



(51) International Patent Classification:
D01G 15/80 (2006.01)

(21) International Application Number:
PCT/IN2011/000856

(22) International Filing Date:
14 December 2011 (14.12.2011)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
3885/CHE/2010 20 December 2010 (20.12.2010) IN

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(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ,
CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO,

DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN,
HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR,
KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME,
MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ,
OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD,
SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR,
TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, GH,
GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ,
UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU,
TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE,
DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU,
LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK,
SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ,
GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

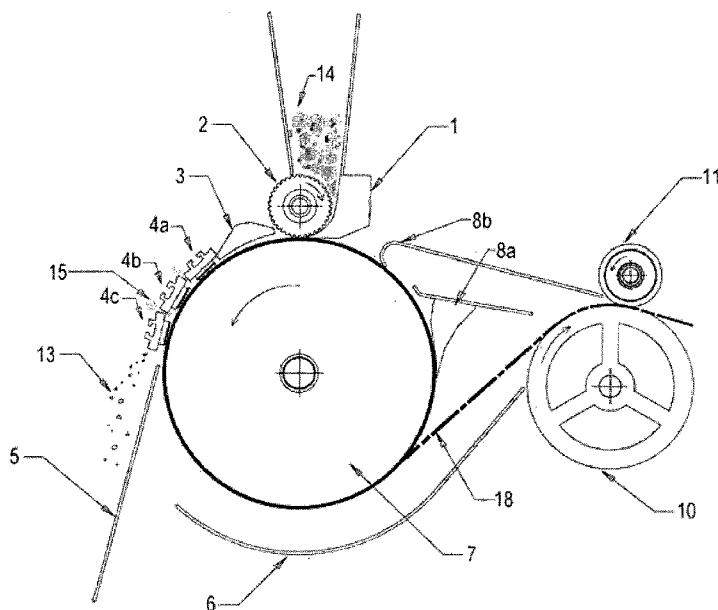
— of inventorship (Rule 4.17(iv))

Published:

— without international search report and to be republished
upon receipt of that report (Rule 48.2(g))

(54) Title: METHOD AND APPARATUS FOR CARDING OF STAPLE FIBERS

FIGURE 2:



(57) Abstract: The present invention relates to a method and apparatus of carding staple fibres like cotton. More particularly, the present invention is directed to an apparatus for carding of staple fibres with minimum number of moving parts and to reduce the need for close tolerances, especially where moving parts are involved, in order to improve the manufacturability of the apparatus. Density of input tufts to the carding machine is reduced. Diameter of carding cylinder is reduced, with corresponding increase in its rotational speed, to maintain the peripheral speed. An air guiding element and at least one air deflection element is used for capturing long fibres on a perforated roller. This enables elimination of close-set moving parts and simplification of design. Advantageously, the present invention minimizes the damage to the fibres so that they retain their natural and desirable properties.

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5 **METHOD AND APPARATUS FOR CARDING OF STAPLE FIBRES**

FIELD OF INVENTION

The present invention relates to a method and apparatus of carding staple fibres like cotton. More particularly, the present invention is directed to an apparatus for carding of staple fibres with
10 minimum number of moving parts and to reduce the need for close tolerances, especially where moving parts are involved, in order to improve the manufacturability of the apparatus. Advantageously, the present invention minimizes the damage to the fibres so that they retain their natural and desirable properties.

15 **DESCRIPTION OF PRIOR ART**

Carding is a process that takes tufts of fibres as input, removes the trash and short fibres contained in them and individualizes the fibres to finally deliver a uniform web of these individualized fibres.

20 In conventional carding machines, the tufts of fibres are fed to the apparatus by a cylindrical rotating member termed as feed-roller and a specially contoured stationary member termed as feed-table that presses against the feed-roller. As the feed-roller rotates slowly, the tufts of fibres are delivered at a slow speed while being firmly gripped between the feed-roller and feed-table. From here these tufts are stripped off by a rotating cylindrical member with pins on the surface,
25 called licker-in, which rotates with a surface-speed much higher than that of the feed-roller, resulting in opening of the tufts. The pins of the rotating licker-in pass the feed-roller before passing the feed-table. The tufts gripped at the nip between these two components are impacted by the pins. The intensity of this impact is enhanced by two aspects: a) Sudden change in direction of movement of the tufts on account of the sharp difference between the direction in
30 which the nip feeds the tufts vis-à-vis the direction in which the pinned surface conveys the tufts b) An extended 'nose' of the feed-table that constrains the tufts to remain close to the pinned surface of the rotating 'licker-in' cylinder to break down the tufts. These features render the fibres vulnerable to breakage, apart from requiring high precision in manufacture and setting of the clearance between the nose and the licker-in cylinder.

35 To reduce this damaging impact, the licker-in is clothed with relatively coarse and spaced-out pins, and made to run at a speed that is in between that of the slow feed-roller and the fast

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- 5 carding cylinder. Thus, a two-stage gradation in tuft-opening is achieved to contain the damage – first from the feed-roller to the licker-in, and then from the licker-in to the carding cylinder. Coarse-trash is dropped beneath the licker-in chiefly on account of gravity, aided by mechanical elements like mote-knives.
- 10 Again, these fibres are stripped off from the licker-in by a closely placed rotating member called carding cylinder, which has an even higher surface speed and much more closely-spaced finer pins leading to further opening of the tufts. The fibres are conveyed by these pins towards a plurality of elongated pinned members, called flats, which are placed close to the carding cylinder. The flats are either stationary or move very slowly compared to the fast surface speed
- 15 of the cylinder. The entanglement of small tufts between the pins of the flats and those of the cylinder cause the separation of fibres from each other and the separation of finer trash particles from the fibres. Trash and short fibres tend to get embedded in the pinned surfaces of the flats, while the longer (useful) fibres tend to travel with the cylinder surface. To maintain the effectiveness of their action, flats have to be cleaned of the trash and short fibres thus collected.
- 20 Either the machine has to be stopped periodically for this or a complicated and costly arrangement of “revolving flats” is used so that the flats can be cleaned without stopping the machine.

