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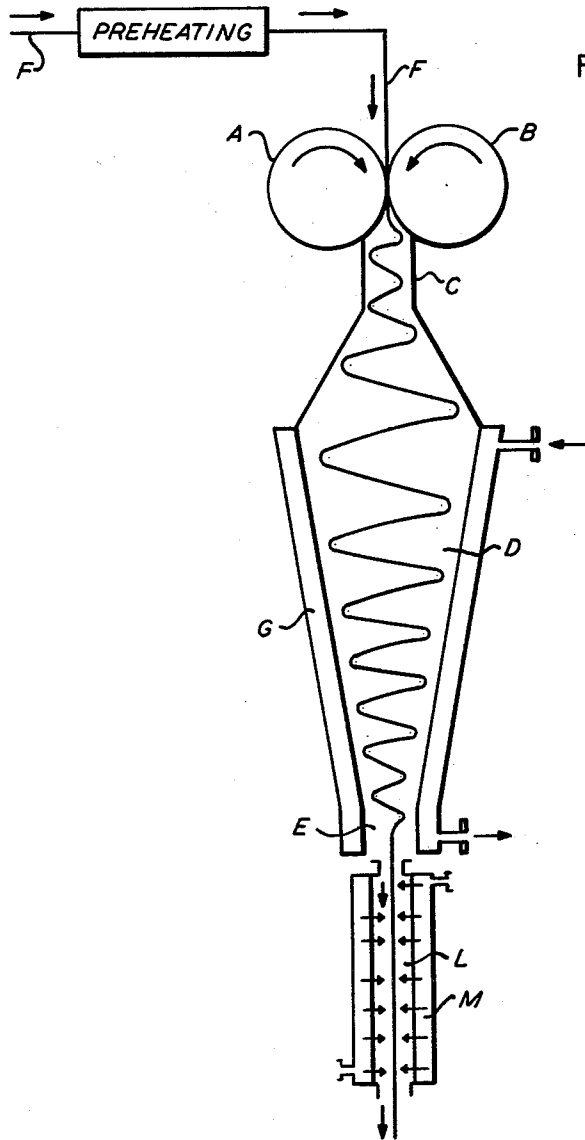
HIDEO SAITO ETAL

3,174,208

PROCESS OF CRIMPING FIBERS DERIVED FROM POLYVINYL ALCOHOL

Filed July 15, 1960

2 Sheets-Sheet 1



INVENTORS
HIDEO SAITO
BY KAZUO MIZUTANI

John A. Casper
AGENT

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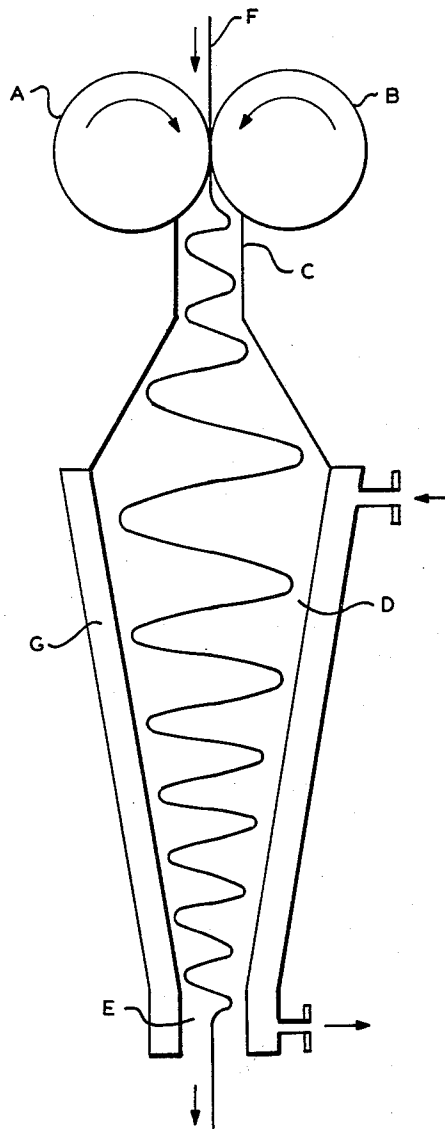


FIG 2

INVENTORS
HIDEO SAITO
KAZUO MIZUTANI
BY *Maynard R. Young*

ATTORNEY

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3,174,208

PROCESS OF CRIMPING FIBERS DERIVED FROM POLYVINYL ALCOHOL

Hideo Saito and Kazuo Mizutani, Kurashiki, Japan, assignors of one-fourth to Air Reduction Company, Incorporated, New York, N.Y., a corporation of New York, and three-fourths to Kurashiki Rayon Co., Ltd., Okayama Prefecture, Japan, a corporation of Japan

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1 Claim. (Cl. 28—72)

This invention relates to the crimping of fibers and is more particularly concerned with a process for crimping fibers of polyvinyl alcohol and polyvinyl alcohol derivatives.

