

PATENT SPECIFICATION

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DRAWINGS ATTACHED.

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COMPLETE SPECIFICATION.

Method of Manufacturing Filamentous Mats and Mats Produced by Said Method.

We, AMERICAN AIR FILTER COMPANY INC., of 215 Central Avenue, Louisville, Kentucky, United States of America, a corporation organised and existing under the laws of the State of Delaware, 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:—

The present invention relates to expanded filamentous mats, and more particularly, relates to an improved method for making expanded filamentous mats and increasing filament concentration in selected portions of the mat.

A method for making expanded filamentous mats, as well known in the art, comprises moving a filament feeding apparatus axially along a drum and feeding filaments from the filament feeding apparatus to the rotating drum. The filaments are collected on the rotating drum and the filament feeding apparatus can be reciprocated back and forth along the length of the drum a plurality of times to form a condensed mat composed of a plurality of layers of filaments. The condensed filamentous mat is then cut parallel the axis of rotation of the drum and removed from the drum as a sheet. As is known in the art, the condensed mat is then drawn in a direction transverse the lay of the filaments to stretch the mat and increase the length of the mat in the direction of draw. Drawing the condensed mat also increases the thickness of the mat by separating the filaments. The stretched, expanded mat is then much longer and much thicker than the condensed mat originally cut from the drum. The average filament concentration of the expanded mat is lower because of the

separation of the filaments which occurs in expanding the mat in the direction of its thickness.

In certain applications, it is desirable to manufacture an expanded mat having different filament concentration in selected portions of the mat. Furthermore, a method to increase filament concentration of predetermined amount in selected portions of a filamentous mat is especially desirable.

In certain other applications, it would be desirable to manufacture a filamentous mat which includes a "skin-like" layer of extremely high filament concentration. The "skin-like" layer provides strength and dimensional stability to the expanded mat. In situations where expanded mat is used to remove particulate matter from fluids and where fluid is passed through the mat in the direction of its thickness, a skin-like layer provides an area for removal of extremely fine particles from the fluid stream.

The present invention provides an advantageous method of manufacturing an expanded filamentous mat by the use of which the filament concentration can be controlled in a straightforward and economical manner and which method is also advantageous to both the number of operational steps necessary and in the amount of material required to be used. The method enables full use of conventional equipment. The method provided by the present invention further enables the manufacture of compressed "skin-like" layers of extremely high filament concentration in desired preselected positions throughout the thickness of the expanded mat so as to meet varying conditions which might be required of the finished product.

A method for making an expanded filamentous mat according to the invention,

[Price 4s. 6d.]

comprises feeding filaments from filament feeder means and depositing them on filament collector means by a combination of rectilinear and rotational motions at at least two different angles of lay relative to the axis of the rotational motion to form at least two filament portions, at least one of the portions comprising filaments deposited at a different angle of lay than the filaments deposited in at least one other portion of the mat, applying a binder to the mat, removing the filaments from the collector means stretching the mat in a direction transverse to the general direction of lay of filaments in the mat to form an expanded filamentous mat, and compressing one of the portions of the mat and retaining said compressed portion in compressed condition.

Referring to the accompanying drawings which disclose one advantageous embodiment of the present invention:

Figure 1 shows an elevational view of an apparatus for forming a condensed, filamentous mat on a rotating drum in accordance with the present invention:

Figure 2 is an elevational view taken along a plane passing through line 2—2 of Figure 1;

Figure 3 is a diagrammatic plan view of an apparatus for expanding and compressing a filamentous mat formed by the apparatus of Figures 1 and 2 in accordance with one method of the present invention; and

Figure 4 is a cross-sectional view taken along a plane passing through line 3—3 of Figure 3.

In accordance with the drawings, there is shown a filament feeder 1 mounted on wheels 9 for reciprocatory motion along tracks 8. Tracks 8 are supported above and generally parallel to a down-turning edge of rotating drum 11 which can be rotated (by means not shown). Filaments of a suitably selected material such as molten glass can be fed from orifices (not shown) in the bottom of feeder 1 to be attenuated by, and helically wound upon, the rapidly rotating drum 11. Orifices in the bottom of the filament feeder 1 can be disposed in any desired geometric configuration, but usually, they are longitudinally-extending rows of orifices. The diameter of filaments 15 drawn from filament feed 1 to drum 11 is influenced by the speed of rotation of drum 11 and the diameter of the orifices.

