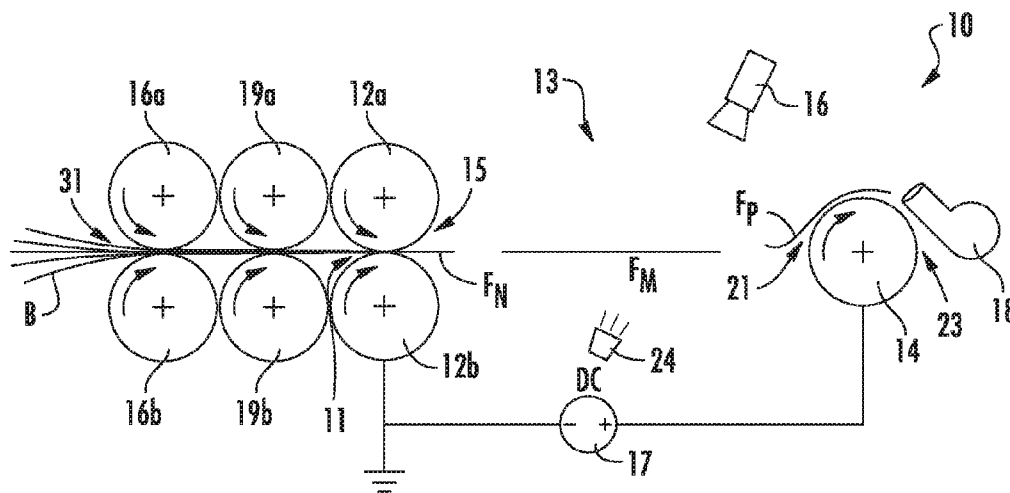


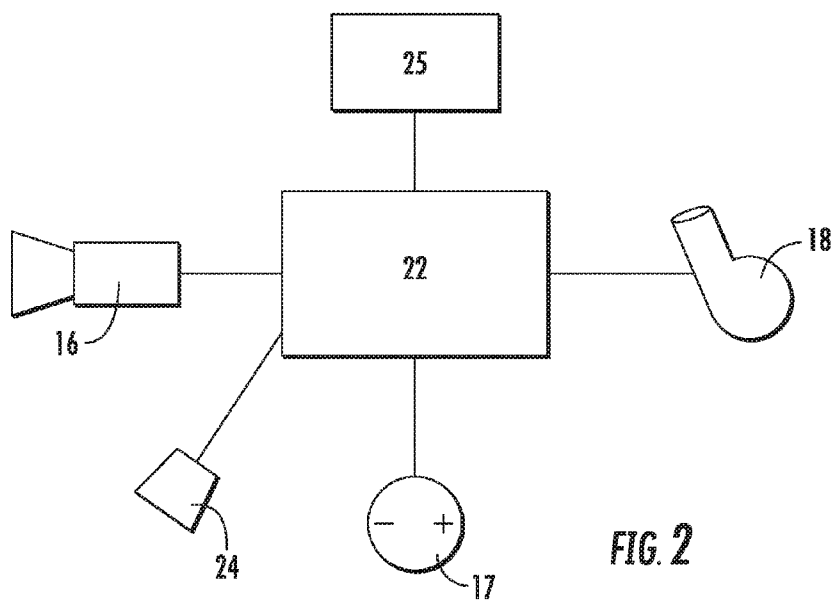
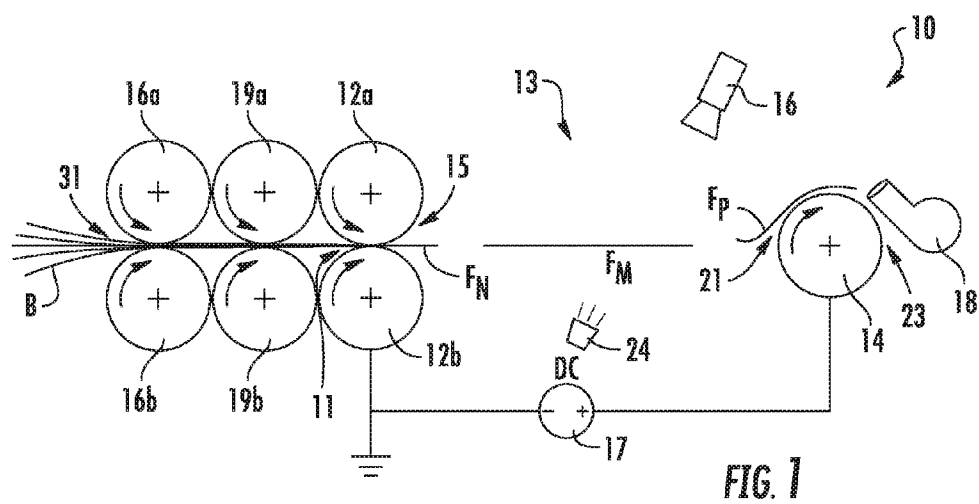


