

PATENT SPECIFICATION

(11) 1212843

DRAWINGS ATTACHED

- (21) Application No. 52046/67 (22) Filed 15 Nov. 1967
(31) Convention Application No. 595 492
(32) Filed 18 Nov. 1966 in
(33) United States of America (US)
(45) Complete Specification published 18 Nov. 1970
(51) International Classification D 04 h 3/00
(52) Index at acceptance
B8G 1B 1D 4
D1R 5



(54) FILAMENTOUS MATS

(71) We, AMERICAN AIR FILTER COMPANY, INC., a Corporation organised and existing under the Laws of the State of Delaware, United States of America of 215, Central Avenue, Louisville 8, 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:—

The present invention relates to a method for making expanded filamentous mat.

One method of making an expanded filamentous mat which is well known in the art includes traversing a filament feeding apparatus back and forth axially along a downturning edge of a horizontally disposed rotating drum and feeding filaments, for example molten glass, from the filament feeding apparatus to the rotating drum. Filaments are collected on the rotating drum and the filament feeding apparatus is traversed back and forth along the downturning edge of the drum a plurality of times at selected traversing speeds so the filaments are drawn to the rotating drum to form a condensed mat having overlying layers of filaments. Each layer of the condensed mat includes filaments lying in approximate parallelism and the filaments of adjacent layers cross each other. The condensed filamentous mat is cut from the drum as a planar condensed mat, which is then drawn in a direction generally transverse the lay of filaments to stretch the mat lengthwise so the individual filaments are separated. Because of the characteristic disposition of filaments in the condensed mat, some of the filaments in each layer curl during the drawing operation, and the curled filaments increase the thickness of each layer of the mat so the over-all thickness of the expanded mat is greatly increased. The expanded mat is fluffy, is much longer and much thicker than the original condensed mat, and the average filament concentration of the mat is decreased because of the separation of the filaments which occurs during the expansion.

For certain applications it is desirable to provide a definite filament concentration in selected portions of a filamentous mat and in some such applications it is desirable to manufacture filamentous mats which include a thin skin-like layer of very high filament concentration at a selected location within the mat. Such skin-like layers, or layers of high filament concentration, provide support and dimensional stability to the fluffy portions of the expanded mat having low filament concentration. When such a product is used to filter a fluid stream to remove particulate matter from the fluid stream, the skin-like layer of high filament concentration can advantageously facilitate the removal of extremely fine particles from the fluid stream.

The method of the present invention provides means by which an expanded filamentous mat can be formed and the filament concentration in selected layers or at a selected location in the mat can be controlled in a straight-forward, economical manner without significant modification of conventional equipment. A compressed skin-like layer of extremely high filament concentration can be formed within an expanded mat and the location of the skin-like layer can be selected to provide desired characteristics in the finished product.

Accordingly this invention provides a method for making expanded filamentous mat, which method comprises feeding filaments from filament feeding means to filament collector means; collecting filaments on the collector means to form a condensed filamentous mat; applying a first binder on a first portion of the condensed filamentous mat; applying a second binder to a second portion of the condensed filamentous mat wherein the viscosity of the binder on one portion of the mat is greater than the viscosity of the binder on the other portion of the mat at a selected temperature; releasing the condensed

filamentous mat from the collector means to form a planar mat; stretching the planar mat in a direction transverse to the general direction of lay of the filaments to separate the filaments so that some of the filaments curl and expand the thickness of the mat to form an expanded filamentous mat; heating the expanded mat to the selected temperature to soften the binder on one portion of the mat; reorienting filaments of the portion of the mat where the binder is softened; and hardening the softened binder.

A preferred method in accordance with this invention is one wherein filaments are collected on the filament collector means at a selected angle of lay relative to a selected axis of the collector means to form the first portion of the condensed filamentous mat to which the first binder is applied and wherein other filaments are collected on the filament collector means at a second angle of lay relative to a selected axis of the collector means to form the second portion of the condensed filamentous mat to which the first binder is applied and wherein other filaments are collected on the filament collector means at a second angle of lay relative to the selected axis of the collector means to form the second portion of the condensed filamentous mat to which the second binder is applied.

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

Figure 1 shows a diagrammatic view of an apparatus for forming a condensed filamentous mat on a rotating drum;

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

Figure 3 is a diagrammatic plan view showing the expansion of a filamentous mat.

