METHOD AND MEANS FOR DEFIBERING MATERIALS

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This invention relates to the dispersion in conjunction with the separation of fibers to maintain the fibers in separated condition for use in the manufacture of fibrous structures and it relates more particularly to the separation of a fibrous mass of fibers, such as commonly used for the manufacture of felts, papers, boards and similar structures, into substantially individual fibrous elements and the maintenance of the individually separated fibers by their dispersion in an air stream for use in the manufacture of these and other felted fibrous structures.

While textile devices such as openers, pickers or cards are capable of taking compacted masses of fibers, as for example from a bale of cotton and converting them into fluffy masses of fibers, such equipment has certain limitations, particularly for the separation of relatively short fibers such as cotton linters since most or all of the short fibers would fall through the opening means used therein. Such equipment also cannot disperse the fibers into individually separate fibrous elements and furthermore they are incapable of交付 even well compacted fibrous material, such as dry wool pulp sheets.

Composite masses of shorter fibers such as sheets of wood pulp and the like have been reduced to some extent into fibrous elements by means of a hammermill or other impacting device or, occasionally, by feeding the sheets radially to a rotary rasp or similar device. While reduction is achieved thereby with either the impacting device or the rotary rasp, fiber separation is incomplete. Small undefibered portions or "neps" in the product result which cannot readily be removed and they are objectionable not only because of their appearance in the final product into which they are felted, particularly if the product is thin enough to be translucent, but because they form discontinuities in the structure and often impair its efficiency in use. When an impacting device is used for breaking up fibrous aggregates, its operation involves a very high consumption of power which may be as much as 5 kilowatt hours per pound of fiber, and moreover, not only is individual fiber separation incompletely achieved, but the action of the device inevitably results in considerable damage to and deterioration of the fibrous elements.

An object of this invention is to produce a defibering means having the function of a disperser which operates neither in the capacity of a picker, a ras, nor a hammermill but which substantially completely separates a mass of fibers into individual fibrous elements and maintains the fibers in their separated state by dispersion in substantially dry form in an air stream for use in the manufacture of felted fibrous structures upon subsequent separation from the air stream, as by the means described in my copending applications Ser. No. 61,674, filed November 23, 1948, and Ser. No. 313,316, filed October 6, 1952, now Pat. No. 2,720,005.

Another object is to provide apparatus and a method for using same in the conversion of fibrous waste into individual fibrous elements for reuse in the manufacture of fibrous structures, which reduces fibrous masses into individual fibers and suspends them in substantially dry form in an air stream for maintaining separation of the fibers, for subsequent use in the manufacture of fibrous structures, and effects this without deterioration of the properties of the fibers and without excessive reduction in their lengths.

In general, it is an object of this invention to provide a method and apparatus for achieving separation of fibers and for maintaining the fibers in their separated condition by dispersing the fibers in a large volume of air for use in the manufacture of new and improved fibrous structures. The fibers so dispersed may be deposited, with or without further processing in an interfelted, haphazard arrangement to form mats or batts which may be felted together to be self-supporting or which may be treated with resinous binders in the manufacture of non-woven fabrics, papers or reinforced plastics, or into other fibrous elements such as threads, fabrics or sheet stock adapted to be used as filters, laminates, papers, insulation materials and the like.

These and other objects and advantages of the invention will hereinafter appear and for purposes of illustration, but not of limitation, embodiments of the invention are shown in the accompanying drawing in which—Figure 1 is a diagrammatical elevational view in section of one modification of a disperser embodying features of this invention;

Figure 2 is a sectional view taken substantially along the line 2—2 of Figure 1;

Figure 3 is a sectional view taken substantially along the line 3—3 of Figure 2;

Figure 4 is an enlarged sectional view taken along the line 4—4 of Figure 3; and

Figures 5, 6 and 7 are sectional elevational views of three other modifications of a disperser embodying features of this invention.

Referring now to the drawing for a specific description of apparatus for dispersing separated fibers in an air stream to maintain the separation thereof in use for the manufacture of interfelted fibrous structures, 10 represents a drum or cylinder adapted to rotate slowly about an axis 11 separately driven by a motor 12.

