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PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Method and apparatus for the Manufacture of Filamentous Mats

5 We, AMERICAN AIR FILTER COMPANY INC., a Corporation organized under the laws of the State of Delaware, United States of America of 215 Central Avenue, Louisville, Kentucky, United States of America, do hereby declare the invention for which we pray that a patent may be granted to us and the method by which it is to be performed to be particularly described in and by the following statement:—

10 The present invention relates to filamentous mats, and more particularly to a method and apparatus for the manufacture of fibrous mats wherein the density is selectively varied throughout the thickness of the mat and unusable waste normally resulting from the manufacture of such mat is reduced.

15 A well-known method and apparatus for formation of filamentous mats of, for example, glass, comprises reciprocating a filament feeding apparatus in a traverse axially along a rotating drum. Molten glass issues through multiple orifices in the bottom of the feeder and the streams issuing therefrom are attenuated into glass filaments by winding upon the rapidly rotating drum. The feeder is reciprocated back and forth across the length of the drum a plurality of times to form a mat composed of a plurality of layers of spun filaments, the layers extending substantially from one to the other end of the drum. When sufficient traverses of the feeder have been effected to build the mat to the desired thickness, the collected mat is slit parallel to the axis of rotation of the drum and removed therefrom as a sheet. The sheet can then be expanded by stretching the same transversely to the line of slit.

20 A disadvantage frequently common to previous methods and apparatus for manufacturing such mats is that fewer filaments are deposited on the drum in the end reversal areas of the feeder traverse. This occurs because the feeder stops momentarily at each end of the traverse and all of the openings in the orifice

45 plate do not pass completely over the drum in the end reversal areas to deposit the same number of filaments as are deposited in the central portions of the drum. Increasing feeder dwell time in the end reversal areas deposits more glass, but the characteristics of the material thus formed are different from the characteristics of the material in the central portion of the mat. The material formed in the end reversal areas is generally of inferior quality and considered scrap material to be discarded as waste.

50 In certain applications it is desirable to manufacture a filamentous mat of varying density throughout the thickness of the mat. This objective is currently accomplished, among other methods, through the use of collector wheels to collect monofilaments of glass to form multi-strand filaments for deposition on the rotating drum, or through the device of slowing the speed of rotation of the rotating drum during the formation of the mat to form filaments of larger diameter.

55 The present invention aims to provide a method and apparatus for manufacturing filamentous glass mats wherein the waste normally associated with the portion of the mat formed in the end reversal areas of the traverse is materially reduced and a method is provided to vary mat density in any desired manner throughout the thickness of the mat without the use of abrasive glass contacting devices or collectors. Further, the present invention provides a method of accomplishing both desirable objectives simultaneously and cooperatively without sacrificing the effectiveness of either objective.

60 A method according to the present invention of making a filamentous mat of a plurality of layers of filaments by winding filaments on to a rotating drum comprises reciprocating a filament feeder at a selected traversing speed axially along the drum so as to lay filaments thereon; rotating said drum a multiplicity of

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revolutions during each traverse of the filament feeder, feeding a plurality of filaments from the feeder to the drum during successive traverses of said feeder to build up a corresponding succession of layers of filaments with each layer containing a plurality of helical filament turns extending continuously through the central area from one end reversal area to another, disposing the filament feeder means in more than one position of angular displacement relative to the rotational axis of the drum, and varying the selected traversing speed of the filament feeder relative to the rotational speed of the drum.

Apparatus for carrying out this method comprises a traversing filament feeder mounted for reciprocatory motion above a drum to feed filaments therefrom to the rotating drum, a filament feeder drive arrangement operative to cause the feeder to automatically traverse the drum; means allowing the traversing speed of the filament feeder to be changed regardless of the position of the said feeder along the drum, and means whereby the filament feeder is pivotally mounted so as to enable changing of the angular relation of the longitudinal axis of the filament feeder to the axis of rotation of the drum.

