatus used for carrying out the first half of the process of the invention in which the rectangular-sectional crimped cake pushed out of a stuffing crimper, is wrapped in a cloth belt, and, after passing between pinch rollers and through a pressure-sealing means at the inlet side, is introduced into a pressurized chamber of saturated steam, the apparatus of the second half as shown in FIG. **2** being joined thereto.

Parallel fibers **1**, which comprise a tow, slivers or yarns, after passing through steam chamber **2** at 100°C, and zigzag bars **3,3'**, are introduced between stuffing pinch rollers **4,4'** of a stuffing crimper under tension, and are formed into a flat rectangular-cross-sectional crimped cake in stuffing box **5** and then discharged at a substantially constant speed.

If the box **5** is too short to wrap the cake at its outlet conveniently a joint guide conduit **6** of the same cross section as that of box **5** or of the same width, but slightly greater in height, is additionally joined thereto, so that one or two sheets, upper and lower ones, of wrapping cloth may be guided along periphery of joint guide conduit **6** to wrap the discharged cake at the outlet of guide **6** to the extent of more than one time, in most cases about one and half times.

When the height of guide conduit **6** is greater than that of box **5**, the fiber density of the cake becomes lower in guide conduit **6** than that in box **5**, and therefore the cake is wrapped in the cloth such that the steam can more easily penetrate into the cake. In general, when the rubbing friction in the stuffing box, which is usually regulated by the upward thrusting pressure of the bottom doctor plate of the stuffing box, is greater, the fiber density becomes higher to give more crimps of acute angles, while when the rubbing friction is lesser the fiber density becomes lower to produce more crimps of obtuse angles.

Since stuffing box **5** of the crimper generally in use is too short to guide the wrapping cloth easily, it is necessary to extend its length by joining a joint guide conduit **6** thereto. The bottom plate of this joint guide conduit **6** need not be moved up and down by pressure. That is, if the bottom doctor plate pressure is lowered by as much as the rubbing friction of the cake in joint guide conduit **6**, as a whole, the rubbing friction of the cake becomes the same as that in usual operation, and thereby crimps of an equal degree to that of the usual operation are obtained. Of course, if a longer stuffing box is provided, joint guide conduit **6** is not necessary. In this case, however, without applying a lesser pressure from the pushing up of the bottom doctor plate, the fibers may be damaged by excessive crimping.

The crimped cake, discharged from stuffing box **5** or from joint guide conduit **6** joined as required, is wrapped in FIG. **1** by a sheet of cloth belt which changes its direction of travel at guide **8** for the cloth, to the extent of more than one time, in most cases about one and a half times, and is directed horizontally to the pressurized steam chamber after passing between pinch rollers **9,9'**. If the width of the pinch rollers **9,9'** is made to be the same as that of the rollers **4,4'** of the crimper and side plates **10** are provided on both sides of the rollers so that the wrapped cake is not forced out from the side ends of the rollers, the cake is allowed to proceed while being pinched in a constant width.

When the direction of travel in the air of the wrapped cake must be changed, rollers of a constant width are always used. This is an absolutely essential condition for avoiding the deformation at side ends or portions of the cake and the disorder of fibers in the case of processing a large number of filament yarns arranged in parallel. This is also desirable in processing a filament tow or a number of slivers, but is not an absolutely nec-

essary condition. The reason for this is that, in the case of a tow it is not necessary to divide the fibers one by one after the completion of the processing because the tow may be cut to use as crimpable staple fibers, or may be used as it is in the form of a tow, and in the case of slivers they are composed of a few and comparatively thick slivers and therefore the operation of dividing into single slivers is not so difficult.

