

Jan. 28, 1964

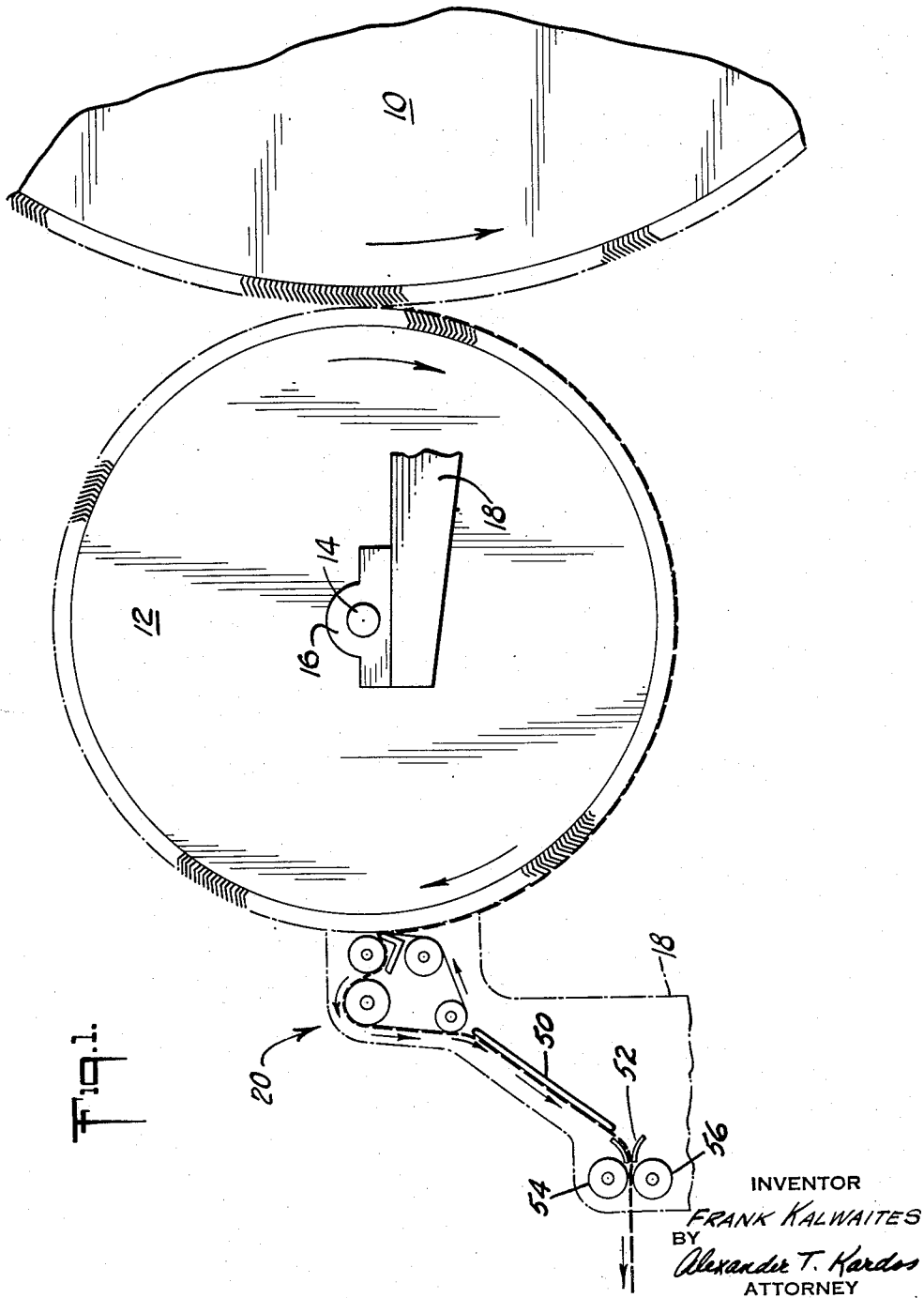
F. KALWAITES

3,119,152

METHODS AND APPARATUS FOR DOFFING AND DRAFTING FIBROUS WEBS

Filed Feb. 19, 1960

4 Sheets-Sheet 1



Jan. 28, 1964

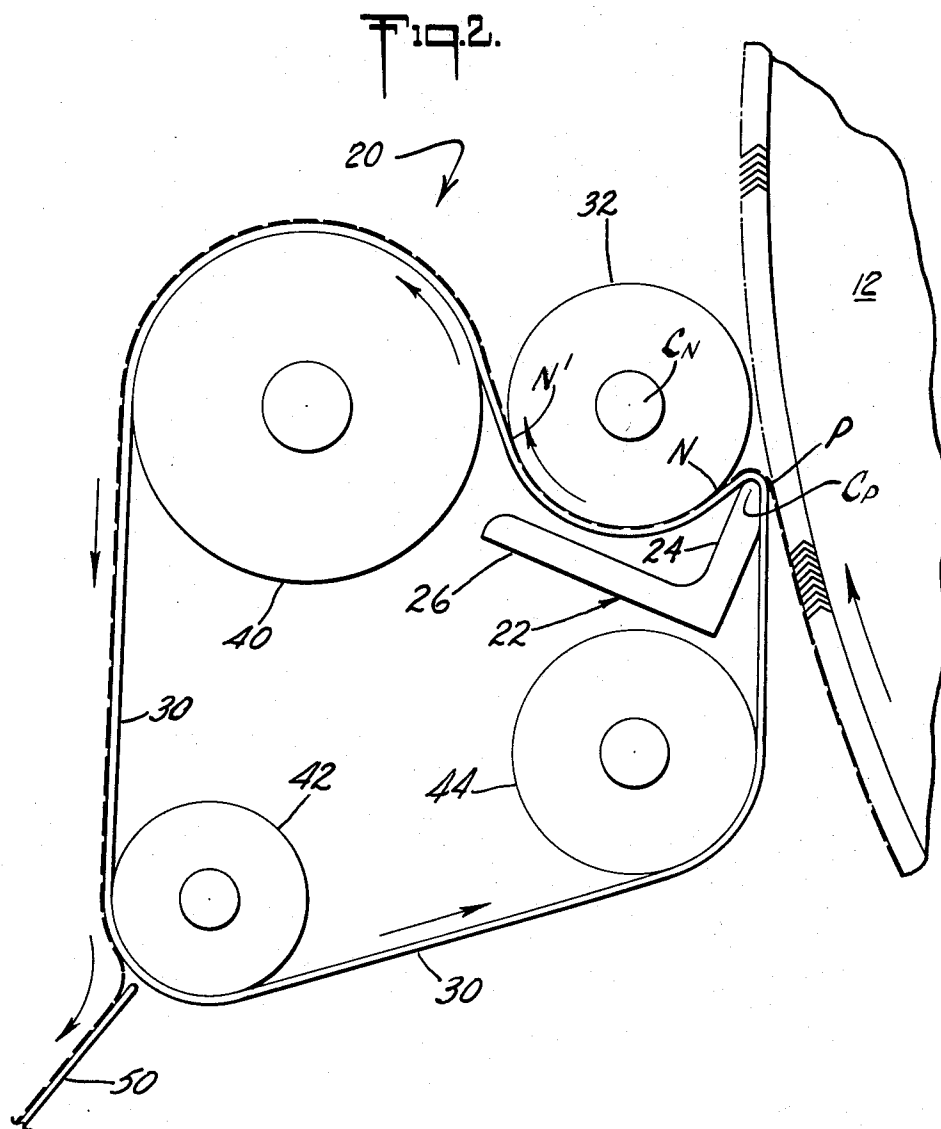
F. KALWAITES

3,119,152

METHODS AND APPARATUS FOR DOFFING AND DRAFTING FIBROUS WEBS

Filed Feb. 19, 1960

4 Sheets-Sheet 2



INVENTOR
FRANK KALWAITES
BY
Alexander T. Kardos.
ATTORNEY

Jan. 28, 1964

F. KALWAITES

3,119,152

METHODS AND APPARATUS FOR DOFFING AND DRAFTING FIBROUS WEBS

Filed Feb. 19, 1960

4 Sheets-Sheet 3

Fig. 3.

