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METHOD FOR FORMING UNIFORM BODIES FROM GLASS FIBERS

Original Filed June 22, 1966

3 Sheets-Sheet 1

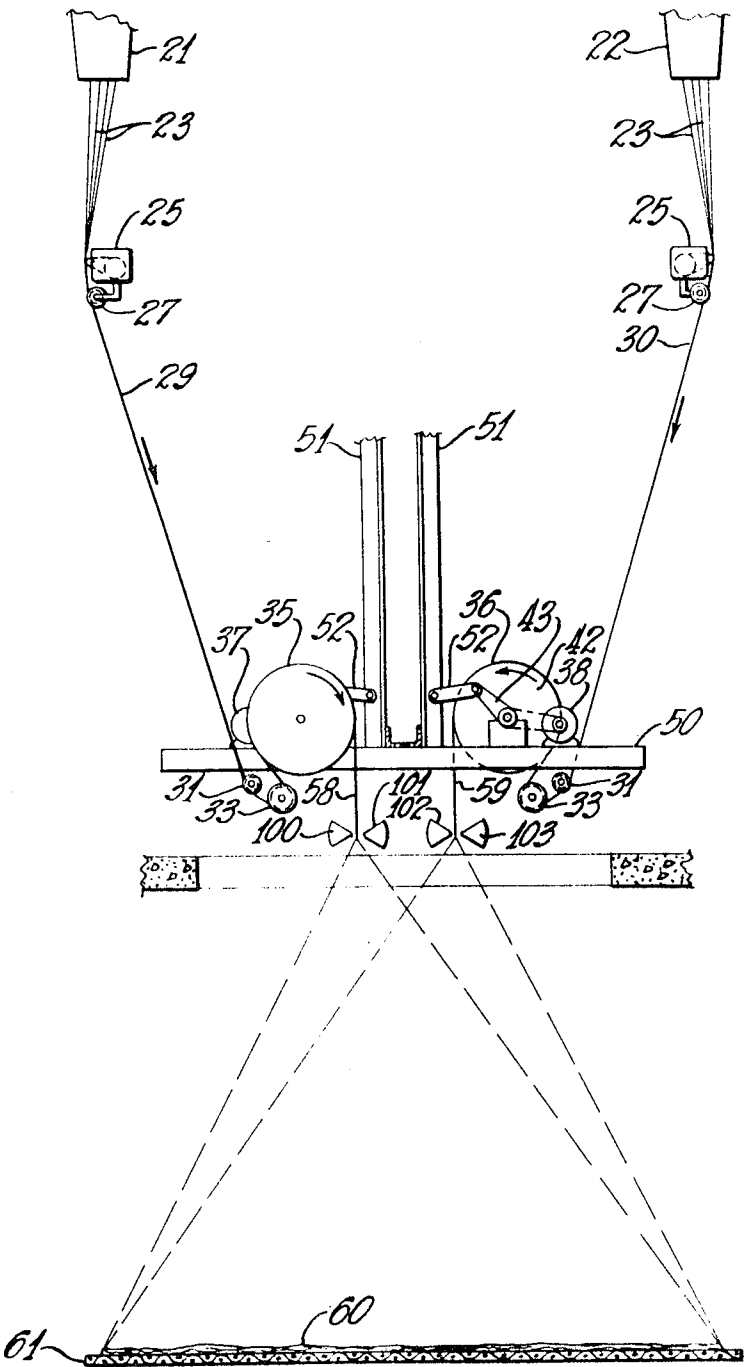


Fig. 1

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3 Sheets-Sheet 2

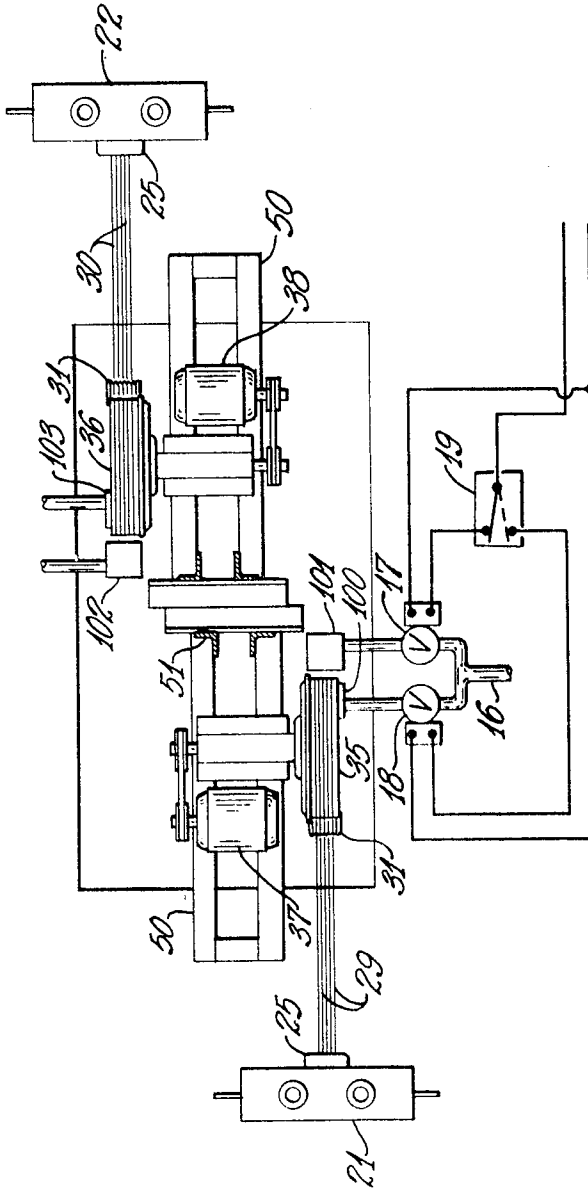


Fig. 2

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3 Sheets-Sheet 3

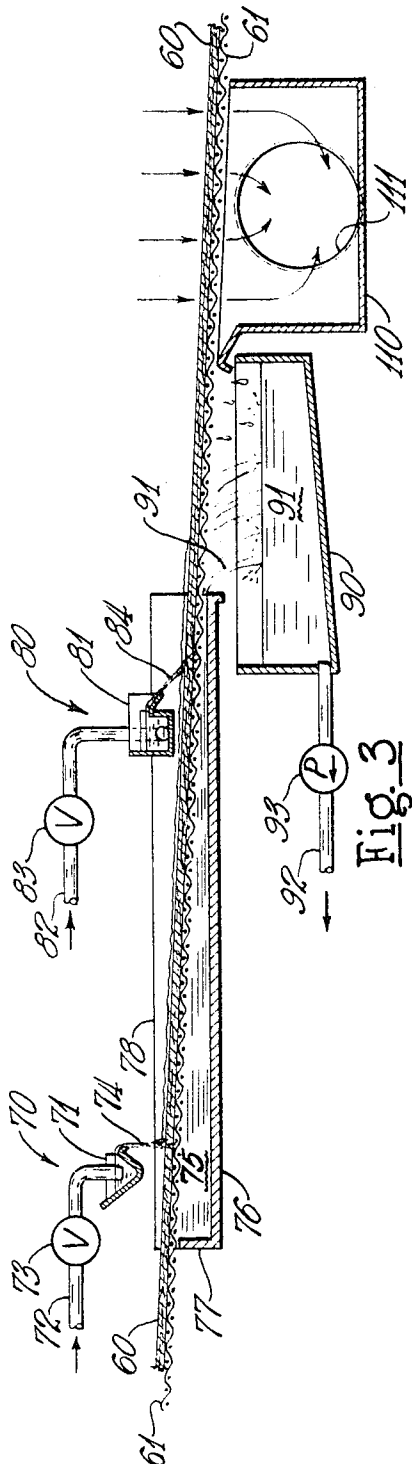


Fig. 3

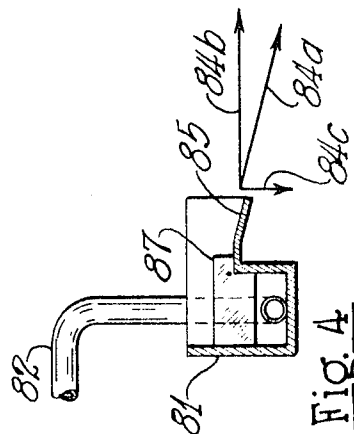


Fig. 4

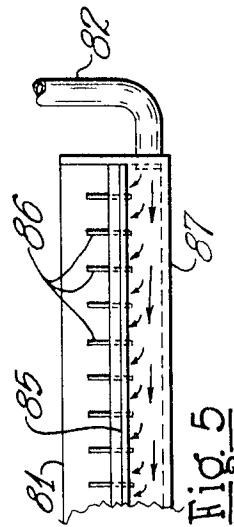


Fig. 5

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3,597,175

## METHOD FOR FORMING UNIFORM BODIES FROM GLASS FIBERS

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Continuation of application Ser. No. 559,459, June 22,  
1966. This application Oct. 27, 1969, Ser. No. 869,941

Int. Cl. C03c 25/02

U.S. Cl. 65—3

6 Claims

### ABSTRACT OF THE DISCLOSURE

A fibrous body of continuous strands uniformly distributed with respect to each other, the strands having the filaments dispersed in the deposited position of the strand. The body is formed of strands composed of only enough filaments to give each strand sufficient mass to be projected to a predetermined or selected area of a collecting surface at a body forming station. The filaments of each strand are then dispersed after the strand is in place on the collection surface.

This application is a continuation of Ser. No. 559,459, filed June 22, 1966, now abandoned.

This invention relates generally to a method for forming uniform fibrous bodies and, further to a method for forming fibrous bodies having filaments uniformly distributed and evenly dispersed throughout the body, and to the novel product formed thereby.