The pressure-sealing means as shown in FIG. 1 comprises a flat, thin-walled tube **11** placed in a chamber **12,** the pressure of which chamber is atmospheric pressure or a pressure lower than that in the pressurized steam processing chamber. The width of the tube **11** is slightly larger than that of the wrapped cake, its height is nearly as thick as the cake, and its length is from 10 to 50 cm per pressure difference of 1 kg/cm². A thin-walled tube of stainless steel, which is from 0.2 to 0.3 mm in thickness, having the above dimensions is used. Its side ends are nearly-semi-circular and the upper and lower walls are substantially flat and parallel. In general, the thin-walled tube **11** requires a longer length in the case of a thicker cake. The area of the inside cross-section of the tube **11** can be changed by moving two axles **14, 14'** attached to the upper plate **13** upwardly and downwardly to regulate the distance between pinch plates **13, 13'** in chamber **12.** In order to pressurize chamber **12,** the steam pressure of chamber **15** is made to communicate with chamber **12** through a pressure-reducing valve **12'.** If the fiber density in thin-walled tube **11** is from about 0.3 to 0.5 and tube **11** has a length of from 10 to 50 cm per pressure difference of 1 kg/cm², the pressure-sealing of a cake from 5 to 20 mm thick is possible. The state of the wrapped cake being passed through thin-walled tube **11** is shown in FIG. **4** and is explained later.

The cake which has passed through the pressure-sealing means then passes through a horizontal, straight, perforated guide passage **16** provided in pressurized chamber **15** of saturated steam maintained at a predetermined temperature. The cross section of the guide passage **16** is shown in FIG. **3** and will be explained later. Pressurized chamber **15** is equipped with a steam inlet pipe **17** and an air vent valve **18.** A small amount of air introduced together with the cake is continuously discharged with a small amount of steam through vent valve **18.** When the pressure-sealing means at the inlet side is operated such that a small amount of steam is always releasd to the atmosphere, the air contained in the cake is replaced by the steam and thus the accompanying air introduced into the pressurized tube becomes less.

Perfect and quick removal to the extent possible of the air contained in the cake serves to promote uniform elevation of the temperature of the cake. For this purpose, the following several means are effective. In the neighboring part of the inlet of the pressurized chamber, (*a*) provision of a steam blowing-in box (not shown), with a device to cover tightly almost all of the steam from the extended end of the steam inlet pipe **17** into the chamber and lightly movable up and down, with a perforated bottom plate of **10** to **30** cm in length and in contact with the cake, into which the steam supplied through the perforations can penetrate in the direction of thickness, (*b*) provision of pinch rollers (not shown) to compress the cake between them, or (*c*) provision of weight rollers (not shown) to compress the cake in perforated conduit **16,** which rollers are placed on the cake and rotated freely with the movement of the cake.

FIG. **2** indicates the outlet side of the pressurized chamber. The chamber shown in FIG. **1** is joined to the chamber shown in FIG. **2** horizontally and in a straight line relationship therewith. The height of the rearward part of guide passage **16** through which the wrapped cake passes is reduced so that the wrapped cake is pressed in order to set the crimps at acute angles. In the rear part of the conduit, shafts **20, 20'** attached to a perforated plate **19** is externally operated from the top-side with respect to the bottom plate of the conduit to regulate the pinching distance, and, accordingly the degree of compression. Excessive compression by making the distance too small results in sticking of fibers and therefore the space should be suitably adjusted. The pressure is indicated by a pressure gauge **21** and the condensed water is drained from a pipe **22.** If pressurized steam free from condensed water is jetted to penetrate through the wrapped cake vertically from above while the cake is passing through the conduit at the inlet side, the remaining air contained therein can be effectively removed. The cake is then drawn out in the air by pinch rollers **23, 23'** through a pressure-sealing means at the outlet side, which is of the same structure as that of the inlet side. In this case, also there is no danger of the deformation of the cake at the side ends, if the width of the rollers is designed to be the same as that of the initial wrapped cake and side plates **24** are provided at both side ends so that the width of the cake is maintained constant.

In this invention, the wrapped cake nipped between the pinch rollers is generally from about 7 to 10 mm in thickness when the total supplied denier is small as in the case of parallel filament yarns, while it is about 20 mm thick in the case of the large total denier of a filament tow. The upper and lower rollers, therefore, are driven by gears engaged with each other, and for the purpose of preventing slipping, the roller surfaces are fluted with grooves.