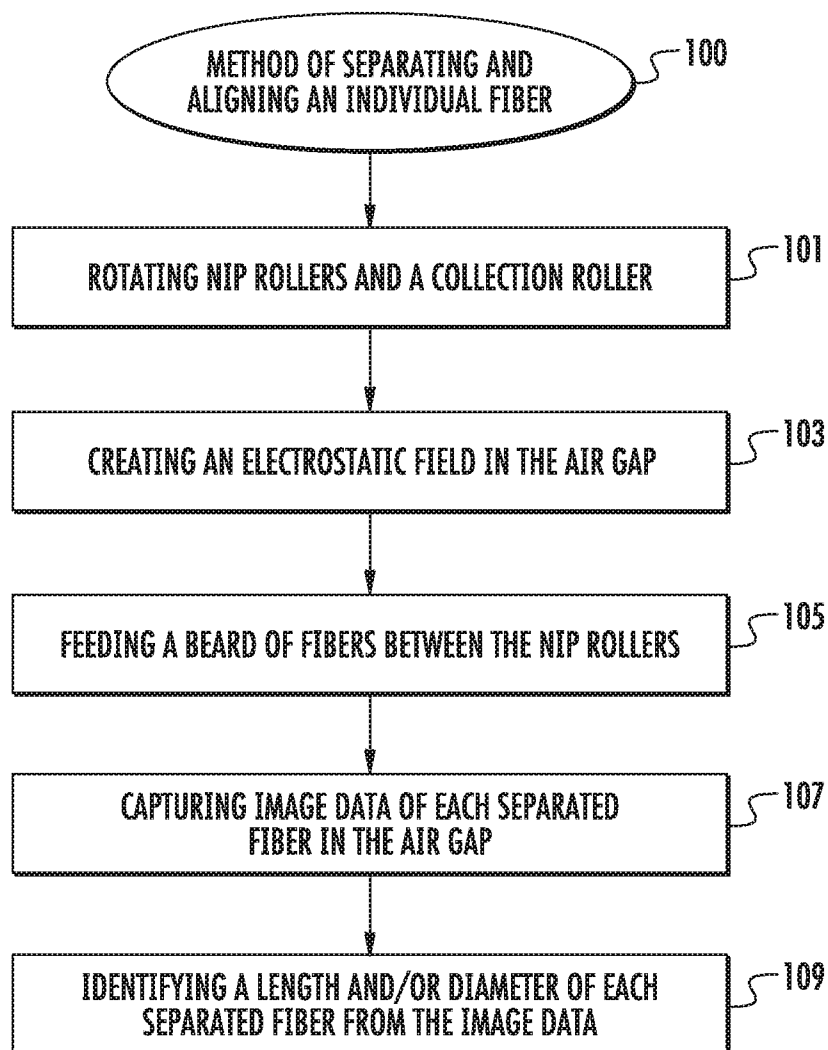
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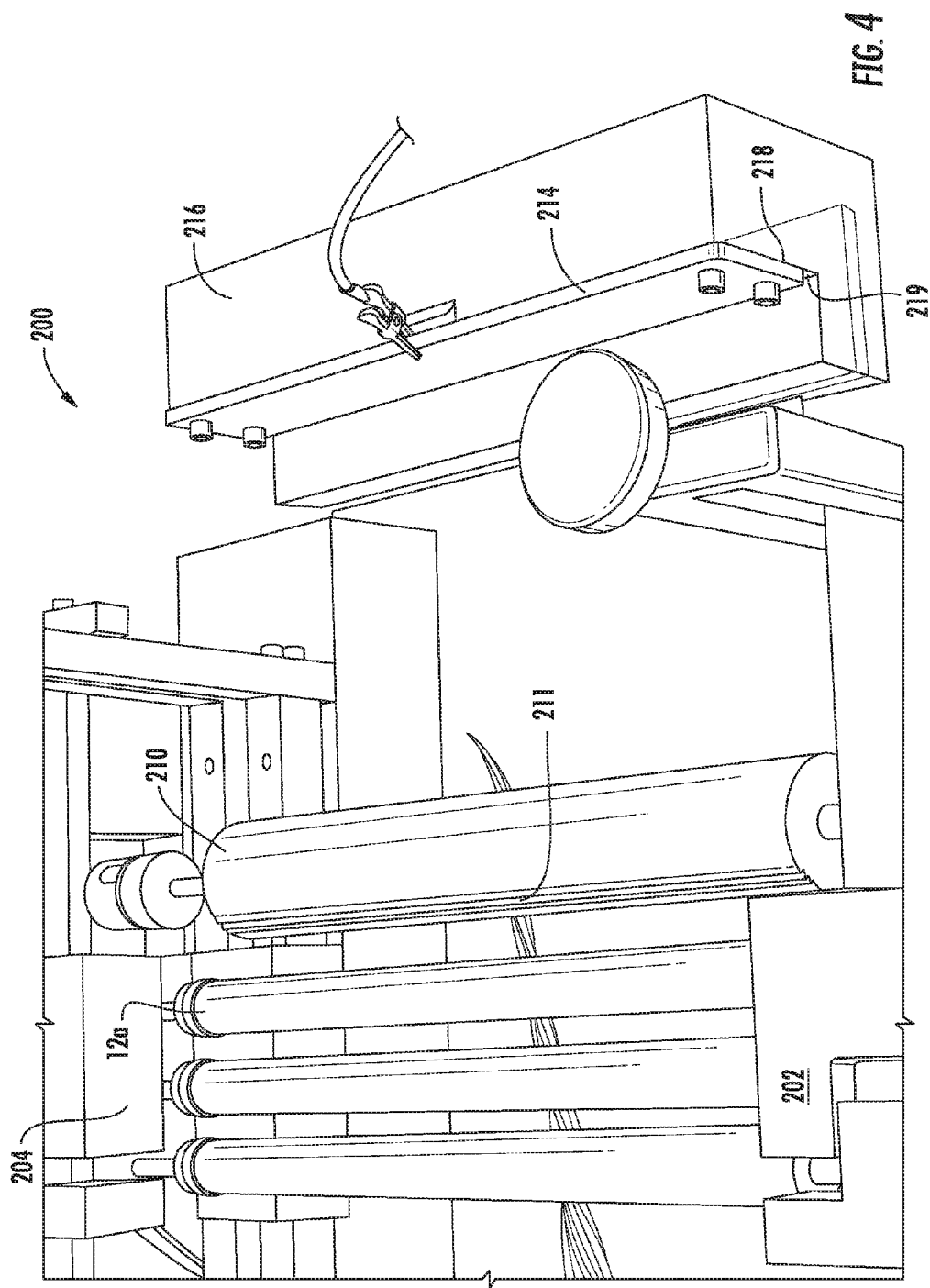
(19) **United States**(12) **Patent Application Publication**
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ELECTROSTATICALLY INDIVIDUALIZING
AND ALIGNING FIBERS**(52) **U.S. Cl.**
CPC .. **D01G 1/088** (2013.01); **D02J 1/18** (2013.01)(71) Applicant: **Board of Regents, The University of
Texas System**, Austin, TX (US)(57) **ABSTRACT**(72) Inventors: **Mourad Krifa**, Austin, TX (US); **Hao
Wu**, Austin, TX (US)(21) Appl. No.: **15/009,401**(22) Filed: **Jan. 28, 2016****Related U.S. Application Data**(60) Provisional application No. 62/109,996, filed on Jan.
30, 2015.**Publication Classification**(51) **Int. Cl.**
D01G 1/08 (2006.01)
D02J 1/18 (2006.01)

Various systems and methods described herein use electrostatic forces to separate fibers with minimal to no breakage and align the individual fibers with minimal handling. These systems and methods allow for testing, such as measuring the length, of individual fibers without the biases caused by breakage or bundling in prior art systems. These systems and methods may also be useful in applications requiring fiber alignment with minimal material handling. One exemplary system includes a pair of nip rollers and a collector that are spaced apart from each other to define an air gap therebetween. The nip rollers are grounded or negatively charged, for example, and the collector is positively charged to create an electrostatic field in the air gap. The electrostatic field separates the fibers, elongates the fibers end to end, and urges the fibers toward the collector.





