APPARATUS AND METHOD FOR PRODUCING FIBROUS STRUCTURES

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APPARATUS AND METHOD FOR PRODUCING FIBROUS STRUCTURES

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Application November 23, 1948, Serial No. 61,674

19 Claims. (Cl. 19—156)

This invention relates to structures formed of fibers haphazardly and randomly arranged in uniform distribution by deposition from a fiber containing gaseous medium. More particularly, it relates to the method and apparatus for manufacturing fibrous structures by an air deposition method employing principles facilitating the production of improved fibrous sheets, batts, felt-like structures, or boards at a rapid rate and by a novel arrangement to make automatic and continuous operation.

Characteristics of fibers, even though they may be initially completely separated from each other, is their tendency to become attached upon contact of one with another, forming clots or mats which grow rapidly by accretion and which cannot readily be separated except by another disintegrating step. It is manifest, therefore, that in the dry processes heretofore used, such as is described in the above patents, clotting of the fibers may readily take place during travel of the fibers from the position where they are separated to the surface wall, and certainly many clots or agglomerates are formed while the fibers are matted together while on the surface wall or while being sifted through the wall.

To the best of my knowledge, no one had devised a method by which fully separated fibers may be quickly deposited in a haphazard, random arrangement to form a web of uniformly distributed fibers. No one employing a dry process had produced a method for continuously and rapidly manufacturing fibrous structures of exceptionally fine quality and of uniform thickness of either thick or very thin section.

It is an object of this invention to provide a novel method and apparatus for producing an improved fibrous structure in which fiber orientation and the presence of fiber agglomerates are greatly minimized or completely prevented.

Another object is to provide a method and apparatus for producing an improved fibrous structure composed chiefly of separated fibers randomly arranged in uniform distribution and interlaced to impart some degree of self-support.

A further object is to provide apparatus and a method for producing fibrous layers of uniform thickness which may be varied from very thin to very thick dimensions and in which clots or fiber bundles are practically absent.

A still further object is to provide a similar method for automatically and continuously producing, by a dry process, either separate sheets or web of fibers, uniform distribution with or without the addition of a bonding agent to impart greater cohesiveness to the mass.

A still further object is to provide a similar method and apparatus for manufacturing extremely fine fibrous webs by fiber deposition from gaseous media with substantially individually separated and unoriented fibers being deposited in the desired distribution.

Another object is to provide apparatus for efficiently, smoothly, and rapidly producing a fibrous structure by an air deposition method requiring a minimum amount of labor and which is substantially free of the objections to wet and dry processes and apparatus heretofore provided.

These and other objects and advantages of this invention will hereinafter become apparent, and for purposes of illustration, but not of limitation, an embodiment of the invention is shown in the accompanying drawing in which—

Figure 1 is a side elevational view partially in section of an assembly embodying features of this invention;

Figure 2 is an enlarged sectional elevational view of the elements in the region of the separating and collecting walls;

Figure 3 is a fragmentary plan view of the separating wall shown in Figure 2;

Figure 4 is a sectional view of a modified form of separating wall.

In carrying out my invention, I employ several new concepts and means by which the concepts are practised. These separately and collectively comprise features of my invention.

For example, in order to deliver individually separated fibers in gaseous media, I have found that it is most desirable to separate the fibers from each other in the immediate vicinity of and just prior to fiber deposition. Thus, factors, such as time and space, which tend to permit fiber contact with resulting agglomeration are minimized, and the technique devised to mitigate against their intertwining while in gaseous suspension is greatly simplified.

The general concept followed by the prior art has been to load the air stream to a very high concentration of fibers in order to build a fibrous structure of the desired thickness at a rapid rate. Also, the trend has been to avoid handling large volumes of air which heretofore had disruptive effects on the deposited fibers.

The prior art has failed to recognize the need for keeping the fibers individually separated immediately prior to their deposition. To maintain fiber separation in this region, I have departed from accepted theory and practice. I have found that a volumetric ratio of gaseous medium and fibers should be used, calculated to enable the entrained fibers, when fully separated, to turn freely about their centers without contact during travel; that is, to define spheres which would not intersect in the space occupied by the conveying medium. For example, this volume is calculated to be about 350 cubic feet of air per pound of chemically prepared confusor wood pulp. Actually, the fibers do not turn or tumble in any such degree. Even for fine structures, I have found that a lower volumetric ratio may be satisfactory; that is, as little as one-fourth the theoretically calculated ratio may be used corresponding, for example, to about 100 cubic feet of air per pound of fibers.