Various methods have been proposed for crimping natural fibers and synthetic fibers. It is, however, difficult to give a stable crimp to fibers of low thermal plasticity such as regenerated cellulose fibers, by means of conventional crimping processes wherein the fibers are heated and pressed with gear wheels. Such fibers are, accordingly, crimped by a slacking process immediately after spinning.

In the case of fibers of high thermal plasticity, such as acetate fibers, methods involving the use of gear wheels are effective to provide relatively good crimping. Synthetic fibers of polyvinyl alcohol or polyvinyl alcohol derivatives, however, have low thermal plasticity. Accordingly, when attempts are made to crimp such fibers with gear wheels, the desired crimping is not achieved. Consequently, fibers of the polyvinyl alcohol type are generally crimped by means of a non-tension heat-treatment after spinning. Non-tension heat treatments, however, are difficult to carry out uniformly on an industrial scale. Such industrial non-tension heat treatments are only partially effective on polyvinyl alcohol fibers and an uneven crimp is applied so that subsequent acetalization of the fibers also gives uneven results. Consequently, polyvinyl alcohol fibers which have been crimped by such prior processes exhibit non-uniform dyeing characteristics, poor hot water resistance and a generally unsatisfactory crimp.

It is an object of the present invention to provide a novel process for crimping fibers which is of particular utility in crimping fibers of polyvinyl alcohol or polyvinyl alcohol derivatives.

In accordance with the invention, fibers of polyvinyl alcohol or polyvinyl alcohol derivatives, are heated while they are passed between closely-spaced conveyor surfaces, suitably provided by a pair of rollers which are maintained at a temperature above 50° C. but below a temperature which would cause adhesive softening of the fibers under treatment, e.g. 300° C., with or without preheating the tows or slivers of the fibers, and the fibers are then fed into a chamber which is closely packed with previously introduced fibers, the fibers being forced into the chamber against a back pressure produced by the fibers already in the chamber, and cooling the fibers in the chamber or immediately after the fibers are discharged from the chamber. When this process is applied to fibers of polyvinyl alcohol or polyvinyl alcohol derivatives, a stable, desirable crimp is imparted to such fibers.

A method has been disclosed in which fibers are fed into a zone substantially closed by a pair of rollers and the fibers are subsequently endowed with a crimp in a crimping chamber just beneath the rollers. The crimp in the fibers is then stabilized with heat, steam or various chemicals in a stabilizing chamber below the crimping

chamber. When this method is applied to fibers derived from polyvinyl alcohol, however, a satisfactory crimp is not obtained by feeding the fibers into the crimping chamber because of the relatively poor thermal plasticity of the fibers. Furthermore, when the crimped fibers are heated or steamed in the stabilizing chamber, the crimp in the fibers is largely eliminated. Accordingly, it is impossible to produce crimped fibers of polyvinyl alcohol or polyvinyl alcohol derivatives by said method. In particular, it is very difficult to apply a crimp by a stabilizing operation to vinylon or other fibers derived from polyvinyl alcohol because the heat-resistant and hot-water resistant properties of the fibers are adversely affected. Furthermore, it is extremely difficult to treat the closely-packed fiber mass uniformly to its innermost portion or area by the use of hot air or steam under conditions approximating the softening temperature of such fibers. Consequently, at least partial discoloring, adhesion, gelatinization or semi-fusion tend to occur.

We have found that fibers of the polyvinyl alcohol type can be provided with a satisfactory crimp by the use of heating rollers as conveying or feeding surfaces but the crimp once imparted to the fibers tends to be lost when the crimped fibers are treated in a crimp-stabilizing chamber by means of hot air, steam or chemicals.

However, we have found that stable crimped fibers can be produced by employing conveying surfaces, e.g. rolls, which are at a temperature above 50° C. and by subsequently exposing the fibers to a cooling atmosphere, preferably in the chamber into which they are introduced by the conveyor surfaces but at least substantially immediately after they issue from this chamber, the cooling being suitably a positively applied cooling, and crimping and fiber accumulation being effected without the use of hot air, steam, or chemicals.