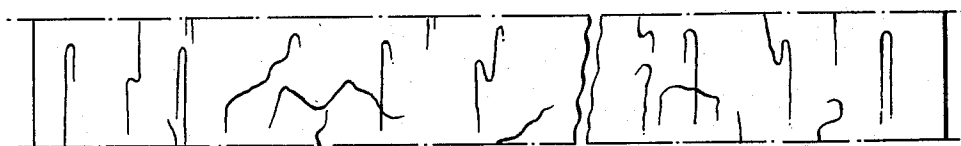
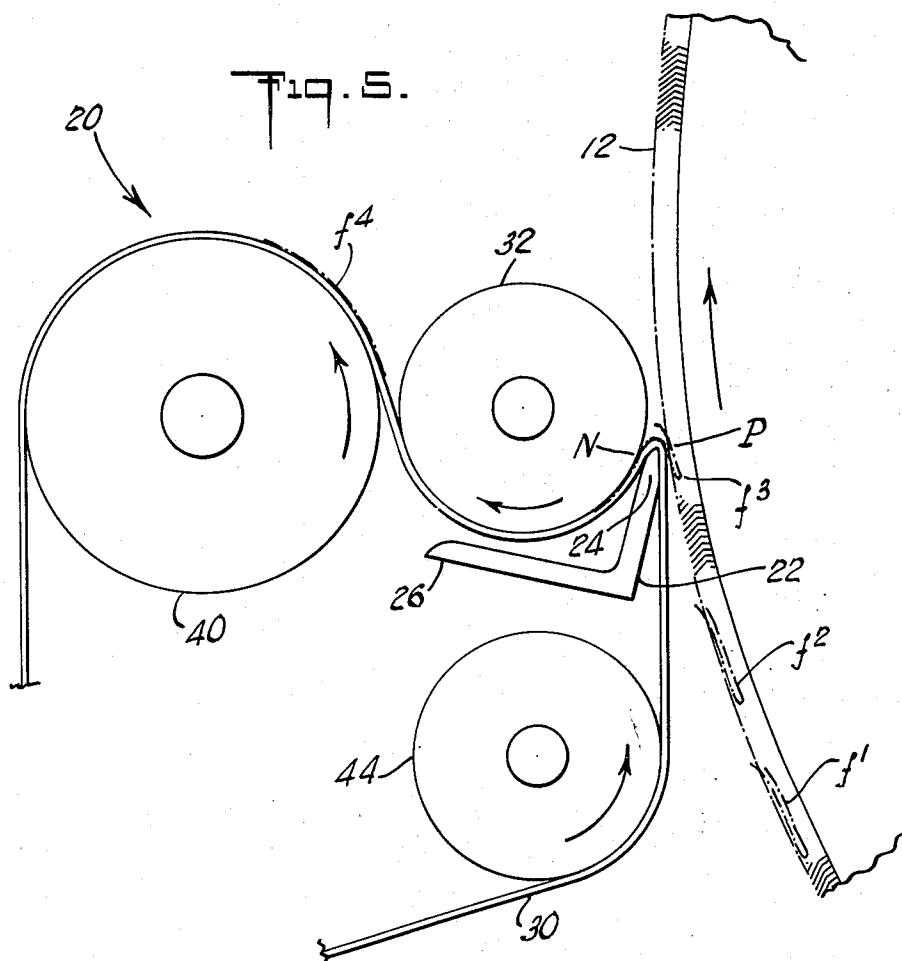


Fig. 5.



INVENTOR
FRANK KALWAITES
BY
Alexander T. Kardos -
ATTORNEY

Jan. 28, 1964

F. KALWAITES

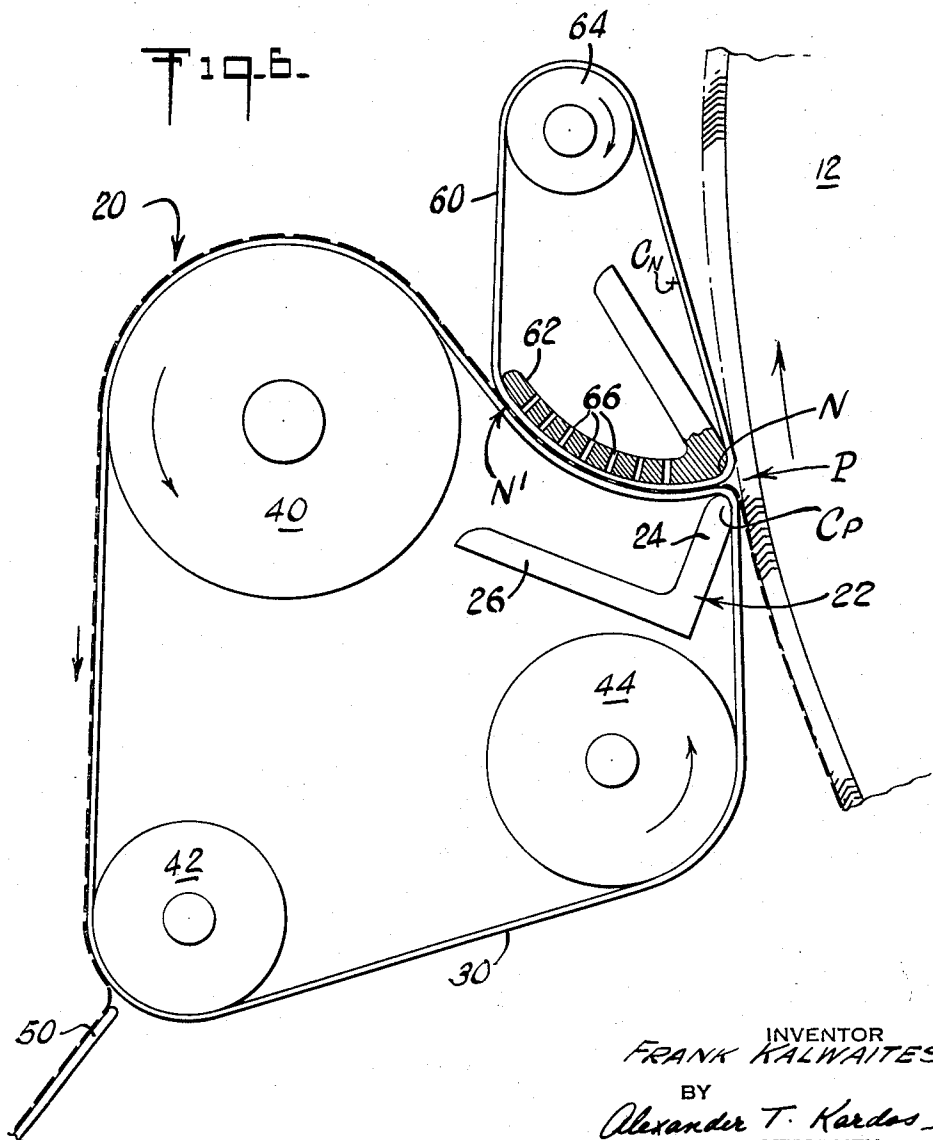
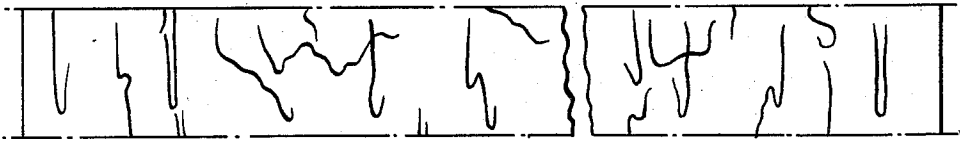
3,119,152

METHODS AND APPARATUS FOR DOFFING AND DRAFTING FIBROUS WEBS

Filed Feb. 19, 1960

4 Sheets-Sheet 4

Fig. 4.



INVENTOR
FRANK KALWAITES
BY
Alexander T. Kardos
ATTORNEY

1

METHODS AND APPARATUS FOR DOFFING AND DRAFTING FIBROUS WEBS

Frank Kalwaites, Somerville, N.J., assignor, by mesne assignments, to Johnson & Johnson, New Brunswick, N.J., a corporation of New Jersey
Filed Feb. 19, 1960, Ser. No. 9,969
10 Claims. (Cl. 19—106)

The present invention relates to the doffing or removing of textile fibers from movable carrier surfaces, such as the rotatable doffing cylinder of a card, for example, and more particularly is concerned with the removing of fibers from such surfaces and the simultaneous drafting or drawing thereof to increase the fiber orientation in the long or machine direction of the resulting web containing these fibers.

In the processing of textile fibers whereby they are converted from a naturally-occurring, intermatted fibrous mass into relatively uniform, fibrous textile materials such as webs and slivers having a predominant fiber orientation in the long direction thereof, the individual fibers are initially separated and formed into a fibrous web on a card. This web, in which the individual fibers are relatively aligned generally in the long direction of the web, is doffed or removed from the doffing cylinder of the card, usually by a rapidly reciprocating doffer comb, and then further processed, as desired or required, such as by being drafted or drawn whereby the orientation of the fibers in the long direction of the web is increased.

During the removal of the fibers from the doffing cylinder by means of the reciprocating comb, the fiber orientation or alignment thereof is usually increased to a limited extent say, up to 70 or 75% and, therefore, subsequent drafting or drawing operations are required to increase the orientation or alignment of the individual fibers in the web above such percentages. These subsequent drafting or drawing operations have had so much orienting or aligning of the fibers to do to produce the desired highly oriented web that difficulties in these operations have ensued.

In accordance with the present invention, individual fibers in a web are removed from the doffing cylinder of a card, or from some other rotatable or movable carrier surface, in a manner which simultaneously increases the fiber orientation in the resulting web. In consequence, a more highly oriented web is obtained and subsequent operations to increase the orientation and alignment of the fibers are minimized and thereby greatly facilitated and expedited.

In a copending patent application Serial Number 9,965, filed simultaneously herewith on February 19, 1960, there are described methods and apparatus for simultaneously doffing and drafting fibrous webs by means of a rotatable stripper roll clothed with metallic or fillet clothing adjacent to but spaced from the rotatable surface of a card doffing cylinder initially carrying the fibrous web. The methods and apparatus described therein have been employed satisfactorily for doffing and drafting fibrous webs having long fibers, say from about 1¼ inches to about 2½ inches or more in length. Where the fibrous webs to be drafted contain shorter fibers, say from about ½ inch to about 1 inch in length, the apparatus of the said copending application does not lend itself to the same general effectiveness in doffing and drafting these fibers as it does for the longer fibers. This is due largely to the absence of the same physical control over the shorter fibers during the drafting operation as the machine exercises upon the longer fibers.

The present invention provides novel methods and apparatus particularly adapted for doffing and simultaneously drafting fibrous webs containing a wide range of fiber

2

lengths; either the shorter fibers of from ½ inch to 1 inch in length, the longer fibers up to about 2½ inches or more in length, or mixtures of such fibers. During doffing and drafting in accordance with the present invention the machine exercises positive physical control over the longer fibers and substantially the same physical control over the shorter fibers. The extent of physical control over the shorter fibers by the machine of the present invention has not been achieved by other machines insofar as is known.