13 represents a brush roll mounted on a shaft 14 for rotation at high speed by motor 15 about an axis parallel to the drum cylinder. The brush roll 13 is formed with bristles 16 extending radially from a central hub and positioned so that the bristles 16 just clear the surface of the drum cylinder 10 during rotation at high speed to form what will be referred to hereinafter as a defibering couple therebetween.

The brush roll 13 is preferably substantially completely enclosed within a hood 17 having an inlet 18 in the upper portion away from the cylinder 10 and an outlet 19 in a portion immediately beyond the cylinder in communication with a duct 20 through which the air and fibers 21 are separated in the manner hereinafter described and conducted for subsequent use in the manufacture of fibrous structures. The hood 17 is open in the portion immediately in the vicinity of the defibering couple to permit a fibrous mass in the form of a web 22 or layer to be advanced over the periphery of the drum cylinder 10 into engagement with the bristles 16 of the rapidly rotating edge of the web and effect separation thereof from the web. The bristles rotating at high speed tend to throw the separated fibers from the ends thereof upon passage beyond the couple, whereby the fibers immediately become entrained with a large volume of air passing as a stream through the hood, if present, from the inlet through
the outlet into the duct 20, or, if the hood is absent, induced by the rotation of the brush. It will be apparent that the rapidly rotating brush roll 13 will function in the manner of a centrifugal blower or, if separated by the circulation of air towards the outlet or its periphery. Since it has been found that for the maintenance of the fibers in a separated condition in the air stream during their conveyance to the fiber depositing device in the manufacture of fibrous structures, it is important to provide for a large volume of air to travel with the fibers upon separation, to achieve such large volume of air for entrainment of the fibers it is often desirable to supplement the amount of air circulated by the brush roll by introducing additional air into the inlet 18. Thus the separated fibers thrown from the tips of the bristles 16 after they pass beyond operative engagement with the leading edge of the fibrous web will become dispersed in a large volume of air traveling through the hood into the duct for maintaining the desired dispersed relationship and for conveyance through the duct to the fiber proccesing unit.

I am aware that others might have used a rapidly rotating brush roll to effect fiber separation, but no one to the best of my knowledge has ever combined the concept of a rapidly rotating brush roll for fiber separation in conjunction with the use of large volumes of air into which the separated fibers are introduced for dispersion and maintaining the desired separated relationship for conveyance in the manufacture of fibrous structures.

In Coghill, Patent No. 2,675,161, the couple is confined within an enclosure to minimize the movement of air and Coghill specifically provides for the maintenance of subatmospheric conditions in the area surrounding the delivering couple. Such minimized air movement at the brush roll and the immediate depositing area of the separated couple by delivering couple are believed necessary for the desired operation of that device. When conditions for limiting air movement to provide for such subatmospheric conditions are maintained within the hood portion following the delivering couple in the apparatus embodying features of this invention, insufficient air is provided for maintaining the fibers in a dispersed condition and the fibers separated by the couple tend rapidly to agglomerate into flakes and bundles by mutual entanglement, and from which they would have to be removed.

The bristles 16 extending radially in the brush roll of applicant's device are preferably formed of steel wire having a thickness of about 0.004 inch but it will be understood that sufficiently stiff bristles of natural or synthetic fibers or wires of other materials may be used. The bristles should be mounted to form a smooth cylindrical contour but the efficiency of the roll is considerably improved when the bristles are further ground to form a true cylinder while the brush roll is caused to revolve at its normal working speed but in a direction opposite to its operational direction of rotation. As illustrated in the drawings, the fibers are fed for separation by the couple, in the form of an endless web 22 which may be unwound from a roll 23 mounted on a spindle 24. If the fibers are cellulose or woody it is preferred to advance the composite mass of fibers for separation with a moisture content within the range of 20-65 percent since the separation of cellulose or woody fibers while in moist condition can be effected more efficiently and without damage to their lengths or character. A web of the type described may be formed, in the alternative, as a continuous operation for advancement to the fiber separating couple by suspension of the fibers in an aqueous slurry 25 from which the fibers are separated to form a continuous layer 26 on the periphery of a rotary filter 27 having a high velocity air stream, as illustrated in Figure 5.