Filament feeder 1 can be driven back and forth on tracks 8 in reciprocatory traverse by variable speed drive means 10. It will be understood that within the scope of the present invention, drive means 10 may include any suitable combination of elements. A drive motor 5 can be connected to variable speed reducer 4 to turn sprocket 3 at a desired speed. Endless chain 12 can be driven by drive sprocket 3 and driven around idler

sprocket 7 where sprockets 3 and 7 can, advantageously, be mounted at opposite ends of drum 11. Drive pin 13 fixed to chain 12 nests in a vertically-extending, pin-receiving slot 14 in arm 2 which is joined to filament feeder 1. Pin 13 is free to move in a vertical direction in slot 14 while driving filament feeder 1 in a generally horizontal direction along tracks 8 in response to movement of chain 12. For example, pin 13 moves with chain 12 in one horizontal direction, and between sprockets 3 and 7, to drive filament feeder 1 accordingly. When pin 13 reaches one of the sprockets, for example sprocket 3, it then moves around sprocket 3 and in a generally vertical direction in slot 14. As pin 13 leaves sprocket 3, filament feeder 1 is driven at the same horizontal speed as chain 12, but in a direction opposite the direction of travel before pin 13 moved around sprocket 3. It will be realized a similar sequence of events occurs as pin 13 passes around sprocket 7, and, therefore, the reciprocatory traverse of filament feeder 1 extends generally from sprocket 3 to sprocket 7 along the afore-mentioned down-turning edge of rotating drum 11.

The relative traversing speed of filament feeder 1 is changed in accordance with the speed of drive motor 5, which speed can be controlled in any desired manner. One method of controlling the speed of drive motor 5 is to provide a speed regulator device 6 in the power supply 16 to drive motor 5. Speed regulator device 6 can be of the rheostat type and operated manually or automatically in accordance with a selected program to control the speed of drive motor 5 and the traversing speed of filament feeder 1. The angle at which the filaments are wound onto the drum 11 hereinafter called the angle of lay of filaments and is determined by the combined relative effect of the traversing speed of feeder 1 and the speed of rotation of drum 11.

A suitable binder can be applied uniformly to mat 19 during its formation by means of spray 18 which can be arranged to periodically traverse the drum surface.

In one example of the present invention, as shown in the drawings, filament feeder 1 can be a furnace containing molten glass. The molten glass can issue from openings (not shown) in the bottom of feeder 1 to form glass filaments 15 which are collected on rotating drum 11 to form condensed mat 19. Separate portions of filamentous mat 19, having differing angles of lay on drum 11, can be created by periodically varying the traversing speed of feeder 1 relative to the rotational speed of drum 11 during formation of mat 19. It will be understood that the angle of lay referred to is the angle measured between the axis of the rotating drum and the projection of filaments 15 collected

on drum 11. The angle of lay is measured to one side of the axis for filaments deposited on drum 11 when feeder 1 traverses drum 11 in one direction. When the direction of traverse of feeder 1 is in the opposite direction the angle of lay is measured to the other side of the axis. It will, therefore, be understood that if the traversing speed of feeder 1 is the same for successive traverses in opposite directions, the angle of lay of the filaments deposited can be considered as the same, even though the angle is measured to opposite sides of the axis.

In accordance with the present invention, it is recognized that the angle at which filaments are laid on drum 11 determines the length to which condensed mat 20 can substantially be expanded; the greater the angle of lay on the drum, the shorter the length to which the condensed mat can subsequently be expanded. Accordingly, portions of mat 19 can be formed during periods of increased traversing speed of feeder 1 to include filaments collected on drum 11 at increased angle of lay. These portions cannot be drawn or stretched to the same length as portions formed during periods of decreased traversing speed to deposit filaments at decreased angles of lay. In mat 19 of the present example, a first portion can be formed on rotating drum 11 at relatively low traversing speed of feeder 1. Also, the relative traversing speed of filament feeder 1 can be changed periodically by speed change linkage 10. Periodically changing the relative traversing speed of feeder 1 during the formation of the first portion of mat 19 introduces filaments having random angles of lay on drum 11, and provides desirable irregularities in the patterns of the filament. The traversing speed can be changed in accordance with a preselected, timed program, regardless of the position of feeder 1 in any particular traverse. In the method of the present example, the portions of the mat having random angles of lay can be provided by periodically stopping the traverse of filament feeder 1 during the formation of first portion of condensed mat 19. The traverse of filament feeder 1 can be periodically stopped by providing speed change linkage 10 with means to stop drive motor 5 for selected periods of time at selected intervals. During the intervals when the traverses of filament feeder 1 are stopped, filaments 15 are drawn directly on rotating drum 11 at a substantially zero degree angle of lay. Therefore, in successive turns of drum 11, filaments 15 fall on top of themselves in contiguous relation to form multi-filament strands. Strands are composed of groups of monofilaments and remain, generally, grouped in the form of filament groups throughout the further processing of mat 19. The filament groups, or strands, can be