With such an arrangement, it is possible to collect the filaments into collected filament strands as the longitudinal axis of the feeder moves toward a substantially perpendicular position relative to the rotational axis of the drum. This collection of filaments with more than one position of angular displacement yields a mat product of graded density. The speed of the feeder drive means can be varied throughout the formation of the filamentous mat, and in particular, can be increased during the time when the filament feeder is in the end reversal areas of the drum to materially reduce the residence time of the feeder in the end reversal areas and thus materially reduce the amount of glass deposited in the end reversal areas of the traverse.

The present invention further provides for formation of filamentous mats of variable density in still a further manner wherein the traversing speed of the reciprocating feeder can be changed relative to the speed of the drum in a preselected manner during the formation of a mat, regardless of the location of the feeder in its traverse and regardless of the aforementioned angular displacement. The preselected speed change results in a deposition of filaments onto the drum at preselected differing angles of lay with such differing angles of lay causing certain filaments to group together upon expansion of the mat so as to produce varied density in the completed mat.

Referring to the drawing which discloses one advantageous embodiment of the present invention:

Figure 1 is an elevational view of an apparatus used to manufacture filamentous mats

taken from the end of the rotating drum, showing the longitudinal axis of the filament feeder in angular relation with respect to the longitudinal axis of the rotating drum;

Figure 2 is an elevational view taken from the front of the rotating drum;

Figure 3 is a horizontal view showing orientation of the gear adjusting mechanism for the feeder assembly; and

Figure 4 is an enlarged, partial view of a sprocket taken in a plane passing through line 4-4 of Figure 1.

Referring to the drawing, there is shown a generally horizontal drum 1 which is normally rotated at speed (by means not shown) whereon filaments 4 are collected to form a mat. Feeder 2, containing suitable molten material, for example glass, has in the bottom side thereof a plate (not shown) including a multiplicity of orifices through which said molten material issues to form filaments 4. The orifices in said plate can be arranged in any desired geometrical configuration but usually there are longitudinally-extending rows of orifices in the plate, and generally each row can contain 50 orifices with the rows spaced approximately one inch apart. The diameter of filaments 4 drawn from the feeder 2 to the rotating drum 1 is influenced by the rotational speed of drum 1. Filaments are drawn to the drum as individual mono-filaments, or as strands composed of a number of monofilaments, depending upon the proximity of adjacent filaments as drawn from the filament feeder. Feeder 2 is supported from feeder carriage 10 by yoke 3 mounted on shaft 6 affixed to rotatable support plate 8. Support plate 8 is rotatably mounted within and to carriage 10 to turn feeder 2 to any desired angular relation with respect to the rotational axis of rotating drum 1.

Gear teeth 5 are provided around the periphery of a support plate 8. These teeth cooperate with worm gear 7 affixed to shaft 20 mounted in worm gear shaft bracket 21. Handle 9, affixed to shaft 20, serves to permit manual turning of the shaft 20 and worm gear 7 to orient the longitudinal axis of the feeder relative to the longitudinal axis of the rotating drum 1 in any desired angular relation. Feeder carriage 10 is mounted on wheels 11 disposed in cooperative spaced relation to move on tracks 12. Tracks 12 are disposed in straddling relation above a downturning edge (i.e. that edge in plan view of the drum which is receding from view) of the rotating drum 1 and extend generally parallel to the longitudinal axis of the drum to carry the feeder carriage 10 in reciprocatory traverses along said downturning edge. Variable speed feeder drive means 17 is provided to move feeder carriage 10 and feeder 2 along tracks 12. Drive means 17 includes motor 18 and variable speed gearbox 19 which is connected to turn sprocket 16 to drive endless chain 15 mounted around