The wrapped cake, after passing between pinch rollers **23, 23',** is separated into the fibers and the wrapping cloth. Upon doing this, if a guide means **26** for peeling off the cloth is provided, the selvage parts of the cloth are prevented from being folded, and thus the cloth is conveniently recycled.

The fibers are taken up by another set of pinch rollers **25, 25'** positioned at the rear, the surface speed of which is sufficiently fast to straighten the bends of the caked fibers and a part or the whole of the crimps. In most cases of a tow or slivers, it is desirable that the crimps remain, while in the case of filament yarns it is better to straighten the crimps to a linear form under sufficient tension to remove the entraining of the fibers and thus to make the dividing operation into single, separate yarns easy.

In applying a number of parallel yarns to the process of this invention, first the cloth belt is passed through the apparatus prior to feeding the yarns, then the yarns, as they are, are passed through the apparatus of the enitre process, with the arrangement order of the respective yarns being fixed, for example by applying pressure sensitive adhesive tapes thereto, and then the yarns at the outlet side are guided through a comb **31** to a beam **30.** Next, the crimper is operated and when the crimped cake comes out from the stuffing box, the circulation of the cloth belt is started. The pressure-

sealing means are then fully opened, and when the wrapped cake reaches the pinch rollers at the outlet side the preliminary operation is stopped. Pressurized steam is then introduced and the pressure-sealing means are adjusted to start full operation.

If a few percent of fine, solid powder, such as talc powder is added to the surface of each yarn at the supply side of the yarn and a vibration plate (not shown) is applied to the surface of parallel arrangement of the yarns in the yarn dividing step at the outlet side, the yarn dividing operation becomes extremely easy.

The crimps which have been set at a high temperature by this processing, even if thus straightened, easily recover the initial crimped state when heated afterward in a tension-free state at about 100°C as required. When short staple fibers cut from a tow are used, excessive crimps will disturb the spinning process. Accordingly, since the fibers immediately after passing between the pinch rollers **23, 23'** as shown in FIG. **2** are still in a wet state at a temperature of from about 90° to 100°C, if suitably adjusted tension is applied to the fibers at this time, the crimps will remain to a desirable degree for the spinning process. The yarns, however, if heated in a tension-free state after spinning, recover the crimps set during the pressurized steam treatment and become bulky yarns. Also, if crimps are developed after weaving, a product of soft touch or hand can be obtained.

The wrapping cloth taken up after passing guide means **26** for peeling off the cloth and pinch rollers **27, 27'**, is made wrinkle-free by roller-irons **28, 28'** on its way to return to the inlet side as shown in FIG. **1**, and is recycled to wrap the cake.

The fibers straightened by the pinch rollers **25, 25'** pass a guide roller **29**, and are wound on a beam **30**. In the case of filament yarns, a comb is provided between the guide roller **29** and the beam **30**, and a vibration plate (not shown) is applied to the parallel yarns before beam **30** to divide them effectively into single yarns, which are then wound in good order through the comb onto the beam **30**, or are directly led to twisters to twist and wind yarn by yarn.

FIG. **3** shows a cross-sectional view of the rear part of the perforated, rectangular-sectional conduit **16** provided in the pressurized chamber as a guide passage for the wrapped cake. In this rear part of conduit **16**, the degree of compression of the wrapped cake is regulated by a horizontally-placed perforated plate **19** attached to axles **20, 20'** which are externally operated from above to move plate **19** up and down.

As mentioned previously, as a guide passage, the conduit as shown in FIG. **3** is not the only type. If the thickness and width and the desirable degree of compression, particularly that of the rear compressive part is known, a steam-permeable tube rectangular in section, the cross sectional area of which in the rear part is designed gradually to be suitably smaller can be used, or as metnioned above the wrapped cake can be passed between a number of pairs of pinch rollers of constant width arranged in series.

Additionally, the wrapped cake before and after the pinch rollers **9, 9'** at the inlet side or in front of the pinch rollers **23 23'** at the outlet side is preferably passed through a tube having a rectangular cross section or through a guide conduit having a compressive plate at the topside (both not shown), in order to prevent the wrapped cake from being shifted or expanded excessively and heaped up in the wrapping cloth, such problems being caused by the pressure generated from the pressurized chamber **15** towards the open air.