**FIG. 3**



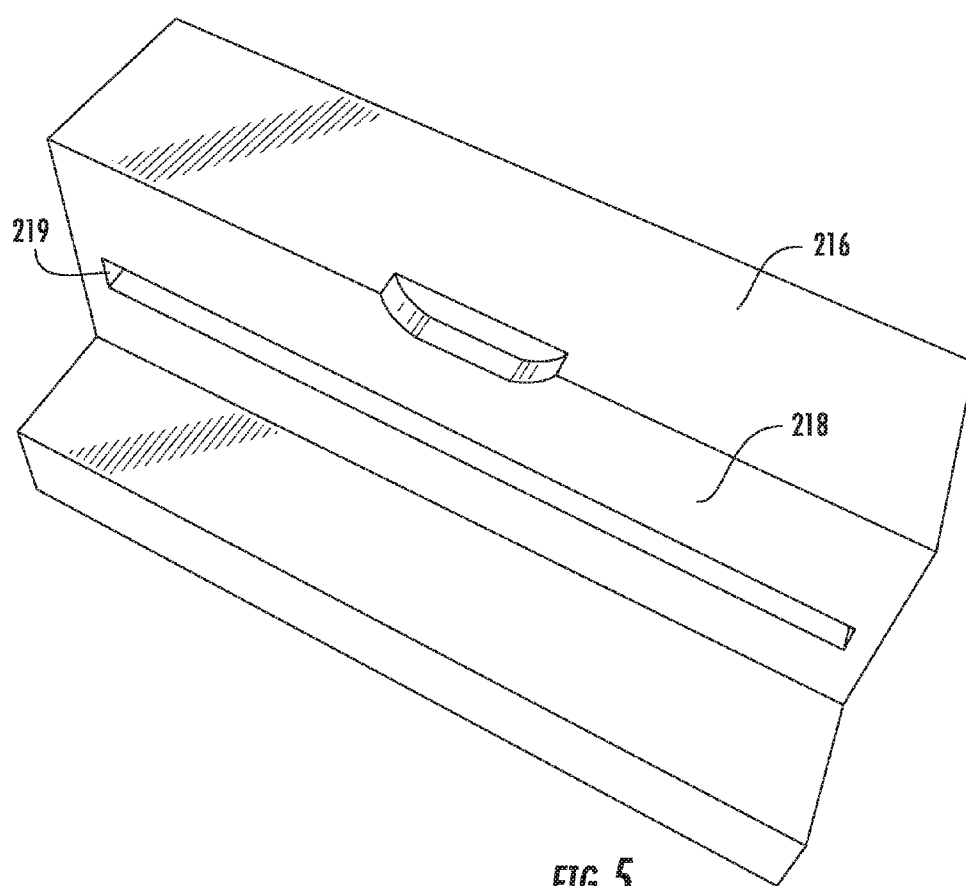


FIG. 5

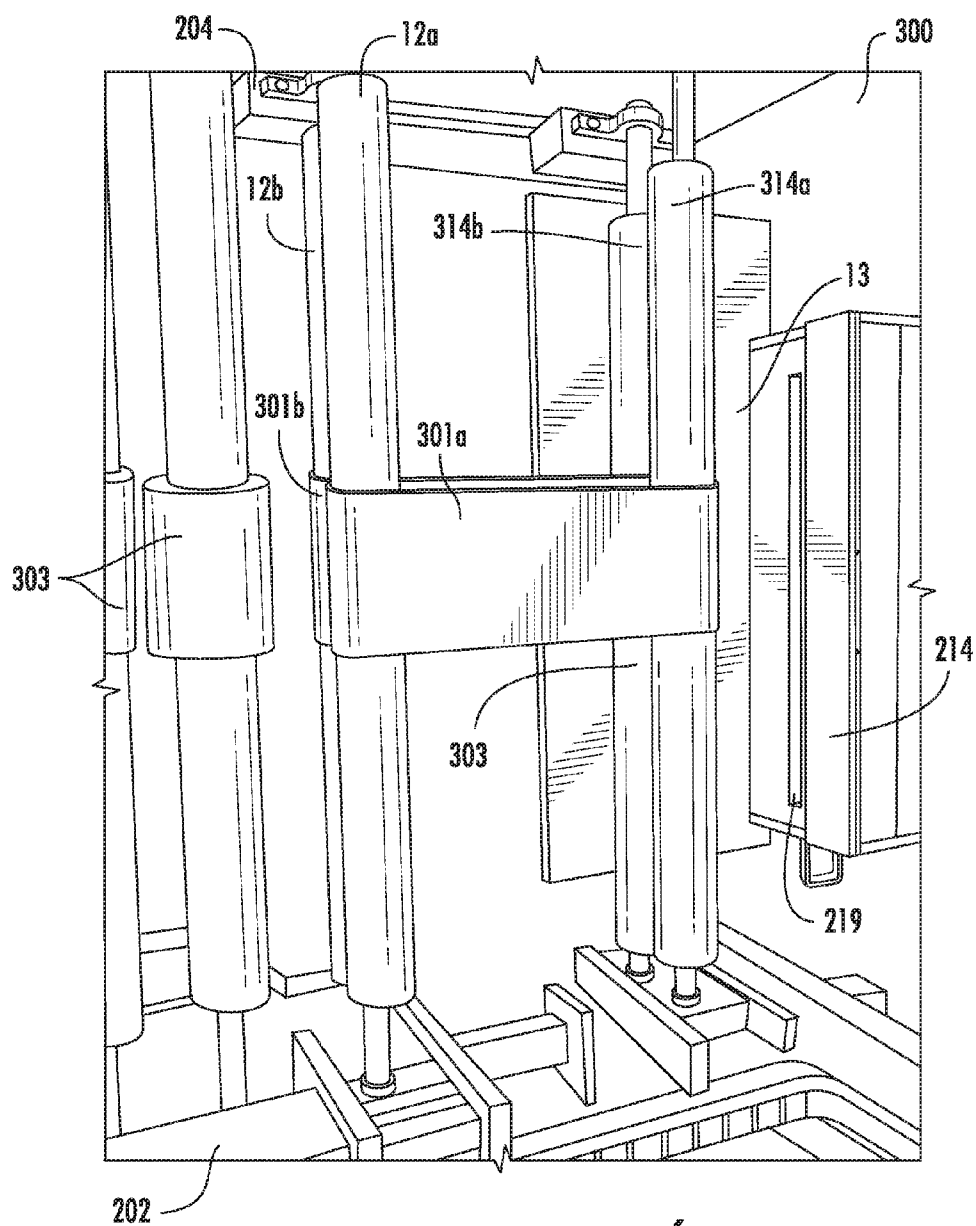


FIG. 6

SYSTEMS AND METHODS FOR ELECTROSTATICALLY INDIVIDUALIZING AND ALIGNING FIBERS

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Patent Application No. 62/109,996 entitled “Systems and Methods for Electrostatically Individualizing and Aligning Fibers,” filed Jan. 30, 2015, which is herein incorporated by reference in its entirety.

BACKGROUND

[0002] Fiber length measurement is a longstanding problem in textile and para-textile materials characterization. It is a particularly challenging task in applications using natural fibers, such as cotton. Among all measured characteristics of cotton and most other fibrous materials, length has typically been considered the most crucial. The market value and end-use of the fiber along with the processes adopted for its transformation are largely determined by its length properties. Unfortunately, reliably characterizing the length distribution in a bulk fiber sample is rather challenging, and existing solutions present multiple biases and shortcomings. One major challenge stems from the intrinsic variability of single fiber lengths, which is typically determined by complex interactions involving genetic, environmental, and processing factors. As a result, obtaining a representative sample from a bulk fiber lot can be troublesome.

[0003] Currently, there are two major approaches for addressing this problem. One approach is fiber bundle sampling, and the other approach is single fiber measurement. Fiber bundle sampling includes clamping a bundle, or “beard,” of parallel fibers by using a set of combs and brushes. The beard is scanned for length measurement, or to determine the “fibrogram.” Due to the sample clamping, the shortest fibers are not scanned, which leads to a bias of the length distribution toward the long fibers. In a single fiber measurement approach, fibers are individualized using an aeromechanical opener or separator and individually conveyed through a set of optical sensors that generate electrical signals proportional to the fiber length. One major shortcoming of current methods using the single fiber measurement approach is that in the process of measuring fibers, breakage typically occurs at the mechanical opening, which biases the measured length distribution toward the shorter fibers.

[0004] Accordingly, systems and methods are needed for individualizing fibers and measuring the individual fibers without breaking the fibers or biasing the measurements.

SUMMARY

[0005] Various implementations include systems and methods of using electrostatic forces to separate samples into individual fibers with minimal to no breakage and align the individual fibers with minimal handling. These systems and methods allow for testing, such as measuring the length, of individual fibers without the biases caused by breakage or bundling that are present in prior art systems and methods. These systems and methods may also be useful in applications requiring fiber alignment with minimal material handling.

[0006] For example, various implementations include a pair of nip rollers and a collector that are spaced apart from

