FIBER FRACTIONATING APPARATUS AND PROCESS

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Claims. (Cl. 209—2)

A nonexclusive, irrevocable, royalty-free license in the invention herein described, for all government purposes, throughout the world, with the power to grant sublicenses for such purposes, is hereby granted to the Government of the United States of America.

This invention relates to an apparatus for fractionating fibers into length-groups.

More specifically, it relates to an apparatus for electrostatically aligning fibers and subsequently separating the aligned fibers into fractions having specific lengths.

Still more specifically, it relates to an apparatus for removing short fibers from cotton lint. The present invention also provides a novel process for determining fiber-length distribution.

As used herein, the term “fibers” relates to the individual components of cellulosic or noncellulosic materials such as cotton, rayon staple, nylon staple, vinyl staple, and the like. Because of its wide use, cotton will frequently be referred to below as “the fiber,” but it is to be understood that this usage is illustrative only.

The term “lint” as used herein, relates to the full-length fiber. The term “short fibers” relates to the shorter portions of the lint, usually portions of fibers not longer than about three-eighths inch.

The presence of these short fibers has several disadvantages in the processing of lint cotton into yarn and/or fabric. In the first place, short fibers reduce the strength of the yarn. This results in a greater number of “ends down” or breakages during spinning thereby decreasing the efficiency of the process and increasing the cost. In the second place, these shorter fibers increase the total number of ends per unit length of the resulting yarn. These ends tend to protrude and impart a fuzzy character detrimental to the quality of the yarn. In the third place, yarns produced without these shorter fibers are characterized by their increased strength, fineness, their evenness, their smoothness, their uniformity, and their commercial desirability.

In the past, these short fibers have been removed only by a low-capacity, costly, combing process. Because of the great expense involved, generally only lint or fibers having a classifier’s staple length of at least about 1½ inch, the more expensive of the cotton fibers, have been subjected to the combing operation. Therefore, it will be seen that prior to this invention there still remained a need for economical means of eliminating the shorter fibers from lint. Such a means should be economically adaptable to the removal from lint of short fibers having a length of not more than ¾ inch. Lastly, but not least important, the means should not break or otherwise physically damage the fibers.

The apparatus which is the subject of our invention comprises any suitable means for introducing loose masses of relatively untangled partially individualized fibers into an electrostatic field having a nonuniform potential gradient produced by specially shaped or positioned electrodes. An endless belt (or belts) moves intimately in a direction transverse to the nonuniform electrostatic field, so that the region between one edge of the moving belt and the electrode has a lower potential gradient than the region between the opposite edge of the belt and the electrode. We prefer to use one endless belt moving over a stationary flat electrode with a stationary curved member comprising the other electrode.

The loose mass of relatively untangled fibers is introduced or fed into the portion of the electrostatic field having a minimum potential gradient. The fibers are then subjected to the influence of the electrostatic field with a force sufficient to orient the individual fibers and align them parallel to each other. With the endless belt moving in a direction away from the feed and as fibers repeatedly move from one electrode to the other they also move in the same direction that the endless belt is moving during the period when in contact with same. The fibers further migrate so that they align themselves in the order of ascending length as the field gradient increases from minimum to maximum.

It was expected that the fibers in the electrostatic field would migrate in a manner such that length distribution would vary inversely as the potential gradient. As will be discussed more fully below, the relatively untangled fibers individually aligned themselves perpendicularly to the moving belt, the longest fibers being in the field of maximum gradient and the length of the individual fibers gradually decreasing toward the side of the belt having the minimum gradient. This was entirely unexpected.

The individually aligned, erect, and length-oriented fibers may then be removed from the moving belt in any desired length-fractions. Various removal means may be employed, suction air being a good practice.

One, but not necessarily the only, embodiment of an apparatus suitable for the practice of our invention is described in the accompanying drawings in which:

FIGURE 1 is a three-dimensional view showing the essential features of the invention.

FIGURE 2 is a sectional view showing the fiber orientation and segregation.

FIGURE 3 is a three-dimensional view showing the essential features of another embodiment of this invention.

In the several figures, structures which are not essential to an understanding of the invention, such as encasing panels, mountings, and the like, have been omitted for purposes of clarity.