Because of the increased general use of fibrous glass mat products, need has arisen for more exacting characteristics and properties for specific applications. Fibrous glass mats have been put to use for such purposes as acoustical, electrical, and thermal insulation as well as for reinforcing and filtering purposes, each such application requiring certain characteristics of strength, porosity and integrity.

One method by which glass fibers for mats can be produced is to mechanically attenuate a plurality of glass streams flowing from a feeder or bushing. Attenuation of the streams may be effected by pulling rolls or wheels which draw the streams into fine fibers or filaments as they solidify by reason of exposure to the atmosphere. The solidified filaments are drawn over a size applicator and are then gathered into strand form whereupon the pulling wheels supply the strand for the purpose desired.

Another method of manufacturing glass fibers involves flowing the glass from feeders as described above and directing a jet of gas thereagainst at high speed to attenuate the stream into fine fibers by disrupting them into varied lengths which collect as a pulpy mass.

Sheet and mat products have been manufactured in the past of both types of glass fibers but strand mats have presented a greater difficulty in manufacture because of their limited ability to form an integral mass. More specifically, the strand has little tendency to intermingle with itself so as to promote formation of an integral mass such as in a mat product. Heretofore, it has been necessary to add agents such as extra quantities of binder material or additional glass fibers of shorter length in order to promote mat integrity. These additions, however, involved additional process steps and correspondingly added equipment complexity and cost.

In an attempt to form a more integral mass, glass fiber strands have been impinged or bounced off of a deflecting surface to provide a fluffy or fuzzy property. That is, an integral glass strand is moved at a relatively high speed and directed against a hard surface so that it impinges such surface with a driving force, the product produced being a strand of fuzzy or fluffed character which tends to take on a curl resulting in a generally helical

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form or swirl. The greater the speed of impingement, the greater the fuzziness created. The fuzziness results from filaments within the strand being dispersed or separated from the main core along at least a portion of their lengths while the remainder are retained in integrated form. While this method did give a better degree of fine porosity desired for use in acoustical, electrical and thermal insulation, the abrading or mechanical handling of the glass strand when deflecting the strand from a surface at a high speed is undesirable since it tends to reduce the mechanical strength of the strand or the filaments. Further, this method makes it difficult to uniformly deposit the strand and filaments with great accuracy over a predetermined area. Uniformity of deposition of strands upon a collecting surface is a problem which also effects integrity of the mat.