FIG. **4** shows a cross section of a type of pressure-sealing means which comprises a flat, thin-walled tube **11** (provided in the chamber **12**) containing packing material of fiber bundles placed along the inner walls of both sides of the tube, and two pinch plates **13, 13'** (top and bottom) to pinch the tube and regulate the distance between the plates so as to seal the pressure. The irregular vacant spaces **41, 41'** which may be developed between the side walls of the tube **11** and irregularly wrinkled surfaces generated at the side ends of the wrapped cake by the pushing pressure of the plates are filled up with the packing material which deforms with the change of the vacant spaces, and consists of fiber having a density of from about 0.3 to 0.5 at this time; thus, the whole pressure-sealing operation is effected by the joint action of the wrapped cake and the packing material.

As packing material, in general, a material composed of a number of cellulosic threads (in consideration of heat resistance) which are bundled in parallel arrangement with the longitudinal direction of the thin-walled tube **11** and are mixed with very fine metallic filaments, particularly in higher concentration about the sliding surface of the wrapped cake, or a material composed of a bundle of cotton threads wrapped with thin Teflon film reinforced with thin glass fiber cloth, is preferably used because of their durability and resilience. Since the parallel fibers can freely shift laterally, they can fill up the vacant space at every moment in accordance with its change. Such packing materials fixed at one end or at both ends to the outside wall of the thin-walled tube at the inlet and outlet of the cake. The packing material is used in an amount of suitable thickness as required by the thickness of the cake upon pressure-sealing. Even in the case of a cake having a narrow width, pressure-sealing can be achieved with a larger amount of the packing material while using the same tube.

FIG. **5** shows a cross section of a pressure-sealing valve in which a stopper **51** is moved up and down in the passage so as to regulate the opening, the width of which passage is the same as that of the wrapped cake. This type of pressure-sealing means is well known by my Japanese Patent Nos. 198,429 and 420,851 and U. S. Pat. Nos. 2,954,687 and 3,213,470 respectively, and can be applied to the present invention only with the proviso that the width of the passage is the same as that of the wrapped cake.

FIG. **6**(*a*) and FIG. **6**(*b*) respectively show cross and longitudinal sections of another type of sealing means. The width of a pair of rollers which rotate at an equal peripheral speed is the same as the initial width of the wrapped cake. Between these rollers, the wrapped cake is compressed with its width maintained constant, and the wall surfaces of the roller box **62** are lined with elastomeric material so that the lining hermetically comes in contact with the roller surfaces and seals the pressure difference between the front and back. In the figure, the upper roller **61** hermetically comes in contact with the elastomeric lining wall **63** at its upper and side surfaces. Especially, the upper surface of the roller intrudes into the elastomeric wall, which is compressed to form an arc-shaped surface, thus the contact surface becomes larger. This roller **61** is fixed by a key **65** to