each other to define an air gap therebetween. The nip rollers are grounded or negatively charged, for example, and the collector is positively charged to create an electrostatic field in the air gap. The electrostatic field separates the fibers, elongates the fibers end to end, and urges the fibers toward the collector. In other implementations, the nip rollers may be positively charged and the collector grounded or negatively charged to create the electrostatic field in the air gap. In certain implementations, the system may also include a power supply (e.g., a high voltage DC power supply) for creating a voltage difference between the nip rollers and collector.

[0007] In certain implementations, the collector is a collection roller that has an axis of rotation that is parallel to the first and second axes of rotation, and the direction of rotation of the collection roller is the same as the direction of rotation of the second nip roller, which is disposed below the first nip roller. The collector may also include a plate or other suitable collection device, according to other implementations.

[0008] In addition, the system may also include an imaging system that has a field of view that includes at least a portion of the air gap between the exit side of the nip rollers and the collector. The imaging system receives image signals of each fiber passing through the air gap, and the image signals may be used to measure a length and/or diameter of each fiber or to inspect each fiber. The imaging system may further include one or more digital cameras and one or more light sources, for example.

[0009] The system may also include a suction device, such as a vacuum collection device, that is disposed adjacent an exit side of the collector. The suction device urges each fiber passing over or through the collector from an entry side of the collector to the exit side of the collector to enter the suction device for collection after one or more images of each fiber is received.

[0010] Furthermore, the system may also include additional pairs of nip rollers disposed upstream of the first and second nip rollers that receive a beard of fibers and feed the fibers toward the entry side of the first and second nip rollers.

[0011] Various implementations further include a method of separating and aligning fibers. The method includes: (1) rotating a pair of nip rollers, an exit side of the nip rollers being spaced apart from an entry side of a collector to define an air gap therebetween; (2) creating an electrostatic field in the air gap; and (3) feeding a beard of fibers between the nip rollers. The electrostatic field separates the fibers, elongates the fibers end to end between the exit side of the nip rollers and the entry side of the collector, and urges the fibers toward the collector. A width of the air gap from the exit side of the nip rollers to the entry side of the collector is larger than a maximum length of any fiber within the beard of fibers.

[0012] In certain implementations, the method also includes capturing image signals of the separated and elongated fibers in the air gap with an imaging device that has a field of view that comprises at least a portion of the air gap. In addition, the method may also include identifying a length and/or a diameter of each separated fiber using the image signals.