In addition to the problem of integrity, other difficulties are experienced with strands in that of themselves they lack the ability to give the degree of fine porosity desired for uses such as acoustical, electrical and thermal insulation. That is, continuous strands by themselves usually fail to provide the multitude of small interstices desired in such insulation materials. Further, in fine mat or thin mat applications where the mat is used as a reinforcing material for such products as roofing materials made from mats impregnated with asphalt, etc., the small interstices are necessary to hold the molten or plastic filler or impregnator and keep it from running on through the mat when the mat is being combined with the filler to make the final product. Also, in this regard, mats made in the past wholly of strand, because of their unusually large interstices, are somewhat rough and fail to provide the fine finish and appearance desired when the glass mats are put to use as reinforcement material in resin laminate structures, particularly when the laminate includes semi-transparent portions.

It has been particularly desirable to incorporate continuous glass strands in mat products, however, because the mechanically attenuated fibers of which such strands are composed have much greater strength than the blown fibers. Such additional strength incorporated into fibrous mats lends greatly to permitting their use in many installations in which they could not otherwise be used. Both burst and tear strengths of such mats can be made extremely high by reason of the high strength of the fibers or filaments embodied in the strands.

Since such superior characteristics result from the use of mats and fibrous bodies made from continuous strands, mats and fibrous bodies made from individual continuous fibers and filaments would provide the strength, integrity, fine porosity and small interstices desired. Difficulties have arisen in the past in the uniform distribution and dispersion of such individual fibers since they are extremely light in weight and a problem to handle by themselves without introducing prohibitive handling and individual forming costs.

Accordingly, it is an object of the present invention to provide a novel and economical method for manufacture of glass filaments or mats having a high degree of integrity and strength.

Another object of this invention is to provide a new type of glass filament mat having a high degree of integrity and strength and a controllable degree of porosity.

Still another object of this invention is to produce a novel filament product capable of providing a large number of interstices and a fine finish in accumulations thereof.

A further object of the invention is to provide a more efficient method than existed heretofore for manufacturing mat and fibrous body products of materials in filament form.

A still further object of this invention is to provide a method for producing fibrous bodies composed of individual filaments and fibers which are uniformly distributed and evenly dispersed throughout the body.

It has been found that strands formed from a number of filaments in a bundle may be reopened or have the filaments dispersed by the impingement of a fluid stream upon the strand. While the fluid stream may be a gaseous fluid, it most advantageously, as shown in the preferred embodiments herein, is a liquid fluid to accomplish the dispersal of the filaments as desired. There is shown the method and means for the dispersal of strands by the use of liquid streams thereon. To obtain an even greater dispersal, a liquid stream may be impinged upon strands and the liquid retained around the strands in a flooded condition to provide a "soaking" or a weakening of bonding forces for a predetermined interval, after which interval a second impingement of a liquid stream upon the strands while still in a flooded condition will effect an even further dispersal of the filaments from the strand.

The strength properties of the strand which have been dispersed or reopened in this manner are not affected, as compared to mechanical impingement of the strand on a hard deflecting surface. Better dispersal can be obtained in this manner than by any other known method. The dispersed characteristic of the filaments provides an attribute which promotes mass integrity when the strand is in mat form. The dispersion of filaments promotes an intermingling and clinging of the strand portions which overlap and cross, or otherwise contact each other, so as to produce a gathering of filaments into a cohesive mass. In addition, the intermingling and clinging causes the formation of a multitude of very small interstices desired in many products and also provides a fine outer finish which is often desired when such a product is used as reinforcement in resin laminate and other structures.

An important feature of this method of filament dispersion is that it does not disturb the distribution or uniformity of distribution or the original orientation of the originally unopened strand in its particular position in the mat. The strand can be distributed quite accurately by newer methods and dispersion or reopening effected without disturbing the uniformity of distribution thus achieving the finest finish, the smallest interstices and the best integrity of any mat product known to date. This is particularly important in the production of the very thin or "fine" mats which are difficult to regulate in uniformity in a unit area and in weight per unit area.