The individualized fibres, from which the trash and short fibres have been removed, are then

25 captured by a doffer. The doffer roller is another cylinder with pinned surface that is set in close proximity to the carding cylinder, but moves at slower surface speed. The fibres transferred from the cylinder to the doffer are then transferred to a succession of doffing rollers moving at progressively slower surface-speeds. Finally, the stream of fibres is removed from the last of these doffing rollers to be condensed into a carded sliver.

30 One key feature of this conventional method of carding is that throughout the process, the fibres are closely held in a very narrow space at the surface of the rotating members, and never allowed to travel freely without mechanical guidance. Also, the fibres experience high stresses due to the mechanical action in various parts. This leads to significant damage to the fibre, which loses

35 several desirable properties it possesses in its natural state.

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- 5 In conventional construction, free air-space around the cylinder is constrained to a very small width by means of stationary or moving parts or shrouds positioned in close proximity, to prevent the disturbing influence of ambient air. As the method described above contains several moving parts that are very close to each other and to other stationary parts, they must be manufactured to very close tolerances. The cylinder is typically a meter in diameter and a meter
- 10 in length, with other components being proportionately sized. Fast-moving members of such mass and size set to move within a fraction of a millimeter of each other require high precision and balancing. This poses formidable challenges in manufacturing and therefore impact the cost of the carding machine.
- 15 Moreover a well-known challenge in carding is the problem of re-circulating fibres – fibres that circulate multiple times around the cylinder because of inefficient doffing. These fibres reduce the effective area available on the carding cylinder for fresh fibres that are fed, necessitating a reduced feed rate to compensate for it, thereby reducing the machine productivity. Prior-art machines have therefore sought to improve the doffing efficiency through closer settings
- 20 between the doffer and the carding cylinder and other means which significantly increase the demands on accuracy of the manufacture.

Against this background, there have been different efforts to improve the design and overcome the limitations described. Blowing air or applying suction to remove trash is disclosed in

25 GB931907, GB2375355, IN241397, US4057877, US4815170, US6477742, US6516497 and several other places in prior art. However, forced draught of air requires substantial power, apart from greater complexity in construction in order to provide leak-free enclosures and ducts. It is best if trash removal is inherent to the core operation of the carding machine without need to forcibly create air-currents through dedicated other means.

30

There have been efforts to enhance the performance of carding machine by having more numbers of components that are regarded as critical to the performance. For instance, in US7111366, multiple carding stages are arranged in series, so that the material is subjected to carding at each successive stage. US6839941 involves multiple feeding modules (each comprising feed-roller,

35 feed-table and licker-in rollers), followed by two sets of revolving flats set against the carding

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5 cylinder. US5016321, US5111551, US5272791, US4712276 and US4219908, US6516497 are other instances that illustrate this approach to improvement in performance. It is obvious that all these methods come with significantly increased complexity, costs and performance overheads.

10 The need to selectively remove short fibres before carding has been an issue of significant importance, because short fibres choke the carding flats and reduce the efficacy of their action. This has led to the development of 'self-cleaning' pin profiles on flats, such flats being positioned before the tufts enter the carding zone. Since these 'self-cleaning' flats do not need cleaning, they do not need to be revolved around to expose their pinned surfaces for cleaning. The carding action of these stationary flats is gentler than that of the flats used in the carding
15 zone, but is adequate to release significant amount of short fibres entrapped in the tufts. Commonly, suction or blowing is applied between these flats to evacuate the short fibres so released. GB2003202, US4542560, US6065190, US6568037, US7730591, WO9700983 illustrate different methods around this idea.

20 While such inventions are directed at improving the performance of the carding machine by adding additional components, it is also recognized that the machine is very bulky, heavy and entails expensive manufacturing operations to achieve acceptable levels of precision. Several efforts have been made to simplify the design, reduce the size and weight of different components or find alternate ways of achieving some of the functionalities that entail less
25 precision and manufacturing difficulty. IN208099 seeks to reduce the diameter of the carding cylinder from the commonly used 1000mm to nearly 700mm, and use fibre-reinforced plastics instead of cast iron. US5295284, on the other hand, seeks to achieve manufacturing ease and improved precision by reducing the working width to 500mm, instead of the conventional 1000mm. US5930871 seeks to eliminate the doffing roll by providing suction to doff fibres
30 away from the carding cylinder onto a perforated roll.

OBJECTS OF THE INVENTION

It is the primary object of this invention to provide for a carding machine that minimizes stresses acting on the fibres, so that they retain their natural and desirable properties.

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- 5 It is another object of the present invention to minimize the number of moving parts, and reduce the need for close tolerances, especially where moving parts are involved, in order to improve the manufacturability of the apparatus.

10 This is principally achieved by ensuring that the density of the input tufts is low, so that a gentler carding action is adequate to perform carding. This is readily achieved by avoiding the use of heavy calendaring rolls through which the material is conventionally passed just before feeding to the card, after it is treated to opening operations prior to carding. The typical density of input tufts is thus maintained at about half of what is conventionally used, or lower. These tufts are presented by a feed-roller rotating relative to a feed-table directly to the carding cylinder, instead
15 being picked up by an intervening licker-in cylinder. This is possible because the action of breaking larger, denser tufts into smaller ones, performed by the licker-in, is redundant on account of the favourable input condition of the input materials.

20 In addition, the need for a close-set 'nose' on the feed-table downstream of the feeding nip is also redundant, since severe action of the pins on the fibres is not required to break down the tufts. This makes for relaxed settings of lower tolerance. The geometry of the nose typically needs to be customised to suit the length of fibre being processed. Eliminating the relevance of the nose thus makes for a more robust design that can accommodate varying fibre lengths.

25 The feed table is typically curved to take the radius of the feed roller close to the nip, to provide for better grip over the fibres. In the conventional configuration, this curvature causes the input material to advance in a direction opposite to the direction in which the impacting pins approach the nip. This causes the fibres to undergo a sharp change of direction as soon as they are impacted by the pins, leading to stressing of the material processed. To avoid this, it is further
30 advantageous to re-position the feed table in opposite disposition relative to the feed-roller, so that the direction of movement of material caused by the feed roller and the direction in which the pins seek to convey them are aligned in the same direction. A knife-edge positioned immediately downstream serves to remove coarse trash, an action similar to that of the mote-knife used in prior-art machines.