I have found that the uniformity of fiber deposition across the face of the wall on which the fibrous web is formed results from the uniform concentration of fibers in the gaseous transporting medium and the flow of controlled volumes of transporting medium across the collecting wall. To effect this condition, a separating wall is interposed between the disintegrating region and the collecting wall. The separating wall is provided with openings adapted to limit passage chiefly to individually separated fibers and to stop passage of fiber bundles or agglomerates. Some of the separated fibers collect as clots or agglomerates on the face of the separating wall, and in order to prevent these clots from obstructing the openings in the separating wall, they may be continuously removed from the face of the wall by means well known in the art, which results in the probable passage of some of the agglomerates through the wall. In order to insure removal without undesirable transmission of fibrous
agglomerates, I provide a new arrangement whereby the clots are disintegrated and fiber accumulation on the wall is prevented by the same element in cooperation with the separating wall.

Fiber distribution in the gaseous medium passing through the separating wall, in general, will be uniform across the wall and will correspond with the arrangement of openings in the separating wall. When the fibers are deposited on a moving wire screen, such variations which may tend to exist in the quantity of fibers deposited in any area are averaged out in the longitudinal or machine direction. Where structures having exceptionally uniform thickness across the width are desired, such variations in fiber density as may tend to exist perpendicular to the direction of travel of the screen may be corrected for by the use of adjustable members adapted to cover or uncover a number of openings over the variations which may be necessary. In addition, the air flow through corresponding areas under the wire screen may be adjusted for the same purpose.

By restricting the number of openings and/or the dimensions of the openings and by giving the air a sufficient differential pressure across the separating wall, the air is caused to pass through each opening at uniform speed. In practice, I have found that the desired pressure differential across the separating wall preferably is greater than 0.2 inch of water for smaller production rates of the order of about three ounces of fiber per square foot of wall per minute. Greater than 0.5 inch of water may be used for larger production rates, such as about three pounds of fiber per square foot per minute. In practice, these differential pressures ordinarily result in an air velocity through the holes in the separating wall which exceeds 1,000 feet per minute. Air velocities as high as 5,000 feet per minute and more have been successfully used. In the manufacture of thick heavy structures where the presence of clots or fiber bundles and non-uniform distribution of the fibers in the web are less objectionable, air velocities below 1,000 feet per minute have been used.

With the use of such high velocities, it will be apparent that gravitational forces will have little, if any, influence on fiber movement no matter in which direction the fibers are carried; that is, the unit may be operated to carry the fibers upward or to a collecting wall or downward to a collecting wall without noticeably modifying the condition of operation because of gravitational effect. As previously pointed out, appreciably lower velocities than the lower limit cited may be used in the manufacture of the other structures where excellence of form, and absence of agglomerates can be subordinated to rate of production. In such case, also, the diameter of the holes in the separating wall can be increased to almost the fiber length.

There are other new concepts which have been utilized in the development of my process. For example, in order to minimize fiber contact after fiber separation, the distance between the separating wall and the collecting wall is kept to a minimum. In practice, the minimum distance is that which enables the air stream coming from the separating wall to become unified and form a continuous stream in the vicinity of the surface of the structure being formed on the collecting wall, whereby fibers will be uniformly deposited throughout the area.

Ordinarily, this minimum distance between walls is set at about two inches. It will be understood that as the thickness of the deposited mat is increased, the spacing between walls will have to be increased correspondingly. Thus, to form an eight inch batt, a spacing of about ten or more inches may be used. It will be further understood that in the use of a curvilinear separating wall in cooperation with a linear collecting wall, the minimum distance will be calculated from the apex of the curvilinear plate and that the spacing will naturally increase at points adjacent thereto. In the manufacture of thick fibrous structures, the varying distance may be used advantageously to regulate the distance between the first wall and top of the fibrous structure to be approximately constant throughout the formation.

An outstanding feature of this invention resides in the means of achieving substantially linear movement of the fiber-entraining air stream between the walls, essentially undisturbed by the movement of air into or from the defined area. This is accomplished by providing conduits creating substantially atmospheric static pressure in the air stream between the separating wall and the collecting wall. I have found that by arranging the air system so that the air pressure above the separating wall is above atmospheric and the air pressure below the collecting wall is below atmospheric, the pressures being in controlled relationship, very little air will enter or leave the air stream carrying the fibers between the two walls. Usually, it is preferable that the differential pressure be regulated to secure a very smooth, slow movement of air from the surrounding area into the region between the walls. To accomplish this, an amount of air equal to that which is drawn in from the surrounding area is vented at some point between the means generating the air stream and the separating wall.