It has been further discovered that by limiting the number of filaments in a strand to the smallest number possible in order to have only sufficient mass to enable the strand to be projected accurately to a predetermined area on a collection surface located a preset distance from the projection point, that the filaments can be substantially completely dispersed from each other in the strand to provide a fibrous body composed of individual filaments. This can be accomplished without destroying the orientation provided by the distribution of the strand with respect to the body and with respect to the uniform distribution of like strands within the body.

The mass of a strand composed of a limited number of individual filaments may be varied by an application of a predetermined or metered amount of sizing to the filaments or strand.

The invention thus features a method of forming a fibrous body having uniformly distributed and evenly dispersed filaments comprising the steps of forming a strand from a group of filaments the number of which are limited to provide a strand mass sufficient only for projection to a predetermined area on a collection surface located a preset distance from the point of projecting said strand to said collection surface, and dispersing the filaments from said strand on said collection surface.

The invention further features a continuous produc-

tion line method which comprises the steps of flowing streams of glass from a molten supply, attenuating said streams into a group of filaments, dividing said group into smaller individual groups of filaments, gathering each of said smaller individual groups into a strand having a mass limited to that sufficient to be projected to a predetermined area on a collection surface which is positioned a preset distance from the point of projection, projecting said smaller individual groups of strands to said collection surface, and dispersing the filaments from each strand on said collection surface.

Although the principles of the present invention are described as applied in the use of glass filaments and strands, the invention is not limited thereto in view of the fact that it has aspects readily applicable to use with strands, yarns and other forms of different materials. For example, the described method can be used for filament distribution and dispersion of strands, yarns or slivers of materials such as cellulose acetate, artificial silk, cotton, wool, and nylon.

Other objects, advantages and features of the invention will become readily apparent when the following description is taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a front elevation of apparatus embodying a portion of the teachings of this invention;

FIG. 2 is an enlarged plan view of the apparatus of FIG. 1;

FIG. 3 is a side elevation in section illustrating apparatus for further dispersing filaments of strands;

FIG. 4 is an enlarged sectional side view of liquid distribution apparatus suitable for use in this invention; and

FIG. 5 is a front elevational view of the liquid distribution apparatus illustrated in FIG. 4.

Referring to the drawings in more detail, the apparatus of FIGS. 1 and 2 includes molten glass feeding bushings 21 and 22 depending from conventional glass melting tanks which are not illustrated. Continuous filaments 23 are drawn or attenuated from the minute streams of molten glass issuing from orifices of the bushing. It will be considered that a bushing with four hundred and eight orifices is here utilized and the filaments are drawn to an average diameter of 50 hundred thousandths of an inch.

Size or a lubricant may be applied to the filaments as the latter pass over the traveling belts or aprons of conventional size applicators 25. The size may be merely water to reduce friction between the filaments as they are subsequently joined in strand form. A more complex size may be desired to promote inter-fiber mobility of the filaments when combined as strands in order to aid subsequent filament dispersion steps. The weight of sizing should be included in calculations regarding the mass necessary to throw a strand a predetermined distance.

The group of filaments from each bushing, after receiving a sizing if desired, are divided to form smaller individual groups of filaments which are combined into strands. In this instance, fifty-one strands are individually segregated as they travel within fifty-one grooves over the respective gathering shoe 27 to the second gathering or aligning shoes 31. For the sake of drawing clarity, only a few strands are shown.

From the shoes 31 the two sets of spaced strands 29 and 30 are led around the two idler wheels 33 and, respectively, travel around the pull wheels 35 and 36. The wheels are similarly constructed but are relatively reversed in position and are on opposite sides of the center line of the receiving conveyor 61. The wheels and the forming stations above them are meant to be representative of a number of forming stations as required to build the thickness or to provide the properties desired for the mat being formed.