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- 5 The small flocks of fibres scraped off from the grip of the feed nip are readily carded by a small number of self-cleaning flats. This makes it possible to avoid the chain of over a hundred revolving flats that are common to prior art. Short fibres, being weakly held by the pins of the carding roller, tend to fly radially outward, and this behaviour can be advantageously exploited to ensure that only the useful longer fibres are conveyed onward in the airstream after carding.
- 10 Subsequent to the fibres being thus carded, the important activities to be carried out are
- Separation of fine trash
 - Doffing of carded fibres from the carding cylinder
 - Delivering the fibres as a uniform web
- 15 It is the objective of the present invention to achieve these with minimal use of moving parts. Further, where moving parts are used, they should not need to be positioned in close setting with other moving parts in a manner that involves fine manufacturing tolerances.

This is achieved in the present invention by using the dynamics of the airstream generated
20 around the carding cylinder by virtue of its rotation.

It is the objective of the invention to enhance the effect of this airstream on the entrained materials by appropriate choice of geometry and introduction of stationary elements that manipulate it.

25

Accordingly, the diameter (d) of the carding cylinder is reduced to about a fourth of that common in conventional carding machines, while the angular speed (ω) is increased by the same factor so that the surface speed (v) remains unchanged. While this leaves the carding efficacy – primarily related to the peripheral speed (v) – unchanged, it has a profound effect on the radial
30 force (F) acting on the materials in the entrained airstream. This force (F) is amplified by the factor by which the diameter (d) is reduced, which is the same as the factor by which the angular speed (ω) is increased. Consequently, radial movement of entrained particles is amplified.

This effect is used to separate fine trash and small unopened knots of fibres in the entrained air-
35 stream by causing them to drift in a radially outward direction downstream of the carding flats.

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5 The longer carded fibres are held close to the surface of the carding cylinder by the retaining forces of the pins, whose inclination is typically in the forward direction. Thus, the airstream develops two clear zones downstream of the flats – one closer to the surface of the cylinder where the carded long fibres are entrained, and one farther away where other extraneous matter (trash) is entrained. By introducing a sheet in the region between them, it is ensured that the
10 trash is conveyed away from the fibres.

Downstream of this, the airstream is enclosed by a sheet that converges airstream towards a narrow exit. The other boundary of the exit emerges from an air-deflecting element that is set close to the rotating cylinder. The edge of this air-deflecting element causes a sharp diversion of
15 the airstream towards the exit. This causes substantial part of the entrained long fibres to migrate along with the airstream towards the exit. The exit is substantially blocked by a perforated roller, whose perforations allows free passage to air but would cause the entrained fibres to deposit on its surface.

20 By rotating this perforated roller at steady speed, a web of required density is delivered. The surface speed of the perforated roller is kept much slower than that of the carding cylinder to obtain a web of adequate density that result in a coherent web. In turn, this causes deposition of multiple layers of fibres in the web, thereby compensating for momentary variations in rates of fibre deposition, leading to web of enhanced uniformity. Further, the spot of deposition of fibre
25 is determined by the flow of air in which it is entrained. Since air tends to flow preferentially in a direction of lower resistance to its flow, regions where fibre deposition is lower would attract more air and hence, more fibre deposition. This effect further enhances the uniformity of the web.

30 The setting of the air-deflection element and the number of such elements plays an important role in the extent of recirculation of fibres. When only one such element is present, the proximity of its edge to the surface of the carding cylinder determines the efficacy of doffing. The closer it is set, lower the percentage of fibres that escape doffing and re-circulate. However, practical considerations like manufacturing tolerance prevent too close a setting. In this
35 situation, additional air-deflecting elements may be placed downstream of the first, to more

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- 5 effectively carry out doffing without needing very close settings. Reducing recirculation enables enhanced production rates.

On the other hand, recirculation creates a blanket of fibres around the carding cylinder which acts as a reserve stock. This is advantageous in smoothening momentary variations in fibre feed-rate
10 and ensuring that the delivered web is uniform.

SUMMARY OF THE INVENTION

Thus according to the basic aspect of the present invention there is provided an apparatus for carding staple fibres, comprising:

- 15 a. a feeding arrangement with a feed table and a feed roller for feeding tufts of staple fibers;
- b. a rotating carding cylinder having carding pins on its surface,
- c. one or more carding flats co-operating with the said carding cylinder for opening of tufts into individual fibres;
- 20 d. a zone downstream of the said carding flats where the air stream entrained by rotation of the said carding cylinder is unconstrained;
- e. an air guiding element to enclose the unconstrained air stream and direct it towards a preferred exit;
- f. at least one air deflecting element to deflect the generated air stream away
25 from the said carding cylinder towards the said preferred exit; and
- g. a perforated roller at the preferred exit for doffing fibres entrained in the said air current.

It is another aspect of the present invention, wherein the diameter of the said carding
30 cylinder is in the range of 200mm to 300mm and the rotational speed is between 1200 to 1500 revolutions per minute.

It is another aspect of the present invention, wherein the said feeding arrangement feeds said tufts directly to the said carding cylinder.

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5 It is another aspect of the present invention, wherein the staple fiber is preferably cotton with density of tufts less than 0.4g/cc.

It is another aspect of the present invention, wherein the said feed table is positioned before the said feed-roller with respect to the direction of approach of the said carding pins.

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It is another aspect of the present invention, wherein the said feed roller is pinned, knurled or has straight or helical flutes.

15 It is another aspect of the present invention, wherein first of at least one of the said air deflecting elements comprising a surface with a blade edge is positioned relative to the said rotating carding cylinder such that the said blade edge is located in proximity to the pinned surface of the said carding cylinder.

20 It is another aspect of the present invention, wherein the said surface with a blade edge deflects the air current carrying substantial part of carded fibers away from the said carding cylinder.

25 It is another aspect of the present invention, wherein a second air deflecting element is positioned after the said first air deflecting element to doff substantial part of remaining fibers, thereby reducing recirculation of un-doffed fibers.

It is another aspect of the present invention, wherein a plurality of secondary air deflecting elements are positioned successively after the said first air deflecting element to further reduce re-circulation of fibers.

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It is another aspect of the present invention, wherein the leading surface of the said carding pins is inclined towards the direction of movement of the said carding cylinder.