The apparatus for forming a condensed filamentous mat as shown in Figures 1 and 2 includes a filament feeder 1 which axially traverses a rotating drum 11, which can be rotated by means not shown, above and generally parallel to the down-turning edge (as viewed in plan) of the drum. Filaments of selected material, for example molten glass, are fed from orifices (not shown) in the bottom of feeder 1 to be attenuated by and collected upon rotating drum 11. The orifices in the bottom of feeder 1 can be arranged in any desired geometric configuration, for example in longitudinally extending rows to feed filaments to the drum on a selected pattern. The diameter of filaments 15 drawn from feeder 1 to drum 11 is influenced by the speed of rotation of drum 11, and the diameter and the temperature of the orifices.

As shown in Figures 1 and 2, tracks 8 are provided above the down-turning edge of drum 11 and filament feeder 1 can be driven back and forth along tracks 8 in reciprocatory traverses. Feeder 1 is cooperatively attached to an endless chain 12 which is

driven by a sprocket 3 turned by variable speed drive means 10. Endless chain 12 also turns around idler sprocket 7, where sprockets 3 and 7 are mounted a selected distance apart and can advantageously be mounted at opposite ends of drum 11. Chain 12 is cooperatively joined to feeder 1 by means of a pin 13 which nests in a vertically extending pin-receiving slot 14 of arm 2 which is joined to filament feeder 1. Pin 13 is free to move in a vertical direction in slot 14 while filament feeder 1 moves in a generally horizontal direction along tracks 8 in response to movement of chain 12.

As feeder 1 is reciprocated back and forth above the down-turning edge of drum 11, pin 13 moves with chain 12 in one horizontal direction between sprockets 3 and 7 to drive filament feeder 1 accordingly. At the end of a feeder traverse, pin 13 reaches one of the sprockets, for example, sprocket 3, and moves around the sprocket in a generally vertical direction in slot 14 so there is relatively little horizontal movement of feeder 1 as pin 13 moves around sprocket 3. As pin 13 leaves sprocket 3, feeder 1 is driven at the same horizontal speed as chain 12 but in a direction opposite to the direction of travel before pin 13 passed around the sprocket. It will be realized that a similar sequence of events occurs as pin 13 passes around each sprocket and therefore filament feeder 1 is driven back and forth along tracks 8 in reciprocatory traverses extending generally from sprocket 3 to sprocket 7 along the aforementioned down-turning edge of rotating drum 11.

The angle of lay filaments deposited on drum 11, which is the same as the angle of lay of the filaments of the planar mat removed from the drum, can be measured as the angle between a transverse axis of the drum and the projection of filament 15 on a plane passing longitudinally through the drum. The angle of lay is determined by the traversing speed of feeder 1 along the down-turning edge of drum 11 relative to the rotational speed of drum 11. It will be noted that the angle of lay of filaments 15 is measured in a first quadrant for those filaments deposited on drum 11 as feeder 1 traverses drum 11 in one direction and when the direction of travel of feeder 1 is in an opposite direction the angle of lay is measured in a mirror quadrant. It will therefore be understood that if the linear traversing speed of feeder 1 is the same for successive traverses in opposite directions along drum 11, the angle of lay of the filaments deposited on drum 11 is the same, even though the angles are measured in mirror quadrants for adjacent filament layers.

Assuming no change in speed of rotation of drum 11, the angle of lay of filaments deposited on drum 11 can be selectively changed by varying the linear traversing speed of

feeder 1. Increasing the feeder traversing speed increases the angle of lay of filaments on the drum, and therefore the angle of lay of filaments of the fully formed condensed planar mat subsequently removed from the drum. The angle of lay of the filaments in the planar mat determines the length to which the planar mat can be stretched during an expansion step wherein the mat is drawn in a direction transverse the lay of the filaments, and as is known in the art, the greater the angle of lay of filaments in the planar mat the shorter the ultimate length of the stretched mat.

During the stretching operation, the filaments of each layer of the condensed mat first separate and buckle or curl so the mat expands in thickness. If the mat is stretched far enough, the filaments or layers of filaments are stretched to their ultimate length, which is determined by the angle of lay of filaments in the condensed mat before expansion, and the filaments are drawn straight. The straightened filaments lose their curled configuration. Filaments in other layers or portions of the mat which were deposited at lesser angles of lay than the straightened filaments are not drawn to their ultimate length and remain curled to provide expanded fluffy portions of the expanded mat. If a condensed mat including layers of filaments at different angles of lay is expanded until the filaments deposited at the greater angle of lay are drawn to their ultimate length and are straightened, the resulting mat includes thin layers of substantially straightened filaments and fluffy layers of curled filaments corresponding to layers of filaments deposited at lesser angles of lay which are not straightened during the expansion.