[0013] Other systems, methods, features, and/or advantages will be or may become apparent to one with skill in the art upon examination of the following drawings and detailed description. It is intended that all such additional systems, methods, features and/or advantages be included within this description and be protected by the accompanying claims.

BRIEF DESCRIPTION OF DRAWINGS

[0014] The components in the drawings are not necessarily to scale relative to each other and like reference numerals designate corresponding parts throughout the several views:

[0015] FIG. 1 is a side view of a system for individualizing and aligning fibers according to one implementation.

[0016] FIG. 2 is a schematic diagram showing various components of the system of FIG. 1

[0017] FIG. 3 is a flow chart illustrating various steps of a method of individualizing and aligning fibers, according to one implementation.

[0018] FIG. 4 is a top perspective view of a system for individualizing and aligning fibers according to another implementation.

[0019] FIG. 5 is a top perspective view of the housing shown in FIG. 4.

[0020] FIG. 6 is a top perspective view of a system for individualizing and aligning fibers according to another implementation.

DETAILED DESCRIPTION

[0021] Various implementations include systems and methods of using electrostatic forces to separate samples into individual fibers with minimal to no breakage and align the individual fibers with minimal handling. These systems and methods allow for testing, such as measuring the length, of individual fibers without the biases caused by breakage or bundling that are present in prior art systems and methods. These systems and methods may also be useful in applications requiring fiber alignment with minimal material handling.

[0022] In particular, FIG. 1 shows a system 10 for using electrostatic forces to individualize and align fibers. The system 10 includes a pair of nip rollers 12a, 12b, a collection roller 14, a power supply 17, an imaging system 16, and a suction device 18. The nip rollers 12a, 12b include an upper nip roller 12a having a first axis of rotation and a first direction of rotation and a lower nip roller 12b having a second axis of rotation and a second direction of rotation that is opposite the first direction. The first and second axes of rotation are parallel and vertically aligned. The collection roller 14 is spaced apart from an exit side 15 of the nip rollers 12a, 12b, and the exit side 15 of the nip rollers 12a, 12b and the collection roller 14 define an air gap 13 therebetween. The axis of rotation of the collection roller 14 is parallel to the first and second axes of rotation of the nip rollers 12a, 12b and lies within a horizontal plane extending between the first and second nip rollers. The horizontal plane in the implementation shown in FIG. 1 is orthogonal to a plane that is tangential to the nip rollers 12a, 12b on the exit side 15. The direction of rotation of the collection roller 14 is the same as the direction of rotation of the lower nip roller 12b so as to move the fibers out of the air gap 13 and toward the suction device 18. In other implementations (not shown), the axis of rotation of the collection roller 14 may be disposed above or below the horizontal plane extending between the first and second nip rollers 12a, 12b and orthogonal to the plane that is tangential to the nip rollers 12a, 12b on the exit side 15.

[0023] Furthermore, the system 10 may also include additional pairs of nip rollers 16a, 16b, 19a, 19b disposed upstream of the upper 12a and lower nip rollers 12b. The nip rollers 16a, 16b, 19a, 19b receive a beard of fibers B and feed the fibers toward the entry side 11 of the upper 12a and lower

nip rollers 12b. In other implementations, more or less than three pairs of nip rollers may be used in the apparatus. Implementations having more than one pair of nip rollers may provide better fiber individualization than implementations having only one pair of nip rollers.

[0024] The nip rollers 12a, 12b, 16a, 16b, 19a, 19b are physically coupled to one or more support rails that support the axis of rotation of each of the nip rollers 12a, 12b, 16a, 16b, 19a, 19b. For example, in the implementation shown in FIG. 4, first ends of the nip rollers are physically coupled to a first rail 202, and second ends of the nip rollers are physically coupled to a second rail 204. In other implementations, all of the nip rollers 12a, 12b, 16a, 16b, 19a, 19b may be physically coupled to one rail (not shown). And, in another implementation (not shown), upper nip rollers 12a, 16a, and 19a may be physically coupled to a first pair of rails, and lower nip rollers 12b, 16b, 19b may be physically coupled to a second pair of rails.

[0025] In addition, in some implementations, the rail(s) includes an electrically conductive material, such as aluminum, such that the nip rollers are electrically coupled to each other through the rails and/or through contact with each other. The collection roller 14 is mounted separately from the nip rollers 12a, 12b, 16a, 16b, 19a, 19b with sufficient electrical insulation to prevent electrostatic discharge between the nip rollers 12a, 12b, 16a, 16b, 19a, 19b and the collection roller 14.

[0026] The power supply 17 is in electrical communication with at least one of the nip rollers 12a, 12b, such as the lower nip roller 12b, and the collection roller 14. The power supply 17 creates a positive electrical charge on the collection roller 14 and a negative electrical charge on the lower nip roller 12b. The voltage difference between the nip rollers 12a, 12b and the collection roller 14 creates an electrostatic field in the air gap 13. As the fibers F pass through the nip rollers 12a, 12b, the electrostatic field causes the fibers F to separate from each other in the air gap 13, elongate end to end between the exit side 15 of the nip rollers 12a, 12b and an entry side 21 of the collection roller 14, and move toward the positively charged collection roller 14. The power supply 17 may be, for example, a DC high voltage power supply, according to certain implementations.

[0027] In some implementations, the power supply 17 may be electrically coupled to the support rail(s) physically coupled to the nip rollers 12a, 12b, 16a, 16b, 19a, 19b and/or to one or more of nip rollers 12a, 12b, 16a, 16b, 19a, 19b. In addition, in other implementations, one or more of the nip rollers and/or rails may be grounded (instead of negatively charged). And, in other implementations, the collector may be grounded or negatively charged, and the nip rollers and/or rails may be positively charged. In one such implementation, the motor and control board are insulated and protected from being influenced by the positive charge.

[0028] Furthermore, as shown in FIG. 2, a motor 25 is provided to drive rotation of one or more of the nip rollers 12a, 12b, 16a, 16b, 19a, 19b. The speed of rotation may be controlled by a computer processing unit 22, which is described below.