35 It is another aspect of the present invention, wherein the preferable number of carding flats is at least 2 but not greater than 4.

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- 5 It is another aspect of the present invention, wherein adjacent carding flats have a gap preferably between 1mm to 3 mm circumferentially long for radially expelling short fibres.

It is another aspect of the present invention, wherein successive flats of the said carding flats have progressively increasing pin densities.

10

It is another aspect of the present invention, wherein successive flats of the said carding flats are set progressively closer to the pinned surface of the said carding cylinder.

- 15 It is another aspect of the present invention, wherein the said one or more carding flats has pin profile and pin-densities which do not allow the accumulation of fibres and trash.

The above said invention further comprises a surface with knife-edge, positioned immediately after the said feeding arrangement.

- 20 The above said invention further comprising a trash separation plate positioned in the unconstrained airstream downstream of the said carding flats, such that the leading edge of the said trash separation plate is positioned between the radially farther zone of the airstream around the said carding cylinder where trash particles are entrained, and the radially proximate zone of the airstream around the said carding cylinder, where long fibers are
25 entrained.

In accordance with another aspect of the present invention there is provided a method for carding staple fibers comprising:

- 30 a. enhancing the radial forces acting on materials entrained in air-current around a rotating carding cylinder of reduced diameter and increasing the rotational speed of the said carding cylinder to maintain the preferred surface speed;
- b. feeding of loose tufts of staple fibres through a feeding arrangement of feed roller and feed table to the said rotating carding cylinder;

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- 5 c. removing of coarse particles by placing a surface with its leading knife-edge close to the pinned surface of the said carding cylinder;
- d. expelling short fibres radially by radial force generated in the said air current;
- e. separating fine trash from carded fibers by allowing entrained trash
- 10 particles to move radially away in an air-stream that is free to expand in the radial direction;
- f. directing the air-current carrying fine trash away from the said cylinder using a trash separation plate;
- g. enclosing the residual air-current carrying entrained long fibers and
- 15 directing it towards a perforated roller by means of an air-guiding element;
- h. allowing long fibres to stay close to the carding cylinder by the retaining action of pins whose leading surfaces are inclined towards the direction of rotation;
- i. forcing the said long fibres to deflect from the carding cylinder onto a
- 20 perforated roller by deflecting the air current away from the carding cylinder using at least one air deflection element proximate to the pinned surface of the said cylinder;
- j. permitting the said air current to escape through the perforations in the roller while retaining the fibres on the perforated surface; and
- 25 k. rotating the perforated roller to deliver carded web.

It is another aspect of the present invention, wherein the staple fiber being fed is cotton with density of tufts less than 0.4g/cc.

- 30 It is another aspect of the present invention, wherein strong radial forces are generated by rotating carding cylinder with diameter in the range of 200mm to 300mm at the rotational speeds lying between 1200 to 1500 revolutions per minute.

- It is another aspect of the present invention, wherein damage due to the impact of pins of the
- 35 said carding cylinder on the fibers gripped in the said feeding arrangement is reduced by

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- 5 positioning the said feed-table before the said feed-roller, with respect to the direction of approach of pins of the said carding cylinder.

It is another aspect of the present invention, wherein intended movement of the fibers and trash in the entrained air is selectively enhanced by the application of suction.

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It is another aspect of the present invention, wherein intended movement of the fibers and trash in the entrained air is selectively enhanced by the application of blowing air.

- 15 It is another aspect of the present invention, wherein uniformity of the web is enhanced by the successive deposition of multiple layers of fibers on the surface of the perforated roller, by rotating the said perforated roller at slow peripheral speed in relation to that of the said carding cylinder.

- 20 It is another aspect of the present invention, wherein uniformity of the web is enhanced by successive deposition of successive layers of fibers on the surface of the perforated roller, preferentially in areas with lesser densities of deposition, on account of reduced flow resistance leading to stronger air-currents directing fibers towards those regions.

- 25 It is another aspect of the present invention, wherein uniformity of the web is enhanced by setting the at least one air-deflecting element at a farther setting from the said carding cylinder, so that a greater number of fibers re-circulate, building up a reserve-stock of re-circulating fibers that smoothen momentary variations in rate of feed of fibers.

BRIEF DESCRIPTION OF THE DRAWINGS

- 30 Figure 1: Illustrates the carding machine existing in the prior art.
Figure 2: Illustrates the carding machine according to the present invention.
Figure 3: Illustrates isometric view of the carding machine according to the present invention.
Figure 4: Illustrates the detailed view of the carding flats according to the present invention.

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5 DETAILED DESCRIPTION OF THE INVENTION WITH REFERENCE TO THE ACCOMPANYING DRAWINGS

With respect to the drawings it is to be understood that only enough of the construction of the invention and the surrounding environment in which the invention is employed have been depicted therein, in order to simplify the illustrations, as needed for those skilled in the art to readily understand the underlying principles and concepts of the invention.

Figure 1 shows, in schematic form, a prior art for the conventional carding apparatus. The tufts of fibres in the form of lap is guided by the feeding arrangement comprising stationary feed table 1 and rotatable feed roller 2 to a lick-in roller 16. The tufts of fibres that are firmly gripped between feed table 1 and feed roller 2 are stripped off by the pins of the lick-in cylinder 16 which rotates at a surface speed higher than that of the feed roller 2 resulting in opening of the tufts. The tufts are then passed on to the carding cylinder 7 from the lick-in cylinder 16. The revolving flats 4 in co-operation with the carding cylinder 7 break down and card tufts into individual fibres. These individual fibres are then transferred from the surface of the carding cylinder 7 onto a doffer roller 17 which rotates at a relatively lower surface speed than that of the carding cylinder 7 to form a continuous web of card sliver.

Accompanying Figure 2 schematically shows the main working elements of a carding apparatus for carding of staple fibres. The carding apparatus essentially consists of a feeding arrangement which in particular contains a stationary feed table 1 and a rotating feed roller 2; a carding cylinder 7 operating in cooperation with one or more of carding flats 4 and an air guiding element 6; and a doffing system which contains at least one air deflection element 8 to deflect air onto the perforated roller 10.