There is shown diagrammatically in the accompanying drawings apparatus providing the conveying surfaces and the accumulating or crimping chamber employed in carrying out the process of this invention. Referring to FIGURE 2, there are seen conveying rollers A and B which receive the fibers F between their cooperating surfaces and positively convey the fibers downwardly into the chamber D through a cylindrical entrance zone C. The chamber D tapers downwardly and has an exit throat E. The chamber D is provided with a cooling jacket G, with the inlet and outlet for a cooling fluid being indicated by the rightwardly-directed and leftwardly-directed arrows at the right. The rollers A and B are adapted to be heated by any convenient means (not shown) to the desired surface temperature. Thus, in carrying out the invention, fibers or tow F are forced into the cylindrical entrance C by heated rollers A and B, both of which have a surface temperature of 50–300° C. In the chamber D the fibers are suitably and positively cooled by means of brine or other known coolant in the jacket G surrounding the downwardly-converging portion of the chamber D. The fibers F closely packed in chamber D are thus quickly and positively cooled before being removed through discharge throat or outlet E. The rollers are heated internally by hot air, steam, hot oil, electric heaters or the like. The surface temperature may be varied according to the specific type of polyvinyl alcohol or polyvinyl alcohol derivative fibers being treated, the total deniers of the fibers being fed, and the feeding speed of the rollers. Generally, the temperature will be higher within the range indicated in the case of fibers having a higher softening point, or having a larger number of total deniers, and the temperature will be higher the greater the rate of feeding provided by the rollers.

In general, the roller temperature is maintained as high as possible within the range indicated but below a

temperature which causes softening, solidifying or adhesion of the fibers.

It will be understood that the accompanying drawings are wholly diagrammatic both with respect to the apparatus shown and with respect to the fibers and their relationship to the walls of the apparatus. Thus, the apparatus is, in practice, completed by the usual weighted doors which close the discharge end of the crimping chamber so that the crimped fibers accumulate in and are packed in the apparatus and issue through the discharge doors (not shown) by forcing the doors slightly open. A typical crimping apparatus of known type having the above-mentioned doors is shown in U.S. Patent 2,575,838. It will also be understood that the crimped fibers issuing from the crimper are subsequently treated in conventional manner as shown, for example, in said patent. Such after-treatment, however, forms no part of the present invention which is concerned solely with a crimping process.

or steam directly introduced into it, or if it is indirectly heated by hot air or steam introduced in jacket G, such slackening of the crimp will occur. Furthermore, chamber D may tend to be heated by the thermal energy of the fiber itself even when no heat is positively applied. It is desirable, therefore, to cool chamber D positively when such heating tends to occur.

There is a problem, therefore, in the setting of crimp in fibers formed from polyvinyl alcohol or polyvinyl alcohol derivatives, i.e. fibers of the polyvinyl alcohol type, such as fibers of acetalized polyvinyl alcohol. However, a fully-effective, set crimp is achieved by the process of this invention. This will be illustrated by the following series of tests: a formalized vinylon-tow of 300,000 deniers was led through an apparatus such as shown in the accompanying drawing at a feed speed of 30 meters per minute and the treated fibers were examined for set crimp. The conditions of operation and the results obtained are shown in the following table.

Temp. of Rollers and tow preheating	Chamber (D)	Crimp Immediately after crimping			Crimp after storage for 10 days		
		No. of Crimps	Degree of Crimp, percent	Degree of retained Crimp, percent	No. of Crimps	Degree of Crimp, percent	Degree of retained Crimp, percent
Room temp.....	Not heated.....	18	7	2.5	9	3.5	1
200° C.....	do.....	22	15	6	19	13	5
Room temp.....	Heated (with steam).....	8	2.5	1.2	4	1	0.3
200° C.....	do.....	12	4	2	8	2.5	0.8
Room temp.....	Cooled (with brine).....	19	8	2.5	12	4	1.5
200° C.....	do.....	25	19	12	24	18	10.5

As shown in the accompanying drawings, a suitable apparatus for use in carrying out the process does, however, advantageously embody certain relationships. Thus, the diameter of cylindrical entrance zone C is selected to accommodate the total deniers of the fiber tow F. Advantageously, the diameter of zone C is less than that of the rollers. In a typical suitable installation having zone C of 4 cm. diameter, fibers of up to 5,000-30,000 total deniers could be readily and smoothly handled.