For proper operation of the apparatus, the fiber must not be fed at an excessive rate; otherwise, an excessive build-up of fibers will occur on the intake side of the first or separating wall, nor should the fibers be fed too slowly. The best operation is secured by adjusting the rate of feed, the size of the holes in the wall, and other conditions so that the zone adjacent the entire going surface of the first wall is kept covered with a thin moving layer of fibers. If the fibrous material is fed too slowly the moving layer of fibers is not maintained over the first wall and the fibers are inclined to come through the wall non-uniformly and irregularly. Increasing the size or the number of openings in the first wall or decreasing the average length of the fiber has the same effect in this respect as decreasing the rate of feed.

All these factors, individually and collectively, are provided for in my new and improved process. The apparatus and method by which it is accomplished comprise features of this invention.

Referring now briefly to the drawing for a description of the apparatus and the method by which a fibrous structure is formed, 19 indicates a fan interposed in a duct system to direct air at high velocity upwardly from duct 12. The fan may be of the rotary type illustrated or of any other suitable construction which provides for movement of the gaseous medium in one direction. The air is circulated at high velocity through the duct 11 into a disintegrating and dispersing chamber 15 and then it passes successively through a separating wall 16 and a closely spaced collecting wall 21 into the duct 12 by which it is led to the circumferential belt.

Operating within the dispersing zone, 15 is a series of blades 18 driven in circumferential movement by a hub 19 which, in turn, is operated by a motor 13 through a belt 14. The blades 18 are mounted on the hub member to either barely touch or closely approach the inner face of the separating wall 16 as they are carried in circumferential movement. In the described arrangement, cooperation takes place between the air stream, the blades 18 and the separating wall 16 to provide a disintegrating action for separating fiber bundles into their individual components and to prevent fiber bundles and agglomerates from collecting on the face of the separating wall.

To secure separation of the fibrous material into its individual components, the blades 18 may be adapted to provide a circumferential speed of a high order. Under normal circumstances, the requirement is satisfied when the circumferential speed of the blades is over 1,000 feet per minute, but speeds in the range of 500 feet or less per minute may be useable, especially when the fibers
have previously been well separated by other means, or if a coarse structure with clumps of undispersed fibers is permissible. Excellent results are secured when the blading is formed of rigid material tipped with resilient rubber or leather-like substances. The use of blades that rubber tipped makes possible the provision for extremely close clearance or even slight contact between the blade tips and the separating wall, producing a more efficient system for preventing the collecting of fibers on the face of the separating wall 16.

Wall 16 may comprise a plate having substantial thickness through which numerous openings 20 are uniformly distributed in spaced relation. It may be a rigid member which, as shown, is curvilinear to correspond concentrically with the hub to which the blades 18 are attached. It will be understood that when other suitable means are provided to effect the desired results secured by the disintegrating unit, a formidable member otherwise contoured may be used. It is possible, when quality is less critical or especially when using relatively inflexible fibers, to make use of a rolled wire screen or the like having the desired arrangement of openings.

To limit passage chiefly to individually separated fibers, the diameters of the openings 20 through the wall 16 are dimensioned to dimensions of less than one-half, and preferably, less than one-fourth the mean length of the fibers. When a heavy coarse structure is made, the openings may be enlarged to approximate the length of the fibers used.

To maintain a pressure drop of the desired character across the wall 16, the openings 20 are arranged in spaced relation to give a predetermined permeability. By maintenance of a sufficiently high pressure drop through the wall and high fiber concentration across the ingoing surface of the wall, air and fiber flow of equal proportions through each opening is secured, corresponding to the operation of a showerhead under high water pressure.

When a flexible fiber is long enough to reach between two openings 20 in the separating wall 16 with each end of the fiber starting to go through an opening, the fiber may be held in such position for a considerable length of time because of the forces acting at each end. It is undesirable for fibers to be so held because they tend to block the openings by forming nuclei upon which fiber agglomerates form. I have found that to prevent this, the openings, preferably, should be spaced apart a distance greater than half the length of the fibers.