a shaft **64** which penetrates the side walls. The shaft **64** is supported by bearings **67,67'** attached to the side walls. A gear **68** fixed to shaft **64** engages with a lower gear **68'** so that the upper and lower rollers **61, 61'** are rotated by a driving gear **69** at an equal peripheral speed. On the lower side, a lower side roller box **62'**, which is of symmetrical structure with the upper roller box **62,** is arranged. The widths of the upper and lower rollers are designed to be substantially the same as that of the stuffing crimper. Between the side walls of the upper roller box and the lower box, there is inserted resilient packings **70, 70'** of nearly the same thickness as the height of the stuffing box of the crimper. The packings are suitably tightened by screwing bolts **71, 71'**, or, without using such bolts, the upper roller box is forced against the lower roller box under the internal pressure of an air cylinder (not shown) so as to regulate the space between the upper and lower rollers. The wrapped cake **72,** which passes between the rollers, is thus compressed in the full width of the upper and lower rollers. The fiber density between the follers is regulated to be from 0.25 to 0.5, preferably from about 0.3 to 0.35 at the inlet side and from about 0.4 to 0.5 at the outlet side, so that the pressure difference between the front and back sides of the rollers is maintained. The pressure-sealing means of pinch type applicable to the present invention is not limited to that illustrated in the figure. Any other pressure sealing means of suitably designed structure can be used, if the pinch roller width is maintained constant to the width of the wrapped cake discharged from the stuffing box or from the joint guide conduit, and the pressure difference between the front and back sides of the rollers is maintained by hermetically sealing all the outer sides except the nipping sides and regulating the space between the upper and lower rollers in the direction of thickness. When the fibers tend to stick to each other by being too strongly nipped by using only one pair of pinch rollers to seal a too high pressure difference, or when the pressure-sealing capacity between the side walls of the rollers and upper and lower roller boxes is not sufficient, several pairs of pinch rollers are connected in series multi-stepwise by inserting bolts into the bolt holes **73, 73'** (as in FIG. **6**(*b*)) of the flanges of the pinch roller boxes. The nipping pressure of each pair of rollers is reduced and thus high pressure can be sealed by gradually sealing smaller pressure differences multi-stepwise. Alternatively, when a part of the pressurized steam leaked from the front between each pair of rollers is directly released to the atmosphere at a constant pressure through a small pipe (not shown) provided as required, high pressure sealing can be achieved without causing fiber sticking by too strongly nipping the cake. In the present invention, even if the supplied fibers travel at a high speed, the discharge speed of the wrapped cake of crimped fibers is low enough, e.g. about one several tenths or more of the speed of the supplied fibers. Thus, the peripheral speed of the rollers is also low. Accordingly, even if elastomer-lined rollers are used, they are sufficient for practical use because of the small degree of wear of the peripheral friction surfaces. Elastomer lining is thus effective indeed for pressure-sealing, but, since the material to be processed is a wrapped cake of crimped fibers, generally from 5 to 20 mm in thickness, which is resilient enough, the use of metallic rollers causes no troubles in practice. High temperature resistant elastomeric rollers, especially those resistant to temperatures above 130°C, are not readily available; therefore, in most cases it is desirable that at least the rollers which come in contact with high temperature in the pressure-sealing means of the combined pairs of rollers should be metallic from the standpoint of durability.

My invention is further illustrated by the following examples.

EXAMPLE 1

A commercially available acrylonitrile copolymer tow of 500,000 d. composed of 3 d. single filaments was steamed at 100°C and was supplied at a speed of 54 m/min to a stuffing crimper having rollers 150 mm in diameter and 110 mm in width and a stuffing box 20 mm in height, as shown in FIG. 1. A joint tube, rectangular in cross section, which was 110 mm in width, 24 mm in height and 400 mm in length had been attached to the stuffing box. The crimped cake of 9,000,000 d. discharged from its outlet was wrapped with cotton sheeting, 400 mm in width (600,000 d., as calculated in terms of denier), to the extent of about one and a half times, with the overlapped part of the cloth upward. The wrapped cake was pinched between pinch rollers, 110 mm in width and equipped with side plates at both side surfaces, in the full width of the rollers.

The inlet side pressure sealing means used had a cross section as shown in FIG. 4. A thick-walled, flat funnel tube, 100 mm in length, had been joined to the inlet opening of, and one end of a thin-walled flat tube, 100 mm in length to the outlet opening of a flat, thin-walled tube, 22 mm in height, 130 mm in width and 600 mm in length, both of its side ends being semi-circular. The other end of the flat tube had been fixed by welding to the flange of the pressurized steam chamber having a 150 mm diameter. In each of the semi-circular sides of the flat, thin-walled tube (which is pinched by two plates, top and bottom, to regulate the tube space) 5000 cotton yarns of No. 20 count bundled in parallel and wrapped with thin Teflon film reinforced with thin glass fiber cloth had been inserted and inlet side end of each of the wrapped bundles had been fixed to the end of the funnel tube.