it and idler sprocket 22 at a preselected speed. The speed of the feeder drive means transmitted to sprocket 16 can be controlled by a variable rheostat (not shown) in the power line to the motor 18, or by integral speed changing mechanism (not shown) in the variable speed gear box 19. Any desired means such as a time clock (not shown) may be used to control the rheostat or the variable speed gear box to change the speed of the feeder drive means 17. Drive pin 14 is affixed to chain 15 and nests in a vertically extending pin-receiving slot 13¹ on arm 13 which is mounted to feeder carriage 10. Pin 14 is free to move in a vertical direction in slot 13¹ while driving the carriage 10 in a generally horizontal direction on tracks 12 in response to the movement of chain 15. For example, the pin moves along with chain 15 in a horizontal direction between sprocket 16 and 22 and drives the feeder correspondingly. The pin then moves around the sprockets and during the period when pin 14 is moving around a sprocket and in a generally vertical direction in the slot, there is a correspondingly decreasing horizontal motion of the feeder 2. Further movement of pin 14 reverses the direction of horizontal travel of feeder 2, and pin 14 once again resumes a generally horizontal movement corresponding to travel between sprockets. The portion of the traverse during the period when drive pin 14 is passing around a sprocket is best described as the end reversal area of the feeder traverse. The portion of the mat formed during the period when the feeder is in the end reversal areas of the traverse is usually of less desirable quality than the part of the mat formed when the feeder is in the central portion of the rotating drum because all of the orifices of the feeder do not pass over the end reversal areas to deposit filaments, so there is less glass deposited in the end reversal areas than in the central portion of the mat, and the edge portions are further undesirable because of undesirable angles of lay of the filaments due to feeder speed changes. It will be realized by those skilled in the art that any other suitable means may be used as a feeder drive means 17 hereinbefore illustrated.

In operation, the drum 1 is rotated at a desired speed and chain 15 moves pin 14 at a speed determined by the preselected speed of the variable speed drive means 17, the feeder 2 being driven accordingly. The width of the mat formed on rotating drum 1 is determined by the length of the feeder traverse.

In one advantageous example, the speed of the feeder drive means 17 is changed relative to the drum speed periodically regardless of the position of the feeder in the traverse, and a mat is formed of filaments, a portion of which have one angle of lay relatively to a plane at right angles to the drum rotational axis and at least another portion of which has another lay. It is to be understood that this

can be done in a number of ways as described hereinafter and it is further to be understood that the preselected periodic change can occur at any location of the filament feeder in its traverse. For example, the feeder can be run for a preselected period of time (one hour — as an illustration) at a constant speed relative to the drum speed. Then for another preselected period of time (one half-hour, for illustration) the feeder can be run on a cycle, combining two preselected but different speeds relative to the drum speed which deposits filaments on the drum at two different angles of lay. One of these two preselected speeds can be approximately equal to the original speed and the other can be less. During subsequent preselected periods of time (one half-hour each, for example) the percentage of time of the lesser of the two preselected speeds can be increased. It is to be understood that the present invention is not to be considered as limited to the specific cycling arrangement aforescribed and that the lower speeds can be taken to zero or standstill without detriment to the concept of the present invention. It further is to be understood that, as is known in the art, suitable binder materials can be applied to the mat during or after its formation. If the mat thus formed is subsequently cut parallel to the longitudinal axis of the drum and expanded by drawing or stretching it from one of its edges, which extends in the general direction of the filaments, an expanded mat results wherein those filaments deposited at a greater angle of lay, corresponding to a higher relative speed between feeder and drum, are substantially straightened, and those filaments deposited at a lesser angle of lay loop or curl and are grouped to provide graded mat density as a function of such grouping. The density of a mat thus formed changes incrementally throughout the thickness of the mat.