Closely associated with the separating wall and co-operating therewith is a disintegrating unit or fiber separator referred to as a collecting wall 21, which is formidable for passage of air or other gaseous medium. The openings through the collecting wall are dimensioned to prevent passage of most of the fibers. The separated fibers, therefore, are deposited on the collecting wall as a fibrous structure. Both the separating wall 16 and the collecting wall 21 may be stationary members to produce individual fibrous webs or the like. The collecting wall 21 is generally, however, adapted for the formation of an endless fibrous web 22, in which event it may be a screen-like endless belt which operates over a driving member 23 and may be continuous to the collecting wall 21.

Fibers 17, which may or may not have been subjected to preliminary separation, are fed from a storage compartment 29, the top of the fiber structure being deposited, as indicated in Figure 2.

In practice, the optimum distance between the walls may be determined by progressively decreasing the distance to the point just above that at which the deposited fibers are disturbed by the jet effects of the oncoming air issuing from the individual openings in the separating wall. The walls should not be separated further than necessary, especially in the formation of a very thin fibrous web where the absence of clots is a requisite. Somewhat closer spacing may be used with similar effect when the openings 20 in the separating wall 16 are tapered in the manner shown by the openings 31 in Figure 4.

In the event that it is desired to incorporate a bonding agent to secure the fibers in web form, an adhesive, preferably in dry form, may be admitted into the system at any stage prior to fiber deposition. Alternatively, a diluted adhesive may be sprayed onto the fibers as they are gathered on the collecting wall. Another method of bonding the structure is to use an appreciable proportion of thermoplastic fibers with nonadhesive fibers. In these methods, bonding and the requisite degree of compactness are secured by the use of heat, where necessary, and pressure, according to methods that are well known.

Fibers 17, which may or may not have been subjected to preliminary separation, are fed from a storage compartment 29 which may be associated with a measuring device of any desired construction, such as a rotary feeder 30 leading to an inlet 27 in the downward portion of the duct 11.

When forming continuous fibrous webs in the manner described, using air as the gaseous medium, disturbance of the fiber-carrying air stream between the separating wall and the collecting wall by flow of air toward the outside of the machine may be kept to a minimum by the use of enclosing walls surrounding the area and suitable rolls between which the travelling collecting wall would pass into and out of the web-forming region. However, when the air stream between the collecting wall and the separating wall is so enclosed, electrostatic or other conditions are usually established which cause the fibers to build up on and subsequently drop off intermittently from the enclosing walls and rolls, resulting in a structure of varying quality and uniformity. It is expedient, therefore, to manufacture continuous webs without the use of enclosing walls. This may be accomplished by venting some of the air from duct 11 to create a condition whereby more air is withdrawn through the collecting wall than is supplied to the separating wall, providing a pressure very slightly less than atmospheric in the forming zone, so that a very slow inflow of air takes place from the surrounding atmosphere. The vent 28 may be situated in any portion of the duct 11 but, preferably, it is positioned on the inner wall of a bend in the duct 11 so as to prevent the discharge of any fibers or solid materials which might have found their way through the collecting wall and into the recycled air stream. Instead of employing means for bleeding or venting the air, the desired pressure differential may be secured by separating the ducts 11 and 12 and providing an exhaust fan for duct 12 and a blower for duct 11, one of which can be driven at a variable speed.

In operation, fibers 17 preferably are introduced through the inlet 27. They are conveyed by the air stream flowing in duct 11 to the distributing or dispersing chamber 15. The fibrous material is forcibly circulated within the dispersing chamber by reaction with the blades and the air stream which effects dispersion into individually separated components. As the fibers are carried by the air stream across the inner face of the separating wall, portions of the individually separated fibers and air stream are caused to pass at high velocity through the openings. Fibrous aggregates and agglomerates are acted upon by the blades to effect further fiber isolation. Separated fibers are carried through the separating wall and to the collecting wall upon which they are deposited.
Thus, it is apparent that in the disintegrating section, masses of fibers are repeatedly operated upon to effect their separation into individual fibers which sooner or later are carried through the separating wall with the air stream to comprise a part of a fibrous structure in which fibers are intermingled in a haphazard manner. In the event that material within the disintegrating chamber 15 resists reduction, means may be provided to enable its removal with or without stopping the various operations.