When formed in this manner, it is expedient to remove the web 26 from the periphery of the filter for advancement as an endless strip to between press rolls 28 and 29 between which the fibrous elements are compressed for the removal of excess amounts of free water to the end that the web 22 advanced through the delivering couple will have a moisture content within the desired range of 20-65 percent by weight. For most efficient operation, it is expedient to provide a roll holding down means such as 30 which cooperates with the periphery of the drum 10 in advance of the delivering couple for feeding the web in the desired relation into the delivering couple.

It will be apparent that a slurry 25 of the type described may be that formed with pulp fibers in conventional paper making processes and that such slurry may be similarly prepared from fibrous waste materials such as rag stock, paper stock and the like, for recovery of their fibrous elements and their subsequent use in the manufacture of fibrous structures.

The web 22 of fibrous material may be carried on the surface of the drum 10 which is rotated slowly for advancement at the desired speed into the delivering couple but it is expedient to provide an auxiliary surface 31 to carry the strip into operative engagement with the brush roll 13, such for example as an endless belt in the form of a stainless steel sheet, woven wire cloth, or, as is shown in Figure 4, a strip of material, on a roll 40 (shown pointing rearward) which turns with the drum and is returned over an idler roller 32 spaced opposite the drum and adapted to carry the strip of the fibrous mass on its surface completely through the delivering area.

In Figure 4, the drum 10 is shown covered with card clothing 31a and the holding down means takes the form of a thin springy plate 50 preferably made of spring steel extending from supporting bar 51 and terminating just short of the line on the upper surface of web 22 where the bristles 16 come into content with the fibers of the web.

As heretofore described, the drum 10 and the brush roll 13 are preferably separately driven, such as by means of a driving motor 12 connected to the drum through suitable gear means 33 for speed reduction while a separate motor 15 preferably axially aligned with the shaft 14 of the brush roll functions to drive the roll at the desired speed. The peripheral speed of the ends of the bristles of the brush roll constitutes one of the important factors for efficient operation. Excellent results have been secured when the roll is rotated to provide a peripheral speed of 2,000 feet per minute and it is undeveloped to operate at a peripheral speed of less than 500 feet per minute. Above 8,000 feet per minute increasingly less satisfactory results are obtained up to the maximum speed of the brush roll in excess of 10,000 feet per minute. It is found that the roll running at its highest speed consistent with good delivering. Under such circumstances usually the volume of air induced to carry the fibers is sufficient to keep them separate even without the hood and supplementary air introduced for passage therethrough.

When dry pulp, such as wood or cotton linters, in the form of a continuous roll is moistened and permitted to remain for an hour or so with a moisture content of between 30-40 percent, in order to soften the bonds holding the fibers together and when the brush roll is properly ground and positioned for reaction with the drum cylinder, a device of the type described is very efficient in achieving substantially complete separation of the fibers from the fibrous mass. If the roll of pulp contains long fibers, well compacted and matted together, it is difficult to deliver thoroughly and in order more completely to avoid formation of undefibered particles, means may be provided in addition for holding down the moistened web against the drum cylinder 10 during fiber separation, such as the flexible blade 30 shown in Figure 7.

However, when the portion thereof the pulp sheet is relatively permeable to air, this operation may be efficiently provided by an adaptation of the auxiliary carrier 31 operating about the idler roll 32 and the drum cylinder 10, as pre-
viously described. The belt 31 is made foraminous and the cylinder 10, which functions as the driving member for the belt 31 is made hollow and is provided with a series of openings 37 which merge into grooves 38 extending crosswise in the peripheral surface of the cylinder whereby suction is applied uniformly to the web 22 at the desired location immediately below the brush roll 13 at the delivering couple. The suction serves to hold down the fibers at the leading edge of the moist web 22 firmly against the auxiliary foraminous carrier 31 operating about the periphery of the cylinder 10 until the fibers comprising the leading edge of the web are completely individually separated by the brush roll 13.