As aforesaid, the portion of the mat formed in the end reversal areas of the traverse has been generally considered waste and therefore discarded. By the method herein disclosed, the amount of waste formed in the end reversal areas is reduced by decreasing the time the feeder is in the end reversal areas, thereby reducing the amount of glass deposited and to be wasted in the end reversal areas. The speed of feeder drive means 17 is increased when pin 14 approaches sprocket 16 or 22 and the feeder 2 is entering the end reversal areas of the traverse as can be seen in Figure 4. The speed increase of the drive means can be accomplished through use of limit switches 23 and 24. Switch 23 initiates an increase in speed of feeder drive means 17 when pin 14 engages the lever of the switch 23 to actuate a control mechanism such as, for example, a cooperating rheostat (not shown in detail) in a suitable power supply circuit 25 to motor 18. As pin 14 leaves the sprocket, it contacts the lever of switch 24 which causes said feeder drive

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means to resume its original speed by actuating the rheostat in the power circuit 25 in a reverse direction. The decreased residence time of the feeder in the end reversal portions of the traverse results in the deposition of fewer filaments in these areas of the drum than would normally occur without increasing the speed of the feeder traverse, and since the portions of the mat formed in the end reversal areas are discarded as waste, the total amount of glass discarded as waste is decreased. It will be understood that a similar action obtains at the other end of chain 15 due to another set of switches 23¹ and 24¹.

As shown in the drawing, feeder 2 is pivotally mounted on the feeder carriage 10 by means of rotatable plate 8 and shaft 6, and the longitudinal axis of the feeder can be turned in angular relation to the longitudinal axis of the drum by turning worm gear 7. Handle 9, attached to worm gear 7 by shaft 20, can be turned as desired to manually adjust the angular position of the feeder. It will be realized by one skilled in the art that gear 7 can be continuously turned during the formation of the mat, either manually or by any suitable means to continuously change the angular relation between the longitudinal axis of feeder 2 and drum 1.

The width of the waste portion of the mat formed in the end reversal areas is approximately equal to the width of the group of filaments 4 wound on the drum. Thus, if the longitudinal axis of the feeder orifice plate is parallel to the longitudinal axis of the drum, the width of the waste portion formed is approximately equal to the width of the feeder 2 plus the radius of the sprocket 16 or 22. As is known in the art, the amount of waste formed in the end reversal areas of the mat is reduced by decreasing the width of the band of filaments 4 wound on drum 1. In most feeders reduced waste will result when the longitudinal axis of the feeder is at an angle other than parallel to the longitudinal axis of the drum. In addition to the waste reduction at the end areas of the drum as a result of effecting a preselected angular relation other than parallel between the longitudinal axis of feeder 2 and drum 1 at such end areas, the present invention recognizes that angular variation intermediate the end reversal areas provides for variable filament grouping with resulting formation of a mat of variable density throughout the thickness of the mat when the mat is expanded. A portion of such mat can be formed with the longitudinal axis of the reciprocating feeder 2 at substantially less than a right angle with respect to the longitudinal axis of the rotating drum. Another portion of the mat can be formed with the longitudinal axis of feeder 2 at an increased angular relation approaching a right angle to the longitudinal axis of rotating drum 1. The portion of the mat formed with the longitudinal axis of

feeder 2 at substantially less than a right angle in relation to the longitudinal axis of rotating drum 1 is composed primarily of individual filaments in comparatively spaced relation formed with only a few filaments composed of a plurality of monofilaments which result when several monofilaments adhere to each other after being attenuated from feeder 2 in contiguous relation. The portion of the mat formed with the longitudinal axis of feeder 2 at an increased angle to the longitudinal axis of drum 1 is composed primarily of strands of monofilaments formed when the filaments are attenuated in contiguous relation and adhere to each other when wound on drum 1. If the mat thus formed is expanded after it has been cut along the direction of the longitudinal axis of the drum and removed therefrom by drawing it from one of its edges transverse to the line of cut, the density of the resulting expanded mat is high in the portion formed when the feeder was disposed at substantially less than a right angle, because of the great number of individual monofilaments in this portion of the mat. The density of the mat is lower in the portion formed when the longitudinal axis of the feeder was disposed at increased angular relation to the longitudinal axis of the drum because filaments are grouped into strands. It will be realized by one skilled in the art that a corresponding mat with similar characteristics could be formed by reversing the sequence of steps above outlined. Likewise, the formation of a condensed filamentous mat having continuously varying filament density through the thickness of the mat can be accomplished by starting the formation of the mat with the longitudinal axis of feeder 2 at a preselected angle with respect to the longitudinal axis of drum 1 and continually increasing the angular relation between the longitudinal axis of feeder 2 with respect to the longitudinal axis of drum 1 at a predetermined rate of movement. The initially formed portion of said mat will be composed primarily of monofilaments, but as the angular displacement increases, the monofilaments will fall one on the other in increasing numbers and therefore increase the total number of filaments which are grouped.

It is to be understood that for the purposes of this invention the longitudinal axis of the feeder can be correlated to the longitudinal axis as determined by a row of holes in the orifice plate.

WHAT WE CLAIM IS:—

1. A method of manufacturing a filamentous mat consisting of a plurality of layers of filaments by winding filaments on a rotating drum, which method comprises reciprocating a filament feeder at a selected traversing speed axially along the drum so as to lay filaments thereon rotating said drum a multiplicity of revolutions during each traverse of the filament feeder, feeding a plurality of filaments from

- means to resume its original speed by actuating the rheostat in the power circuit 25 in a reverse direction. The decreased residence time of the feeder in the end reversal portions of the traverse results in the deposition of fewer filaments in these areas of the drum than would normally occur without increasing the speed of the feeder traverse, and since the portions of the mat formed in the end reversal areas are discarded as waste, the total amount of glass discarded as waste is decreased. It will be understood that a similar action obtains at the other end of chain 15 due to another set of switches 23¹ and 24¹.
- As shown in the drawing, feeder 2 is pivotally mounted on the feeder carriage 10 by means of rotatable plate 8 and shaft 6, and the longitudinal axis of the feeder can be turned in angular relation to the longitudinal axis of the drum by turning worm gear 7. Handle 9, attached to worm gear 7 by shaft 20, can be turned as desired to manually adjust the angular position of the feeder. It will be realized by one skilled in the art that gear 7 can be continuously turned during the formation of the mat, either manually or by any suitable means to continuously change the angular relation between the longitudinal axis of feeder 2 and drum 1.
- The width of the waste portion of the mat formed in the end reversal areas is approximately equal to the width of the group of filaments 4 wound on the drum. Thus, if the longitudinal axis of the feeder orifice plate is parallel to the longitudinal axis of the drum, the width of the waste portion formed is approximately equal to the width of the feeder 2 plus the radius of the sprocket 16 or 22. As is known in the art, the amount of waste formed in the end reversal areas of the mat is reduced by decreasing the width of the band of filaments 4 wound on drum 1. In most feeders reduced waste will result when the longitudinal axis of the feeder is at an angle other than parallel to the longitudinal axis of the drum. In addition to the waste reduction at the end areas of the drum as a result of effecting a preselected angular relation other than parallel between the longitudinal axis of feeder 2 and drum 1 at such end areas, the present invention recognizes that angular variation intermediate the end reversal areas provides for variable filament grouping with resulting formation of a mat of variable density throughout the thickness of the mat when the mat is expanded. A portion of such mat can be formed with the longitudinal axis of the reciprocating feeder 2 at substantially less than a right angle with respect to the longitudinal axis of the rotating drum. Another portion of the mat can be formed with the longitudinal axis of feeder 2 at an increased angular relation approaching a right angle to the longitudinal axis of rotating drum 1. The portion of the mat formed with the longitudinal axis of feeder 2 at substantially less than a right angle in relation to the longitudinal axis of rotating drum 1 is composed primarily of individual filaments in comparatively spaced relation formed with only a few filaments composed of a plurality of monofilaments which result when several monofilaments adhere to each other after being attenuated from feeder 2 in contiguous relation. The portion of the mat formed with the longitudinal axis of feeder 2 at an increased angle to the longitudinal axis of drum 1 is composed primarily of strands of monofilaments formed when the filaments are attenuated in contiguous relation and adhere to each other when wound on drum 1. If the mat thus formed is expanded after it has been cut along the direction of the longitudinal axis of the drum and removed therefrom by drawing it from one of its edges transverse to the line of cut, the density of the resulting expanded mat is high in the portion formed when the feeder was disposed at substantially less than a right angle, because of the great number of individual monofilaments in this portion of the mat. The density of the mat is lower in the portion formed when the longitudinal axis of the feeder was disposed at increased angular relation to the longitudinal axis of the drum because filaments are grouped into strands. It will be realized by one skilled in the art that a corresponding mat with similar characteristics could be formed by reversing the sequence of steps above outlined. Likewise, the formation of a condensed filamentous mat having continuously varying filament density through the thickness of the mat can be accomplished by starting the formation of the mat with the longitudinal axis of feeder 2 at a preselected angle with respect to the longitudinal axis of drum 1 and continually increasing the angular relation between the longitudinal axis of feeder 2 with respect to the longitudinal axis of drum 1 at a predetermined rate of movement. The initially formed portion of said mat will be composed primarily of monofilaments, but as the angular displacement increases, the monofilaments will fall one on the other in increasing numbers and therefore increase the total number of filaments which are grouped.
- It is to be understood that for the purposes of this invention the longitudinal axis of the feeder can be correlated to the longitudinal axis as determined by a row of holes in the orifice plate.
- WHAT WE CLAIM IS:—**
1. A method of manufacturing a filamentous mat consisting of a plurality of layers of filaments by winding filaments on a rotating drum, which method comprises reciprocating a filament feeder at a selected traversing speed axially along the drum so as to lay filaments thereon rotating said drum a multiplicity of revolutions during each traverse of the filament feeder, feeding a plurality of filaments from