The wrapped cake was then passed through this inlet side pressure-sealing means. A small amount of steam was leaked towards the inlet side, whereby the air contained in the wrapped cake was replaced with steam. The cake was passed horizontally and straightly through a guide conduit (110 mm in width, rectangular in cross section and having perforated walls and bottom) disposed in the saturated pressurized steam chamber, 6 m in length and maintained at 130°C. (1.72 kg/cm^2 gauge) Immediately after introducing the wrapped cake into the conduit, the contained air was expelled by a free weight roller which rotated with the movement of the cake. A rear one-meter length of the cake in the conduit was then pinched by an upwardly and downwardly movable plate placed in parallel with the bottom of the conduit. The cake was then pressed to an extent that the fibers in the wrapped cake were not allowed to stick to each other. Thereafter, the cake was passed through the outlet side pressure-sealing means which was of substantially the same structure as that of the inlet side. After being heated for about two minutes, the cake was drawn out by pinch rollers (110 mm in width, placed in the atmosphere and equipped with side plates) in the full width of the rollers. While

the cake was being drawn out, tension was applied to the wrapping cloth by the outlet side pinch rollers, which rotated at a slightly higher speed than that of the inlet side pinch rollers. The cake thus drawn out was collected while the folds of the crimped fibers were straightened by pinch rollers, which were placed further behind, and was rotated at a speed of 46 m/min. At the same time, the wrapping cloth was peeled off and was returned to the inlet side for recycling and reuse. The thus-obtained crimps of the fibers, even if straightened mechanically, exhibited extremely excellent recovery when heated in a tension-free state in the succeeding processing step.

EXAMPLE 2

Three hundred polyester filament yarns of each 100 d., after having been dusted on their surfaces with talc powder in an amount of 3 percent by weight of the yarns, were converged in good order and were supplied at a speed of 150 m/min to a steam chamber at 100°C under tension. The filament yarns were then introduced into a crimper having stuffing rollers, 150 mm in diameter and **80** mm in width, and a stuffing box, 80 mm in width, 8 mm in height and 500 mm in length. An air pressure of 0.7 kg/cm² was applied to the bottom doctor plate of the stuffing box. The discharged cake of 3,000,000 d. was wrapped with cloth to the extent of one and half times. The wrapped cake was then passed through a pressure sealing-means which was of a structure similar to that in Example 1 but in which the thin-walled tube was smaller both in height and width. The wrapped cake was passed through a horizontal, straight and perforated guide conduit, 80 mm in width, placed in a saturated pressure steam chamber at 140°C (2.65 kg/cm² gauge), while the air contained in the cake was replaced by leaking steam at the inlet side. At the rear part of the conduit, the wrapped cake was pressed to make crimps with acute angles. After being heated for two minutes, the wrapped cake was discharged through the outlet side pressure-sealing means and was passed between pinch rollers, 80 mm in width, placed in the atmosphere while maintained in that constant width. Then, the cake was drawn backwardly to straighten the crimps of the yarns, and the wrapping cloth was peeled off and recycled at a speed of about 1.5 m/min. A suitable speed ratio between the inlet and outlet pinch rollers was selected so that the wrapping cloth was maintained under tension during the heat treatment. Even if the crimps were straightened in the dividing operation of the yarns, the initial crimps applied in the crimp setting operation were always rcovered and bulky yarns were formed, when heated afterward in a tension-free state.

To facilitate the yarn dividing operation when processing a large number of yarns arranged in parallel the operational order was carried out as mentioned in the detailed description of the drawings.

EXAMPLE 3

Three hundred polyester filament yarns, each 100 d., similar to those used in Example 2 were padded with a disperse dye solution by passing between padding rollers, with the yarns arranged in 2.5 mm pitches in a width of 500 mm. After drying in parallel arrangement, 2.2 percent Dianix (Registered Trademark of disperse dyestuff) Fast Yellow YL and 0.55 percent Dianix Fast Blue on the weight of the fibers remained on the yarns. The dried yarns were passed through a stuffing crimper and then passed under the same processing conditions as in Example 2, except that the yarns were treated in pressurized steam at 155°C (4.51 kg/cm² gauge) for two minutes. Crimp-fixed yarns of green color free from uneven dyeing were obtained. No refining treatment was performed just after dyeing, but in the refining step after weaving a suitable dye refining step was included.