Simultaneous doffing and drafting may be obtained in accordance with the present invention by initially providing a carded fibrous web on a movable carrier surface, such as the doffing cylinder of a card, and then positioning a relatively smooth-surfaced endless flexible belt adjacent to but spaced from the doffing cylinder by a predetermined distance, whereby the carded fibrous web is transferred from the doffing cylinder to the movable belt. This movable belt, being flexible, may be trained over relatively small diameter rods or bars or equivalent elements positioned in close proximity to the movable fiber-carrying surface so that the moving belt approaches that surface at any desired angle, and rapidly departs therefrom at any other angle as desired. This is to be contrasted to the gradual departure of the surface of a cylinder, for example, the radius of which cannot be made too small for physical strength reasons. The flexible belt, by then cooperating with a second rotatable or movable surface which presses against the belt and forms a nip therewith, is able to seize the leading ends of the fibers at a point relatively close to the periphery of the first movable or fiber-carrying surface and to draw the fibers in positive fashion therefrom.

By suitably adjusting the surface linear velocity of the movable flexible belt with reference to the surface peripheral linear velocity of the movable fiber-carrying surface, the movable belt may be made to draw the fibers away from the fiber-carrying surface at any desired greater velocity whereby they are drafted or drawn and assume a more highly oriented or aligned configuration with respect to the long axis of the drafted fibrous web. Such a more highly oriented web is more suitable for further processing, as desired or required.

The fibrous web or layer which is processed to form the products of this invention may contain natural or synthetic, vegetable, animal or mineral fibers such as cotton, silk, wool, vicuna, mohair, alpaca, flax, ramie, jute, etc.; synthetic or man-made fibers such as the cellulosic fibers, notably cuprammonium, viscose or regenerated cellulose fibers; cross-linked cellulosic fibers such as "Corval" and "Topel"; cellulose ester fibers such as cellulose acetate ("Celanese") and cellulose tri-acetate ("Arnel"); the saponified cellulose ester fibers such as "Fortisan" and "Fortisan-36"; the polyamide fibers such as nylon 420, nylon 6 (polycaprolactam), nylon 66 (hexamethylene diamine-adipic acid), nylon 610 (hexamethylene diamine-sebacic acid), nylon 11 (11-amino undecanoic acid—"Rilsan"); protein fibers such as "Vicara"; halogenated hydrocarbon fibers such as "Teflon" (polytetrafluoroethylene); hydrocarbon fibers such as polyethylene, polypropylene, polybutadiene and polyisobutylene; polyester fibers such as "Kodel" and "Dacron"; vinyl fibers such as "Vinyon" and saran; dinitrile fibers such as "Darvan"; nitrile fibers such as "Zefran"; acrylic fibers such as "Dynel," "Verel," "Orlon," "Acrilan," "Creslan," etc.; mineral fibers such as glass, metal; etc.

The lengths of the fibers in the starting fibrous web may vary from about ½ inch up to about 2½ inches or more in length, depending upon the particular properties and characteristics required or desired in the resulting fibrous web. If desired, the fibrous layer may have fibers other than those of textile length added thereto.

The amount of such other fibers to be added will depend upon the properties desired in the final products to be produced from the fibers, and upon how close to the fiber-carrying surface the fibers can be gripped for doffing. The amount may vary from about 1 or 2% by weight up to about 100% by weight, but will usually be preferably less than about 50% by weight. These other fibers may be of papermaking length, which extend from about $\frac{3}{8}$ inch in length down to about $\frac{1}{16}$ of an inch or less in length, which shorter fibers normally are not used in conventional methods of producing fibrous webs.

Illustrative of these short papermaking fibers are the natural cellulosic fibers such as woodpulp and wood fibers, cotton linters, cotton hull shavings fibers, mineral fibers such as asbestos, glass, rockwool, etc., or any of the hereinbefore-mentioned natural or synthetic fibers in lengths less than about $\frac{1}{2}$ inch and down to about $\frac{1}{16}$ of an inch or less.

The denier of the individual synthetic fibers referred to above is preferably in the range of the approximate thickness of the natural fibers mentioned and consequently deniers in the range of from about 1 to about 5 are preferred. Where greater opacity or greater covering power is desired, special fiber deniers of down to about $\frac{3}{4}$ or even about $\frac{1}{2}$ may be employed. Where desired, deniers of up to about 5.5, 6, 8, 10, 15, or higher, may be used. The minimum and maximum denier are naturally dictated by the desires or requirements for producing a particular fibrous web, by the machines and methods for producing the same, and so forth.

The weight of the fibrous web or layer of starting material on the doffing cylinder may be varied within relatively wide limits above a predetermined minimum value, depending upon the requirements of the intermediate or the final products. A single, thin web of fibers, such as produced by a card and as presented by the doffing cylinder, may have a weight of from about 30 to about 250 or more grains per square yard and may be used in the application of the principles of the present invention. Within the more commercial aspects of the present invention, however, web weights on the doffing cylinder of from about 60 grains per square yard to about 175 grains per square yard are contemplated.

If heavier web weights are desired for the final web of highly aligned fibers, such as up to 1800 grains, for example, several individual webs of highly aligned fibers produced in accordance with this invention may be combined into a laminated structure to obtain the desired weight. The product of one doffing and drafting machine may be folded, doubled, tripled, etc., on itself to reach the heavier weight, or the products from a plurality of doffing and drafting machines may be used and the individual products stacked or laminated for a similar purpose.

The invention will be more fully understood from the description which follows, taken in conjunction with the accompanying drawings in which there are illustrated preferred designs of machines and modes of operation embodying the invention. It is to be understood, however, that the invention is not to be considered limited to the constructions disclosed except as determined by the scope of the appended claims. In the drawings:

FIGURE 1 is a simplified, fragmentary, schematic view in elevation showing the general principles of operation of the present invention;

FIGURE 2 is a simplified, fragmentary, schematic view in elevation showing in greater detail the structure and operation of one embodiment of the doffing and drafting mechanism of the present invention;

FIGURE 3 is a simplified, fragmentary, schematic view of a 1-inch strip of web disposed upon the surface of the doffing cylinder, extending across the width thereof at approximately the four o'clock position in FIGURE 1, showing a few illustrative individual fibers as seen by

one looking at the surface of the doffing cylinder from the right hand side of FIGURE 1;

FIGURE 4 is a showing of the same 1-inch strip of web upon the surface of the doffing cylinder at approximately the eight o'clock position in FIGURE 1, showing the same illustrative individual fibers as are seen in FIGURE 3 except that in this figure they are shown as seen by one looking at the surface of the doffing cylinder from the left hand side of FIGURE 1;

FIGURE 5 is a simplified, fragmentary, schematic view in elevation, very similar to FIGURE 2, but showing in detail the doffing and drafting of an illustrative fiber; and

FIGURE 6 is a simplified, fragmentary, schematic view in elevation showing the structure and operation of another embodiment of the doffing and drafting mechanism of the present invention.

In the embodiment of the invention illustrated in FIGURES 1 through 5 of the drawings, a conventional textile card is used and comprises a conventional rotatable main card cylinder 10 which is used to provide for the normal carding of the fibers fed to the card whereby the fibers are disentangled and the bunches or tufts of fibers are separated more or less into individual fibers. The initial attenuating of the fibers into a generally aligned condition takes place on the surface of the main cylinder 10 and the individualized fibers are sparsely spread over the rotating surface in an amount weighing but a few grains per square yard.

These substantially individualized fibers which do not normally constitute a self-sustaining fibrous web are presented to and deposited on the surface of a doffing cylinder 12 which rotates on a shaft 14 mounted in bearings 16 secured to the card frame 18. The doffing cylinder 12 rotates at a much lower peripheral surface linear velocity than the main cylinder 10, in accordance with standard practice. This velocity differential, which may be varied as desired, creates a condensing of the individual fibers into a thin, fibrous carded web normally weighing from about 30 grains to about 250, and preferably from about 60 to about 175 grains per square yard, on the peripheral surface of the rotatable doffing cylinder 12.

As shown in FIGURE 3, the individual fibers which were hooked upon the pins of the card cylinder are pulled off those pins by the teeth of the doffing cylinder and are deposited on the surface of the doffing cylinder in U-shaped or hook-shaped fashion. One end of the fiber lies in a leading or forwardly-directed position on the doffing cylinder, and normally the trailing portion is hooked reversely to form a U-shaped configuration, but occasionally it meanders rearwardly in various shapes and random configurations. (In FIGURE 3, the "forward" direction of movement of the doffing cylinder corresponds to the downward direction in the drawing.)

When U-shaped, the lengths of the leading leg portion and trailing leg portion vary from some shapes in which the trailing leg portion is very small and constitutes only a minor fraction of the total length of the individual fiber to other shapes in which the trailing leg portion is almost as long as the leading leg portion and thus constitutes almost 50% of the total length of the individual fiber. When the trailing portion merely meanders rearwardly, the configurations are almost infinite and defy any specific classification. In substantially all configurations, however, it is noted that one end of the fiber extends forwardly more than the other portions of the fiber, and that portion of the fiber is thus the so-called "leading end portion" to be discussed in greater detail hereinafter.

FIGURE 4 shows the same strip of fibrous web engaged with the pins of the doffing cylinder as is shown in FIGURE 3. However, the web is now shown at approximately the eight o'clock position on the doffing cylinder of FIGURE 1. FIGURE 4 may be considered to be the result obtained by "flopping" FIGURE 3 over.