considered as equivalent to large diameter monofilaments and effectively decrease the average filament concentration in the expanded mat ultimately formed from mat 19. The number of strands in any portion of mat 19, and therefore, the relative filament concentration, can be controlled by the length of the intervals in which feeder 1 is stopped and the frequency at which feeder 1 is stopped. By appropriate selection of frequency and interval of time during which feeder 1 is stopped, a desired filament concentration can be obtained in any selected portion of mat 19.

In the method of the present example, the second portion of mat 19 can be formed by transversely reciprocating filament feeder 1 at increased relative traversing speed along a down-turning edge of rotating drum 11. It will be understood that the maximum relative traversing speed of feeder 1 during formation of second portion of mat 19, for the most part, can be greater than the maximum relative traversing speed of feeder 1 during formation of first portion of mat 19. The filaments drawn to rotating drum 11 are deposited on drum 11 at increased angle of lay with respect to angle of lay of filaments of the first portion. Further, in one method of the present invention where it is desired to form a skin-back filamentous mat, the second portion of mat 19 can be advantageously less than one half as thick as the first formed portion of mat 19.

Preferably the total thickness of said second portion is not more than 30% of the total thickness of said mat when said mat is removed from said drum.

It has been found that, advantageously, in the expansion of mat 20, the angle of lay of filaments 15 in the aforementioned second formed portion of mat 19 can be 5 to 40 per cent greater than the maximum angle of lay of filaments in the aforementioned first portion.

A suitable binder can be applied at any desired time during the formation of mat 21. For purposes of the present example, a water soluble binder can be applied by means of spray 18, which can traverse the rotating drum during the formation of mat 19 on drum 11.

Condensed mat 19 can be cut parallel to the longitudinal axis of the drum 11 and removed therefrom to form a condensed mat 20. Flat condensed mat 20 can be expanded by hand or any other suitable method by drawing or stretching one edge in a direction generally transverse to the general lay of filaments in the mat. In stretching mat 20, it expands in the direction of stretching and in the direction of the thickness of the mat to form expanded mat 21. In expanded mat 21, some of the filaments are substantially

straight, while others assume a looped or curled configuration.

From the foregoing, it can be seen that mat 21 includes second portion 29 formed at increased feeder traversing speed, so as to include filaments collected on drum 11 at increased angle of lay. The filaments of portion 29 are substantially straightened in the expansion of mat 20 to form mat 21 and the ultimate length of mat 21 can be controlled by these straightened filaments. Expanded mat 21 also includes portion 30, corresponding to the first portion of mat 19 collected at a maximum feeder traversing speed substantially lower than the feeder traversing speed in the formation of portion 29. The maximum angle of lay of filaments of portion 30 determines the ultimate length to which portion 30 can be stretched. Since the maximum angle of lay of filaments of portion 30 is less than the angle of lay of filaments of portion 29, it follows that, if stretched independently, portion 30 could be stretched further than portion 29.

In expanding mat 20, certain changes occur in the geometric configuration of the mat. Portion 29 would normally stretch to a lesser maximum length than portion 30, with comparable distortion in all its dimensions, because its filaments were collected on drum 19 at a greater angle of lay than the filaments comprising portion 30. However, in the expansion of mat 20, the mat advantageously is drawn beyond the maximum length of stretch for portion 29. Therefore, since portions 29 and 30 are bound together by the binder and by intertwining filaments at the common interface, portion 29 will be stretched to the same length as portion 30, causing portion 29 to be decreased in its dimensional thickness, and filaments in portion 29 to be straightened to form a thin layer of filaments relative to the expanded layer of filaments of portion 30.