The feeding arrangement consists of a rotating feed roller 2 rotating in a clockwise direction and working in co-operation with the feed table 1 to guide the loose tufts 14 towards the surface of the carding cylinder 7. The carding pins 9 are located on the carding cylinder 7 and are inclined towards the rotation of the carding cylinder 7. The feed table 1 is positioned before the feed-roller 2 with respect to the direction of approach of carding pins 9 (as shown in figure 4) so as to

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- 5 reduce the damaging impact of the carding cylinder 7 on the fibres that are in the grip of the feeding arrangement.

One or more of the carding flats 4a, 4b, 4c is located downstream to the feeding mechanism and above the periphery of the carding cylinder and working in co-operation with the carding
10 cylinder 7 rotating in anti-clockwise direction. The diameter of the carding cylinder 7 is lower than the diameter of the conventional carding cylinder used in the prior art. The diameter of the carding cylinder in the present invention is preferably between 200mm to 300mm. The rotational speed of the carding cylinder 7 is preferably between 1200 to 1500 revolutions per minute in order to maintain the peripheral velocity of the present day carding cylinder. The increase of the
15 speed of rotation of the carding cylinder correspondingly increases the radial force of the circumferential airstream generated by the rotation of the carding cylinder 7.

The carding pins located on the surface of the carding flats 4 have self cleaning pin profiles and pin densities which allow the fibres to pass through them without being lodged between the
20 carding pins. Carding flats 4a, 4b, 4c have progressively increasing pin densities (as shown in the figure 4). For example, pin density of the carding flat 4a that is proximate to the feed roller 2 is less when compared to the pin density of the carding flat 4c located farther from feed roller 2. This increase in pin density in the successive carding flats enhances the intensity of carding as the tuft size breaks down to smaller and smaller size, ensuring complete carding in a short
25 distance of travel. Such a gradual progression of carding intensity may also be achieved by positioning successive flats closer to the surface of cylinder 7.

The preferable number of carding flats is 2 to 4 wherein a gap of preferably between 1 to 3 mm circumferentially long is provided between the adjacent carding flats for radially expelling short
30 fibres 15 that are held weakly, without releasing the long fibres 18 that are held strongly, due to engagement with multiple pins 9 on the carding cylinder 7.

A trash separation plate 5 is positioned downstream of one or more of the carding flats, such that the leading edge of the trash separation plate 5 is positioned between the radially farther zone of
35 the airstream around the carding cylinder 7 where trash particles 13 are entrained, and the

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- 5 radially proximate zone of the airstream around the carding cylinder 7, where long fibres are entrained. An air-guiding element 8 is located below the carding cylinder 7 and downstream the trash separation plate 5 to guide the entrained air towards the doffing roller 10.

- 10 The doffing system consists of at least one air deflecting element 8 to deflect air onto the perforated roller 10. The air deflecting element 8 is a surface with a blade edge positioned relative to the rotating carding cylinder 7 in such a way that the blade edge is located in proximity to the carding cylinder 7. Secondary air deflection elements 8b are positioned successively after the first air deflecting element 8a.

- 15 The carding apparatus further comprises a surface with knife-edge 3, positioned immediately after feeding arrangement and before the carding flats 4.

The working of the carding apparatus is explained below.

- 20 As shown in Figure 2 and Figure 3, loose tufts 14 are fed through the feeding arrangement consisting of stationary feed table 1 and rotatable feed roller 2 rotating in clockwise direction. Feed table 1 operates in cooperation with the feed roller 2 and directly feeds loose tufts 14 to the carding cylinder 7 rotating in the opposite direction to that of the feed roller 2. The tufts are gripped at the nip between these two components and are impacted by the carding pins 9 in a direction that aligns with the direction in which the tufts are already being fed. This reduces the stresses on the fibres when they are transferred from the slow feed roller to the fast-moving cylinder. Hence the lick-in rotating with intermediate speed is eliminated entirely, to transfer fibres directly from the feeding arrangement to the carding cylinder.

- 30 These loose tufts 14 contain unwanted material like seeds, coarse trash particles, finer trash particles etc. The coarser trash like seeds is removed by the surface with its leading knife-edge, 3, positioned close to the surface of carding cylinder 7 and located after the feeding arrangement. The loose tufts 14 along with the trash get entrained in the circumferential air stream generated by the rotation of the carding cylinder 7.

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5 The tufts used as a raw material for carding apparatus can be selected from any one of the staple fibres selected from silk, banana-fibre, jute, pineapple-fibre, cotton, wool, flax, hemp or synthetic fibre. As is understood in the prior art, more than one type of fiber may be blended if they are of compatible staple lengths and other fiber properties. Preferably, the staple fibre used is cotton with a density less than 0.4g/cc.

10

Preferably, the diameter of the carding cylinder 7 is reduced by about four folds in comparison with the diameter of conventional carding cylinder. To maintain the peripheral velocity of the conventional carding cylinder, the rpm (rotations per minute) of the lower diameter carding cylinder needs to be increased to around 1200-1500 rpm. The increased rpm of the carding
15 cylinder 7 leads to a corresponding increase in the radial forces acting upon the material being processed. These increased radial forces compel the unwanted material to be thrown out of the entrained air. The difference in the physical properties and differing behaviour of the unwanted material entrained in the air stream leads to the unwanted material taking differing trajectories that gradually separates them from the carding cylinder.

20

The unwanted material generally contains coarse trash, fine trash and short fibres which need to be separated from the preferred output which is long fibres 18. Generally, long fibres tend to stay close to the surface of the carding cylinder 7 and short fibres 15 tend to fly radially away from the carding cylinder 7. Coarse trash particles are influenced primarily by their velocity and the
25 effect of gravity, rather than by effects of air stream. Finer trash particles are affected by both gravity and air stream, and hence tend to follow a trajectory that gradually diverges from the surface of the carding cylinder 7.

The entrained air with unwanted material expels the short fibres 15 through the gaps between the
30 adjacent carding plates 4. Short fibres 15 tend to fly away radially from the carding cylinder 7 through the gaps existing between the carding plates 4. Since the short fibres 15 are not retained by the pin-profiles, they are free to fly away as they do not lodge in the carding flats. So, further cleaning process for the flats is avoided. The entrained air with fine trash 13 moves downstream of carding flats 4 to a zone wherein the air entrained by rotation of carding cylinder 7 is
35 unconstrained.