A pressure drop of at least 0.2 inch of water, provided across the wall 16, causes a flow of essentially equal volumes of air through each opening 20 at high velocity, such as 1,000 to 5,000 feet per minute and thereby causes substantially equal quantities of fiber to be carried through each opening and to be deposited in the desired distribution throughout the operating surface of the wall 21. Because of the spaced relation of the openings 20 in the separating wall 16, the ratio of air to fibers, when calculated on a volumetric basis, and the close association between the separating wall and the collecting wall, the individually separated fibers are carried through the separating wall and to the collecting wall with a minimum amount of mutual contact.

Depending on the rate of fiber deposition and the lineal speed of the collecting screen 21, mats or sheets varying in thickness from very thin to very thick section may be produced. When practicing my invention, it is possible to achieve a production speed exceeding those presently possible in the manufacture of similar structures by present paper or board machines, with the added improvement that the structures produced by my invention are composed of individual fibers in uniform distribution.

Unlike conventional systems for forming fibrous structures, the rate of travel of the collecting wall in my process bears no significant relation within practical operating limits to the rate of travel of the fiber suspending fluid.

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

I claim as my invention:

1. Apparatus for producing a fibrous structure by air deposition comprising a foraminous separating wall and a foraminous collecting wall in substantially parallel relation with the space in between left open to the atmosphere means for supplying a stream of air under positive pressure to the separating wall, means drawing greater volumes of air through the collecting wall than is supplied to the separating wall whereby the air travels in substantially linear flow from the separating wall to the collecting wall accompanied by slight inflow of air into the area between the walls from the surrounding atmosphere, and means for entraining fibers in the air stream in advance of the separating wall whereby fibers are carried through the separating wall and are deposited on the collecting wall.

2. In a method for providing a fibrous structure by fiber deposition from an air stream passing successively through a stationary foraminous separating wall and a collecting wall in closely spaced parallel relation with the space in between left open to the atmosphere, the step of maintaining atmospheric pressure in the open space between the separating wall and the collecting wall by drawing slightly greater volumes of air through the collecting wall than passes through the separating wall, the insufficiency being supplied by slight inflow of air into the open space between the walls from the surrounding atmosphere.

3. Apparatus for depositing fibers to form fibrous structures comprising duct-work having an inlet and an outlet closely spaced with the area therebetween being open to the atmosphere, a stationary foraminous separating wall arranged in the outlet and having openings dimensioned to limit passage chiefly to individually separated fibers, a foraminous collecting wall arranged in the inlet and having openings dimensioned so that they pass therethrough, means for supplying air under positive pressure to the outlet, means for withdrawing air through the inlet, means cooperating with the outlet for causing the air supplied under positive pressure to travel as a transient layer over the surface thereof whereby substantially equal volumes of air are caused to pass through the openings, and means for supplying individually separated fibers to the outlet whereby the fibers are entrained in the air streams and carried through the separating member and deposited in an interlaced layer on the collecting member as the air streams pass therethrough.

4. Apparatus, as claimed in claim 3, in which a vent is provided in the ductwork between the means in the ductwork to cause air to flow under positive pressure to the outlet and the outlet to bleed some of the air whereby by a lesser volume is delivered to the foraminous member at the outlet than is drawn through the secondary foraminous member at the inlet.

5. Apparatus for producing a fibrous structure by air deposition of dry fibers comprising a housing, a stationary foraminous separating wall forming an outlet in the housing, a foraminous collecting wall spaced a short distance from the outer surface of the separating wall and in substantially parallel relation therewith the area between the separating wall and the collecting wall remaining open to the atmosphere, means supplying air into the housing and for withdrawing air through the collecting wall including means for regulating the amount of air to supply less air by volume into the housing than is drawn through the collecting wall whereby the deficiency in the amount of air issuing through the separating wall is made up by inflow from the atmosphere surrounding the open spaces between the walls, and means entraining separated fibers into the air stream in advance of the separating wall whereby the fibers are carried with the air through the separating wall to the collecting wall for deposition onto the surfaces thereof as the air coupled with that flowing in from the surrounding atmosphere passes through the collecting wall.

6. Apparatus, as claimed in claim 5, in which the foraminous in the separating wall are flared outwardly in the direction of air flow.

7. Apparatus, as claimed in claim 5, including means for supplying the air in amounts and under pressure sufficient to cause the air to pass through the foraminous in the separating wall at a velocity greater than 1000 feet per minute.

8. Apparatus, as claimed in claim 5, in which the spacing between the separating and collecting walls is about that distance required for the air streams flowing from the separating wall to become unified into a single stream before reaching the area of deposition.