It will be understood that within the scope of the present invention, the binder may be softened by any desired means. In the present example, binder solvent dispenser means 22 can be a flexible sack 23 which is elongated and extends transversely across the width of expanded mat 21. Furthermore, sack 23 can be disposed so that the lower portion contacts mat 21. Sack 23 holds a quantity of suitable binder solvent such as water and includes appropriate openings (not shown) in the bottom. The openings permit emission of solvent from sack 23 which, advantageously, flows into the area of contact between sack 23 and mat 21. Mat 21 can be partially compressed by the weight of sack 23 during the application of binder solvent. The binder solvent can be continuously supplied to sack 23 as by feed pipe 24, and the rate of emission of solvent from openings in sack 23 can be controlled by the

pressure of solvent within sack 23 as by valve 25. In this connection, it will be noted that the straightening and concentration of filaments in portion 29 facilitates uniform distribution of the binder solvent through such portion.

When the binder is softened, the filaments in portion 29 move freely. Since portion 30 stretches portion 29 beyond its normal expansion length, portion 30 pulls and holds portion 29 in tension, and the filaments in portion 29 are further straightened when allowed to move freely. When the filaments are further straightened, the thickness of portion 29 is further decreased, and therefore, the filament concentration of portion 29 is increased. To further decrease the thickness of portion 29, mat 21 can then be passed through compressive conveyors 27 and 28 to further compress mat 21 and increase the filament concentration in portion 29. Compression assures the formation of a "skin-like" layer. In accordance with the present invention, the compression occurs primarily in portion 29 because the binder is in softened condition during the compression steps and the filaments have been straightened and concentrated in the manner aforescribed.

After the desired compression is attained, the binder can then be hardened by any convenient means, and in the method of the present example, the binder can be hardened by heating in oven 28, while mat 21 is in the desired compressed condition.

It will be understood that within the scope of the present invention, filamentous mats may be made having more than the two portions of differing angle of lay as herein-described. Further, in forming the condensed mat, the portions may be deposited on the drum in any desired order.

WHAT WE CLAIM IS:—

1. A method for making an expanded filamentous mat comprising feeding filaments from filament feeder means and depositing them on filament collector means by a combination of rectilinear and rotational motions at at least two different angles of lay relative to the axis of the rotational motion to form at least two filament portions, at least one of the portions comprising filaments deposited at a different angle of lay than the filaments deposited in at least one other portion of the mat, applying a binder to the mat, removing the filaments from the collector means, stretching the mat in a direction transverse to the general direction of lay of filaments in the mat to form an expanded filamentous mat, and compressing one of the portions of the mat and retaining said compressed portion in compressed condition.

2. A method according to claim 1 where in two portions are deposited, each forming

straight, while others assume a looped or curled configuration.

From the foregoing, it can be seen that mat 21 includes second portion 29 formed at increased feeder traversing speed, so as to include filaments collected on drum 11 at increased angle of lay. The filaments of portion 29 are substantially straightened in the expansion of mat 20 to form mat 21 and the ultimate length of mat 21 can be controlled by these straightened filaments. Expanded mat 21 also includes portion 30, corresponding to the first portion of mat 19 collected at a maximum feeder traversing speed substantially lower than the feeder traversing speed in the formation of portion 29. The maximum angle of lay of filaments of portion 30 determines the ultimate length to which portion 30 can be stretched. Since the maximum angle of lay of filaments of portion 30 is less than the angle of lay of filaments of portion 29, it follows that, if stretched independently, portion 30 could be stretched further than portion 29.

In expanding mat 20, certain changes occur in the geometric configuration of the mat. Portion 29 would normally stretch to a lesser maximum length than portion 30, with comparable distortion in all its dimensions, because its filaments were collected on drum 19 at a greater angle of lay than the filaments comprising portion 30. However, in the expansion of mat 20, the mat advantageously is drawn beyond the maximum length of stretch for portion 29. Therefore, since portions 29 and 30 are bound together by the binder and by intertwining filaments at the common interface, portion 29 will be stretched to the same length as portion 30, causing portion 29 to be decreased in its dimensional thickness, and filaments in portion 29 to be straightened to form a thin layer of filaments relative the expanded layer of filaments of portion 30.