Referring to FIGURE 1, the loose masses of relatively untangled, disoriented fibers 11 are dropped from supply dust 12 in the region between curved electrode 13 and flat electrode 14 near such a convergence. Electrodes 13 and 14 may be shaped in any desired form so that when an electrostatic potential is applied to the electrodes a nonuniform field will be produced. For simplicity and efficiency we prefer to use a flat plate for one electrode and a transitionally curved plate formed as a segment of an ellipse for the other electrode. Electrodes 13 and 14 are energized through conductors 15 and 16 with a potential which may be either alternating or, preferably, direct. Either of these potentials may be supplied by any means (not shown) common to the art. Although not so limited, we prefer to have electrode 13 connected to the ground as shown by conductor 15. A continuously moving endless belt 17 traveling in the direction from fiber feed to discharge over rolls 18 and 19 is rotatably mounted in conventional bearings (not shown) and driven by any conventional means such as motor 20 through pulleys 21 and 22, and belt 23. The endless belt 17 may be of any suitable conductive or nonconductive material. However, we prefer to use a nonconductive webbing such as a vinyl-coated-canvas fabric. A flexible belt, such as rubber, and impregnated with a conducting metallic powder, also causes satisfactory results to be obtained. When such a belt is employed, only the side next to the disoriented fibers 11 is impregnated with the metallic powder. The powder may be of any commercially-available, corrosion-resistant material, aluminum powder causing excellent results to be obtained.
As those skilled in the art will recognize from FIGURES 1 and 2, the respective longitudinal edges of electrodes 13 and 14 are parallel to each other. Therefore, any transverse division will have the appearance shown in FIGURE 2, with the result that the intensity of the field and the potential gradient will vary only transversely to the direction of travel of endless belt 17, increasing from the more widely separated edges to the closer edges of the electrodes.

Fibers fed from duct 12 coming under the influence of the electrostatic field at the minimum potential gradient become individualized and oriented in a direction parallel to the lines of force of the field. As a result of the nonuniform potential gradient and the motion of the continuously moving endless belt 17, the fibers are agitated sufficiently to effect the migration of the longer fibers toward the side of the belt having the higher potential gradient. As noted above, under the influence of the electrostatic field the fibers tend to migrate and align themselves in an increasing order of fiber length. FIGURE 2 depicts the arrangement by which the fibers ultimately migrate. Specifically, the shorter fibers remain in the relatively weak section of the field 31, while the longer fibers migrate to the stronger section of the field 32. As noted above, this order of alignment was entirely unexpected. Subsequently, the fibers which are thus aligned by length may be differentially removed in fractions in any suitable manner such as suction air either just before or immediately after they get out of electrostatic field.

In FIGURE 1 we have shown one fiber removal arrangement which incorporates a vacuum chamber 24. Said chamber 24 is divided into subchambers 25 and 26 by a partition 27 which is positioned so that the fibers processed can be differentially removed by length into two groups, those shorter than, and those longer than, some predetermined length. The short and long fiber fractions removed in subchambers 25 and 26 are conveyed for subsequent processing by ducts 28 and 29, respectively, which are connected to any conventional suction means, as shown in FIGURE 1. Chamber 24 may be subdivided into as many subchambers as desired. By providing each subchamber with an outlet duct the fibers may be fractions into as many length-groups as required. The fiber length distribution may then be determined by weighing each fraction.

It is a critical feature of our invention that the distance between the moving belt and the electrode is greater than the length of the longest of the disoriented fibers. While the distance between the endless moving belt and the electrode is less than the length of the longest fibers, the latter will "crowd" into the closer space and "bunch up." This distorted alignment of these long fibers is detrimental to their subsequent removal without entanglement and subsequent possible breakage.

It is an advantage of our invention that a traditionally curved plate formed as a segment of an ellipse may be used with one endless belt. For optimum performance, it is necessary that the fiber mass be fractionated into the long- and short-fiber fractions as rapidly as possible, while at the same time maintaining fiber openness. These aims are best fulfilled by the nonuniform electrostatic field as obtained with a straight electrode and a traditionally curved electrode. This arrangement provides the initial rapid increase in electrostatic field strength with a consequent rapid migration of the longer fibers and the fractionating of the longer from the shorter fibers. As the rate of approach of the two electrodes decreases, whereby providing a slower, more gradual increase in the potential gradient, the tendency for the fibers to "bunch up" at the highest potential is reduced, or usually completely eliminated.

It is a further advantage of our invention that by proper positioning of subchambers 25 and 26, the shorter fibers, e.g., not more than 1/8 inch, may be separated from the longer fibers, i.e., fibers having a length greater than 1/8 inch. As noted above, removal of these shorter fibers causes yarns to be produced with desired characteristics, such as their increased strength, their evenness, their smoothness, their uniformity, and their commercial desirability.

It is a still further advantage that our novel apparatus provides a method for determining fiber-length distribution characterized by its simplicity, its great accuracy, and its ability to determine the fiber distribution in large samples. Heretofore the hand-combing method has been practically restricted to small samples because of the tediousness of the process and the great length of time required. Lastly, but not least important, the physical degradation of fibers encountered in the hand-combing process, i.e., fiber breakage, is eliminated by our novel method.