A filamentous mat is formed on a collecting means, for example a rotating drum as shown in Figures 1 and 2, and different layers of the mat are sprayed with different advantageously selected binder substances. The binder can be applied, for example, by a sprayer 18 which traverses the drum during the deposition of the filaments. By the method of the present invention, the condensed mat can include filaments at only one angle of lay and the desired characteristics can be obtained by proper manipulation of the binder system or the mat formed on the drum can include layers of filaments at different angles of lay.

In one example, a condensed mat can be formed on drum 11 to include one first portion including at least one layer deposited when feeder 1 traverses drum 11 at a relatively high rate of speed so the filaments are deposited on drum 11 at a first angle of lay. The first portion is sprayed with a binder solution having a selected viscosity-temperature relationship. A second portion of the filamentous mat, including at least one layer

of filaments, is then formed when the filament feeder traverses the rotating drum at relatively low rate of speed, less than the average speed of the filament feeder during the formation of the first portion of the mat, so filaments are deposited at a lower angle of lay. The second formed portion of the filamentous mat is sprayed with a second selected binder also having a selected viscosity-temperature relationship. In accordance with the present invention, the relative viscosity relationship of the different binders is such that at a selected temperature the viscosity of one binder, the second binder in this example, is greater than the viscosity of the other binder, in this example the first binder, so that at the selected temperature, the first binder is softened to permit reorientation of filaments in the first formed portion of the filamentous mat while the second binder is in a relatively more viscous condition to restrict movement of filaments of the second portion.

It is to be noted that the second formed portion of the mat can also include groups of filaments formed by periodically stopping the traversing motion of feeder 1 during the formation of the second portion of the filamentous mat so filaments are drawn directly to the rotating drum at essentially a zero angle of lay and fall on top of one another in contiguous relation. The strands so formed are composed of multi-filaments and remain grouped in the form of multi-filament strands throughout the further processing of the mat. The grouped filaments can be considered as monofilaments and can be selectively distributed throughout the mat to control the filament density in selected portions of the mat.

The binder applied to a selected portion of the mat during the formation of the condensed mat may be softened after the is expanded to allow filaments of that portion to be freely or selectively reoriented. While the binder in one portion of the mat is softened, the binder in another portion of the mat is maintained in a relatively viscous condition to hold the filaments in their expanded orientation.

In the example of Figure 3, mat 20 is stretched to expand the mat as hereinbefore described and the expanded mat is passed through an oven 28 on a conveyor 23. The binder in one portion of the mat is softened to allow reorientation of the filaments in the one portion while the binder in the other portion of the filamentous mat remains in a highly viscous condition to prevent the reorientation of the filaments of the second portion.

The binder on the one portion which advantageously is softened at the selected temperature and is used in the formation of the one portion of the filamentous mat, can be, for example, composed of the reaction product of 1.7 parts of urea with one part of formaldehyde in a solution with solids

70

75

80

85

90

95

100

105

110

115

120

125

130

concentration approximately 65%. The binder on the other portion used in the formation of the other portion of the mat which has a higher viscosity at the selected temperature can for example be of the same general composition but with a higher solids concentration so the viscosity is higher at the selected temperature. The binder on the other portion can also be a thermosetting composition which is advantageously thermally reacted at the selected temperature while the binder on the one portion is softened.

The filamentous mat, including the one and the other formed portions, can be cut parallel to the longitudinal axis of drum 11 and removed from the drum as a condensed mat 20. In the example of the figures mat 20 includes at least one portion, or number of layers 21, deposited on drum 11 at increased angle of lay, and at least one portion, or number of layers 22, deposited at lesser angles of lay. Mat 20 can be drawn by hand or other suitable means in a direction transverse the general direction of lay of the filaments in the mat and during the stretching operation, mat 20 is lengthened in the direction of draw so the filament curl and the thickness of the mat 20 is increased to form an expanded mat 29. Expanded mat 20 includes expanded portion 21a, which results from the expansion of layer 21, and a portion 22a resulting from the expansion of portion 22 of mat. The expanded thickness of portion 21a is less than the expanded thickness of portion 22a because the increased angle of lay of filaments in portion 21 permits less curling and expansion than is experienced by layers 22 deposited on drum 11 at lesser angle of lay.

An expanded filamentous mat in accordance with the invention can include only curled fibers, or, as hereinbefore described where it is desired to form a skin-like layer in the final product, the condensed mat can include selectively distributed layers of straightened filaments. When this procedure is followed, the resulting stretched mat includes expanded layer of curly filaments and selectively distributed, relatively thin, layers of generally straight filaments.