9. The method of making a uniform fibrous web comprising the steps of maintaining an excess of separated air entrained fibers on one side of a foraminous surface and with the air under positive pressure whereby both fibers and air are caused to pass in substantially uniform concentrations through the foraminous, drawing the air through a moving surface having relatively small foraminous by maintaining a pressure below atmosphere on the outgoing side thereof whereby the fibers are deposited on the ingoing side as an interlaced mass, and maintaining the space between the surfaces open to the atmosphere whereby a slight inflow of air occurs from the surrounding atmosphere into the space between the surfaces to prevent fibers from being blown out into the atmosphere and to effect substantially linear flow of air and fibers from the foraminous surface to the moving surface.

10. The method of forming a continuous web of fibers comprising the steps of maintaining air above atmos...
pheric pressure and an excess of fibers dispersed in the air on one side of a wall having large foramens, maintaining air at atmospheric pressure between the other side of the wall and the adjacent side of an adjacent second wall having foramens dimensioned to cause the separation of fibers onto the surfaces thereof, maintaining an atmosphere below atmospheric pressure on the other side of the second wall whereby fiber-laden air is drawn through the foramens of the first wall and passed with the air to the second wall where the fibers are separated from the air onto the surfaces thereof, and continuously advancing the second wall in one direction to form a continuous web on the surfaces thereof.

11. Apparatus for making a fibrous web comprising a pair of foraminous walls with faces spaced a short distance apart in substantially parallel relation and of substantially equivalent dimension, the first wall having foramens dimensioned to permit the passage of individual fibers entrained in an air stream, the second wall having foramens dimensioned to filter the fibers from the air stream onto the surface thereof, the area between the walls being free and open to the atmosphere to permit the flow of air into and out of the space between the walls, means for maintaining air pressure above atmospheric on the ingoing side of the first wall and means for maintaining the air pressure below atmospheric on the outgoing side of the second wall, means for maintaining an excess of dispersed fibers in the air stream adjacent the ingoing side of the first wall and means for maintaining a constant movement of air and entrained fibers over the ingoing side of the first wall to provide a shower-head principle whereby air and fibers are carried uniformly through the foramens in the first wall into the open space between the walls and to the surface of the second wall for deposition of the fibers on the ingoing side of the second wall, and means for moving the second wall continuously in one direction relative the first wall to form a continuous web of fibers on the surface thereof.

12. The method of making a uniform fibrous web comprising the steps of maintaining an excess of dispersed air entrained fibers on one side of a foraminous surface and with the air under positive pressure whereby both fibers and air are caused to pass in substantially uniform concentrations through the foramens, drawing air through and maintaining fibers onto a moving surface having relatively small foraminous areas, maintaining a pressure below atmospheric on the outgoing side thereof whereby the fibers are deposited on the ingoing side as an interlaced mass, and maintaining the space between the surfaces open to the atmosphere, the air drawn through said moving surface consisting of a minor fraction from the atmosphere and a major fraction comprising all the air from the foraminous surface, whereby a slight inflow of air occurs from the surrounding atmosphere into and through the moving surface to prevent fibers from being blown out into the atmosphere and to effect an air-confined column of flowing air and fibers from the foraminous surface to the moving surface, and to divide the material passing through said moving surface into the region of subatmospheric pressure on said outgoing side into an air fraction and a residue, and discharging the air fraction to the atmosphere.

13. The method of making a uniform fibrous web comprising the steps of maintaining an excess of dispersed material including essentially separated air entrained felt fibers on one side of a foraminous surface and with the air under positive pressure whereby both fibers and air are spaced to pass in substantially uniform concentrations through the foraminous surface, drawing air through and said fibers onto a moving surface having relatively small foraminous areas, maintaining a pressure below atmospheric on the outgoing side thereof whereby the fibers are deposited on the ingoing side as an interlaced mass, and maintaining the space between the surfaces open to the atmosphere, the air drawn through said moving surface consisting of a minor fraction from the atmosphere and a major fraction comprising all the air from the foraminous surface, whereby a slight inflow of air occurs from the surrounding atmosphere into and through the moving surface to prevent fibers from being blown out into the atmosphere and to effect an air-confined column of flowing air and fibers from the foraminous surface to the moving surface, and to divide the material passing through said moving surface into the region of subatmospheric pressure on said outgoing side into an air fraction and a residue, said air fraction consisting of an amount of air at least equal to the amount being drawn through the moving surface from the atmosphere, discharging the air fraction to the atmosphere, and feeding said residue to the positive-pressure side of said foraminous surface.