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5 Leaving the airstream unconstrained in this zone allows materials other than fibres, that is, finer trash 13 to move radially away from the carding cylinder 7 (as shown in the figure2). The trash separation plate 5 positioned in the un-constrained airstream downstream of the carding flats 4 diverges' a substantial part of the air stream containing finer trash 13 away from the carding cylinder 7 which is then collected in a trash collector (not shown in the figure). The distance and
10 orientation of positioning of trash separation plate 5 is optimized by trial-and-error based on the nature of fibre and trash being processed.

The residual air entraining the long fibres 18 is guided by the air guiding element 6, positioned below the carding cylinder 7, towards perforated roller 10 rotating in the clockwise direction for
15 doffing. The air guiding element 6 is provided to gently converge the entrained air towards the preferred exit. The entrained air is deflected away from the carding cylinder 7 by at least one of the air deflection elements 8. The first air deflection element 8a is contoured with a blade edge such the blade edge is located in proximity to the carding cylinder 7 to deflect the entrained air with long fibres 18 away from the carding cylinder 7 and towards the perforated roller 10. The
20 perforated roller 10 is set rotating to convey the web of deposited fibers, in which action it may be aided by a co-operating crush-roller 11 or by another perforated roller 10. The deflection of substantial air stream by at least one air deflecting element leads to a sudden drop in pressure in a zone immediately after the air deflection element. This drop in pressure causes widening of air stream which sucks out most of the re-circulating fibres away from the surface of the carding
25 cylinder 7, facilitating easy doffing by a next air-deflection element 8b.

The positioning of at least one of the air deflection elements 8 is optimized in such a way that it allows most of the long fibres 18 to be deposited on the perforated roller 10 and at the same time build up a reserve-stock of re-circulating fibres that smoothen momentary variations in rate of
30 feed of fibres.

A plurality of secondary air deflecting elements 8b can be positioned successively after the first air deflection element 8a to enhance the deflection of air and thus avoiding re-circulation of fibres towards the carding cylinder 7.

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- 5 The air deflected towards the perforated roller 10 by at least one of the air deflecting elements 8 percolates through the perforated roller 10. The perforated roller 10 acts as a filter by allowing the air to pass through and simultaneously capturing the long fibres 18 on its surface.

10 Uniformity of the web deposited on the perforated roller 10 is enhanced by successive deposition of successive layers of long fibres 18 on the surface of the perforated roller 10 (as shown in figure 3), preferentially in areas with lesser densities of deposition, on account of reduced flow resistance leading to stronger air stream directing fibres towards those regions.

15 Uniformity of the web deposited on the perforated roller 10 is enhanced by successive deposition of multiple layers of fibres on the surface of the perforated roller 10, by rotating perforated roller 10 at slow peripheral speed in relation to that of carding cylinder 7.

20 In one embodiment, the movement of fibres and trash in the entrained air is selectively enhanced by the application of blowing air.

In another embodiment, the movement of fibres and trash in the entrained air is selectively enhanced by the application of suction.

25 The main advantage of the present carding apparatus is that it simplifies the carding apparatus by eliminating the need of a licker in roller and a doffing roller. As a result, not only are a number of components minimized, several close tolerances required in the conventional machines are also relieved, thereby reducing the complexity of manufacture.

30 The application of this apparatus is not limited to carding of staple fibres to make slivers, but can be extended to production of non-woven webs.

35 While there are shown and described present preferred embodiments of the invention, it is distinctly to be understood the invention is not limited thereto, but may be otherwise variously embodied and practiced within the scope of the following claims.

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5 I CLAIM:

1. An apparatus for carding staple fibres, comprising:
 - a. a feeding arrangement with a feed table and a feed roller for feeding tufts of staple fibers;
 - b. a rotating carding cylinder having carding pins on its surface,
 - 10 c. one or more carding flats co-operating with the said carding cylinder for opening of tufts into individual fibres;
 - d. a zone downstream of the said carding flats where the air stream entrained by rotation of the said carding cylinder is unconstrained;
 - e. an air guiding element to enclose the unconstrained air stream and direct it
15 towards a preferred exit;
 - f. at least one air deflecting element to deflect the generated air stream away from the said carding cylinder towards the said preferred exit; and
 - g. a perforated roller at the preferred exit for doffing fibres entrained in the said air current.
- 20 2. The apparatus as claimed in claim 1, wherein the diameter of the said carding cylinder is in the range of 200mm to 300mm and the rotational speed is between 1200 to 1500 revolutions per minute.
- 25 3. The apparatus as claimed in claim 1, wherein the said feeding arrangement feeds said tufts directly to the said carding cylinder.
4. The apparatus as claimed in claim 1, wherein the staple fiber is preferably cotton with density of tufts less than 0.4g/cc.
- 30 5. The apparatus as claimed in claim 1, wherein the said feed table is positioned before the said feed-roller with respect to the direction of approach of the said carding pins.

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- 5 6. The apparatus as claimed in claim 5, wherein the said feed roller is pinned, knurled or has straight or helical flutes.
- 10 7. The apparatus as claimed in claim 1, wherein first of at least one of the said air deflecting elements comprising a surface with a blade edge is positioned relative to the said rotating carding cylinder such that the said blade edge is located in proximity to the pinned surface of the said carding cylinder.
- 15 8. The apparatus as claimed in claim 7, wherein the said surface with a blade edge deflects the air current carrying substantial part of carded fibers away from the said carding cylinder.
- 20 9. The apparatus as claimed in claim 8, wherein a second air deflecting element is positioned after the said first air deflecting element to doff substantial part of remaining fibers, thereby reducing recirculation of un-doffed fibers.
- 25 10. The apparatus as claimed in claim 8, wherein a plurality of secondary air deflecting elements are positioned successively after the said first air deflecting element to further reduce re-circulation of fibers.
- 30 11. The apparatus as claimed in claim 1, wherein the leading surface of the said carding pins is inclined towards the direction of movement of the said carding cylinder.
- 35 12. The apparatus as claimed in claim 1, wherein the preferable number of carding flats is atleast 2 to but not greater than 4.
13. The apparatus as claimed in claim 12, wherein adjacent carding flats have a gap preferably between 1 mm to 3 mm circumferentially long for radially expelling short fibres.