[0029] The width of the air gap 13 is selected such that it is greater than the maximum expected length of a fiber F to be passed through the system 10. This allows the fiber F to be elongated, or extended, to its full length and oriented end to end between the exit side 15 of the nip rollers 12a, 12b and the entry side 21 of the collection roller 14. In addition, the size of

the air gap 13 may be based on the minimum length that allows a fiber F to travel through the air gap 13 and be captured by the imaging system 16 and that allows for proper installation of the imaging system 16 and light source 24, according to some implementations. For example, in certain implementations, the air gap 13 may be between about 90 and about 100 millimeters.

[0030] The imaging system 16 has a field of view that includes at least a portion of the air gap 13 between the nip rollers 12a, 12b and the collection roller 14. The imaging system 16 receives image signals of each fiber F passing through the air gap 13, and these image signals may be used to measure a length or diameter of or inspect each fiber F. The imaging system 16 may include one or more digital cameras, according to certain implementations. In other implementations, the imaging system 16 may include one or more line scan cameras or optical sensor arrays. In addition, the system 10 may include one or more light sources 24 to illuminate at least a portion of the field of view of the imaging system 16, according to certain implementations. Light sources 24 may include one or more light emitting diodes (LEDs) or other suitable light source.

[0031] The suction device 18 is disposed adjacent an exit side 23 of the collection roller 14. The suction device 18 urges fibers F passing over the collection roller 14 from the entry side 21 of the collection roller 14 to the exit side 23 to enter the suction device 18 for collection after one or more images of each fiber F is collected. According to certain implementations, the suction device 18 may include a vacuum collection device. For example, the vacuum collection device may include a Venturi suction device.

[0032] FIG. 1 illustrates three fibers F being urged through the system 10. The full length of fiber F_M is within the air gap 13 and is being imaged by the imaging system 16. The fiber F_P adjacent the collection roller 14 is the fiber that just passed through the air gap 13 and is being (or is about to be) collected by the suction device 18. The fiber F_N adjacent the nip rollers 12a, 12b is the fiber that is next to enter the air gap 13. Occasionally, two or more fibers F advance through the air gap 13 simultaneously, but these fibers F are separated, or spaced apart from each other, by the electrostatic field, which allows the imaging system 16 to capture image signals for each fiber F.

[0033] FIG. 2 illustrates a schematic diagram of the system 10 according to one implementation. As shown, the system 10 further includes computer processing unit 22 for receiving the image signals from the imaging system 16 and processing the image signals. The computer processing unit 22 may include at least one memory and at least one processor, according to certain implementations. For example, the memory of the computer processing unit 22 may be configured for storing a set of instructions to be executed by the processor that allow the processor to identify a length, a diameter, and/or other characteristics of each fiber F based on the received image signals. The memory of the computer processing unit 22 may also be configured for storing image signals or portions thereof.

[0034] In certain implementations, the computer processing unit 22 may also be configured for controlling the speed of rotation of one or more motors 25 driving the rotation of one or more of the nip rollers 12a, 12b, 16a, 16b, 19a, 19b and the collection roller 14, the suction power of the suction device 14, the voltage difference between the nip roller 12a, 12b and the collection roller 14, and/or the light intensity of the light

source 24. For example, the processing unit 22 may be configured to adjust these parameters based on the image signals received from the imaging device 16. For example, if the image signals indicate that the fibers F are not passing through the air gap 13 individually or aligned as expected, the computer processing unit 22 may adjust the voltage and/or speed of the rollers 12a, 12b, 16a, 16b, 19a, 16b, 14 and/or the suction power of the suction device 18. In other implementations (not shown), one or more additional computer processing units may be provided to perform one or more of these functions.

[0035] FIG. 3 illustrates a method 100 of separating and aligning fibers according to one implementation. The method 100 begins as step 101 with rotating the pair of nip rollers, such as nip rollers 12a, 12b. Step 103 includes creating an electrostatic field in the air gap. For example, this step may include applying a positive electrical charge to the collector and grounding or applying a negative electrical charge to at least one nip roller. Alternatively, this may include grounding or applying a negative electrical charge to the collector and applying a positive electrical charge to at least one nip roller. The voltage difference between the nip rollers and the collector creates an electrostatic field in the air gap. Steps 101 and 103 may be performed simultaneously or in sequence. Then, in step 105, a beard of fibers is fed between the nip rollers. The electrostatic field separates the fibers, elongates the fibers end to end between the exit side of the nip rollers and the entry side of the collector, and urges the fibers toward the collector. Furthermore, a width of the air gap from the exit side of the nip rollers to the entry side of the collector is larger than a maximum length of any fiber within the beard of fibers. Next, at step 107, image signals of each separated and aligned fiber in the air gap are captured with an imaging device that has a field of view that includes at least a portion of the air gap. Then, at step 109, a length or diameter of each separated fiber is identified using the image signals.

[0036] FIG. 4 illustrates a system 200 for separating and aligning fibers according to another implementation. The system 200 includes elements similar to those described in relation to FIG. 1 except as noted. In particular, the system 200 includes a fringe roller 210 disposed immediately adjacent the exit side 15 of nip rollers 12a, 12b. The fringe roller 210 has an axis of rotation that is parallel to the axes of rotation of nip rollers 12a, 12b and rotates in the same direction as the lower nip roller 12b. At least a portion of the fringe roller 210 includes a combing surface 211 that is configured for gently urging the fibers F exiting the nip rollers 12a, 12b into the air gap 13. Thus in certain implementations, the spacing between the exit side 15 of the nip rollers 12a, 12b and the fringe roller 210 is sufficiently small to allow the combing surface 211 to contact the fibers as they exit the nip rollers 12a, 12b.