14. The method of producing a fibrous structure comprising conveying vehicular air at superatmospheric pressure toward a foraminous first wall, discharging said air and suspended solids predominating in individualized felt fibers through said first wall at high velocity into a region of subatmospheric pressure by movement to and through a foraminous second wall exposed to the atmosphere and closely spaced from the first wall, the vehicular air being in sufficient volume to prevent excessive contact between fibers as they travel between the first and second wall, the foramens or openings through the first wall being dimensioned to permit passage of said felted fibers and particles of said suspended solids smaller than said feltable fibers, and the foramens or openings through the second wall being dimensioned so that it will retain feltable fibers on its surface and so that it is capable of passing at least some of said smaller particles, constantly preventing fibers from being collected on the first wall to enable all said vehicular air to pass through both walls, divesting the material leaving the discharge side of the second wall into a solids-free air fraction at atmospheric pressure and a solids-containing fraction, and returning the solids of said solids-containing fraction to the receiving side of said first wall as a part of said suspended solids.

15. The method of making a uniform fibrous web comprising the steps of maintaining an excess of dispersed material including essentially separated air entrained felt fibers on one side of a foraminous surface and with the air under positive pressure whereby both fibers and air are caused to pass in substantially uniform concentrations through the foramens, drawing air through and said fibers onto a moving surface having relatively small foraminous areas, maintaining a pressure below atmospheric on the outgoing side thereof whereby the fibers are deposited on the ingoing side as an interlaced mass, and maintaining the space between the surfaces open to the atmosphere, the air drawn through said moving surface consisting of a minor fraction from the atmosphere and a major fraction comprising all the air from the foraminous surface, whereby a slight inflow of air occurs from the surrounding atmosphere into and through the moving surface to prevent fibers from being blown out into the atmosphere and to effect an air-confined column of flowing air and fibers from the foraminous surface to the moving surface, and to divide the material passing through said moving surface into the region of subatmospheric pressure on said outgoing side into an air fraction and a residue, said air fraction consisting of an amount of air at least equal to the amount being drawn through the moving surface from the atmosphere, discharging the air fraction to the atmosphere, and feeding said residue to the positive-pressure side of said foraminous surface.
being collected on the first wall to enable all said gaseous medium to pass through both walls, dividing the material leaving the discharge side of the second wall into a solids-free gaseous fraction and a solids-containing fraction, and returning the solids of said solids-containing fraction to the receiving side of said first wall as a part of said suspended solids.

17. The method of producing a fibrous structure comprising conveying suspended solids predominating in individualized feltable fibers through a foraminous first wall by vehicular air leaving said wall at superatmospheric pressure and traveling at high velocity into a region of subatmospheric pressure by movement to and through a foraminous second wall closely spaced from the first wall, the vehicular air being in sufficient volume to prevent excessive contact between fibers as they travel between the first and second wall, the foramens or openings through the second wall being dimensioned so that it will retain feltable fibers on its surface and so that it is capable of passing at least some of said smaller particles, constantly preventing fibers from being collected on the first wall to enable all said vehicular air to pass through both walls, dividing the material leaving the discharge side of the second wall into a solids-free air fraction at atmospheric pressure and a solids-containing fraction, and returning the solids of said solids-containing fraction to the receiving side of said first wall as a part of said suspended solids.

18. The method of producing a fibrous structure comprising conveying suspended solids predominating in individualized feltable fibers through a foraminous first wall by vehicular air leaving said wall at superatmospheric pressure and traveling at high velocity into a region of subatmospheric pressure by movement to and through a foraminous second wall exposed to the atmosphere and closely spaced from the first wall, the vehicular air being in sufficient volume to prevent excessive contact between fibers as they travel between the first and second wall, the foramens or openings through the first wall being dimensioned to permit passage of said feltable fibers and particles of said suspended solids smaller than said feltable fibers, and the foramens or openings through the second wall being dimensioned so that it will retain feltable fibers on its surface and so that it is capable of passing at least some of said smaller particles, constantly preventing fibers from being collected on the first wall to enable all said vehicular air to pass through both walls, dividing the material leaving the discharge side of the second wall into a solids-free air fraction at atmospheric pressure and a solids-containing fraction, and returning the solids of said solids-containing fraction to the receiving side of said first wall as a part of said suspended solids.

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