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- 5 14. The apparatus as claimed in claim 12, wherein successive flats of the said carding flats have progressively increasing pin densities.
15. The apparatus as claimed in claim 12, wherein successive flats of the said carding flats are set progressively closer to the pinned surface of the said carding cylinder.
- 10 16. The apparatus as claimed in claim 1, wherein the said one or more carding flats have pin profile and pin-densities which do not allow the accumulation of fibres and trash.
- 15 17. The apparatus as claimed in claim 1 further comprises a surface with knife-edge, positioned immediately after the said feeding arrangement.
18. The apparatus as claimed in claim 1, further comprising a trash separation plate positioned in the un-constrained airstream downstream of the said carding flats, such that the leading edge of the said trash separation plate is positioned between the radially farther zone of the airstream around the said carding cylinder where trash particles are entrained, and the radially proximate zone of the airstream around the said carding cylinder, where long fibers are entrained.
- 20 19. A method for carding staple fibers comprising:
- 25 a. enhancing the radial forces acting on materials entrained in air-current around a rotating carding cylinder of reduced diameter and increasing the rotational speed of the said carding cylinder to maintain the preferred surface speed;
- 30 b. feeding of loose tufts of staple fibres through a feeding arrangement of feed roller and feed table to the said rotating carding cylinder;
- c. removing of coarse particles by placing a surface with its leading knife-edge close to the pinned surface of the said carding cylinder;
- 35 d. expelling short fibres radially by radial force generated in the said air current;

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- 5 e. separating fine trash from carded fibers by allowing entrained trash particles to move radially away in an air-stream that is free to expand in the radial direction;
- f. directing the air-current carrying fine trash away from the said cylinder using a trash separation plate;
- 10 g. enclosing the residual air-current carrying entrained long fibers and directing it towards a perforated roller by means of an air-guiding element;
- h. allowing long fibres to stay close to the carding cylinder by the retaining action of pins whose leading surfaces are inclined towards the direction of rotation;
- 15 i. forcing the said long fibres to deflect from the carding cylinder onto a perforated roller by deflecting the air current away from the carding cylinder using at least one air deflection element proximate to the pinned surface of the said cylinder;
- j. permitting the said air current to escape through the perforations in the
- 20 roller while retaining the fibres on the perforated surface; and
- k. rotating the perforated roller to deliver carded web.
20. The method as claimed in claim 19, wherein the staple fiber being fed is cotton with density of tufts less than 0.4g/cc.
- 25 21. The method as claimed in claim 19, wherein strong radial forces are generated by rotating carding cylinder with diameter in the range of 200mm to 300mm at the rotational speeds lying between 1200 to 1500 revolutions per minute.
- 30 22. The method as claimed in claim 19, wherein damage due to the impact of pins of the said carding cylinder on the fibers gripped in the said feeding arrangement is reduced by positioning the said feed-table before the said feed-roller, with respect to the direction of approach of pins of the said carding cylinder.

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- 5 23. The method as claimed in claim 19, wherein intended movement of the fibers and trash in the entrained air is selectively enhanced by the application of suction.
24. The method as claimed in claim 19, wherein intended movement of the fibers and trash in the entrained air is selectively enhanced by the application of blowing air.
- 10 25. The method as claimed in claim 19, wherein uniformity of the web is enhanced by the successive deposition of multiple layers of fibers on the surface of the perforated roller, by rotating the said perforated roller at slow peripheral speed in relation to that of the said carding cylinder.
- 15 26. The method as claimed in claim 19, wherein uniformity of the web is enhanced by successive deposition of successive layers of fibers on the surface of the perforated roller, preferentially in areas with lesser densities of deposition, on account of reduced flow resistance leading to stronger air-currents directing fibers
- 20 towards those regions.
27. The method as claimed in claim 19, wherein uniformity of the web is enhanced by setting the at least one air-deflecting element at a farther setting from the said carding cylinder, so that a greater number of fibers re-circulate, building up a
- 25 reserve-stock of re-circulating fibers that smoothen momentary variations in rate of feed of fibers.
- 30

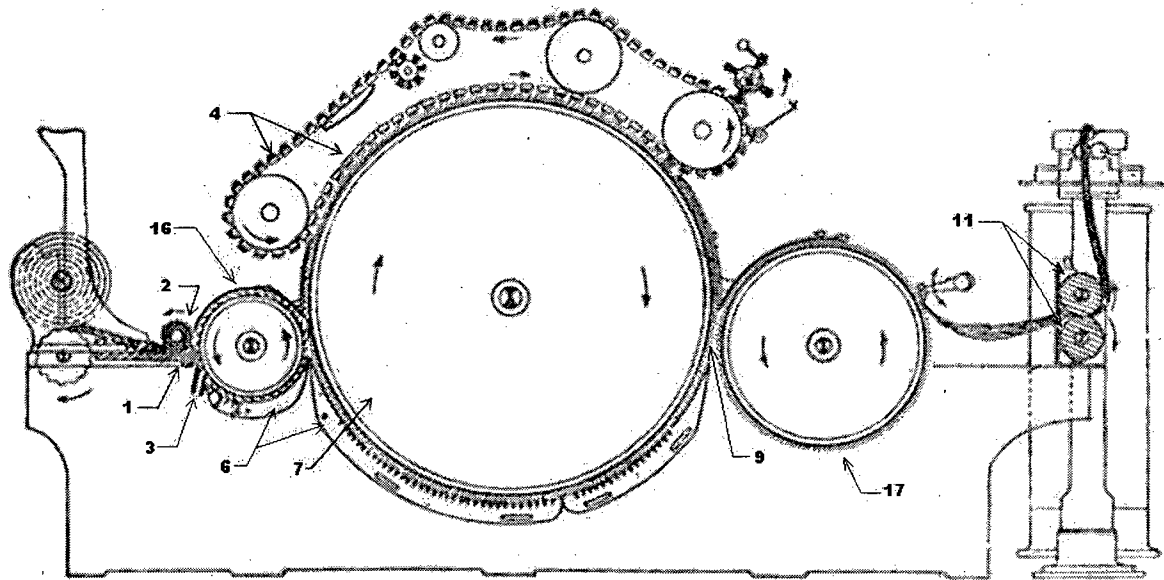
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TOTAL NO. OF SHEETS: 4