[0037] A second motor (not shown) is configured for driving rotation of the fringe roller 210, and the processing unit 22 is configured for controlling the rotation of the second motor. To process a fiber F through the system 200, the processing unit 22 instructs motor 25 to rotate the nip rollers 12a, 12b until a leading end of fiber F exits the nip rollers 12a, 12b at a length sufficient to be controlled by the fringe roller 210. For example, this length may include the leading end being in contact with a surface of the fringe roller 210 or in contact a certain amount of the surface of the fringe roller 210. The processing unit 22 then stops rotation of nip rollers 12a, 12b and directs the second motor to rotate the fringe roller 210 a half revolution to capture the leading end of fiber F and

another half revolution to present the leading end of fiber F into the air gap 13. The cycle repeats after image signals for the fiber F have been received by the imaging device 16. In some implementations, motor 25 may control the rotation of fringe roller 210 (not shown). In addition, in some implementations, motor 25 and/or the second motor may be controlled by another processing unit (not shown).

[0038] In addition, the collector in system 200 shown in FIG. 4 includes a stationary collection plate 214 and housing 216, instead of the collection roller 14 shown in FIG. 1. The collection plate 214 includes an electrically conductive material, such as aluminum or stainless steel. The housing 216 is made of a non-conductive material, such as, for example, polycarbonate or acrylic. FIG. 5 illustrates the housing 216 without the collector plate 214 disposed on it. The housing 216 includes an entry face 218 that faces the air gap 13 and the exit side 15 of the nip rollers 12a, 12b. The entry face 218 defines a horizontal slot 219 that extends through the entry face 218. The air gap 13 is in fluid communication with an interior of the housing 216 through this slot 219. The collection plate 214 is embedded onto the entry face 218 above the slot 219 and attracts the fibers F passing through the air gap 13 toward the housing 216 and through slot 219. This collector arrangement guides the fibers F within a consistent plane through the air gap 13, minimizing image acquisition depth variation. The suction device 18 is disposed adjacent another face of the housing and is in fluid communication with the interior of the housing 216 to allow for evacuation of the fibers F after the imaging device 16 has captured image signals for the fibers F. In other implementations (not shown), the collection plate 214 may be embedded below the slot 219.

[0039] FIG. 6 illustrates a system 300 for separating and aligning fibers according to another implementation. The system 300 includes elements similar to those described in relation to FIGS. 1 and 4 above except as noted. In particular, the system 300 includes a set of nip rollers 314a, 314b that are horizontally spaced apart from the exit side 15 of nip rollers 12a, 12b. The nip rollers 314a, 314b have axes of rotation that are parallel to the axes of rotation of nip rollers 12a, 12b. Upper nip roller 314a rotates in the same direction as the upper nip roller 12a, and lower nip roller 314b rotates in the same direction as the lower nip roller 12b. The upper nip roller 314a is coupled to the upper nip roller 12a by an apron 301a that extends around portions of the rollers 314a, 12a through which the fibers F are expected to pass. The lower nip rollers 12b and 314b are coupled by an apron 301b. The apron 301a and apron 301b gently urge the fibers F from nip rollers 12a, 12b toward nip rollers 314a, 314b and prevents slippage of the fibers F. The cots 303 and apron 301 may be formed of rubber or other suitable, non-conductive material for gently urging the fibers through the rollers 12a, 12b, 314a, 314b. In addition, to further prevent slippage of the fibers passing through the nip rollers 12c, 12d that are upstream of the nip rollers 12a, 12b, each nip rollers 12c, 12d may include a cot 303 around an outer diameter thereof.

[0040] In some implementations, motor 25 may control the rotation of nip rollers 314a, 314b, and the nip rollers 12a, 12b may be driven by the aprons 301a, 301b.

[0041] The air gap 13 is defined between an exit side 315 of nip rollers 314a, 314b and collection plate 214. In this system 300, nip rollers 12a, 12b are not charged, but at least one of the nip rollers 314a, 314b are grounded or negatively charged, and the collection plate 214 is positively charged. As noted above in relation to FIGS. 4 and 5, the electrostatic field

created in the air gap 13 urges the fibers F from the exit side 315 of the rollers 314a, 314b toward the slot 219 in the collection plate 214.

[0042] The above-described implementations create an electrostatic field within an air gap, and the electrostatic field separates, aligns, and allows for inspection and collection of fibers passing through the air gap. However, it should be understood that the systems and methods described above may be used with other types of materials other than fibers, such as dust particles and impurities.

[0043] Various modifications of the devices and methods in addition to those shown and described herein are intended to fall within the scope of the appended claims. Further, while only certain representative devices and method steps disclosed herein are specifically described, other combinations of the devices and method steps are intended to fall within the scope of the appended claims, even if not specifically recited. Thus, a combination of steps, elements, components, or constituents may be explicitly mentioned herein. However, other combinations of steps, elements, components, and constituents are included, even though not explicitly stated. The term “comprising” and variations thereof as used herein is used synonymously with the term “including” and variations thereof and are open, non-limiting terms.

1. An apparatus for separating and aligning an individual fiber sample comprising:

at least one pair of nip rollers comprising a first nip roller and a second nip roller; and

a collector spaced apart from an exit side of the pair of nip rollers, the exit side of the pair of nip rollers and an entry side of the collector defining an air gap there between, wherein an electrostatic field is created within the air gap between the nip rollers and the collector,

wherein the electrostatic field separates the one or more fibers from each other as the one or more fibers enter the air gap, elongates the one or more fibers end to end in the air gap between the exit side of the nip rollers and the entry side of the collector, and urges the one or more fibers toward the collector.

2. The apparatus claim 1, wherein the nip rollers are negatively charged or grounded and the collector is positively charged.

3. The apparatus of claim 1, wherein the nip rollers are negatively charged and the collector is positively charged, and the nip rollers induce a negative electrical charge on one or more fibers moving between the nip rollers from an entry side of the nip rollers to the exit side of the nip rollers.

4. The apparatus of claim 1, wherein the nip rollers are positively charged and the collector is negatively charged or grounded, and the nip rollers induce a positive electrical charge on one or more fibers moving between the nip rollers from an entry side of the nip rollers to the exit side of the nip rollers.

5. The apparatus of claim 1, wherein an axis of rotation of the first nip roller is vertically aligned with an axis of rotation of the second nip roller, and a direction of rotation of the first nip roller is opposite a direction of rotation of the second nip roller.

6. The apparatus of claim 5, wherein the collector comprises a collection roller, and an axis of rotation of the collection roller is horizontally aligned with a plane that extends between the first and second nip rollers.