EXAMPLE 4

A commercially available acrylonitrile fiber tow of 500,000 total denier composed of 3 d. single filaments, after the crimps were straightened in steam at 100°C, was padded in a dye solution at 60°C comprising 1.5 percent Cathilon (Registered Trademark of cationic dyestuff) Red BLH, 5.4 percent Cathilon Red 7BNH, 3.9 percent Cathilon Yellow 3GLH, 2.5 percent acetic acid and 1.0 percent tailing agent, so that 35 percent dye solution on the weight of the fibers remained in the fibers. Thereafter, the tow was treated under the same processing conditions, following the same processing steps as in Example 1, including the stuffing crimping, cloth wrapping, continuous pressurized steam treatment at 130°C (1.72 kg/cm² gauge) for **2** min., and drawing out into the atmosphere. A uniformly dyed, deep red, crimped tow was obtained, with the dyes being penetrated into the cores of the fibers. Moreover, the crimps were perfectly set, which, even after repeated straightening, when heated in steam at 100°C, recovered the crimps given in the pressurized steam setting treatment.

What is claimed is:

1. In a process for producing crimped fibers by continuous stuffing crimper to provide crimps on the fibers, the crimped fiber from the crimper is wrapped with at least one cloth belt, the wrapped fiber is introduced to a zone maintained at an elevated temperature under the pressure of saturated steam, and the treated wrapped fiber is withdrawn from the zone into the open air, the improvement which comprises:

a. wrapping the crimped fiber cake, while maintaining the width thereof substantially the same as that of the cake as it is removed from the stuffing crimper and the height thereof nearly the same as, but not less than that of the cake as it is thus removed, with at least one cloth belt moving under tension at a speed at least substantially equal to, and up to slightly in excess of, the exit speed of the cake from the crimper;

b. introducing the wrapped crimped fiber cake into a pressure-sealed straight elongated pressure zone maintained at a predetermined elevated temperature;

c. guiding the wrapped cake in a substantially straight line along the full length of the center of the zone to subject the cake to the action of the saturated steam while maintaining the moving cloth belt enveloping the cake under tension and maintaining the width of the cake substantially the same as that of the cake removed from the crimper;

d. withdrawing the wrapped fiber from said pressurized zone into the open air while compressing the wrapped fiber cake to maintain its width; and

e. immediately after withdrawing, taking up the fibers at a speed at least sufficient to straighten the folds of the drimped fiber formed in the cake, and simul-

taneously peeling off the cloth belt and returning the belt to the inlet side for reuse.

2. The process of claim 1, wherein the wrapped cake moving through the rearward part of the pressure zone is pressed so as to give acute crimp bends.

3. The process of claim 1, wherein the wrapped fiber cake, while being introduced and withdrawn from the pressure-sealed zone, is positively protected against expansion in a lateral direction, thus maintaining the width of the cake, and also against escaping steam from the pressure chamber.

4. The process of claim 1, wherein parallel fibers, which have been padded with dyeing solution, are introduced to the pressure-sealed zone.

5. The process of claim 4, wherein the parallel fibers are fibers in form of filament tow.

6. The process of claim 4, wherein the parallel fibers are a plurality of slivers.

7. The process of claim 4, wherein the parallel fibers are a large number of filament yarns regularly arranged in parallel.

8. The process of claim 7, wherein the crimped fiber cake, composed of a large number of filament yarns regularly arranged in parallel, is taken up at a speed sufficient to straighten all of the crimps of the yarns, and, just after withdrawal, is divided into separate filament yarns in the final processing step.

9. In an apparatus for producing crimped fibers by continuous wet heat setting of parallel fibers, which comprises a serial arrangement of a stuffing crimper, wrapping means for crimped fiber, pinching means positioned adjacent said wrapping means, a pressure chamber for treating the fibers at high temperature under the pressure of saturated steam, said chamber being provided with inlet side and outlet side pressure sealing means, withdrawing means for the treated wrapped crimped fiber, and means for removing the wrapper, the improvement which comprises:

a. a rectangular guide conduit attached to and conforming with a rectangular stuffing crimper exit opening and associated with wrapping means for crimped fiber cake, said conduit having the same inside width as that of the crimper exit opening and a height nearly the same as, but not less than that of the said exit opening;