SHEET NO: 1/4

FIGURE 1:



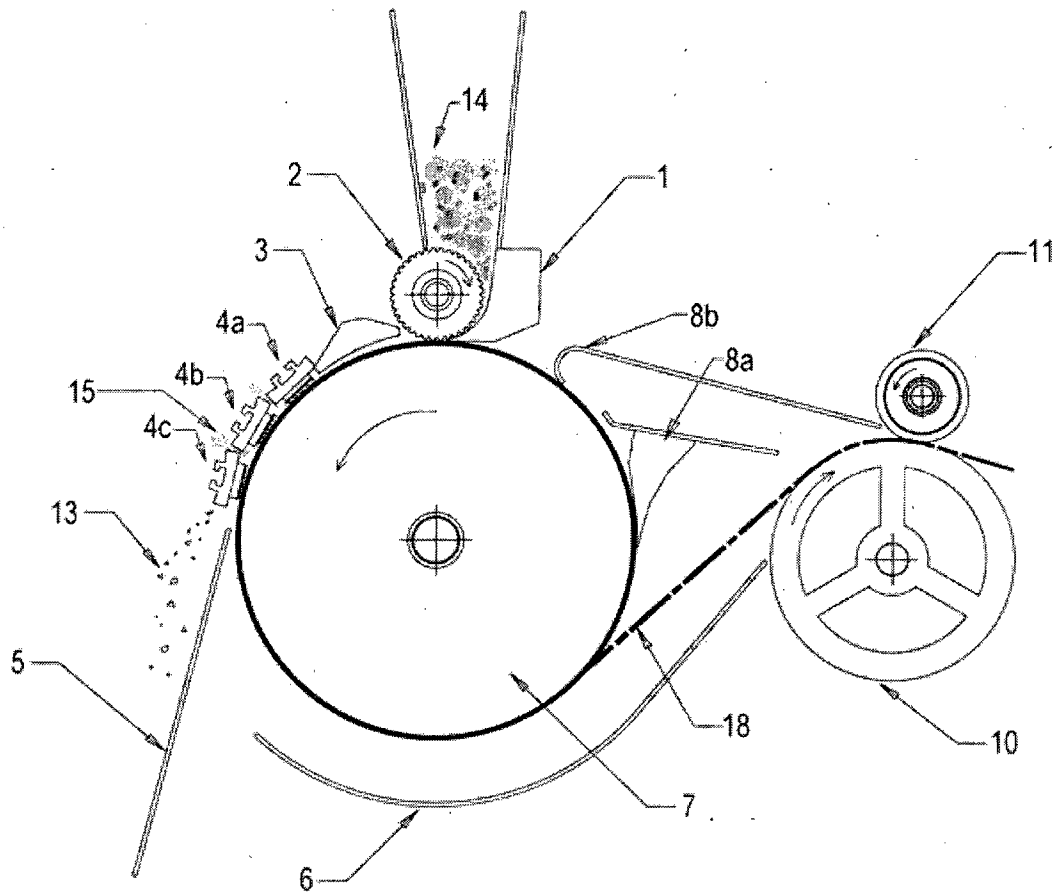
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TOTAL NO. OF SHEETS: 4

SHEET NO: 2/4

FIGURE 2:



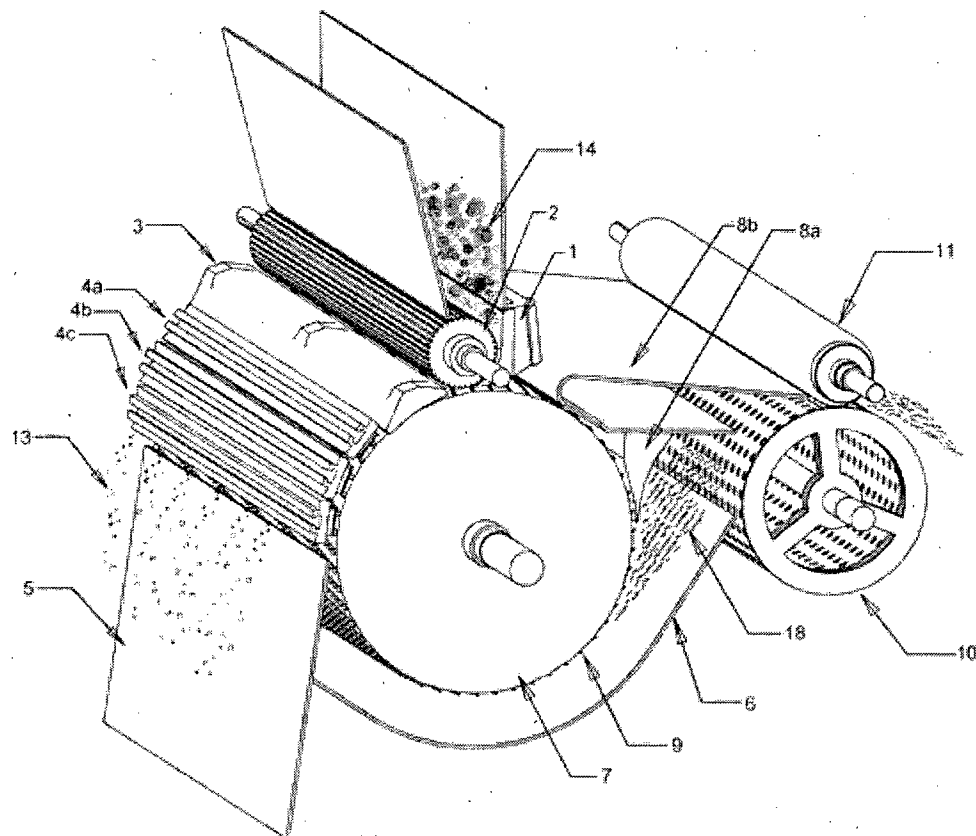
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TOTAL NO. OF SHEETS: 4

SHEET NO: 3/4

FIGURE 3:



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FIGURE 4:

