May 6, 1947. R. A. FAIRBAIRN 2,420,036

MEANS FOR SEPARATING SHORT COARSE FIBERS FROM LONG FINE FIBERS

Original Filed Sept. 10, 1941 4 Sheets-Sheet 1

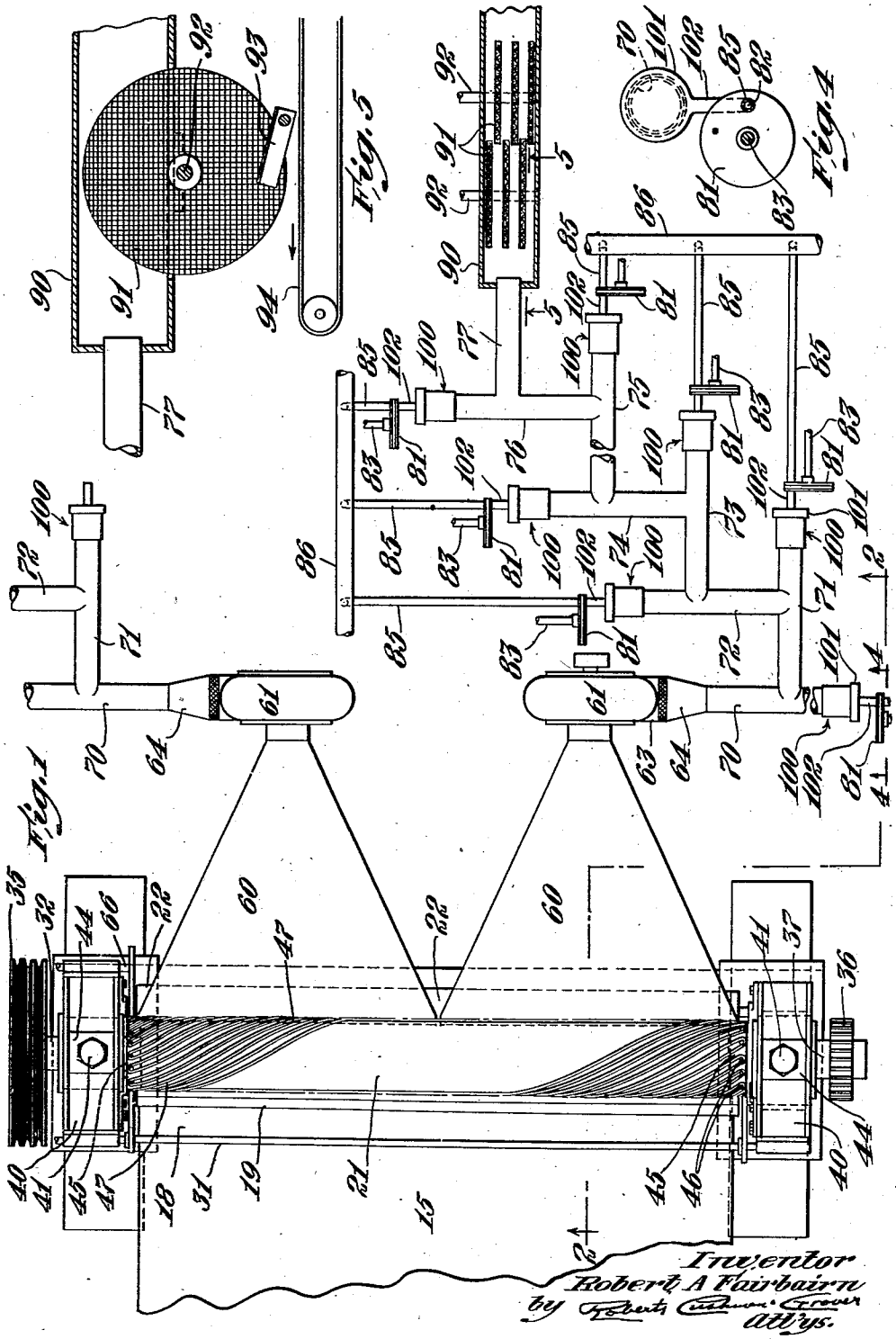


Fig. 1

Fig. 3

Fig. 4

Fig. 5

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MEANS FOR SEPARATING SHORT COARSE FIBERS FROM LONG FINE FIBERS

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Fig. 2

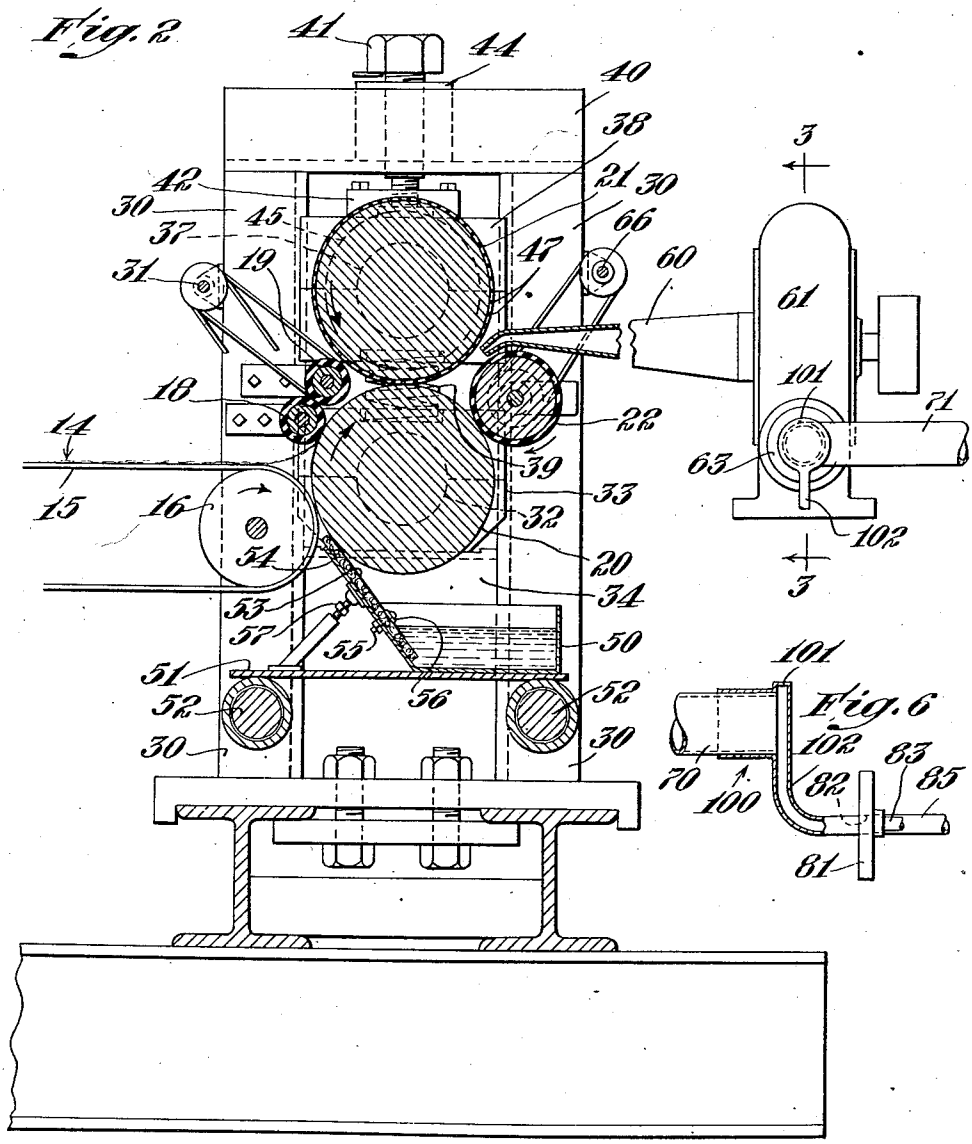
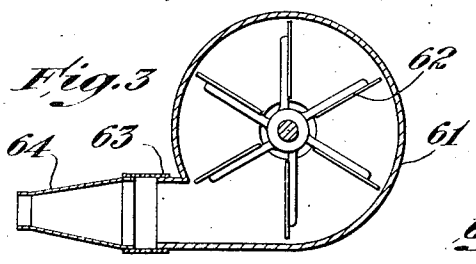


Fig. 6

Fig. 3



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MEANS FOR SEPARATING SHORT COARSE FIBERS FROM LONG FINE FIBERS

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Fig. 7

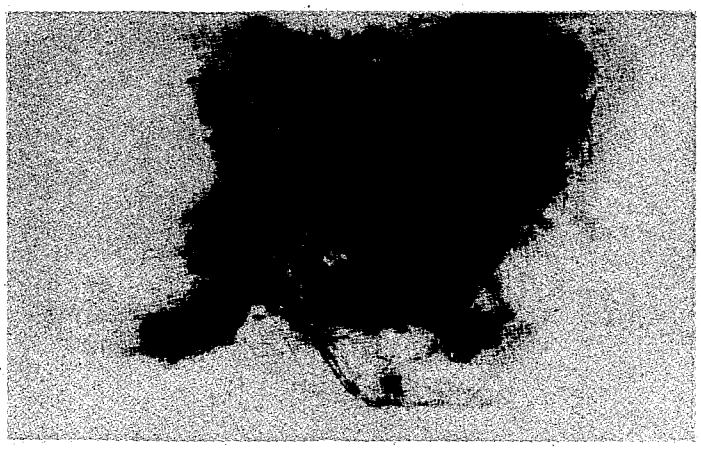
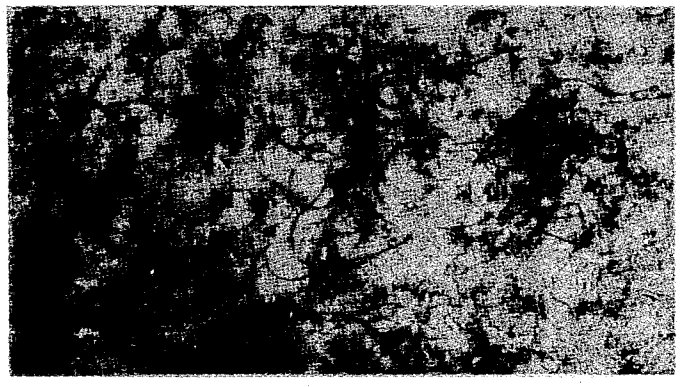


Fig. 8



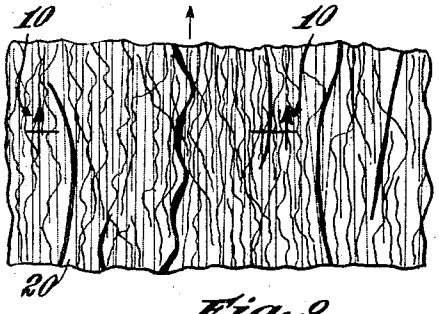


Fig. 9



Fig. 10

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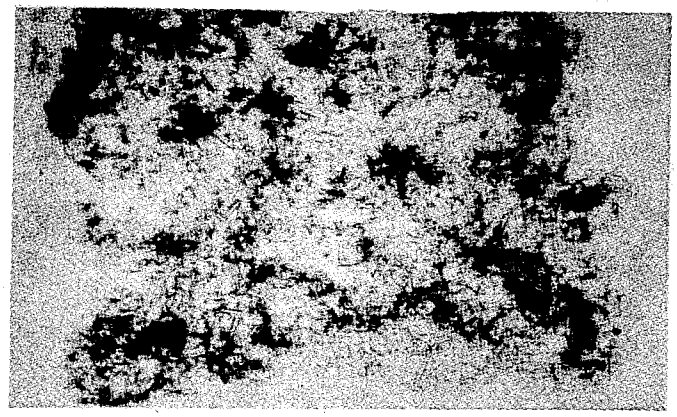


Fig. 11

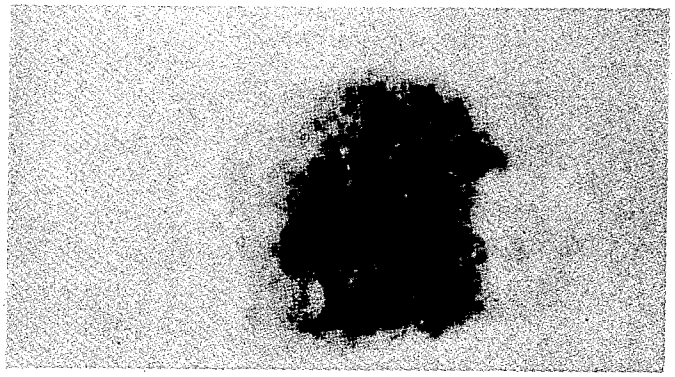


Fig. 12

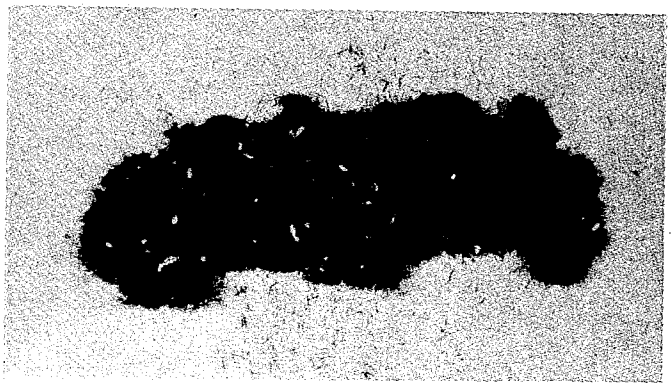


Fig. 13

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Patented May 6, 1947 2,420,036

UNITED STATES PATENT OFFICE

2,420,036

MEANS FOR SEPARATING SHORT COARSE FIBERS FROM LONG FINE FIBERS

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Original application September 10, 1941, Serial No. 410,300. Divided and this application March 15, 1945, Serial No. 582,852

3 Claims. (Cl. 19—76)

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This invention concerns the separation of the textily-useful, fine and curly down fibers from the relatively coarse, stiff, straight and brittle beard hairs or fibers which together constitute cashmere, camel's-hair or similar fleeces. In copending application Serial No. 410,300, filed September 10, 1941, of which this is a division, there is disclosed a novel method of and apparatus for automatically and mechanically separating the hairs from the down fibers, said separation involving as a step the division of the coarse hairs or fibers into short lengths, for example, into lengths approximating ⅛ inch without substantial injury to or shortening of the down fibers as a preliminary to the actual segregation of the coarse from the fine fibers.

The principal object of the present invention is to provide a novel method of and apparatus for separating the useful down fibers from the fragments of beard hairs after the latter have been divided into short lengths as above suggested.

Cashmere fleece is obtained from the Cashmere goat which is native in Tibet and Northern India. The fleece is received in this country in bale form and consists of a mixture of down fibers, beard fibers, dandruff, natural oil or grease and dirt. The grease and dirt are removed by scouring, leaving a jumbled mass which consists of approximately 75% by weight of down fibers, 25% beard fibers, plus dandruff. Prior to this invention so far as I know the beard fibers and dandruff were removed by repeated carding and combing and also, in Japan, by picking out the beard fibers by hand. During each carding and each combing operation many of the down fibers cling to the beard fibers and are removed with them so that a cashmere top (long down fibers more or less freed from beard fibers) is very expensive due both to the many carding and combing operations necessary for removal of the beard fibers and to the waste of down fibers which are removed with the beard fibers. Furthermore, a cashmere top made by that process still contains some beard fibers, the percentage often being as high as 10% by weight. When free cashmere noils (short down fibers substantially free from beard fibers) are produced by carding and combing, it is necessary to set the combs very closely in order to comb the down fibers out of the beard fibers, and this causes the down fibers to be broken up into very short lengths of the order of about ½ an inch, and the value of such fibers is quite limited.

Further objects will be apparent from a consideration of the following description and of the annexed drawings, in which one embodiment of my apparatus is chosen for the purpose of illustration.

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In the drawings:

Fig. 1 is a plan view of a machine embodying my invention;

Fig. 2 is an enlarged section taken on the line 2—2 of Fig. 1;

Fig. 3 is a section taken on the line 3—3 of Fig. 2;

Fig. 4 is an enlarged section taken on the line 4—4 of Fig. 1;

Fig. 5 is an enlarged partial section taken on the line 5—5 of Fig. 1;

Fig. 6 is a side elevation of that part of the apparatus which is shown in Fig. 4;

Fig. 7 is a top plan photograph of a jumbled mass of cashmere fleece as it appears upon arrival in this country prior to the removal of dirt and grease by scouring;

Fig. 8 is a top plan photograph of the web or film of cashmere fleece produced by scouring the fleece of Fig. 6 and then passing it through a carding machine;

Fig. 9 is a plan view of the web or film of aligned cashmere beard and down fibers produced by a preferred step of my method;

Fig. 10 is an enlarged section taken on the line 10—10 of Fig. 9;

Fig. 11 is a top plan photograph illustrating the appearance of the fibers of Fig. 9 after the beard fibers have been cut into short segments during another step of my method;

Fig. 12 is a top plan photograph illustrating the appearance of the cashmere down fibers after the cut segments of beard fibers and dandruff have been removed; and

Fig. 13 is a top plan photograph showing cut segments of beard fibers and dandruff as they appear after removal from the down fibers.

The cross section of cashmere down fibers is quite uniformly circular, the average diameter is about 15 microns, and the length varies from about 1¼ to about 3½ inches. The cross section of cashmere beard fibers varies from circular to ribbon-like, the diameter or thickness varies from about 30 to about 150 microns, the average diameter or thickness is about 60 microns and the length varies from about 1½ inches to about 5 inches. The beard fibers are not only thicker than the down fibers, but they are more brittle. The down fibers are normally very soft and very crinkly, whereas the beard fibers are much stiffer and straighter. These characteristics are illus-

trated to some extent by Figs. 7 and 8 in which the beard fibers appear as distinct black hairs, whereas it is difficult to distinguish the finer crinkly down fibers which comprise about 75% by weight of the mass illustrated.

In one aspect, my preferred method comprises arranging the beard and down fibers in a film or web (illustrated diagrammatically in Figs. 9 and 10) in which the beard hairs or fibers are substantially only one fiber deep and are aligned to extend substantially in the same direction; supporting this web or film on a hard surface; then causing spaced cutting devices to engage the beard fibers to cut them into short segments without substantially cutting the down fibers (see Fig. 11) and thereafter separating the substantially uncut down fibers (Fig. 12) from the cut segments of the beard fibers and the dandruff (Fig. 13).

The jumbled mass of cashmere fleece (shown in Fig. 7) is first subjected to a scouring operation, using soap and water, to thereby remove the grease and dirt. After drying, the resultant mass of beard fibers, down fibers and dandruff is passed through a carding machine (not shown) which is preferably provided with metallic clothing. This produces a thin web or film 14 which is about five feet wide and in which the fibers are not aligned, but cross and recross each other, as shown in Fig. 8. This web is fed from the carding machine to a conveyor belt 15 (Fig. 2) which continuously advances the web from the carding machine to the bite of the rolls 18 and 20. The conveyor belt passes around the roll 16 which is mounted for rotation in suitable bearings supported by the frame members 30. The speed of this belt may be about two feet per second.

The shafts of the rolls 18 and 19 are mounted for rotation each in suitable bearings located adjacent to the ends of each roll and supported by the frame members 30. The surface of the roll 18 engages both the surface of the roll 20 and the surface of the roll 19, but the surface of the roll 19 is spaced from the surface of the roll 20, as shown in Fig. 2. Each of the rolls 18 and 19 is provided with a rubber covering, and each is rotated in a counterclockwise direction (looking at Fig. 2) by suitable connections with the driven shaft 31, the roll 18 being rotated at a surface speed of about two feet per second, and the roll 19 at a greater surface speed which may be of the order of six feet per second.

The shaft 32 of the roll 20 is mounted for rotation in suitable bearing blocks 33 which are located adjacent to each of its ends and are supported by the frame members 30 and 34. One end of the shaft 32 is provided with a pulley 35 which may be driven by a belt (not shown), the belt in turn being driven from any suitable source of power. The other end of this shaft 32 is provided with a gear (not shown) which meshes with the gear 36 (Fig. 1) secured to the shaft 37 of the upper roll 21. These rolls 20 and 21 are driven at a greater surface speed than that of the roll 18 and their surface speed may be about six feet per second, the roll 20 being rotated in a clockwise direction and the roll 21 in a counterclockwise direction (looking at Fig. 2).

The shaft 37 of the roll 21 is mounted for rotation in bearing blocks 38 which are located adjacent to its ends. These blocks 38 are mounted for vertical sliding movement along ways provided in the frame members 30. The blocks are urged upwardly by springs 39 (Fig. 2), the lower end of each spring being retained in a recess

provided in the top of the block 33, and the upper end of each spring being retained in a recess provided in the bottom of the block 38. These springs 39 are strong enough to support both the weight of the blocks 38 and that of the roll 21. These springs 39 would thus hold the surface of the roll 21 out of contact with the surface of the roll 20 unless an additional downward force is applied of sufficient intensity to further compress these strong springs.

An adjusting bolt 41 is provided for each bearing block 38. The upper portion of the shank of each bolt 41 is provided with screw threads, and these screw threads engage the threads of an interiorly threaded aperture which extends through a steel block 44 which is welded to the frame cross member 40. The lower end of the shank of each bolt is of reduced diameter and is provided with screw threads. These threads engage the threads of an interiorly threaded aperture which is provided in a steel block 42, said block being secured to the top of the bearing block 38. Fewer screw threads per linear inch are provided on the upper portion of the bolt shank than on the lower reduced portion thereof, for example 12 threads per inch on the former portion and 13 on the latter portion, and both sets of threads are right-hand or both sets left-hand. In such an arrangement, one complete turn of the bolt 41 lowers or raises the associated bearing $^{65}/_{10,000}$ of an inch. Turning the two bolts 41 thus serves very slowly to force the bearing blocks 38 downwardly against the upward pressure of the springs 39 and thereby to delicately adjust the spacing of the peripheral surface of the roll 21 from that of the roll 20.

Interiorly threaded rings or collars 45 are screwed to exteriorly threaded depressed portions at opposite ends of the roll 21, the peripheral surfaces of the collars being substantially flush with the surface of the roll. A series of pins 46 is secured to each collar 45. Steel wire 47, having a diameter of about $^{1}/_{100}$ of an inch, is looped around a pin 46, wound once around the surface of the roll 21, and then looped around a pin 46 directly opposite the first pin but located at the opposite end of the roll. The roll is thus continuously wound with a single strand of steel wire. Each length of the wire is parallel to the adjacent length and is spaced about ⅛ of an inch therefrom. The collars 45 may be screwed outwardly with respect to the respective ends of the roll to thereby pull the wire as tightly against the surface of the roll as desired and after such adjustment the wire may be anchored to the pins by soldering. Each collar 45 may be secured in adjusted position by set screws (not shown) which pass through interiorly threaded apertures in the end of the collar and engage the adjacent end of the roll 21.

The surface of each of the metal rolls 20 and 21 is ground with extreme accuracy both longitudinally and concentric with the bearing surface of its shaft and this causes the surface of the wires 47 to exert a uniform pressure against the surface of the roll 20 throughout the length of the surface of the roll and during each complete revolution of the rolls 20 and 21. Thus the surface of the upper roll 21 is provided with a series of closely spaced steel wires 47 which rotate in unison with the roll and which engage the surface of the lower roll 20 with a uniform pressure, the amount of which may be delicately varied by turning the bolts 41.

A moistening reservoir 50 is supported on a

shelf 51 which in turn is supported by the frame cross members 52. A sheet of fibrous material 53 is secured to the resilient metal wall 54 of the reservoir by a series of bolts 55 which pass through the longitudinally extending rigid crossbar 56. A series of thumbscrews 57 serve to adjust or vary the angle of the resilient member 54 to thereby vary the amount of pressure exerted by the fibrous material against the surface of the roll 20. The length of the reservoir 50 and of the fibrous material 53 is substantially the same as that of the surface of the roll 20, so that the fibrous material engages the entire length of the surface of said roll. The fibrous material preferably is closely compacted, degreased, wool felt and it transfers the water or other moistening agent from the reservoir 50 to the surface of the roll 20 to continuously apply to said surface a thin coating or film of moisture. The characteristics of this coating may be controlled by adjustment of the set screws 57 to increase or decrease the pressure of the fibrous material against the surface of the roll and by adjustment of the bolts 55 to increase or decrease the pressure of the crossbar 56 against the surface of the fibrous material.

A rubber-covered roll 22 is mounted on a shaft which is mounted for rotation in suitable bearings supported by the frame members 30. The roll 22 is rotated in a clockwise direction (looking at Fig. 2) by suitable connections with a drive shaft 66, the surface speed of rotation of the roll being substantially the same as that of the roll 20.

A pair of metallic conduits 60 extends from a point adjacent to the surface of the roll 22 to the fan housings 61. Each fan housing is provided with a fan 62 which, upon rotation, is adapted to create suction in the associated conduit 60 and positive pressure in the associated housing outlet 63. The housing outlet member 63 is connected by the member 64 with the end of a length of glass tubing 70. The opposite end of the glass tubing 70 is provided with a cap 100 (Figs. 1, 4 and 6) the end portion of which is of greater diameter than the body portion so as to provide a circumferentially extending channel 101. A discharge tube 102 leads downwardly from the lower portion of this channel 101.

A branch tube 71, arranged at substantially right angles to the tube 70, has one end communicating with the interior of the tube 70 at a point adjacent to the cap 100. The opposite end of this tube 71 is also provided with a cap 100 similar to the cap just described. The tube 71 is provided with a branch 72 having its axis disposed substantially at right angles to that of the tube 71 and communicating with the tube 71 just in advance of the capped end of the latter, the tubes 70 and 71 being the first of a series constituting a system of branched tubes which, as here illustrated, includes the tubular branches 73, 74, 75 and 76, it being understood that a greater or lesser number of branches may be employed in accordance with circumstances and in particular with reference to the type of fiber being handled and the degree of separation desired. It is to be noted that the several branches diverge from each other at a substantially right angle as here illustrated so that the air current, in passing from one branch to the next of he series, is compelled to change its direction very abruptly. While as here shown the several branches diverge each at a right angle from the

preceding tube, it is contemplated that they may be so arranged as to cause the air to make an even more abrupt change in direction if desired. It is further to be noted that each branch extends beyond its junction with the next succeeding branch of the series so as to provide a dead air chamber in direct axial alignment with each branch passage, such dead air chamber in each instance having a terminal cap 100 with its annular channel 101 from which leads a discharge tube 102.

A series of closure disks or valves 81 is provided, one for each of the tubes 102 and each having one of its faces located adjacent to and normally closing the lower end of the corresponding tube 102. Each of these disks is provided with an orifice or aperture 82 (Fig. 4) which is of substantially the same diameter as the opening at the lower end of the corresponding tube 102. Each disk is mounted on a shaft 83 which is continuously rotated from any available source of power so that the orifice 82 of each disk intermittently registers with the opening of the corresponding tube 102, thereby periodically to afford communication between the interior of the tube 102 and the interior of an associated tube 85, coaxial with the tube 102 and having its open end close to the opposite radial face of the disk. The several tubes 85 lead to a main collection trunk 86.

A tube 77 is connected to the last branch 76 of the system and provides communication between the interior of this last branch 76 and a chamber 90 provided in an elongate casing (Figs. 1 and 5).

The floor of the chamber 90 is provided with a series of parallel slots which receive the upper portions of fiber entraining disks 91 having rough edges and preferably having rough radial surfaces. For example, these disks may consist of stiff wire screen fabric. The disks 91 are secured to shafts 92 which are arranged outside the casing and which are rotated in a counterclockwise direction as viewed in Fig. 5.

Scrapers 93 located outside of the casing constitute means for removing the fibers which cling to the edge of each of the disks, it being understood that a scraper 93 is arranged at each side of each disk. The fibers so removed from the disks drop onto a conveyor belt 94.

In operation, the web or film 14 consisting of dandruff and crossed beard and down fibers (Fig. 8) is advanced by the belt 15 to the bite of the rolls 18 and 20 (Fig. 2), the speed of the web being about two feet per second, the surface speed of the roll 18 being about the same as the speed of the web and the surface speed of the roll 20 being greater than the surface speed of the roll 18. The surface of the roll 20 is continuously coated with moisture by the fibrous material 53, and this moisture tends to retain the fibers in engagement with the surface of the roll 20 as they leave the bite of the rolls 18 and 20 and until they reach the bite of the rolls 21 and 20.