7. The apparatus of claim 6, wherein the second nip roller is disposed vertically below the first nip roller, and a direction

of rotation of the second nip roller is the same as the direction of rotation of the collection roller.

8. The apparatus of claim 7, further comprising at least one motor that drives rotation of one of the first or the second nip roller.

9. The apparatus of claim 1, wherein a width of the air gap between the exit side of the nip rollers and the entry side of the collector is greater than a maximum length of fiber to be passed through the apparatus.

10. The apparatus of claim 1, further comprising an imaging device, wherein the imaging device has a field of view comprising at least a portion of the air gap and is configured for capturing image signals of the one or more fibers in the air gap.

11. The apparatus of claim 10, wherein the image signals are received by a computer processing unit, and the computer processing unit is configured for identifying a length of each of the one or more fibers from the image signals.

12. The apparatus of claim 11, wherein the computer processing unit is further configured for identifying a diameter of each of the one or more fibers from the image signals.

13. The apparatus of claim 10, wherein the image signals are received by a computer processing unit, and the computer processing unit is configured for identifying a diameter of each of the one or more fibers from the image signals.

14. The apparatus of claim 10, further comprising:

a suction collection device disposed adjacent an exit side of the collector, the suction collection device urging the one or more fibers into the suction collection device after the one or more fibers have passed through the air gap, and a computer processing unit configured for adjusting a suction power of the suction collection device and receiving image signals from the imaging device.

15. The apparatus of claim 14, wherein the computer processing unit is further configured for adjusting a voltage difference from a power supply that creates the electrostatic field between the nip rollers and the collector.

16. The apparatus of claim 1, further comprising a computer processing unit configured for adjusting a voltage difference from a power supply that creates the electrostatic field between the nip rollers and the collector.

17. The apparatus of claim 1, further comprising a suction collection device disposed adjacent an exit side of the collector, the suction collection device urging the one or more fibers into the suction collection device after the one or more fibers have passed through the air gap.

18. The apparatus of claim 1, further comprising one or more additional pairs of nip rollers adjacent to and upstream of the entry side of the first and second nip rollers.

19. The apparatus of claim 1, wherein the collector comprises a stationary collection plate.

20. The apparatus of claim 19, wherein the collection plate is disposed on an exterior, vertical entry face of a non-conductive housing, the entry face defining a slot extending horizontally along at least a portion of the entry face and through the entry face such that the air gap is in fluid communication with an interior of the housing, the slot being defined adjacent an edge of the collection plate, and the entry face facing the exit side of the nip rollers, wherein fibers F passing through the air gap pass through the slot into the interior of the housing.

21. The apparatus of claim 20, wherein a suction device is coupled to the housing such that the suction device is in fluid

communication with the interior of the housing, the suction device configured for evacuating fibers F within the interior of the housing.

22. The apparatus of claim 20, further comprising a fringe roller having an axis of rotation and an outer surface, the outer surface of the fringe roller being disposed adjacent the exit side of the second nip roller in the air gap, a direction of rotation of the fringe roller being the same as the direction of rotation of the second nip roller, and at least a portion of the outer surface of the fringe roller defining a combing surface, the combing surface being configured for urging a fiber into the air gap from the exit side of the nip rollers when the fringe roller is rotated.

23. The apparatus of claim 1, further comprising a fringe roller having an axis of rotation and an outer surface, the outer surface of the fringe roller being disposed adjacent the exit side of the second nip roller in the air gap, a direction of rotation of the fringe roller being the same as the direction of rotation of the second nip roller, and at least a portion of the outer surface of the fringe roller defining a combing surface, the combing surface being configured for urging a fiber into the air gap from the exit side of the nip rollers when the fringe roller is rotated.

24. The apparatus of claim 1, wherein the at least one pair of nip rollers comprises a first pair of nip rollers and a second pair of nip rollers that are horizontally spaced apart from each other, each pair of nip rollers includes the first nip roller and the second nip roller, a first apron extends around and couples a portion of an outer diameter of the first nip rollers and a second apron extends around an outer diameter of each of the second nip rollers.

25. A method of separating and aligning an individual fiber sample comprising:

rotating a pair of nip rollers, an exit side of the nip rollers being spaced apart from an entry side of a collector to define an air gap there between,

creating an electrostatic field between the collector and the nip rollers; and

feeding a beard of fibers between the nip rollers, wherein:

the electrostatic field separates the fibers, elongates the fibers end to end between the exit side of the nip rollers and the entry side of the collector, and urges the fibers toward the collector, and

a width of the air gap from the exit side of the nip rollers to the entry side of the collector is larger than a maximum length of any fiber within the beard of fibers.

26. The method of claim 25, further comprising capturing image signals of the separated and elongated fibers in the air gap with an imaging device, the imaging device having a field of view that comprises at least a portion of the air gap.

27. The method of claim 26, further comprising identifying a length of each separated fiber using the image signals.

28. The method of claim 27, further comprising identifying a diameter of each separated fiber using the image signals.

29. The method of claim 25, wherein creating an electrostatic field between the collector and nip rollers comprises applying a positive electrical charge to the collector and grounding or applying a negative electrical charge to the nip rollers.

30. The method of claim 25, wherein creating an electrostatic field between the collector and nip rollers comprises

grounding or applying a negative electrical charge to the collector and applying a positive electrical charge to the nip rollers.

31. The method of claim **25**, wherein creating an electrostatic field comprises applying a voltage difference between the nip rollers and the collector.

32. The method of claim **25**, wherein the collector comprises a collection roller.

33. The method of claim **25**, wherein the collector comprises a stationary collection plate.

34. The method of claim **25**, further comprising rotating a fringe roller through a first angle to capture an entry end of a fiber exiting the exit side of the nip rollers and through a second angle to present the fiber further into the air gap, wherein an outer surface of the fringe roller is disposed adjacent the exit side of the nip rollers, and at least a portion of the outer surface of the fringe roller defines a combing surface, the combing surface being configured for capturing the fiber when the fringe roller is rotated through the first angle and urging the fiber further into the air gap from the exit side of the nip rollers when the fringe roller is rotated through the second angle.

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