When fibers of a total denier of 30,000, for example, are fed between the rollers at a feeding speed of 6 meters per minute, the best results are obtained, when the surface temperature of the rollers is maintained at about 230° C.

Chamber D has a larger diameter than entrance zone C, in order to loosen the fiber tow slightly in passing into chamber D so that the fibers which are closely packed in zone C will flow smoothly into zone D. On the other hand, if zone C is unduly long, difficulty in removal of fibers may be experienced because the fibers may tend to become too tightly packed in zone C. Accordingly, it is recommended that the length of zone C be about 2 cm.-100 cm. The length of zone C is variable depending on the smoothness of its internal surface, the type of fiber, the kind of oil used as a lubricant, the value of the total denier of the tow, extent of crimp, and the like. The less is the resistance to movement, the longer zone C can be. Similarly, the lengths and the diameters of chamber D and throat E can be varied to provide the general relative relationships shown in the drawing.

It is advantageous to preheat fibers F, as shown in FIGURE 1, so that the heating action on the fibers exerted by the heated rollers A and B will be more prompt and more rapidly effective. For preheating the fibers in this embodiment, conventional fiber-heating processes and devices such as a hot-air bath, a steam bath, other vapor baths, a melt bath, contact with a heating device, and the like may be used. The temperature of such preheating is, of course, within the range referred to above.

Crimp in the fibers of polyvinyl alcohol or polyvinyl alcohol derivatives produced in zone C will tend to be completely slackened if heated in zone C or as they pass from zone C. Thus, if chamber D is heated either by hot air

As will be seen from the foregoing, when fibers derived from polyvinyl alcohol are treated with heated rollers, their crimp is materially better than that of the same fibers otherwise treated. This satisfactory crimp, however, will be substantially lost if chamber D is heated. By positively cooling chamber D, the excellent crimp in the fibers brought about by use of the heating rollers will be maintained in satisfactory form without appreciable deterioration. In other words, an entirely satisfactory and stable crimp can be obtained on fibers of the polyvinyl alcohol type by passing the fibers between heated rollers followed by cooling. Advantageously, positive cooling is effected in chamber D, i.e. the accumulation chamber or zone, but the invention also comprises operation, as shown in FIGURE 1, in which the fibers are positively cooled immediately after the fibers are discharged from throat E into chamber M with cooling medium L. The temperature at which the fibers are maintained immediately after discharge from chamber D or throat E, is below 120° C., preferably below 80° C.

Thus, the process of the present invention is characterized by the following factors. Polyvinyl alcohol fibers, this term including fibers composed substantially wholly of vinyl alcohol units and fibers of polyvinyl alcohol derivatives, such as acetalized polyvinyl alcohol, and having varying thermal plasticity, are crimped by the use of heated rollers maintained at a predetermined temperature, with or without previous preheating of the fibers. To prevent the crimp in the fibers from being lost, the fibers, after crimping, are directly exposed to a positive cooling atmosphere in order to fix or stabilize the desired crimp in the fibers. As mentioned above, this cooling is preferably effected in the chamber D itself, but positive cooling may be effected immediately after discharge of the crimped fibers from the chamber D into chamber M of FIGURE 1. In this manner, there are produced fibers with a uniform, evenly stable, desirable crimp.

Such positive cooling becomes more and more important with increasing total denier value of the tow treated. In the case of fiber tow having a large total denier value, the temperature of the fibers under treatment, if cooling is not applied, may frequently reach 160° C. even when the fiber coming out of chamber D is

taken up on a winder. Under such circumstances, the crimp in the fibers will be greatly reduced. As previously mentioned, in accordance with the process of the present invention, the surface temperature of the heated rollers is above 50° C., but preferably the surface temperature is maintained above 120° C. but in any case below a temperature which would cause adhesive softening of the fibers. In the positive cooling step following heating and crimping, the fibers are cooled to a temperature below 120° C., preferably below 80° C. The fibers to be treated are suitably in the form of tows of fibers of the polyvinyl alcohol type produced by conventional methods, and slivers produced during the spinning processes, e.g. in a spinning machine of the Perlock type or in a cotton spinning machine, as described below in Examples 3 and 4. The most stable and the best crimp can be produced on benzalized polyvinyl alcohol fibers and on formalized polyvinyl alcohol fibers. However, as indicated above, other synthetic fibers of the polyvinyl alcohol type can be effectively treated and crimped by means of the process of the present invention. If desired, spun or heat-treated fibers may also be used. While subsequent conventional treatments may be applied, the crimped fibers produced by the method of the present invention ordinarily require neither slacking nor softening.