In the film or web of fibers as it enters the bite of the rolls 18 and 20 the fibers cross and recross each other and are several fibers deep, as shown in Fig. 8. As one end of a fiber is advanced through the bite of said rolls and becomes freed from said bite the action of the moist surface of the faster moving roll 20 against the surface of said freed end portion of the fiber causes it to be rearranged on the surface of the roll 20 and to extend along said surface in a direction substantially at right angles from the line of the bite of the rolls 18 and 20 where the lower part of the

fiber is still engaged by said bite. This aligning action is caused by the tendency of the freed end portion of the fiber to seek the position of least resistance on the surface of the rapidly moving roll 20 while the lower part of the fiber is still engaged by the roll 18. Each of the fibers is thus progressively aligned as it progressively advances through said bite so that before the fibers pass through the bite of the rolls 21 and 20 they have been rearranged in a web or film of a thickness approximating the average diameter of the beard fibers and in which they are aligned to extend along the surface of the roll 20 substantially in the same direction. This web or film of aligned fibers is shown diagrammatically in Figs. 9 and 10, the arrow at the top of Fig. 9 indicating the direction of movement of the surface of the roll 20, the beard fibers being indicated by the heavy lines and the down fibers by the lighter lines.

The moisture on the surface of the roll 20 serves to keep the fibers in engagement with the surface of the roll 20 both when they are being aligned and after the alignment has been completed. Without the use of moisture the crinkly down fibers tend to separate or free themselves from the surfaces of the roll 20 so that alignment is less complete and so that they do not as readily remain in such realigned arrangement until they enter the bite of the rolls 21 and 20.

The function of the rolls 19 is to remove from the surface of the roll 18 any fibers which adhere thereto and to direct or return such fibers to the surface of the roll 20.

As this web or film of aligned fibers progressively passes between the bite of the rolls 20 and 21 (see Figs. 9 and 10) the spaced wires 47 progressively engage each beard fiber at spaced intervals, and the curved surface of the wire (a radius of about $1/200$ of an inch) cuts through each beard fiber to progressively separate it into short segments of about $1/8$ of an inch in length. When the pressure of the wire against the surface of the lower roll 20 is properly adjusted the beard fibers are thus cut into short segments but the down fibers are substantially uncut. I believe this result is due to the fact that the beard fibers are thicker and more brittle than the down fibers so that by accurate adjustment of the cutting pressure of the wires their pressure on the down fibers is insufficient to sever them, whereas their pressure on the beard fibers is greater and is sufficient to sever them.

The bite of the rolls 21 and 22 is preferably located slightly more than $3\frac{1}{2}$ inches from the bite of the rolls 18 and 20 so that down fibers will not be gripped at the same time both by the bite of the rolls 18 and 20 and by the wires 47 to thereby break the down fibers. By reducing the pressure at the bite of the rolls 18 and 20, however, the machine may be satisfactorily operated with a shorter distance between said bites.

Fig. 11 illustrates the material as removed after passing the bite of the rolls 20 and 21, the material then consisting of cut segments of beard fibers, substantially uncut down fibers and pieces of dandruff. It will be observed that the length of the cut segments of beard fibers varies. This is probably due to the fact that the diameter or thickness of beard fibers varies so that the pressure exerted by the wires is insufficient to sever the fiber in some localities, whereas it is sufficient to sever the fiber at most localities. Some of the down fibers may be cut, but the majority of them are uncut and after the short cut segments of beard fibers have been removed the resultant mass consisting of substantially uncut down fibers is of great value in the manufacture of yarn and fabrics. Even if all of the down fibers are cut once or twice (which result may be accomplished by passing the card web shown in Fig. 8 directly from the carding machine through the bite of the rolls 21 and 20) the resultant down fibers are long enough to make an end product which is acceptable for some purposes.

The suction which is created by the fans at the mouth of the conduits 60 draws the material emerging from the bite of the rolls 21 and 20 into the conduits 60. Any of this material which continues to adhere to the surface of the roll 20 is removed therefrom by the roll 22 and the suction at the mouth of the conduits 60 removes such material from the surface of the roll 22 as well as any material which adheres to the surface of the roll 21 and draws said material into the conduits 60.

The mass of down fibers, cut beard fibers, and dandruff then passes to the fan housing 61 where it is agitated by the fan 62 and is thereafter blown out through the outlet 63, the connecting member 64, and into the tube 70. When the fibers reach the entrance to the tube 71 many of the lighter weight and longer down fibers are forced around the corner into the tube 71 whereas many of the shorter segments of the beard fibers pass beyond the entrance to the tube 71 and into the cap 100. The exit opening of the tube 102 is normally closed so the segments of beard fibers collect in said tube. Some dandruff and some of the down fibers also pass beyond the entrance to the tube 71, the adjacent portion of the tube 70 and into the cap 100. The eddy air currents which are set up in the cap agitate these down fibers and continuously force them back to the entrance to the tube 71, and thence into the tube 71. These same eddy currents tend to remove the dandruff and the beard fiber segments which adhere to the down fibers, which thus pass to the extension portions of the tube 70, said dandruff and beard fiber segments being thrown outwardly into the channel 101 from which they fall to the tube 102.