Motors 37 and 38, respectively, drive pull wheels 35 and 36. The strands carried by pull wheel 35 are released

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therefrom by the successive projection of fingers of an oscillating spoke wheel through slots in the peripheral surface of the pull wheel 35. Similarly, fingers of another spoked wheel serve this purpose in connection with the pull wheel 36. The strands are kinetically projected in tangential paths from the pull wheel. That is, the rotation of the pull wheels 35, 36 at high speeds imparts a kinetic energy to each segment of the strand as it is pushed off of the wheel. Since the strand segments are all pushed off tangentially in the same direction in this apparatus, the strand segments and thus the entire strand acquires a linear velocity which is utilized in uniformly distributing the strands.

The rear side of each pull wheel is covered by an independently mounted, oscillatable back plate on which the associated spoked wheel is carried. Back plate 42 of the assembly including pull wheel 36 may be arcuately oscillated through arm 43. The entire assembly may be positioned on the platform 50 to support the pull wheels 35 and 36 and the equipment associated therewith. Platform 50 may be suspended by angle iron hangers 51. The arm 43 may be arcuately turned to a position to determine the tangential push off of the strand from the pull wheel 36. If, as in this instance, it is desired that the tangential push-off causes the strands to be carried perpendicularly downwardly with their linear velocity, then the arm 43 may be secured to hanger 51 by a link 52 to retain the strand push-off at the position desired. The pull wheels just described are particularly suited for use in this invention since they allow the uniform distribution of a plurality of "fine" strands, rather than a larger coarse strand. A finer strand lends itself more readily to reopening techniques described herein.

The group of strands 58 thrown down by the pull wheel 35, which has its push-off point also anchored by a link 52 connected to hanger 51, and the group of strands 59 thrown down by the pull wheel 36 are accumulated, after distribution, in mat form 60 upon the collecting surface, in this case traveling conveyor 61, which may be of a foraminous, perforated or mesh construction.

After the sets of strands 58 and 59 have had imparted thereto kinetic energy and thus provided with a predetermined linear velocity, aerodynamic diversion means, in this instance fluid nozzle means 100, 101 and 102, 103 for the sets or groups 58 and 59, respectively, distribute the strands across the width of the collecting surface. It may be desired to reciprocate the oscillatable back plates by moving the links 52 through a predetermined repetitive pattern to uniformly distribute the strands instead of utilizing the aerodynamic distributing means.

Referring to FIG. 2, a fluid supply line 16 is shown connected to opposing nozzle means 100, 101 via control valves 17 and 18. The control valves 17 and 18 may be regulated manually or, as shown, an automatic control means 19 may be used to effect electrical regulation of the valves to deliver a fluid stream from the nozzles 100, 101 to most effectively distribute the strands. In addition, the control valves 17 and 18 and the control means 19 may be utilized to modulate the flow of fluid from the nozzles 100, 101 to effect a sweeping distribution of the strands across the collecting surface below. Nozzles 102, 103 may be similarly controlled.

Referring to FIG. 3, there is illustrated apparatus for performing filament dispersal steps in the novel method disclosed herein. At a first liquid impingement station 70, a liquid 74 is distributed evenly across the strand mat 60 by weir means 71. A supply line 72 supplies liquid to the weir means 71. Valve means 73 may be utilized to control the flow of the liquid to the weir 71 and thus the amount of liquid impinging the strands in the mat 60. The liquid 74 collects on a liquid retaining means 76 in a flooded condition as noted at 75 to inundate the mat 60 either at the impingement point, or at earlier or later points as desired. An end plate 77 may be utilized

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to prevent the flood area 75 from flowing to the left and off of the back of the liquid retaining plate 76. If the liquid retaining plate 76 is slightly tilted and if the conveyor 61 and mat 60 speed is sufficiently fast, the end plate 77 may not be required. Side plates 78, however, are required to prevent a flow transverse to the direction of travel of the mat and the stream formed by the flooded area 75. This insures that the natural stream formed by the flooded area 75 will proceed to the right side of the retaining plate 76 and pour over into catch basin 90. A sufficient flow is advantageously provided by regulating valve 73 so that the flooded area 75 will become a stream moving at substantially the same rate and in the same direction as the mat 60. This prevents any forward or reverse disruption of uniformly distributed or oriented strands in the mat 60.