It will be understood that within the scope of the present invention, the binder may be softened by any desired means. In the present example, binder solvent dispenser means 22 can be a flexible sack 23 which is elongated and extends transversely across the width of expanded mat 21. Furthermore, sack 23 can be disposed so that the lower portion contacts mat 21. Sack 23 holds a quantity of suitable binder solvent such as water and includes appropriate openings (not shown) in the bottom. The openings permit emission of solvent from sack 23 which, advantageously, flows into the area of contact between sack 23 and mat 21. Mat 21 can be partially compressed by the weight of sack 23 during the application of binder solvent. The binder solvent can be continuously supplied to sack 23 as by feed pipe 24, and the rate of emission of solvent from openings in sack 23 can be controlled by the

pressure of solvent within sack 23 as by valve 25. In this connection, it will be noted that the straightening and concentration of filaments in portion 29 facilitates uniform distribution of the binder solvent through such portion.

When the binder is softened, the filaments in portion 29 move freely. Since portion 30 stretches portion 29 beyond its normal expansion length, portion 30 pulls and holds portion 29 in tension, and the filaments in portion 29 are further straightened when allowed to move freely. When the filaments are further straightened, the thickness of portion 29 is further decreased, and therefore, the filament concentration of portion 29 is increased. To further decrease the thickness of portion 29, mat 21 can then be passed through compressive conveyors 27 and 28 to further compress mat 21 and increase the filament concentration in portion 29. Compression assures the formation of a "skin-like" layer. In accordance with the present invention, the compression occurs primarily in portion 29 because the binder is in softened condition during the compression steps and the filaments have been straightened and concentrated in the manner aforescribed.

After the desired compression is attained, the binder can then be hardened by any convenient means, and in the method of the present example, the binder can be hardened by heating in oven 28, while mat 21 is in the desired compressed condition.

It will be understood that within the scope of the present invention, filamentous mats may be made having more than the two portions of differing angle of lay as herein-described. Further, in forming the condensed mat, the portions may be deposited on the drum in any desired order.

WHAT WE CLAIM IS:—

1. A method for making an expanded filamentous mat comprising feeding filaments from filament feeder means and depositing them on filament collector means by a combination of rectilinear and rotational motions at at least two different angles of lay relative to the axis of the rotational motion to form at least two filament portions, at least one of the portions comprising filaments deposited at a different angle of lay than the filaments deposited in at least one other portion of the mat, applying a binder to the mat, removing the filaments from the collector means, stretching the mat in a direction transverse to the general direction of lay of filaments in the mat to form an expanded filamentous mat, and compressing one of the portions of the mat and retaining said compressed portion in compressed condition.

2. A method according to claim 1 wherein two portions are deposited, each forming



one of the surfaces of the mat, the first portion comprising filaments deposited at a smaller angle of lay than the filaments in the second portion, and wherein the said second portion is compressed.

3. A method according to claim 2 including softening the binder after stretching the mat, and hardening the binder after compressing the second portion and while the second portion is in compressed condition.

4. A method according to claim 2 or 3 wherein the mat is stretched a sufficient amount to substantially straighten and concentrate the filaments of the second portion.

5. A method according to claim 2 wherein the filament collector means is a rotatable drum, the method comprising rotating the drum and reciprocating the filament feeder means along the drum at a first velocity to form the first portion and at a second velocity to form the second portion, and cutting the mat, after the binder has been applied, parallel to the axis of the drum and removing the mat from the drum as a sheet before stretching it.

6. The method of claim 5 wherein the total thickness of said second portions is not more than 30 per cent of the total thickness of said mat when said mat is removed from said drum.

7. The method of claim 5 wherein the angle of lay of said filaments of said second

portion are 5 to 40 per cent greater than the angle of lay of filaments of said first portion as said filaments are collected on said rotating drum.

8. The method of claim 5 including: stopping said filament feeder means for selected portions of time at selected intervals in the formation of said first portion of said filamentous mat.

9. The method of claim 5 wherein the binder applied to said mat is water soluble; applying water to said second portion of said mat to soften said binder after expanding said mat.

10. The method of claim 5 wherein: said stretching is effected until said filaments in said second portion are substantially straightened.

11. A method of manufacturing filamentous mats substantially as described herein with reference to the accompanying drawings.

12. A filamentous mat manufactured by a process in accordance with any one of the preceding claims.

For the Applicants:—
LLOYD WISE, BOULY & HAIG,
Chartered Patent Agents,
Norman House,
105—109 Strand,
London, W.C.2.



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