By way of a specific illustration, a brush roll forming a cylinder of about 6 inches in diameter and formed of steel wires 0.004 inch thick was rotated by a 2 horsepower motor at a peripheral speed of about 8000 feet per minute. A strip of pulp having a moisture content between 30–40 percent was advanced into the delivering couple formed by the nip between the brush roll and the periphery of the cylinder 10 at a rate of about 10 feet per minute. The production of fiber per minute of foot of width of the web which is equivalent to 27 pounds of fiber per horsepower hour. When a web of the same material having an equivalent moisture content was delivered by a swinging hammermill of the conventional type used for such purposes, the product which resulted was found to have a relatively large number of undelivered particles and the production amounted to only 1.5 pounds of fiber per horsepower hour.

When it is desired to deliver waste paper, because of the unusual quantities of cellophane, string and other substances generally included, it is preferable first to proceed by means well known in the paper making art to pulp the material in water and to settle and screen out the undesirable components. Thereafter, the cleaned and diluted pulp may be introduced by a pump through the inlet 40 into a vat 41 for separation of the fibers from the slurry 25 to form the web of wet fibers as previously described. In this case, the overflow from the vat 41 passes through outlet 42 for recirculation to the pulp supplying the inlet 40.

When effecting separation of fibers having the described moisture content or even when separating fibers in the manner described having a moisture content in excess of 50 percent, it has been found desirable to introduce a supply of hot dry air into the hood 17 to achieve the desirable drying of the fibers but otherwise the quantity of air displaced by the brush roll in normal operation is generally sufficient to dry the separated fibers sufficiently. From the brush roll, the separated fibers may be conveyed while dispersed in the air stream to a dry felting apparatus, such as is disclosed in my copending application Ser. No. 61,674, filed on November 23, 1948, or my copending application Ser. No. 110,212, filed on August 13, 1949, now Pat. No. 2,698,271, or my copending application Ser. No. 313,316, filed on October 6, 1952, for use in the manufacture of felted structures.

It will be apparent from the foregoing description that I have provided apparatus and means to effect substantially complete separation of fibers from fibrous masses without deterioration of the fibers nor destruction of the lengths of the fibers in conjunction with means for maintaining the fibers in their separated relation for use and conveyance in use in the manufacture of fibrous structures. It will be apparent from the description that such means may be employed not only for the separation and use of fibrous material from previously prepared webs or pulps but that such processes may be used efficiently for the recovery of fibers from waste material and use thereof in the manufacture of new and improved felted fibrous structures.

When the fibers in the sheet or web to be delivered are well bonded together, as in dry or dampened paper, in order to secure complete delivering with a minimum number of nips, it has been found desirable to reduce the peripheral speed of the brush roll to about 1500–2000 feet per minute with the type of apparatus shown in Figures 6 and 7 and to slow down the rate of feed of the sheet or web to about 3–4 feet per minute.

In every case, the thickness of the web to be delivered and the rate of its feed should be such that no more fibers are dispersed by the brush than are able to be suspended in a separated condition by the volume of the air stream induced to carry the fibers away.

It will be understood that changes may be made in the details of construction, arrangement and operation without departing from the spirit of the invention, especially as defined in the following claims.

I claim:
1. A in a fiber separator and disperser, a cylinder mounted for rotational movement at slow peripheral speed, a brush roll mounted for rotational movement at high peripheral speed about an axis parallel to but spaced from the axis of the cylinder by an amount to enable the ends of the bristles of the brush roll substantially to engage the peripheral surface of the cylinder to form a delivering couple therebetween, a hood enclosing the brush roll and the area forming the delivering couple and having an inlet in advance of the cylinder and an outlet beyond the couple for introducing a web of unseparated fibers to the delivering couple whereby the fibers in the leading edge of the web are engaged by the bristles of the brush roll for displacement and dispersion as separated fibers into the air stream flowing towards the outlet for conveyance of the separated fibers for use in the manufacture of fibrous structures.

2. A fiber separator and disperser as claimed in claim 1 which includes means for introducing large volumes of air into the hood through the inlet whereby air under positive pressure passes in large volumes from the inlet to the outlet.