The most effective dispersal of the filaments of the strands within the mat 60 may be effected by using a second liquid impingement station 80. The second liquid impingement station 80 is spaced from the first station 70 at a distance, depending upon the speed of the conveyor 61, adapted to provide a predetermined soaking or bond weakening interval. The second impingement station comprises a weir 81 supplied via supply line 82, which supply is controlled by valve 83. The control valve 83 in combination with the construction of the forward lip 85 of the weir 81 combine to provide a predetermined forward velocity of the impinging stream 84 with respect to the mat 60 and the flood stream 75. It is desirable to provide the impinging stream 84 with a slightly higher velocity than that of the flood stream 75 and the mat 60, for most effective dispersal.

Referring to FIG. 4, it will be noted that the lip of the weir 85 may be inclined, for example, 15° from the horizontal, so that in combination with the fluid control by the supply valve 83 the impinging stream 84 may be provided with a velocity in the direction indicated by the arrow 84a. The weir means 81 is situated sufficiently close to the surface of the flood stream 75 and the mat 60 so that gravity will have little effect upon the direction of travel of stream 84. As will be noted, the direction of travel and speed of the stream 84 may be illustrated in vectorial form by vectors 84b and 84c. The horizontal vector 84b is substantially greater than the gravity or vertical vector 84c, thus insuring that the stream 84 will properly impinge the mat 60 and flooded area 75 to most effectively disperse the filaments from the strands within mat 60.

After dispersement, the excess liquid may be removed from the mat by two means. First, the liquid is allowed to drain through the foraminous conveyor 61 into the catch basin 90 as is noted by streams 91, which include both flow-through from the mat 60 and a portion of the flood stream 75. By allowing the excess liquid to drain vertically, the liquid will proceed toward holes or interstices still left in the mat 60 thus carrying dispersed filaments in such hole-seeking flow. This further disperses the filaments and insures even smaller interstices and more uniformity in the mat 60. The liquid material 91 from the catch basin 90 may be removed via conduit 92 and pump 93. The conduit 92 and pump 93 may, if desired, be connected to recirculate the liquid into supply conduits 72, 82. In a second liquid removal step, a suction chamber 110 having a suction opening 111 connected to a suitable air exhaust system (not shown) may be situated beneath the foraminous conveyor 61. As will be noted by the direction of the arrows showing the vertically downward air flow, the filaments are held in their dispersed position while further excess liquid is removed from the mat.

Referring to FIG. 5, there is illustrated a front view of the weir apparatus shown in FIG. 4, which apparatus may be also used for the weir at station 70. The weir means 81 of FIG. 5 is connected with a supply conduit 82 which supplies the liquid along the bottom 87 of the

weir means 81. A plurality of parallel vanes or baffles 86 have been placed within the weir means 81 to insure that very little side to side flow with respect to the travel of the mat issues from the lip 85 of the weir 81 to disrupt the uniform distribution of the strands and dispersed filaments. Baffle or vane means 86 are spaced from the bottom so that liquid may be supplied to the entire weir means by a single supply pipe 82. Thus a curtain or sheet of impinging liquid may be supplied at either station 80 or at station 70 to the mat 60 and the strand therein for filament dispersal.

It should be noted that the liquid for dispersement of filaments at stations 70 and 80 may be simply water. It has been noted that with some lubricants which are used to provide inter-fiber mobility that the water may be made alkaline to aid dispersal. The addition of a small amount of, for example, ammonium caseinate will change the pH value of the water surrounding the strands from acid to alkaline.

In addition to the use of plain water, or the alkaline water, it is desirable to reopen the strands or to disperse the filaments by using a liquid which is a solution containing the binder that will eventually be used to integrate the mat. That is, a number of aqueous solutions may be utilized which carry a binder which will be deposited upon the filaments and, after heat or other treatment, will bind the filaments together and integrate the mat. Other forms of binders not in aqueous solutions may, of course, also be used if there is sufficient liquidity to provide a flooded area around the mat and the strands therein to produce the dispersing effect from the soaking and/or impinging as described hereinbefore. Although the method of dispersal discussed hereinbefore is the preferred method to carry out the teachings of this invention, other suitable methods may be used.

There has thus been described and disclosed herein novel methods for uniformly distributing individual filaments by first gathering a limited number of the filaments into a strand to provide the strand with sufficient mass to be projected to a predetermined area on a collection surface. This insures that the strand is uniformly deposited with respect to the fibrous body and with respect to like strands in the body. The mass of the strand depends upon the number and weight of filaments. The projection or throw of the strands depends upon the mass of the strand and the size or shape of the strand which affects the air resistance thereof and the speed of rotation of the pull wheel. For example, a four glass-filament strand, in which the filaments are approximately 50 hundred thousandths of an inch in diameter, may be projected approximately 36 inches when the pull wheel is rotating at 5,000 feet per minute. Other projecting means, such as aerodynamic means, may be utilized to provide the strand with the kinetic energy required.

The formation and accurate or uniform deposition of the strand being accomplished, then the limited number of filaments may be dispersed uniformly from strand formation as described. A novel fibrous body or mat product results.

Possible modifications and substitutions of elements of the apparatus and method of the invention will occur to those skilled in the art, and such obvious changes are considered within the spirit and scope of the invention.

There has thus been described and disclosed herein novel method and means for dispersal of filaments from strands and the making of mat products therefrom. Possible modifications and substitutions of elements of the apparatus and method of this invention will occur to those skilled in the art, and such obvious changes are considered within the spirit and scope of this invention.

#### I claim:

1. A method of forming a fibrous strand mat comprising the steps of forming a continuous strand from a group of continuous glass filaments, imparting kinetic energy to said strand to project said strand with a linear velocity

from the point of projection to a selected area on a collection surface, limiting the number and total weight of said filaments in said strand to provide a total strand mass sufficient only for accurate projection of said mass from the point of projection to said area of said collection surface in response to the kinetic energy imparted to said strand mass, and dispersing filaments of said strand in the deposition place of said strand on said collection surface to obtain a controlled distribution of individual filaments which provides a fine and uniform porosity for said mat.

2. A method as defined in claim 1 which includes the further step of applying sizing to said filaments when forming said strand to obtain a desired total strand mass.

3. A method as defined in claim 1 in which said step of forming said strand includes the steps of attenuating said filaments from streams of molten glass and gathering said attenuated filaments into said strand.

4. A method of forming fibrous strand mats comprising the steps of flowing streams of glass from a molten supply of glass, attenuating said streams into a group of continuous glass filaments, dividing said group of filaments into smaller individual groups of filaments to form a continuous strand from each of said smaller groups of filaments, imparting kinetic energy to each of said strands to project each strand with a linear velocity from the point of projection to a selected area on a collection surface, limiting the number and total weight of filaments in each strand to provide a total strand mass sufficient only for accurate projection of each strand from the point of projection to the selected area of said collection surface in response to the kinetic energy imparted to each strand mass, and dispersing filaments of each strand in the deposition area of the strand on the collection surface to obtain controlled distribution of individual filaments to provide a mat having a fine porosity.

5. A method as defined in claim 4 which further includes a step of applying a measured amount of sizing to said filaments to obtain a desired mass for each strand.

6. A method of uniformly distributing continuous glass filaments on a moving collection surface to form a thin glass fiber mat having substantially uniform porosity and integrity comprising the steps of gathering groups of continuous filaments together to form a plurality of continuous strands, uniformly distributing the strands with respect to each other on the surface by projecting each of said strands from a preset distance above said collection surface to a selected area for each strand on said surface by imparting kinetic energy to each strand to provide each strand with a linear velocity toward said surface, providing a total mass for each strand which is sufficient only for accurate projection of each strand over the preset distance in response to the kinetic energy imparted thereto by limiting the number and weight of filaments in each strand, and dispersing the filaments of each strand after the strand is in place on the collection surface substantially within the original orientation of the strand on the surface.

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U.S. Cl. X.R.

19—66; 28—15, 76; 65—4, 9; 156—62.2, 62.6; 226—7, 97