The invention will be further understood from the following specific examples of practical application. However, it will be understood that these examples are not to be construed as limiting the scope of the present invention in any manner. In these examples, all parts are by weight, unless otherwise indicated.

Example 1

A vinyon-tow (total deniers: 80,000) which had been spun, heat-treated and formalized in accordance with conventional techniques was passed into a crimping apparatus corresponding to that shown in the accompanying drawings. A series of tests were made in which the surface temperature of the rollers A and B was (a) ambient or room temperature, (b) 70° C., (c) 100° C., (d) 150° C., (e) 200° C., (f) 230° C., (g) 250° C., (h) 280° C. and (i) 350° C., with the fibers being fed at a speed of 6 meters per minute. The fibers were positively cooled in chamber D so as to maintain the temperature of the fibers at 40–60° C. The number of crimps (per inch), the degree of crimping (percent), and the degree of retained crimp immediately after production up to (several hours after production), and after storing the fibers for a period of 7 days, were determined, with the following results:

Immediately after crimping			After storage for 7 days		
Number of Crimps/in.	Degree of Crimp, percent	Degree of retained Crimp, percent	Number of Crimps/in.	Degree of Crimp, percent	Degree of retained Crimp, percent
(a) 17	8	2.5	11	3.5	1.5
(b) 18	12	5	13	9	3
(c) 19	14	6.5	16	12	5.5
(d) 21	16	8	19	15	7
(e) 24	19	11	23	18	10
(f) 27	21	13	26	20	11.5
(g) 25	21	12	24	20	10.5
(h) 23	20	11	20	19	10
(i) Partially adhering.					

Furthermore, the percentages of crimp elasticity of samples (a), (d) and (f), as determined immediately after production, were 8%, 28% and 36% respectively. The strengths of these samples were 4.3 g./denier, 4.5 g./denier and 4.4 g./denier, respectively, it being seen that there were substantially no differences in strength among them.

Example 2

Fibers of polyvinyl alcohol spun and heat-treated in conventional manner were benzalized, also in conventional manner. The resultant tow (total deniers: about 30,000), having a degree of benzalization of 25%, was led through a crimping apparatus such as shown in the accompanying drawings. Using a feed rate of 10 meters per minute, the fibers were fed into the rollers A and B in a series of tests in which the surface temperature of the heated rollers was (a) room or ambient temperature, (b) 100° C., (c) 150° C., (d) 200° C. and (e) 230° C. The fibers were positively cooled in chamber D to control their temperature to 40–50° C. The number of crimps and the degree of crimp in the fibers immediately after treatment and after the crimped fibers were stored for a period of 10 days are shown in the following table:

	Number of Crimps/in.	Degree of Crimp, percent	Degree of retained Crimp, percent
(a)-----	13	5	2.5
(b)-----	17	13	6
(c)-----	22	17	9
(d)-----	26	21	12
(e)-----	25	21	11

Moreover, the percentage crimp elasticity for samples (a) and (e) was 20% and 42%, respectively. No difference in the tensile strength of these two samples was found.

Example 3

A vinyon-tow having a strength of 6.5 g./denier was prepared by formalizing polyvinyl alcohol fibers in conventional manner after heat-treating the spun fibers under high elongation. The fibers after elongation crimped very slightly even when subjected to non-tension heat-treatment by cutting. This tow was treated with a spinning machine of the Perlock type. The resultant sliver was continuously fed to the heated rolls A and B after passing through a hot-air bath 2 meters in length heated at 180° C. The rollers had a surface temperature of 210° C. and a feeding speed of 3 meters per minute. The sliver was positively cooled to control its temperature at 50°–70° C. in chamber D. As the result of such treatment, the sliver had 26 crimps per inch, a degree of crimp of 22% and a degree of retained crimp of 10%. The sliver showed no appreciable change from the above values after it had been stored for a period of a month. The strength of the sliver was 6.6 g./denier, this value also showing no change during the storage period.