In the example of the present invention, as shown in Figure 3, oven 28 includes heat source 27 to heat the expanded mat to the selected temperature so the binder in the first portion 21a is softened, and the filaments of the portion of the expanded mat including the softened binder are reoriented while the binder is in softened condition. In the example of Figure 3, if mat 20 is not stretched to the ultimate length of the filaments of portion 21 the filaments of layer 21a can be compressed to selectively decrease the thickness of layers 21a. Figure 3 is an illustration of an example where the filaments of the expanded mat are not stretched to the ultimate

length so there is compression of layers 21a when the binder is softened.

At 24 the binder in portion 21a begins to soften and compression begins as shown by the decreasing thickness of layer 21a. At point 26, as indicated, the binder has been softened and compression is complete so that the filamentous mat emitted from oven 28 includes an expanded portion 22a and a compressed portion 21a. Compression means can be provided to facilitate compression of the mat, or (it has been recognized that by the method in accordance with the present invention as shown in the example of Figure 3, the weight of layers 22a can be utilized to provide the compressive force necessary to decrease the thickness of portion 21 a selected degree so additional equipment is not necessary to accomplish the compression.

If the filaments of layer 21a of expanded mat 29 have been stretched to their ultimate length, softening the binder facilitates reorientation of the already essentially straight filaments to provide more uniform configuration and distribution so there is correspondingly less decrease in the thickness during compression.

After the compression of the filamentous mat, the binder can be hardened in a convenient manner, for example, by heating the binder (to cure the resin) or by cooling the binder to permit solidification. The filamentous mat is then packaged for further processing.

WHAT WE CLAIM IS:—

1. A method for making expanded filamentous mat, which method comprises feeding filaments from filament feeding means to filament collector means; collecting filaments on the collector means to form a condensed filamentous mat; applying a first binder on a first portion of the condensed filamentous mat; applying a second binder to a second portion of the condensed filamentous mat wherein the viscosity of the binder on one portion of the mat is greater than the viscosity of the binder on the other portion of the mat at a selected temperature; releasing the condensed filamentous mat from the collector means to form a planar mat; stretching the planar mat in a direction transverse to the general direction of lay of the filaments to separate the filaments so that some of the filaments curl and expand the thickness of the mat to form an expanded filamentous mat; heating the expanded mat to the selected temperature to soften the binder on one portion of the mat; reorienting filaments of the portion of the mat where the binder is softened; and hardening the softened binder.

2. A method according to claim 1 wherein filaments are collected on the filament collector means at a selected angle of lay relative to



concentration approximately 65%. The binder on the other portion used in the formation of the other portion of the mat which has a higher viscosity at the selected temperature can for example be of the same general composition but with a higher solids concentration so the viscosity is higher at the selected temperature. The binder on the other portion can also be a thermosetting composition which is advantageously thermally reacted at the selected temperature while the binder on the one portion is softened.

The filamentous mat, including the one and the other formed portions, can be cut parallel to the longitudinal axis of drum 11 and removed from the drum as a condensed mat 20. In the example of the figures mat 20 includes at least one portion, or number of layers 21, deposited on drum 11 at increased angle of lay, and at least one portion, or number of layers 22, deposited at lesser angles of lay. Mat 20 can be drawn by hand or other suitable means in a direction transverse the general direction of lay of the filaments in the mat and during the stretching operation, mat 20 is lengthened in the direction of draw so the filament curl and the thickness of the mat 20 is increased to form an expanded mat 29. Expanded mat 20 includes expanded portion 21a, which results from the expansion of layer 21, and a portion 22a resulting from the expansion of portion 22 of mat. The expanded thickness of portion 21a is less than the expanded thickness of portion 22a because the increased angle of lay of filaments in portion 21 permits less curling and expansion than is experienced by layers 22 deposited on drum 11 at lesser angle of lay.

An expanded filamentous mat in accordance with the invention can include only curled fibers, or, as hereinbefore described where it is desired to form a skin-like layer in the final product, the condensed mat can include selectively distributed layers of straightened filaments. When this procedure is followed, the resulting stretched mat includes expanded layer of curly filaments and selectively distributed, relatively thin, layers of generally straight filaments.

In the example of the present invention, as shown in Figure 3, oven 28 includes heat source 27 to heat the expanded mat to the selected temperature so the binder in the first portion 21a is softened, and the filaments of the portion of the expanded mat including the softened binder are reoriented while the binder is in softened condition. In the example of Figure 3, if mat 20 is not stretched to the ultimate length of the filaments of portion 21 the filaments of layer 21a can be compressed to selectively decrease the thickness of layers 21a. Figure 3 is an illustration of an example where the filaments of the expanded mat are not stretched to the ultimate

length so there is compression of layers 21a when the binder is softened.