In FIGURE 4 one observes the same illustrative in-

5

dividual fibers as are contained in FIGURE 3, except that they are now in the position occupied by them after they have moved through substantially one-third of a revolution of a doffing cylinder from their positions shown in FIGURE 3.

The main cylinder 10 and the doffing cylinder 12 are conventional; the main cylinder being about 50 inches in outside diameter and about 45 inches wide; and the doffing cylinder being about 26 or 27 inches in outside diameter and also about 45 inches wide. The main cylinder and the doffing cylinder are both covered with conventional card clothing, comprising a large number of pins which constitute protuberances acting together as a carrier surface, adapted to have fibers entwined with the protuberances in slidable engagement therewith.

As seen in FIGURE 1, the top portions of the pins of the doffing cylinder are slanted in the opposite direction from the direction in which the leading free ends of the fibers slant which are intertwined with the pins as described above. (In the embodiment shown, the latter direction is the direction of linear movement of the surface of the doffing cylinder.) As a result, when a given fiber is slid off the fiber-carrying surface of the doffing cylinder by the doffing and drafting mechanism 20 to be described below, the slidably restrained trailing portion of the fiber will not ordinarily be prematurely pulled off the slanted top end of the pin or pins with which it is entwined. It is important that the slidable engagement between a fiber being doffed and drafted and the pin or pins of the doffing cylinder with which it is engaged be maintained for as much of the period of time during which that fiber is being straightened out and pulled off the pins as is possible. The longer the slidable engagement is continued, the longer the period of positive drafting control at both ends of the fiber being drafted continues.

Immediately adjacent the doffing cylinder 12, and approximately at the position where the fibrous web formed thereon is conventionally removed by the usual textile doffing comb, there is located a doffing and drafting mechanism 20.

In the embodiment illustrated in FIGURE 1, the doffing and drafting mechanism 20, as shown more particularly in FIGURE 2, comprises a stationary, angular nose bar 22 having an elongated nose portion 24 and a reinforcing base portion 26. The reinforcing base portion 26 strengthens and steadies the nose portion 24 but may be omitted when the nose portion 24 is sufficiently strong and steady by itself. The nose bar 22 is adjustable so that the nose portion 24 thereof can be controllably and accurately positioned at any desired angular relationship, or with any desired clearance, with respect to the peripheral surface of the doffing cylinder 12. The point of closest proximity of the nose portion 24 to the peripheral surface of the doffing cylinder 12 is referred to herein as the "pickoff point" P and is of importance for reasons to be made clear hereinafter.

An endless, flexible doffing and drafting belt 30 is passed around the nose portion 24 and is then passed under a movable pressure member—in the embodiment under discussion a rotatable, pressure nip roll 32—which is adjustably positioned with respect to the nose portion 24 and the peripheral surface of the doffing cylinder 12. Due to the elongated configuration of the nose portion 24, the rotatable nip roll 32 is able to be positioned not only very close to the nose portion 24 but also to the adjacent pick-off point P on the peripheral surface of the doffing cylinder 12.

As a result, the nip roll 32 is able to make initial contact with the flexible doffing and drafting belt 30 at a point relatively close to the pick-off point P, as measured along the flexible belt 30. This point of first contact between the rotatable nip roll 32 and the doffing and drafting belt 30 is referred to herein as the "nip point" N and is of importance for reasons to be made clear hereinafter.

The region through which the endless doffing and

6

drafting belt passes which begins at about the pick-off point P in FIGURE 2 and extends around the nose portion 24 to nip point N may be characterized as the "doffing zone." It will be noted that a portion of the guide means or nose bar 22 is located within the doffing zone.

Because of its location, guide means or nose bar 22 acts to position doffing and drafting belt 30, as it travels through the doffing zone, in close proximity to the carrier surface constituted of the pins on doffing cylinder 12. At the same time, the guide means positions belt 30 in pressing contact with the movable pressure member or nip roll 32. The guide means presses the endless belt into first contact with the movable pressure member or nip roll 32 at nip point N, which is in close proximity to the moving carrier surface 12, and as a result exposed free ends of individual fibers engaged by the carrier surface are grasped by the bite formed by the nip roll 32 and the endless belt 30.

It is to be noted that the doffing and drafting belt 30 is so guided in its approach to the "pick-off point" that the space lying between the belt and the doffing cylinder gradually narrows down over a considerable arcuate area to a relatively narrow throat. In this way, any fibers which protrude more or less from the wire-toothed surface of the doffing cylinder are gradually pressed against such wire teeth into a more compacted, denser web.

One advantage of such gradual pressing into a more compacted web is that the fiber-to-fiber cohesion is improved. Consequently, any short fibers which are present are also drafted and straightened when the nip formed by the pressure roll 32 and the doffing and drafting belt 30 pull the fibers forwardly inasmuch as, even if the trailing portions of the fibers are no longer being restrained by the surface of the doffing cylinder, they are being restrained by the fiber-to-fiber cohesion of the compacted web. As a consequence, therefore, in many cases of shorter fibers, the surface of the doffing cylinder restrains the fibers for a short time only, or not at all, and the interfiber cohesion may exert the major restraint.

The nip roll 32 is adjustably pressed against the movable doffing and drafting belt 30 and has a surface linear velocity which is substantially equal to the surface linear velocity of the belt. The pressure of the nip roll 32 against the movable belt is such that a definite arcuate length is formed in which the nip roll contacts the belt and in which fibers positioned therebetween are pressed over a substantial portion of their lengths. This increased length of pressing contact on the fiber is vastly superior to the pressing contact obtained by using two cylindrical tangentially positioned rolls having only a rolling point contact on the fibers whereby slippage is possible and probable.

The length of arcuate contact may be varied widely depending upon the particular circumstances. In FIGURE 2, the arcuate length covers about 130° of the circumference of the roll. A greater arcuate length would provide greater arcuate contact. Lesser arcuate lengths down to 15° or 20° provide sufficient contact under many circumstances.

It is also to be noted that this arcuate contacting region is concavely curved as compared to the convexly curved region where the fibers pass over the nose bar 22. It is believed that such configuration assists in the grasping of the fibers properly.

The downstream end of the arcuate contacting region may be identified as point N'. The region through which endless belt 30 passes which extends from point N to N' may be characterized as the "gripping zone."

It will be noted that the arcuate path followed by drafting belt 30 through the gripping zone has a center of curvature C_N which coincides with the axis of nip roll 32. The path followed by the belt in passing through the gripping zone has a corresponding radius of curvature, which is measured from point C_N to the surface of roll 32.

The doffing and drafting belt 30 after passing under the rotatable nip roll 32 passes upwardly over a driving rotatable guide roll 40. The driving rotatable guide roll 40 may be driven by any suitable driving means such as an electric motor (not shown).

The doffing and drafting belt 30 is then directed downwardly and passes over an adjustable, rotatable, guiding and tensioning roll 42. The mounting of the rotatable, guiding and tensioning roll 42 is so arranged that it can be adjusted, as desired, in order to supply the desired tension to the belt.

The doffing and drafting belt 30 passes around a rotatable guide roll 44 and is then directed upwardly over the nose portion 24 of the nose bar 22. As can be seen, the belt is endless and moves in a continuous cycle, as described.

The operation of the doffing and drafting mechanism is as follows. The carded web which is formed on the doffing cylinder is carried on the periphery thereof around to the pick-off point P. At this point, the elongated nose portion 24 positions the doffing and drafting belt 30 with the desired clearance from the periphery of the doffing cylinder 12 and the fibers are doffed or removed from the doffing cylinder and positioned on the doffing and drafting belt 30 by adhesion and perhaps by electrostatic attraction. In this removal, it is to be noted that the leading ends of the fibers of the web on the doffing cylinder 12 are picked off first and are carried from the pick-off point P to the nip point N and are then pressed against the doffing and drafting belt 30 by the rotatable nip roll 32.

By having the doffing and drafting belt 30 move with a linear velocity which is greater than the peripheral surface linear velocity of the doffing cylinder, the individual fibers are drawn or drafted forwardly and slid off the teeth or needles of the doffing cylinder 12 whereby they are straightened and aligned with a considerably higher degree of orientation on the doffing and drafting belt 30.

The ratio of the surface linear velocity of the doffing and drafting belt to the surface linear velocity of the doffing cylinder must be greater than 1 to 1 in order that drafting and increased alignment of the fibers is accomplished. In some instances, ratios as low as about 1.1 to 1 have been used successfully depending primarily upon the nature and characteristics of the fibers involved. In most instances, ratios of from about 1.5 to 1 to about 4 to 1 have been found preferable, with optimum results being noted at about 3 to 1. Ratios higher than 4 to 1 are utilizable within the principles of the present invention, with values of up to 10 to 1 or higher being of use in special cases.

The nose portion 24 of the nose bar 22 so positions the doffing and drafting belt 30 that the clearance between the belt and the doffing cylinder 12 is maintained within closely controlled limits. Within the broader aspects of the present invention, it has been found that this clearance should be as small as physically possible and should be on the order of from about 0.005 inch to about 0.150 inch for cotton or rayon fibers of typical lengths. Within the more commercial aspects of the present invention, it has been found, again with cotton and rayon fibers of typical lengths, that a narrower range of from about 0.007 inch to about 0.040 inch is preferred.

The rotatable nip roll 32 is also adjustably positioned in such a way that the clearance between its peripheral surface and the peripheral surface of the doffing cylinder 12 is as small as physically possible and is in the range of from about 0.005 inch to about 0.150 inch for the types of fibers just referred to. Within the more commercial aspects of the present invention, such clearance is preferably in the range of from about 0.007 inch to about 0.040 inch for fibers of the type indicated.