Example 4

Polyvinyl alcohol fibers elongated by 30% at 180° C. after spinning, were cut and heat-treated for crimping at 230° C. Fibers having 8 crimps per inch and a degree of crimp of 3% were produced. The fibers were subsequently acetalized with chlorobenzaldehyde to a degree of chlorobenzalization of 28%. The acetalized fibers were treated on a cotton-spinning machine of the afore-mentioned type. The resultant sliver was led to rollers A and B after being passed through a steam bath at 1 atmosphere pressure having a length of 2 meters and heated to 140° C. The heated rollers had a surface temperature of 230° C. and were rotated to provide a feeding speed of 10 meters per minute. The heated sliver was positively cooled to 30 to 40° C. in chamber D. There were thus produced fibers having 25 crimps per inch, a degree of crimp of 19% and a degree of retained crimp of 10.5%. These thus-treated fibers were much superior in tensile strength and other properties when compared with fibers which were not thus treated.

Example 5

A vinyon-tow (total deniers: 600,000), formalized in conventional manner after spinning and heat-elongating, was continuously led to rollers A and B of the apparatus shown in the drawings after passing through a series of preheating rollers heated to 180° C. The rollers A and B had a surface temperature of 180° C. and were rotated to provide a feeding speed of 50 m./minute. The tow heated in the preceding operation was quickly cooled in and out of the chamber D to various temperatures in a series of tests by the use of brine or cooled water. The temperature of the fibers, the number of crimps, the degree of crimp, and the degree of retained crimp in the fibers issuing from the chamber are given in the following table.

Temperature of fibers immediately after issuing from chamber	Number of Crimps/in.	Degree of Crimp, percent	Degree of retained Crimp, percent
160° C (Not cooled)-----	16	7	3
120° C-----	22	12.5	6.5
80° C-----	23	14	7
60° C-----	25	18	10.5

No differences in the above values were observed after storage of the fibers for a period of a month.

As previously indicated, the process of this invention is applicable to all types of fibers derived from polyvinyl alcohol produced in conventional manner and subjected to conventional treatments and processing operations, such as acetalization, stretching, heat-treatment and the like. Such fibers are conventionally spun from spinning solutions by known wet and dry spinning techniques. Spinning techniques are described, for example, in Cline et al., U.S. Patent 2,610,360 and Osugi et al., U.S. Patent 2,906,594. An especially preferred spinning technique is described in U.S. Patent 2,988,802 of Tomonari et al., dated June 20, 1961. Typical processes of treating polyvinyl alcohol fibers are also described in the foregoing patents.

As typical fibers adapted to be treated by the process of this invention, reference has been made above to vinyon fibers which are, more particularly, polyvinyl alcohol fibers which have been acetalized in accordance with known procedures by means of aldehydes, such as formaldehyde, acetaldehyde, benzaldehyde, and the like, to render them resistant to water. Vinyon is described,

for example, in vol. 13 of the "Encyclopedia of Chemical Technology," by Kirk and Othmer (1954), and in the "Man-made Textile Encyclopedia," edited by J. J. Press (1959).

It will be understood that the conditions and the relative relationships set forth in the examples which are illustrative of the invention are those preferred in carrying out the process of the invention but it will be understood that other conditions and relationships may be used within the scope of the invention.

It will, therefore, be further understood that various changes and modifications may be made in the embodiments of the invention herein described without departing from the scope of the invention as defined in the appended claim. It is intended, therefore, that all matter contained in the foregoing description and in the drawings shall be interpreted as illustrative only and not as limitative of the invention.

We claim:

A process for crimping polyvinyl alcohol fibers which comprises,

heating polyvinyl alcohol fibers to a temperature above 140° C. but below a temperature tending to cause adhesive softening of said fibers,

passing said heated fibers between conveyor surfaces maintained at a temperature above 210° C. but below a temperature tending to cause adhesive softening of said fibers,

feeding said fibers which have passed between said conveyor surfaces into a crimping and accumulating chamber wherein said chamber contains closely packed previously introduced fibers whereby said fibers fed to said chamber are crimped,

and positively cooling said crimped fibers to a temperature below 80° C. substantially immediately after said crimping.

References Cited in the file of this patent

UNITED STATES PATENTS

2,090,669	Dreyfus et al. -----	Aug. 14, 1937
2,394,165	Getaz -----	Feb. 5, 1946
2,575,839	Rainard -----	Nov. 20, 1951
2,733,122	Herele et al. -----	Jan. 31, 1956
2,895,786	Schlack -----	July 21, 1959
2,914,810	Robinson et al. -----	Dec. 1, 1959
3,111,740	Stanley -----	Nov. 26, 1963