the feeder to the drum during successive traverses of said feeder to build up a corresponding succession of layers of filaments with each layer containing a plurality of helical filament turns extending continuously through the central area from one end reversal area to another, disposing the filament feeder means in more than one position of angular displacement relative to the rotational axis of the drum, and varying the selected traversing speed of the filament feeder relative to the rotational speed of the drum.

2. A method according to Claim 1 wherein the selected traversing speed of the filament feeder is periodically changed in accordance with a preselected time cycle regardless of the position of the feeder means in any traverse cycle thereof along the drum.

3. A method according to claim 1 or claim 2 wherein the traversing speed of the filament feeder is increased when it is in the end reversal areas of its reciprocatory traverse travel path, and decreased when it leaves the end reversal areas.

4. A method according to any one of the preceding claims comprising the steps of forming a portion of the mat wherein the longitudinal axis of the traversing filament feeder is in a position of angular displacement relative to the axis of rotation of the rotating drum, the angular displacement being measured from the axis of rotation to the longitudinal axis of the feeder means wherein the angular dis-

placement of the filament feeder is made greater than 0 degrees but less than a right angle, and the feeder means is then moved to a position where said angle is a right angle and the remainder of the mat is formed.

5. Apparatus for forming a filamentous mat by winding filaments on a rotating drum which comprises a traversing filament feeder mounted for reciprocatory motion above a drum to feed filaments therefrom to the rotating drum, a filament feeder drive arrangement operative to cause the feeder to automatically traverse the drum; means allowing the traversing speed of the filament feeder to be changed regardless of the position of the said feeder along the drum and means whereby the filament feeder is pivotally mounted so as to enable changing of the angular relation of the longitudinal axis of the filament feeder to the axis of rotation of the drum.

6. A method according to claim 1 of manufacturing filamentous mats and substantially as described herein.

7. Apparatus according to Claim 5 for manufacturing filamentous mats constructed and arranged to operate substantially as described herein with reference to, and as illustrated by, the accompanying drawings.

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