Due to the unusual elongated nature of the nose portion 24, the distance from the pick-off point P on the

doffing cylinder to the nip point N on the nip roll 32, as measured along the flexible belt 30, is kept to a minimum. In this way, positive removal of all the fibers from the doffing cylinder is obtained for all the fibers whose free leading ends extend outward from the cylinder far enough to be grasped between the bite at the nip point N, and any tendency of the fibers to return to the doffing cylinder 12 as it passes beyond nip point N is reduced to a minimum.

The maximum distance between the pick-off point and the nip point should be not more than about one-half the staple length of the fibers being carded. More specifically, it has been found that the distance from the fiber pick-off point to the nip point should be from about 20% to about 50% of the average staple length of the fibers. Within the more commercial aspects of the present invention, however, from about 30% to about 50% of the average staple length has been found preferable. These percentages will be discussed in greater detail hereinafter and the scientific basis for such values will be made clear.

It is realized that the distance from the fiber pick-off point to the nip point may be decreased even further by providing a narrower and more elongated nose portion 24. However, the requirements for adequate physical strength of the nose portion prevent the making of the nose portion too thin. Additionally, the wear and tear on the doffing and drafting belt increases as it is flexed more sharply over narrower nose portions whereby its service life is drastically reduced. It has been found that a nose portion with a controlling end portion having a radius of from about $\frac{1}{16}$ inch to about $\frac{3}{16}$ inch is satisfactory for best over-all performance characteristics when cotton or rayon fibers of typical lengths are involved.

Nose portion 24 has a center of curvature C_P , as shown in FIGURE 2. The corresponding radius of curvature is measured from point C_P to the end of the curved portion of the guide means or nose bar 22 around which the endless doffing and drafting belt 30 moves as it passes through the doffing zone into the gripping zone.

The fact that the radius of curvature for the portion of the nose bar 22 located in the doffing zone is less than the radius of curvature of the path followed by the endless belt 30 from point N to point N' through the gripping zone makes the distance from nip point N to pick-off point P smaller than has heretofore been achievable in the prior art. Similarly, the distance between the nip point N and pick-off point P is reduced by the fact that the center of curvature C_P is closer to the carrier surface of the doffing cylinder 12 than is the center of curvature C_N .

The materials of which the doffing and drafting belt and nip roll are made are of importance. Substantially any suitable material is satisfactory including metal, leather, rubber, plastic, fabric, film, etc. However, it is desired that the surface of the roll be made of a harder material than the belt, to improve the grip on the fibers during drafting. If incorrect materials are used, the nip roll will tend to slide on the doffing and drafting belt and the advantages of the present invention are lost.

The diameter of the nip roll is also a factor to be considered. If the nip roll is too small, there is a tendency for the fibers to lap or wrap around the nip roll rather than to stay with the doffing and drafting belt. If the nip roll, however, is made too large, the distance between the pick-off point P and the nip point N becomes too large and the advantages of the present invention are lost. Within the more practical aspects of the present invention, the diameter of the nip roll is in the range of from about $\frac{3}{4}$ inch to about 3 inches for cotton or rayon fibers of typical lengths. Commercially, the range for such fibers has been found to be preferably between $1\frac{1}{4}$ inches and $2\frac{1}{4}$ inches.

The individual fibers of the fibrous web on the doffing cylinder are doffed at the pick-off point P, are gripped between the doffing and drafting belt 30 and the rotatable nip roll 32 at the nip point N and, due to the higher linear velocity of the drafting belt 30, are simultaneously drawn forwardly at a greater speed, and are drafted.

During this simultaneous doffing and drafting operation, an unusual advantage of the present invention is noted. The fibers on the doffing cylinder are for the most part positioned thereon in a hooked or U-shaped configuration with the open end of the U facing forwardly in the direction of movement of the doffing cylinder. In the case of those fibers which are not hooked or U-shaped, there is nevertheless still a leading end which operates in the same way as the end of the leading leg of a U-shaped fiber. A simplified, diagrammatic showing of how fibers having a U shape or other configuration such as just described may be distributed in a typical portion of a card web is given in FIGURE 3 and also in FIGURE 4. The following description, although specific with respect to using a U-shaped fiber as the illustrative fiber nevertheless is generically applicable to all fibers of the web.

The lengths of the legs of the U-shaped fibers are of all varying lengths, depending to a large extent upon the manner in which they are transferred from the main card cylinder and deposited on the doffing cylinder. As a practical matter, the two legs of a U-shaped fiber will rarely, if ever, be exactly equal and consequently in practically every case one leg of a U-shaped fiber is ahead of the other leg. As a result, it is this leading leg of the U-shaped fiber (or the leading end of a non-U-shaped fiber) which is first positioned on the flexible movable belt 30 and first gripped by the pressure nip roll 32 and drawn forwardly in positive fashion.

FIGURE 5 illustrates four illustrative fibers: the first two fibers (f^1 and f^2) as they approach the pick-off point P; the third (f^3), as it is being pulled forwardly by the doffing and drafting belt 30 and the nip roll 32 and aligned thereby with its trailing portion still being restrained on the pins of the doffing cylinder; and the fourth (f^4), after it has been drafted and aligned and is moving forwardly over roll 40. Fibers f^1 and f^2 would occupy substantially the position shown at the extreme right end of FIGURE 4, when observed by one looking at the doffing cylinder from the left hand side of FIGURE 1 or FIGURE 5.

Since the movable belt 30 and nip roll 32 have a higher surface linear velocity than the doffing cylinder, as soon as they grasp the leading end of a fiber they immediately begin to draw the leading leg forwardly at an increased velocity and, since the base or trailing portion of the U-shaped fiber is hooked around a wire or a tooth on the doffing cylinder, the shorter leg of the U-shaped fiber is gradually pulled or slid around that point or tooth whereby it is ultimately drawn out as straight as possible, considering its inherent physical characteristics, and so positioned on the drafting belt. In this way, the individual fibers are straightened or aligned in the machine direction to a very high degree and considerably higher than previously possible.

It is immediately apparent that, in order to insure that each individual fiber of at least average length will be grasped between the bite formed by the doffing and drafting belt and the pressure nip roll and will be restrained by the doffing cylinder at the same time, the maximum distance from the pick-off point to the nip point must be no greater than about 50% of the length of the average individual fiber. This distance will insure the positive control just described at both ends of all fibers of at least average length (so long as the fiber forms no more than one hook) even in the extreme case in which both legs of the hook are of substantially the same length.

A nip point to pick-off point distance of less than 50% of the average fiber length is, of course, preferred, and

percentages down to about 20 or 25% are highly advantageous. Less than 20% is even more highly advantageous, but the physical weakening of the strength of the nose bar begins to be noted and deflection of the supporting rolls and other members enters to disrupt the uniformity and continuity of the operation.

On the other hand, inasmuch as only a small percentage of the individual fibers are bent almost in half, and thus require a distance of no more than 50% average fiber length from pick-off point to nip point, and, inasmuch as in many cases the shorter leg of the U-shaped fiber is only about one-third of the total length of the individual fiber, rather than about half, it has been found that satisfactory drafting may actually take place if the distance from the pick-off point to the nip point is increased to about $\frac{2}{3}$ or about 67% of the average length of the fiber being treated. Not all of the fibers will be drafted and aligned with positive control when such higher percentages are used, but this can be tolerated in many cases where lower degrees of fiber orientation are permissible.

The drafted and straightened fibers are carried forward on the movable belt 30 over the driving roll 40 down over the tensioning roll 42 and are permitted to fall upon an inclined plate or conveyor 50 to be led forward to be further processed as desired. In FIGURE 1, there is shown a trumpet 52 which is used to form the fibrous web into a conventional cylindrical sliver which passes between pressing rollers 54 and 56 and is then led forwardly by conveyor or other delivery means for further processing. Other devices than a trumpet 52 could be employed, or the fibrous web could be further processed in web form or in other shapes, as desired, and the trumpet 52 is employed to illustrate merely one of many devices which could be used.

Another embodiment of the doffing and drafting mechanism of the invention is shown in FIGURE 6. In that figure, the movable pressure member of the embodiment described in detail above (rotatable nip roll 32) is replaced by the endless belt 60. Endless belt 60 passes around guide means 62 and adjustable rotatable guide and tensioning roll 64. Endless belts 30 and 60 move at substantially the same rate of speed.

The other guide rolls 40, 42 and 44 of the embodiment of FIGURE 6 are the same as in the embodiment previously described. In addition, guide means or nose bar 22, with its nose portion 24, is the same as in the previous embodiment.

It is seen that use of two belts permits bringing the nip point N even closer to the fiber pick-off point P on the doffing cylinder 12 than was true with the embodiment employing one endless belt and a pressure nip roll.

The material of which the endless belts 30 and 60 are formed should be of different hardness, in order to produce the best grip on the fibers in the gripping zone extending from point N to N'.

The guide means 62 may be provided with openings 66 to assist in dissipating the frictional heat produced by passage of the endless belt 60 over the guide means. Other suitable lubricating and cooling means may also be employed to diminish and dissipate this heat of friction.

The guide means 62 has a radius of curvature greater than the radius of curvature of the portion of the nose bar 22 located in the doffing zone, with the attendant advantage of reduction in the distance from the nip point N to the pick-off point P. The radius of curvature of the guide means 62 is measured from its face which is in contact with endless belt 60 to center of curvature C_N . The radius of curvature of the nose portion 24 of guide means 22 is measured from the curved surface at the end of the nose portion to center of curvature C_P .