b. wrapping means for the crimped fiber cake having at least one cloth belt traveling under tension;

c. a first open-top rectangular guide conduit of the same inside width as the width of the wrapped fiber cake and having a movable upper cover to adjust the thickness of the wrapped fiber cake inside the conduit along the full length thereof;

d. feed side pinching means adjusted for nipping to an extent substantially equal to the width of the wrapped crimped fiber cake and provided with devices for preventing the wrapped cake from being forced out laterally beyond the said nipping width at the time of nipping, said pinching means being capable of pulling wrapped cake at a speed at least substantially the same as, up to a speed slightly higher than that of the cake pushed out of the crimper;

e. a second open-top guide conduit of substantially the same structure as that of the first, but having a movable upper cover eall extending along the whole length thereof and being capable of pressing the wrapped cake;

f. a straight elongated pressure chamber provided equipped with pressure sealing means capable of receiving and discharging the wrapped cake while keeping the width thereof substantially intact at both the inlet and outlet ends of the chamber;

g. a third elongated straight open-top steam permeable rectangular guide conduit positioned within and along the center line of the chamber;

h. a fourth guide conduit of substantially the same structure as that of the second, said conduit being positioned on the exterior of said chamber adjacent its outlet end;

i. withdrawing pinching means of substantially the same structure as that of the feed side pinching means and capable of withdrawing wrapped fiber cake at a rage slightly faster than the feeding speed thereof;

serially positioned elements (d) through (i) being arranged to maintain the least possible space between adjoining elements during the processing operation so as to form a substantially straight passage for the wrapped cake, said passage having a substantially constant inside width; and

j. separating means for removing the cake from the wrapping cloth belt, positioned next to the withdrawing means, said separating means being capable of taking up the treated fibers at a speed at least sufficient to straighten the folds of the crimped fibers formed in the cake.

10. The apparatus of claim 9 including at least one ironing cylinder on the return path of the wrapping means.

11. The apparatus of claim 9, wherein the third elongated straight open-top rectangular guide conduit has a readily steam permeable movable wall covering the rearward part thereof and is capable of pressing the wrapped cake.

12. The apparatus of claim 9, wherein the third elongated conduit has a readily steam permeable fixed rearward wall which is tapered to decrease gradually the distance between the said wall and the bottom of the conduit in the area of the exit side of the conduit.

13. The apparatus of claim 9, wherein a substantial portion of third elongated conduit is replaced by a plurality of pairs of upper and lower rollers, all having the same nipping width as the width of the wrapped cake, said rollers being provided with devices for preventing the wrapped cake from being forced out laterally beyond the nipping area and being arranged to form a substantially straight passage for the wrapped cake.

14. The apparatus of claim 9, wherein the inlet and outlet pressure sealing means each comprise a flat thin walled tube of an effective length having upper and lower flat walls of substantially the same width as the wrapped cake and curved walls on both sides; two pinching plates capable of pinching the tube from the top and bottom to regulate the cross-sectional opening area of the tube, and packing material inserted along the inner walls of both sides of the tube to the extent required to keep the width of the passage for the wrapped cake substantially the same as that of the wrapped cake in the course of processing.

15. The apparatus of claim 9 which is designed for producing a large number of crimped filament yarns including:

a. means for arranging a large number of filament yarns in parallel; and

b. separating means comprising means for withdrawing the treated yarns at a speed sufficient to strengthen substantially all of the folds and bends of the yarns, means for removing the wrapping cloth, means for dividing the straightened yarns into separate yarns and means for winding the processed filament yarns.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,763,527 Dated October 9, 1973

Inventor(s) MASAHIDE YAZAWA

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 3, line 31 change "tube" to --box--.

Column 3, line 38 change "tube" to --box--.

Column 10, line 54, change "entraining" to --entwining--.

Column 16, line 67, change "drimped" to --crimped--.

Column 17, line 65, change "eall" to --wall--.

Column 18, line 16, change "rage" to --rate--.

Signed and sealed this 4th day of June 1974.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
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