3. A fiber separator and disperser as claimed in claim 1 which includes means for heating the air entering the hood to an elevated temperature.

4. In the method of separating fibers and dispersing the separated fibers for maintaining a separated relation, the steps of rotating a brush roll at high peripheral speed, advancing a web of fibrous material at a substantially tangential to and against a peripheral portion of the brush roll whereby the bristles of the brush detach individual fibers from the leading edge of the web and throw the separated fibers from the ends thereof upon passage beyond the web, maintaining free access to the atmosphere in advance of the nip between the brush roll and web whereby the roll functions as a blower to cause the passage of a large volume of air with the fibers through the nip whereby the separated fibers are dispersed in the air stream upon being thrown from the brush roll beyond the nip, and continuing the passage of the brush roll except for the area through which the web of fibers is advanced and from which the separated fibers are delivered and introducing additional air under positive
pressure into the confined space in advance of engagement between the brush roll and the web to increase the volume of air passing through the confined space with the separated fibers.

5. The method as claimed in claim 4 which includes the additional step of heating the air for drying the separated fibers.

6. In a fiber separator and disperser, a cylinder mounted for rotational movement at relatively slow peripheral speed, a brush roll mounted for rotational movement at high peripheral speed about an axis parallel to but spaced from the axis of the cylinder by an amount to enable the ends of the bristles of the brush roll substantially to engage the peripheral surface of the cylinder to form a defibering couple therebetween, means for rotating the brush roll at high peripheral speed without obstruction to the free flow of air whereby a large volume of air is caused to flow as an air stream away from the outlet portion of the defibering couple, means for rotating the cylinder at slow peripheral speed about its axis, and an endless carrier in the form of a carding cloth with the tips of the teeth inclined rearwardly relative to the direction of movement and operative about the portion of the cylinder in the region of the defibering couple and operative at a linear speed corresponding to the speed of the cylinder for supporting an endless web of unseparated fibers during advancement to the defibering couple whereby the fibers in the leading edge of the web are engaged by the bristles of the brush roll for displacement and dispersion as separated fibers into the air stream moving away from the couple.

7. In a fiber separator and disperser, a cylinder mounted for rotational movement at relatively slow peripheral speed, a brush roll mounted for rotational movement at high peripheral speed about an axis parallel to but spaced from the axis of the cylinder by an amount to enable the ends of the bristles of the brush roll substantially to engage the peripheral surface of the cylinder to form a defibering couple therebetween, means for rotating the brush roll at high peripheral speed without obstruction to the free flow of air whereby a large volume of air is caused to flow as an air stream away from the outlet portion of the defibering couple, means for rotating the cylinder at slow peripheral speed about its axis, and an endless carrier in the form of a carding cloth with the tips of the teeth inclined rearwardly relative to the direction of movement and operative about the portion of the cylinder in the region of the defibering couple and operative at a linear speed corresponding to the speed of the cylinder for supporting an endless web of unseparated fibers during advancement to the defibering couple whereby the fibers in the leading edge of the web are engaged by the bristles of the brush roll for displacement and dispersion as separated fibers into the air stream moving away from the couple.

8. In a fiber separator and disperser, a cylinder mounted for rotational movement at relatively slow peripheral speed, a brush roll mounted for rotational movement at high peripheral speed about an axis parallel to but spaced from the axis of the cylinder by an amount to enable the ends of the bristles of the brush roll substantially to engage the peripheral surface of the cylinder to form a defibering couple therebetween, means for rotating the brush roll at high peripheral speed without obstruction to the free flow of air whereby a large volume of air is caused to flow as an air stream away from the outlet portion of the defibering couple, means for rotating the cylinder at slow peripheral speed about its axis, means for advancing an endless web of unseparated fibers to the defibering couple whereby the fibers in the leading edge of the web are engaged by the bristles of the brush roll for displacement and dispersion as separated fibers into the air stream moving away from the couple, means for wetting the fibrous web prior to advancement into the defibering couple, and means for extracting moisture from the web in excess of 20–65 percent by weight prior to advancement of the web into the couple.

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