At 24 the binder in portion 21a begins to soften and compression begins as shown by the decreasing thickness of layer 21a. At point 26, as indicated, the binder has been softened and compression is complete so that the filamentous mat emitted from oven 28 includes an expanded portion 22a and a compressed portion 21a. Compression means can be provided to facilitate compression of the mat, or (it has been recognized that by the method in accordance with the present invention as shown in the example of Figure 3, the weight of layers 22a can be utilized to provide the compressive force necessary to decrease the thickness of portion 21 a selected degree so additional equipment is not necessary to accomplish the compression.

If the filaments of layer 21a of expanded mat 29 have been stretched to their ultimate length, softening the binder facilitates reorientation of the already essentially straight filaments to provide more uniform configuration and distribution so there is correspondingly less decrease in the thickness during compression.

After the compression of the filamentous mat, the binder can be hardened in a convenient manner, for example, by heating the binder (to cure the resin) or by cooling the binder to permit solidification. The filamentous mat is then packaged for further processing.

WHAT WE CLAIM IS:—

1. A method for making expanded filamentous mat, which method comprises feeding filaments from filament feeding means to filament collector means; collecting filaments on the collector means to form a condensed filamentous mat; applying a first binder on a first portion of the condensed filamentous mat; applying a second binder to a second portion of the condensed filamentous mat wherein the viscosity of the binder on one portion of the mat is greater than the viscosity of the binder on the other portion of the mat at a selected temperature; releasing the condensed filamentous mat from the collector means to form a planar mat; stretching the planar mat in a direction transverse to the general direction of lay of the filaments to separate the filaments so that some of the filaments curl and expand the thickness of the mat to form an expanded filamentous mat; heating the expanded mat to the selected temperature to soften the binder on one portion of the mat; reorienting filaments of the portion of the mat where the binder is softened; and hardening the softened binder.

2. A method according to claim 1 wherein filaments are collected on the filament collector means at a selected angle of lay relative to

a selected axis of the collector means to form the first portion of the condensed filamentous mat to which the first binder is applied and wherein other filaments are collected on the filament collector means at a second angle of lay relative to the selected axis of the collector means to form the second portion of the condensed filamentous mat to which the second binder is applied.

10 3. A method according to claim 2 wherein the first angle of filament lay and the second angle of filament lay are equal.

15 4. A method according to claim 2 wherein the first angle of filament lay is greater than the second angle of filament lay.

20 5. A method according to any one of the preceding claims wherein the second portion of the mat is sprayed with a second binder having a viscosity greater than the viscosity of the first binder at the selected temperature.

25 6. A method according to claim 5 wherein the expanded mat is heated to the selected temperature to soften the binder in the first portion of the mat, wherein the first portion of the mat is compressed while the first binder is in a softened condition; and wherein the first binder is hardened to maintain the first portion of the mat in a compressed condition.

30 7. A method according to claim 4 or any claim when appendant thereto wherein the condensed mat is stretched in a direction transverse to the direction of lay of the filaments of the condensed mat until the filaments of the first portion of the mat are straightened and the filaments of the second portion of the mat remain in curled configuration.

40 8. A method according to any one of the preceding claims wherein the filament collector means comprises a drum; and wherein the filaments are collected on the drum by rotating the drum and by reciprocating the feeder means longitudinally back and forth along a down-turning edge of the rotating drum to distribute filaments longitudinally along the

rotating drum, the filaments being collected upon the rotating drum as the feeder means is reciprocated back and forth in successive traverses along the down-turning edge of the rotating drum. 50

9. A method according to any one of the preceding claims wherein the condensed filamentous mat is removed from the collector means by being slit in the axial direction 55 of the collector means.

10. A method according to claim 8 or claim 9 wherein the filament feeder means is traversed at a relatively greater speed during the formation of the first portion than during the formation of the second portion so that the average angle of lay of filaments collected on the drum during the formation of the first portion is greater than the average angle of lay filaments collected on the drum during the formation of the second portion; wherein the filamentous mat is stretched until filaments of the first portion are drawn straight; wherein the expanded filamentous mat is heated to the selected temperature to soften the binder of the first portion, while binder in the second portion remains in a relatively viscous condition; and wherein the binder in the first portion is hardened. 60 65 70

11. A method according to any one of the preceding claims wherein a solution of the first binder is sprayed onto the first portion of the mat. 75

12. A method for making expanded filamentous mat substantially as herein described and with reference to the accompanying drawing. 80

13. Expanded filamentous mat whenever produced by the method claimed in any one of the preceding claims. 85

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

Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1970.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.



* C L M S *