When the opening 82 in the disk 81 periodically registers with the exit end of the tube 102, the beard fiber segments and the dandruff, which have collected at the end of said tube, are forced out through the opening 82 into the tube 85 and thence into the collection tube 86. This waste product is illustrated in Fig. 13.

The cap 100 and the portion of the tube 70 which extends beyond the entrance to the tube 71 form what is referred to in the claims as a substantially dead air chamber. This phraseology is used notwithstanding the eddy air currents which are present in that part of the apparatus because the main air current set up by the fan 62 is directed toward said dead air chamber but since the exit end of the tube 102 is normally closed the greatest part of said main air current does not pass into said dead air chamber and is forced to pass around the corner into the tube 71. Each down fiber is much longer than each cut section of beard fiber and has substantially the same weight, and consequently the main air current, as it turns the corner into the tube 71, is more easily able to change the direction of the longer down fibers than of the shorter section of beard fibers. It is for this reason that many of the beard fiber sections pass into the substantially dead air chamber, whereas most of the down

fibers do not enter it at all but pass directly around the corner into the tube 71.

Not all of the beard fiber segments and dandruff are removed in the first substantially dead air space of the tube 70, and the down fibers, together with the remaining dandruff and beard fiber segments continuously pass along the tube 71 in which the same process of removal takes place as that which has been described above with respect to the tube 70. A sufficient number of branch tubes, similar to the tubes 70 and 71, is provided to completely remove the down fibers from the undesirable beard fiber segments and dandruff, seven such tubes being illustrated as associated with each of the two fan housings 61 in the embodiment shown in the drawings.

The down fibers which pass from the last of these tubes 76 into the tube 77 are illustrated in Fig. 12 and they are satisfactory for use in the manufacture of yarn. However, they present a somewhat tangled and disorderly appearance because of the agitation to which they have been submitted by the air currents in the series of tubes. The rotating disks 91 tend to untangle the down fibers and to rearrange them so that they present a more attractive appearance for marketing. As the fibers are blown from the tube 77 into the chamber 90, they catch intermediate their ends on the edge of the rotating disks 91 and are thus removed from the mass. The disks carry the fibers downwardly and some of them fall from the edge of the disks to the conveyor belt 94, whereas those which continue to adhere to the disks are removed by the scrapers 93 from which they fall to the surface of the belt 94. The end product is collected from the surface of the belt 94 and consists of substantially uncut down fibers which are substantially free from beard fibers and dandruff.

Those aspects of the method and apparatus which relate solely to reducing the thickness of the carded web or film, to parallelizing the beard and down fibers or to advancing the resultant web or film are claimed in my copending continuation in part application, Serial No. 662,240, filed April 15, 1946.

I claim:

1. Textile apparatus for use in the separation of relatively long and fine down fibers from short lengths of beard hair intermingled therewith, the apparatus comprising separating means comprising a series of passages each branching from the preceding passage and each extending beyond its junction with the next following passage to provide a dead air chamber, each dead air chamber having an exit opening, means normally closing each exit opening, means operative at regular

intervals to open each exit opening, and pneumatic means operative to withdraw collected material from each dead air chamber when the exit opening is open.

2. Textile apparatus for use in the separation of fibers of different diameters, the coarser fibers being much shorter than the finer fibers, the apparatus comprising separating means to which the mingled fiber is delivered and comprising a series of passages each branching from the next preceding passage and each extending beyond its junction with the next following passage thereby to define a dead air chamber, each dead air chamber having an exit opening, rotary disks each so disposed that one face thereof normally closes one of the exit openings, each disk having an aperture therethrough registrable with the corresponding exit opening, and means operative to turn the disks thereby at intervals to register the apertures with said exit openings.

3. Textile apparatus for use in the separation of intermingled relatively long and fine down fibers and short lengths of coarse fiber, the apparatus comprising separating means to which the mingled fine and coarse fiber is delivered, said separating means including a system of connected branch passages each terminating in a dead air chamber, the several branches being disposed each at substantially right angles to the next, means providing an inlet to said system, means providing an outlet to said system, means for creating a fiber-carrying air current from end to end of said system, means affording communication with the atmosphere at the inlet end of said system and means affording communication with the atmosphere at the outlet end of said system, said system being free from communication with the atmosphere except at said inlet and outlet ends.

ROBERT A. FAIRBAIRN.

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460,078	Barnard	Sept. 22, 1891
821,819	Neumann	May 29, 1906
1,023,750	Morscher	Apr. 16, 1912