In the embodiment shown in FIGURE 6, the radius of curvature of the guide means 62 is constant throughout the gripping zone. It may be desired to provide a curvature that is not constant for the path followed by

the endless belts 30 and 60 as they move through the gripping zone. In such case, the path will still have a general curvature which can be approximated by drawing an arc through point N at one end of the gripping zone, another point near the middle of the zone, and point N' at the other end of the gripping zone. To attain the advantages of this invention, the general radius of curvature thus approximated must be greater than the radius of curvature of the curved portion of the guide means 22 within the doffing zone.

It may also be desired to decrease the curvature of the path followed by the belts of the gripping zone until it is substantially zero. It will be recognized that such a path could be considered as having an infinite radius of curvature.

Whether the movable pressure member of the doffing and drafting mechanism of this invention is a rotatable nip roll or a rotatable endless belt, it is desirable to make the gripping zone at least as long as the longest fiber being doffed and drafted. A gripping zone of this length insures positive control at the forward end of each fiber as it is straightened out while being slid off the fiber carrying surface.

No matter what the nature of the movable pressure member, the gripping zone formed by the pressing contact of that member against the endless doffing and drafting belt should have as large a radius of curvature as is consistent with the remainder of the mechanism. The more gradual the curve of the path followed by the doffing and drafting belt through the gripping zone, the less the tendency will be toward fouling by the adhering of fibers to the movable pressure member.

The invention will be further illustrated in greater detail by the following specific examples. It should be understood, however, that although these examples may describe in particular detail some of the more specific features of the invention, they are given primarily for purposes of illustration and the invention in its broader aspects is not to be construed as limited thereto.

Example I

The starting fibrous material, as delivered by the doffing cylinder to the doffing and drafting belt, is a 45 inch-wide card web of viscose rayon staple fibers, weighing about 75 grains per square yard and containing fibers having a substantially uniform length of about 1 inch and a denier of about $1\frac{1}{2}$. The peripheral surface linear velocity of the doffing cylinder is 20 yards per minute. The doffing cylinder is covered with metallic clothing having 11 points per inch with 26 wraps per inch of cylinder.

The fibrous web is transferred to a flexible movable doffing and drafting belt which passes over a nose bar and is accurately spaced 0.005 inch from the peripheral surface of the doffing cylinder. The doffing and drafting belt has a peripheral surface linear velocity of 22 yards per minute. This is equivalent to a 1.1 to 1 ratio (belt to doffing cylinder). The nose portion of the nose bar is about $\frac{3}{16}$ inch thick and the radius of the controlling end is about $\frac{1}{16}$ inch. The belt then passes under a nip roll having a diameter of 2 inches. The distance from the pick-off point the doffing cylinder to the nip point on the nip roll, as measured along the flexible belt, is about $\frac{1}{2}$ inch, or 50% of the average staple length of the fibers.

Examination of the fibrous web, after it has been removed from the flexible belt, reveals that the drafted web has a weight of about 68 grains per square yard and a much higher degree of fiber orientation than that present in a similar fibrous web prepared from similar materials on similar equipment but removed from the doffing cylinder by a conventional doffing comb.

The degree of fiber orientation of the fibrous web on the doffing cylinder is about 70%; the degree of fiber orientation of the drafted web is about 85%. The web is well suited for further processing and ultimate spinning into yarn.

Example II

The starting fibrous material, as delivered by the doffing cylinder to the doffing and drafting belt, is a 45 inch-wide card web of viscose rayon staple fibers, weighing about 80 grains per square yard and containing fibers having a substantially uniform length of about $1\frac{1}{4}$ inches and a denier of about $1\frac{1}{2}$. The peripheral surface linear velocity of the doffing cylinder is 20 yards per minute. The doffing cylinder is covered with metallic clothing having 11 points per inch with 26 wraps per inch of cylinder.

The fibrous web is transferred to a flexible movable doffing and drafting belt which passes over a nose bar and is accurately spaced 0.007 inch from the peripheral surface of the doffing cylinder. The doffing and drafting belt has a peripheral surface linear velocity of 25 yards per minute. This is equivalent to a 1.25 to 1 ratio (belt to doffing cylinder). The nose portion of the nose bar is about $\frac{3}{16}$ inch thick and the radius of the controlling end is about $\frac{1}{16}$ inch. The belt then passes under a nip roll having a diameter of 2 inches. The distance from the pick-off point on the doffing cylinder to the nip point on the nip roll, as measured along the flexible belt, is about $\frac{1}{2}$ inch, or 40% of the average staple length of the fibers.

Examination of the fibrous web reveals that the drafted web has a weight of about 64 grains per square yard and a much higher degree of fiber orientation than that present in a similar fibrous web prepared from similar materials on similar equipment but removed from the doffing cylinder by a conventional doffing comb.

The degree of fiber orientation of the fibrous web on the doffing cylinder is about 70%; the degree of fiber orientation of the drafted web is about 90%. The web is well suited for further processing and ultimate spinning into yarn.

Example III

The starting fibrous material, as delivered by the doffing cylinder to the doffing and drafting belt, is a 45 inch-wide card web of viscose rayon staple fibers, weighing about 100 grains per square yard and containing fibers having a substantially uniform length of about $1\frac{1}{16}$ inches and a denier of about $1\frac{1}{2}$. The peripheral surface linear velocity of the doffing cylinder is 20 yards per minute. The doffing cylinder is covered with metallic clothing having 11 points per inch with 26 wraps per inch of cylinder.

The fibrous web is transferred to a flexible movable doffing and drafting belt which passes over a nose bar and is accurately spaced 0.010 inch from the peripheral surface of the doffing cylinder. The doffing and drafting belt has a peripheral surface linear velocity of 30 yards per minute. This is equivalent to a 1.5 to 1 ratio (belt to doffing cylinder). The nose portion of the nose bar is about $\frac{1}{4}$ inch thick and the radius of the controlling end is about $\frac{3}{32}$ inch. The belt then passes under a nip roll having a diameter of 2 inches. The distance from the pick-off point on the doffing cylinder to the nip point on the nip roll, as measured along the flexible belt is about $\frac{1}{2}$ inch, or 32% of the average staple length of the fibers.

Examination of the fibrous web reveals that the drafted web has a weight of about 67 grains per square yard and a much higher degree of fiber orientation than that present in a similar fibrous web prepared from similar materials on similar equipment but removed from the doffing cylinder by a conventional doffing comb. The degree of fiber orientation of the fibrous web on the doffing cylinder is about 70%; the degree of fiber orientation of the drafted web is about 92%. The web is well suited for further processing and ultimate spinning into yarn.

Example IV

The starting fibrous material, as delivered by the doffing cylinder to the doffing and drafting belt, is a 45 inch-wide card web of cotton staple fibers having an average staple length of about 1 inch and weighing about 100 grains per

square yard. The peripheral surface linear velocity of the doffing cylinder is 20 yards per minute. The doffing cylinder is covered with metallic clothing having 11 points per inch with 26 wraps per inch of cylinder.

The fibrous web is transferred to a flexible movable drafting belt which passes over a nose bar and is accurately spaced 0.015 inch from the peripheral surface of the doffing cylinder. The drafting belt has a peripheral surface linear velocity of 30 yards per minute. This is equivalent to a 1.5 to 1 ratio (belt to doffing cylinder). The nose portion of the nose bar is about $\frac{1}{4}$ inch thick and the radius of the controlling end is about $\frac{3}{32}$ inch. The belt then passes under a nip roll having a diameter of 2 inches. The distance from the pick-off point on the doffing cylinder to the nip point on the nip roll, as measured along the flexible belt, is about $\frac{3}{8}$ inch or 37% of the average staple length of the fibers.

Examination of the fibrous web reveals that the drafted web has a weight of about 67 grains per square yard and a much higher degree of fiber orientation than that present in a similar fibrous web prepared from similar materials on similar equipment but removed from the doffing cylinder by a conventional doffing comb. The degree of fiber orientation of the fibrous web on the doffing cylinder is about 70%; the degree of fiber orientation of the drafted web is about 90%. The web is well suited for further processing and ultimate spinning into yarn.

Example V

The starting fibrous material, as delivered by the doffing cylinder to the drafting belt, is a 45 inch-wide card web weighing about 100 grains per square yard and containing 50% by weight of cotton staple fibers having an average length of about $1\frac{1}{4}$ inches and 50% by weight of viscose rayon staple fibers having a length of about $1\frac{1}{16}$ inches and a denier of about $1\frac{1}{2}$. The peripheral surface linear velocity of the doffing cylinder is 20 yards per minute. The doffing cylinder is covered with metallic clothing having 11 points per inch with 26 wraps per inch of cylinder.

The fibrous web is transferred to a flexible movable drafting belt which passes over a nose bar and is accurately spaced 0.012 inch from the peripheral surface of the doffing cylinder. The drafting belt has a peripheral surface linear velocity of 30 yards per minute. This is equivalent to a 1.5 to 1 ratio (belt to doffing cylinder). The nose portion of the nose bar is about $\frac{1}{4}$ inch thick and the radius of the controlling end is about $\frac{3}{32}$ inch. The belt then passes under a nip roll having a diameter of 2 inches. The distance from the pick-off point to the nip point is about $\frac{9}{16}$ inch or about 40% of the average staple length of the fibers.

Examination of the fibrous web reveals that the drafted web has a weight of about 67 grains per square yard and a much higher degree of fiber orientation than that present in a similar fibrous web prepared from similar materials on similar equipment but removed from the doffing cylinder by a conventional doffing comb. The degree of fiber orientation of the fibrous web on the doffing cylinder is about 70%; the degree of fiber orientation of the drafted web is about 90%. The web is well suited for further processing and ultimate spinning into yarn.

Although several specific examples of the inventive concept have been described, the same should not be construed as limited thereby nor to the specific features mentioned therein but to include various other equivalent features as set forth in the claims appended hereto. It is understood that any suitable changes, modifications and variations may be made without departing from the spirit and scope of the invention.

What is claimed is:

1. The method of doffing a web of fibers from a rotating surface and substantially simultaneously drafting the same which comprises:

(a) carrying a web of fibers on a rotating surface with

ends of the fibers protruding outwardly beyond the periphery of the rotating surface;

- (b) gradually guiding a moving surface movable in a closed path toward said rotating surface whereby the protruding ends of the fibers contact the moving surface and providing a stationary support for said moving surface to control the point of closest proximity between said moving surface and said rotating surface, said stationary support contacting said moving surface substantially only at said point of closest proximity;
 - (c) driving said moving surface from within said closed path at a linear speed greater than the linear speed of the rotating surface whereby the ends of the fibers contacting the moving surface are gradually inclined forwardly and drawn forwardly in the direction of movement of the moving surface;
 - (d) gradually pressing the fibers of said web against said rotating surface over an arcuate area thereof to form a more compacted web having increased fiber-to-fiber cohesion and capable of being restrained more positively on the surface of said rotating surface;
 - (e) transferring the leading free ends of individual fibers of the compacted web carried by said rotating surface to said moving surface;
 - (f) grasping the leading free ends of the individual fibers carried by said moving surface at a region in close proximity to said rotating surface; and
 - (g) drawing said leading free ends of the individual fibers away from said rotating surface at a linear speed greater than the linear speed of the fibers on said rotating surface, while maintaining substantially the uniformity of the fiber weight distribution of the fibrous web and while restraining the trailing ends of said fibers by sliding engagement with the rotating surface and by said increased fiber-to-fiber cohesion, whereby the individual fibers are straightened and their degree of orientation in the long direction of the web is increased.
2. The method of doffing a web of fibers from a rotating surface and substantially simultaneously drafting the same which comprises:
- (a) carrying a web of fibers on a rotating surface with ends of the fibers protruding outwardly beyond the periphery of the rotating surface;
 - (b) gradually guiding a moving surface movable in a closed path toward said rotating surface whereby the protruding ends of the fibers contact the moving surface and providing a stationary support for said moving surface to control the point of closest proximity between said moving surface and said rotating surface, said stationary support contacting said moving surface substantially only at said point of closest proximity;
 - (c) driving said moving surface from within said closed path at a linear speed greater than the linear speed of the rotating surface whereby the ends of the fibers contacting the moving surface are gradually inclined forwardly and drawn forwardly in the direction of movement of the moving surface;
 - (d) gradually pressing the fibers of said web against said rotating surface over an arcuate area thereof to form a more compacted web having increased fiber-to-fiber cohesion and capable of being restrained more positively on the surface of said rotating surface;
 - (e) transferring the leading free ends of individual fibers of the compacted web carried by said rotating surface to said moving surface;
 - (f) grasping the leading free ends of the individual fibers carried by said moving surface at a region spaced from said rotating surface by a distance less than about one-half the average length of the fibers being doffed and drafted; and

- (g) drawing said leading free ends of the individual fibers away from said rotating surface at a linear speed greater than the linear speed of the fibers on said rotating surface, while maintaining substantially the uniformity of the fiber weight distribution of the fibrous web and while restraining the trailing ends of said fibers by sliding engagement with the rotating surface and by said increased fiber-to-fiber cohesion, whereby the individual fibers are straightened and their degree of orientation in the long direction of the web is increased. 5 10
3. The method of doffing a web of fibers from a rotating surface and substantially simultaneously drafting the same which comprises:
- (a) carrying a web of fibers on a rotating surface with ends of the fibers protruding outwardly beyond the periphery of the rotating surface; 15
- (b) gradually guiding a moving surface movable in a closed path toward said rotating surface whereby the protruding ends of the fibers contact the moving surface at a point well in advance of a hereinafter-mentioned pick-off point and providing a stationary support for said moving surface to control the spatial relationship of said moving surface and said rotating surface at said pick-off point, said stationary support contacting said moving surface substantially only at said pick-off point; 20 25
- (c) driving said moving surface from within said closed path at a linear speed greater than the linear speed of the rotating surface whereby the ends of the fibers contacting the moving surface are gradually inclined forwardly and drawn forwardly in the direction of movement of the moving surface as they approach the hereinafter-mentioned pick-off point; 30
- (d) gradually pressing the fibers of said web against said rotating surface over an arcuate area thereof immediately preceding the hereinafter-mentioned pick-off point to form a more compacted web having increased fiber-to-fiber cohesion and capable of being restrained more positively on the surface of said rotating surface; 35 40
- (e) transferring the leading free ends of individual fibers of the compacted web carried by said rotating surface to said moving surface at a pick-off point which is the point of closest proximity of the moving surface to the rotating surface; 45
- (f) grasping the leading free ends of the individual fibers carried by said moving surface at a region in close proximity to said pick-off point; and
- (g) drawing said leading free ends of the individual fibers away from said pick-off point, at a linear speed greater than the linear speed of the fibers on said rotating surface, while maintaining substantially the uniformity of the fiber weight distribution of the fibrous web and while restraining the trailing ends of said fibers by sliding engagement with the rotating surface and by said increased fiber-to-fiber cohesion, whereby the individual fibers are straightened and their degree of orientation in the long direction of the web is increased. 50 55 60
4. The method of doffing a web of fibers from a rotating surface and substantially simultaneously drafting the same which comprises:
- (a) carrying a web of fibers on a rotating surface with ends of the fibers protruding outwardly beyond the periphery of the rotating surface; 65
- (b) gradually guiding a moving surface movable in a closed path toward said rotating surface whereby the protruding ends of the fibers contact the moving surface at a point well in advance of a hereinafter-mentioned pick-off point and providing a stationary support for said moving surface to control the spatial relationship of said moving surface and said rotating surface at said pick-off point, said stationary support 70 75

- contacting said moving surface substantially only at said pick-off point;
- (c) driving said moving surface from within said closed path at a linear speed greater than the linear speed of the rotating surface whereby the ends of the fibers contacting the moving surface are gradually inclined forwardly and drawn forwardly in the direction of movement of the moving surface as they approach the hereinafter-mentioned pick-off point;
- (d) gradually pressing the fibers of said web against said rotating surface over an arcuate area thereof immediately preceding the hereinafter-mentioned pick-off point to form a more compacted web having increased fiber-to-fiber cohesion and capable of being restrained more positively on the surface of said rotating surface;
- (e) transferring the leading free ends of individual fibers of the compacted web carried by said rotating surface to said moving surface at a pick-off point which is the point of closest proximity of the moving surface to the rotating surface;
- (f) grasping the leading free ends of the individual fibers carried by said moving surface at a region spaced from said pick-off point by a distance less than about one-half the average length of the fibers being doffed and drafted; and
- (g) drawing said leading free ends of the individual fibers away from said pick-off point, at a linear speed greater than the linear speed of the fibers on said rotating surface, while maintaining substantially the uniformity of the fiber weight distribution of the fibrous web and while restraining the trailing ends of said fibers by sliding engagement with the rotating surface and by said increased fiber-to-fiber cohesion, whereby the individual fibers are straightened and their degree of orientation in the long direction of the web is increased.
5. Apparatus for doffing a web of fibers from a rotatable surface and substantially simultaneously drafting the same which comprises:
- (a) a rotatable cylindrical surface for carrying a web of fibers with ends of the fibers extending outwardly beyond the periphery of the rotatable cylindrical surface;
- (b) a movable surface movable in a closed path adjacent said rotatable cylindrical surface;
- (c) guide means for gradually bringing said movable surface into a position of close proximity to said rotatable cylindrical surface whereby the protruding ends of the fibers contact the movable surface at a point well in advance of a hereinafter-mentioned pick-off point, said guide means including stationary means contacting said movable surface substantially only at said pick-off point;
- (d) means within said closed path to drive said movable surface at a linear speed greater than the linear speed of the rotatable cylindrical surface whereby the ends of the fibers contacting the movable surface are gradually inclined forwardly and drawn forwardly in the direction of movement of the movable surface as they approach the hereinafter-mentioned pick-off point, said fibers being gradually pressed by said movable surface against an arcuate area of the rotatable cylindrical surface to form a more compacted web thereon having increased fiber-to-fiber cohesion, said movable surface being brought into such close proximity to said rotatable cylindrical surface as to provide for fiber transfer from said rotatable cylindrical surface to said movable surface at a pick-off point which is the point of closest proximity of said movable surface to said rotatable cylindrical surface; and
- (e) means cooperating with said movable surface to grasp the leading free ends of the advancing individual fibers of the compacted web carried on said

- movable surface at a region in close proximity to said pick-off point,
 said driving means in direct contact with said movable surface driving the same and drawing said leading free ends of the individual fibers away from said pick-off point with a linear speed greater than the surface linear speed of the rotatable cylindrical surface, while maintaining substantially the uniformity of the fiber weight distribution of the fibrous web and while restraining the trailing ends of said fibers by sliding engagement with said rotatable cylindrical surface and by the increased fiber-to-fiber cohesion, whereby the individual fibers are straightened and their degree of orientation in the long direction of the web is increased.
6. Apparatus for doffing a web of fibers from a rotatable doffing cylinder and substantially simultaneously drafting the same which comprises:
- (a) a rotatable doffing cylinder for carrying a web of fibers with ends of the fibers extending outwardly beyond the periphery of the doffing cylinder;
 - (b) a movable doffing and drafting belt movable in a closed path adjacent said rotatable doffing cylinder;
 - (c) guide means for gradually bringing said movable doffing and drafting belt into a position of close proximity to said rotatable doffing cylinder whereby the protruding ends of the fibers contact the movable doffing and drafting belt at a point well in advance of a hereinafter-mentioned pick-off point, said guide means including stationary means contacting said movable doffing and drafting belt substantially only at said pick-off point;
 - (d) means within said closed path to drive said movable doffing and drafting belt at a linear speed greater than the linear speed of the rotatable doffing cylinder whereby the ends of the fibers contacting the movable doffing and drafting belt are gradually inclined forwardly and drawn forwardly in the direction of movement of the movable doffing and drafting belt as they approach the hereinafter-mentioned pick-off point, said fibers being gradually pressed by said movable doffing and drafting belt against an arcuate area of the rotatable doffing cylinder to form a more compacted web thereon having increased fiber-to-fiber cohesion, said movable doffing and drafting belt being brought into such close proximity to said rotatable doffing cylinder as to provide for fiber transfer from said rotatable doffing cylinder to said movable doffing and drafting belt at a pick-off point which is the point of closest proximity of said movable doffing and drafting belt to said rotatable doffing cylinder; and
 - (e) means cooperating with said movable doffing and drafting belt to grasp the leading free ends of the advancing individual fibers of the compacted web carried on said movable doffing and drafting belt at a region in close proximity to said pick-off point, said driving means in contact with said movable doffing and drafting belt driving the same and drawing said leading free ends of the individual fibers away from said pick-off point with a linear speed greater than the surface linear speed of the rotatable doffing cylinder, while maintaining substantially the uniformity of the fiber weight distribution of the fibrous web and while restraining the trailing ends of said fibers by sliding engagement with said rotatable doffing cylinder and by the increased fiber-to-fiber cohesion, whereby the individual fibers are straightened and their degree of orientation in the long direction of the web is increased.
7. The method of doffing a web of fibers from a rotating surface and substantially simultaneously drafting the same which comprises:
- (a) carrying a web of fibers on a rotating surface with

- ends of the fibers protruding outwardly beyond the periphery of the rotating surface;
 - (b) gradually guiding a moving surface movable in a closed path toward said rotating surface whereby the protruding ends of the fibers contact the moving surface and providing a stationary support for said moving surface to control the point of closest proximity between said moving surface and said rotating surface, said stationary support contacting said moving surface substantially only at said point of closest proximity;
 - (c) driving said moving surface from within said closed path at a linear speed greater than the linear speed of the rotating surface by a ratio of from about 1.5 to 1 to about 4 to 1, whereby the ends of the fibers contacting the moving surface are gradually inclined forwardly and drawn forwardly in the direction of movement of the moving surface;
 - (d) gradually pressing the fibers of said web against said rotating surface over an arcuate area thereof to form a more compacted web having increased fiber-to-fiber cohesion and capable of being restrained more positively on the surface of said rotating surface;
 - (e) transferring the leading free ends of individual fibers of the compacted web carried by said rotating surface to said moving surface;
 - (f) grasping the leading free ends of the individual fibers carried by said moving surface at a region in close proximity to said rotating surface; and
 - (g) drawing said leading free ends of the individual fibers away from said rotating surface at a linear speed greater than the linear speed of the fibers on said rotating surface, said speeds having a ratio of from about 1.5 to 1 to about 4 to 1, while maintaining substantially the uniformity of the fiber weight distribution of the fibrous web and while restraining the trailing ends of said fibers by sliding engagement with the rotating surface and by said increased fiber-to-fiber cohesion, whereby the individual fibers are straightened and their degree of orientation in the long direction of the web is increased.
8. The method of doffing a web of fibers from a rotating surface and substantially simultaneously drafting the same which comprises:
- (a) carrying a web of fibers on a rotating surface with ends of the fibers protruding outwardly beyond the periphery of the rotating surface;
 - (b) gradually guiding a moving surface movable in a closed path toward said rotating surface whereby the protruding ends of the fibers contact the moving surface and providing a stationary support for said moving surface to control the point of closest proximity between said moving surface and said rotating surface, said stationary support contacting said moving surface substantially only at said point of closest proximity;
 - (c) driving said moving surface from within said closed path at a linear speed greater than the linear speed of the rotating surface by a ratio of about 3 to 1 whereby the ends of the fibers contacting the moving surface are gradually inclined forwardly and drawn forwardly in the direction of movement of the moving surface;
 - (d) gradually pressing the fibers of said web against said rotating surface over an arcuate area thereof to form a more compacted web having increased fiber-to-fiber cohesion and capable of being restrained more positively on the surface of said rotating surface;
 - (e) transferring the leading free ends of individual fibers of the compacted web carried by said rotating surface to said moving surface;
 - (f) grasping the leading free ends of the individual

- fibers carried by said moving surface at a region in close proximity to said rotating surface; and
- (g) drawing said leading free ends of the individual fibers away from said rotating surface at a linear speed greater than the linear speed of the fibers on said rotating surface, while maintaining substantially the uniformity of the fiber weight distribution of the fibrous web and while restraining the trailing ends of said fibers by sliding engagement with the rotating surface and by said increased fiber-to-fiber cohesion, whereby the individual fibers are straightened and their degree of orientation in the long direction of the web is increased.
9. The method of doffing a web of fibers from a rotating surface and substantially simultaneously drafting the same which comprises:
- (a) carrying a web of fibers on a rotating surface with ends of the fibers protruding outwardly beyond the periphery of the rotating surface;
- (b) causing said web of fibers by the rotation of said rotating surface to enter a zone extending over a considerable arcuate area of said rotating surface and narrowing gradually throughout the extent of said area toward a throat, said zone being defined on one side by said rotating surface and on the opposite side by a moving surface movable in a closed path traveling in the same direction as the rotating surface at their points of adjacency and at a greater linear speed, whereby ends of fibers protruding from said rotating surface and engaged by said moving surface are inclined forwardly in the direction of fiber travel as said fibers move from the entrance end of said zone to the throat thereof;
- (c) driving said moving surface from within said closed path;
- (d) gradually pressing the fibers of said web against said rotating surface over said considerable arcuate area thereof as said fibers move towards said throat to form a more compacted web having increased fiber-to-fiber cohesion and capable of being restrained more positively on the surface of said rotating surface;
- (e) providing a stationary support for said moving surface to control the point of closest proximity between said moving surface and said rotating surface, said stationary support contacting said moving surface substantially only at said point of closest proximity;
- (f) transferring the leading free ends of individual fibers of the compacted web carried by said rotating surface to said moving surface;
- (g) grasping the leading free ends of the individual fibers carried by said moving surface at a region in close proximity to said rotating surface; and
- (h) drawing said leading free ends of the individual fibers away from said rotating surface at a linear speed greater than the linear speed of the fibers on said rotating surface, while maintaining substantially the uniformity of the fiber weight distribution of the fibrous web and while restraining the trailing ends of said fibers by sliding engagement with the rotating surface and by said increased fiber-to-fiber cohesion, whereby the individual fibers are drawn forwardly and straightened and their degree of orientation in the long direction of the web is increased.
10. The method of doffing a web of fibers from a rotat-

ing surface and substantially simultaneously drafting the same which comprises:

- (a) carrying a web of fibers on a rotating surface with ends of the fibers protruding outwardly beyond the periphery of the rotating surface;
- (b) causing said web of fibers by the rotation of said rotating surface to enter a zone extending over a considerable arcuate area of said rotating surface and narrowing gradually throughout the extent of said area toward a throat, said zone being defined on one side by said rotating surface and on the opposite side by a moving surface movable in a closed path traveling in the same direction as the rotating surface at their points of adjacency and at a greater linear speed by a ratio of from about 1.5 to 1 to about 4 to 1, whereby ends of fibers protruding from said rotating surface and engaged by said moving surface are inclined forwardly in the direction of fiber travel as said fibers move from the entrance end of said zone to the throat thereof;
- (c) driving said moving surface from within said closed path;
- (d) gradually pressing the fibers of said web against said rotating surface over said considerable arcuate area thereof as said fibers move towards said throat to form a more compacted web having increased fiber-to-fiber cohesion and capable of being restrained more positively on the surface of said rotating surface;
- (e) providing a stationary support for said moving surface to control the point of closest proximity between said moving surface and said rotating surface, said stationary support contacting said moving surface substantially only at said point of closest proximity;
- (f) transferring the leading free ends of individual fibers of the compacted web carried by said rotating surface to said moving surface;
- (g) grasping the leading free ends of the individual fibers carried by said moving surface at a region in close proximity to said rotating surface; and
- (h) drawing said leading free ends of the individual fibers away from said rotating surface at a linear speed greater than the linear speed of the fibers on said rotating surface, said speeds having a ratio of from 1.5 to 1 to about 4 to 1, while maintaining substantially the uniformity of the fiber weight distribution of the fibrous web and while restraining the trailing ends of said fibers by sliding engagement with the rotating surface and by said increased fiber-to-fiber cohesion, whereby the individual fibers are drawn forwardly and straightened and their degree of orientation in the long direction of the web is increased.

References Cited in the file of this patent

UNITED STATES PATENTS

1,422,581	Laurency et al. -----	July 11, 1922
1,862,542	Laurency -----	June 14, 1932

FOREIGN PATENTS

1,127,219	France -----	Aug. 6, 1956
255	Great Britain -----	of 1853
593	Great Britain -----	of 1865
3,168	Great Britain -----	of 1869