In FIGURE 3 there is shown a modified arrangement of the invention similar in operation to the preferred embodiment discussed above. The curved plate electrode of FIGURE 1 is replaced by a second flat plate electrode 34 and endless belt 35 identical in construction and operation to the original electrode 14 and belt 17. In this embodiment of our invention the longitudinal faces of the two belts 17 and 35 and the two electrodes 14 and 34 are angularly displaced in the transverse direction so that change in potential gradient from side to side is uniform, whereas in the preferred embodiment it is not uniform. The belts may travel in the same direction or in opposite directions at either the same speed or at different speeds; however, we prefer to have opposing faces moving in the same direction with one belt slightly outrunning the other. Under these conditions there is increased agitation of the fibers and they are more readily individualized and aligned in the field. Fibers may be fed into and removed from this embodiment in any suitable manner, such as the ones described in the preferred embodiment. Thus, fibers can be introduced by means of a similar duct 12 and collected by chamber 36 in separate compartments 37 and 38, separated by partition 39. The short and long fibers are conveyed from compartments 37 and 38 through ducts 40 and 41, which are connected to any conventional suction means, as shown in FIGURE 3. As noted above, the minimum distance between the electrodes should be slightly greater than the length of the longest fibers.

In another embodiment of this invention, the transitionally curved plate formed as a segment of an ellipse is replaced with a multicurved plate having both concave and convex portions. The concave portions are viewed from the charged plate form the low-gradient sectors of the field, while the convex portions of the surface form the high-gradient sectors of the field. The surface may be curved such that the location of the inflection points (point at which a concave portion reverses to a convex portion), as described in spatial coordinates on any curvilinear segment of the multicurved plate in the plane of the applied field (x axis) and the field gradient (y axis), may vary in both x and y coordinates with respect to the direction of fiber movement (x axis). This embodiment is not claimed in the instant application, but is described and claimed in copending application of Joseph J. Lafranca, Jr., Mayer Mayer, Jr., and Heber W. Weller, Jr., Serial No. 502,747, filed October 22, 1965.

We claim:

1. Apparatus for fractionating loose masses of disoriented textile fibers into different length groups comprising:
   (a) endless conveying means having a surface for conveying a mass of fibers from a point of deposit to a point of removal;
   (b) means for activating said conveying means connected thereto;
   (c) an electrode member mounted on each side of the endless conveying means substantially coextensive
therewith and together defining a fiber fractionating zone having an input end and an output end, said zone containing said conveying means, respective opposed edges of said electrodes being parallel to each other in the direction of travel of the conveying means, a first pair of said opposed edges of said electrodes being closer to each other than the second pair of opposed edges whereby the electrodes diverge transversely to the direction of travel of the conveying means, the distance between the conveying surface and the adjacent edge of the first pair of opposed edges of the electrodes being not smaller than the average length of the longest fibers of the mass to be separated;

(d) means connected to the electrodes for applying an electrostatic charge thereto, thereby to produce between said electrodes a nonuniform electrostatic field having a zone of minimum field intensity and potential gradient at the more widely separated edges of the electrodes and which increases transversely to the direction of travel of the conveying means to a zone of maximum intensity where said electrodes are closer together, the intensity of said electrostatic field being constant in the longitudinal direction;

(e) fiber introducing means adjacent the conveying means at the end of the fiber fractionating zone so located as to introduce a loose mass of disoriented fibers into the zone of minimum field intensity;

(f) compartmented fiber receiving means mounted transversely and in contiguous relation to the conveying means at the output end of the fiber fractionating zone;

(g) means for removing fibers of different lengths from adjacent transverse portions of the conveyors and for depositing said fibers in separate compartments of said fiber receiving means.

6. The apparatus of claim 5 wherein the endless moving surfaces are conductive.

7. The apparatus of claim 5 wherein the endless moving surfaces are nonconductive.

8. A method for fractionating fibers of varying length in a mass of disoriented, loose fibers comprising:

(a) forming an electrostatic field having an increasing potential gradient in one direction and a constant potential gradient in a direction perpendicular thereto;

(b) introducing a mass of disoriented, loose fibers into said electrostatic field at a point of lowest potential gradient;

(c) moving said mass of fibers through the electrostatic field in the direction of constant potential gradient, whereupon the fibers simultaneously migrate under the influence of the field transverse to the direction of movement, the longer fibers migrating to the region of higher potential gradient, thereby fractionating said mass of fibers into different length groups; and

(d) separately recovering fibers of different length groups from the electrostatic field.

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