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METHOD OF FORMING FLUFFED FILAMENTARY
MASSES AND ARTICLE PRODUCED THEREBY

2,644,780

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2 Sheets-Sheet 1

Fig. 1

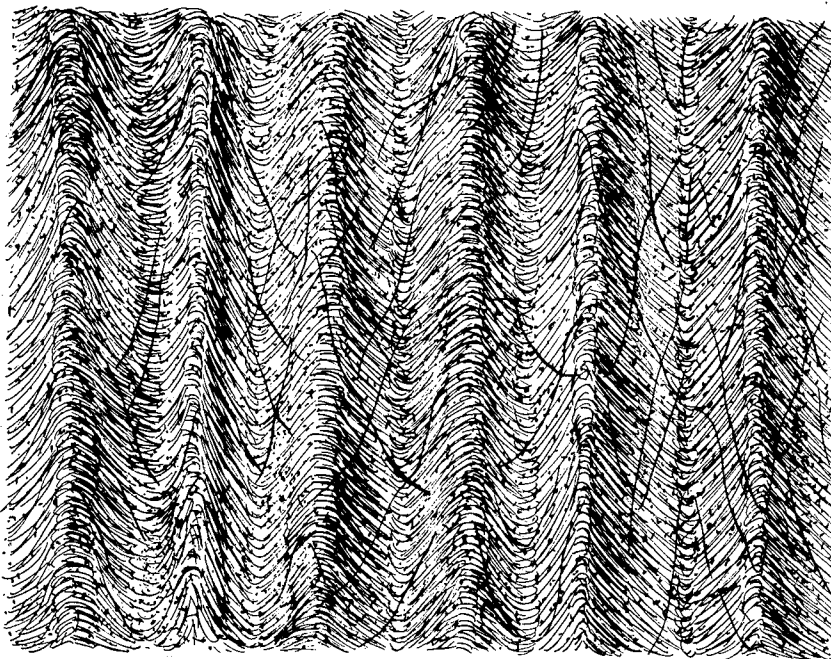
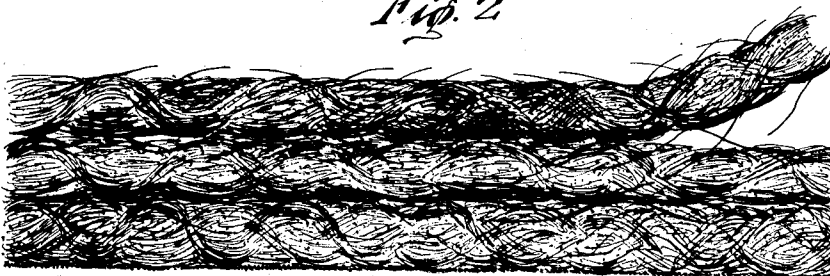


Fig. 2



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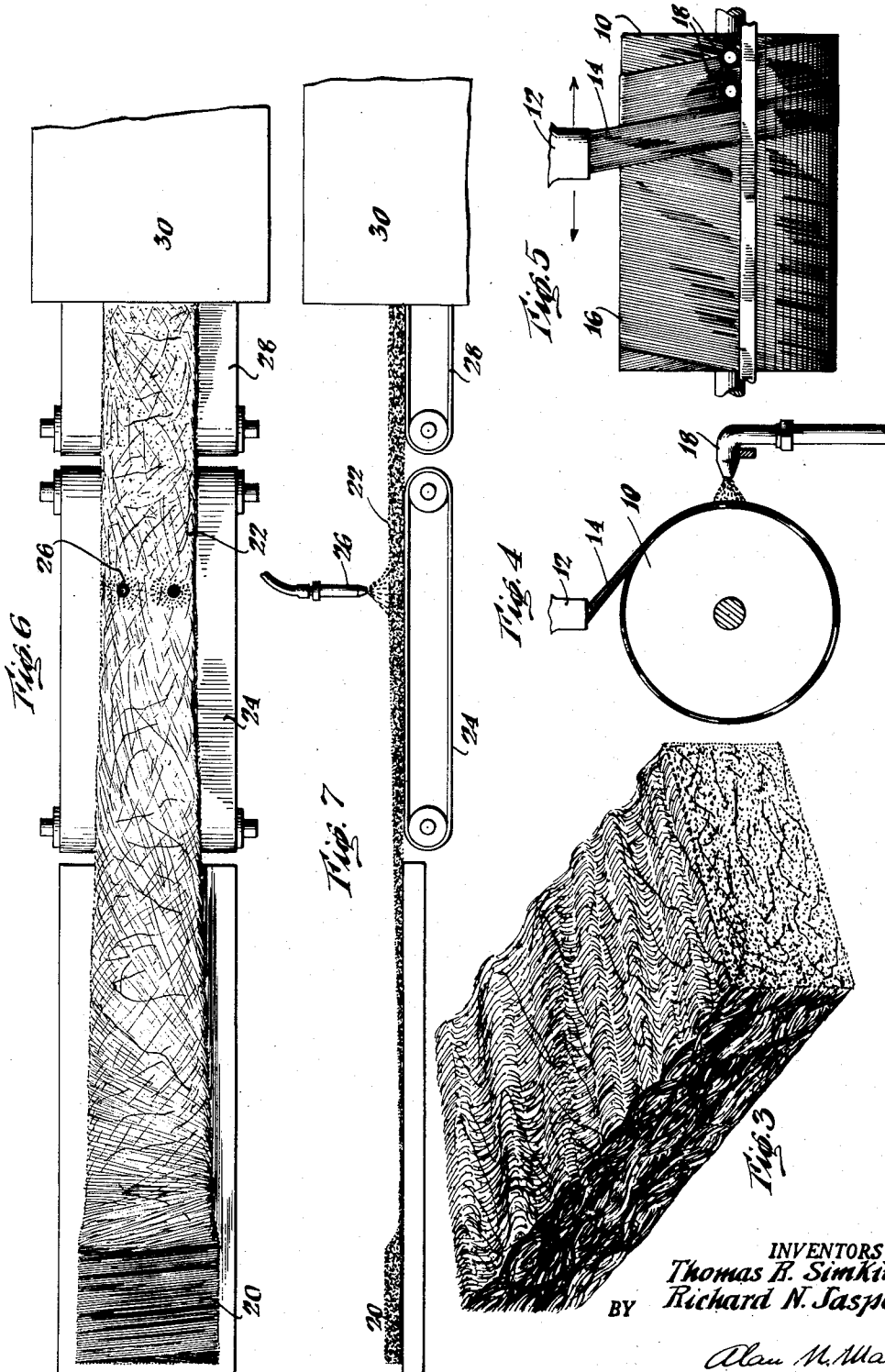
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METHOD OF FORMING FLUFFED FILAMENTARY MASSES AND ARTICLE PRODUCED THEREBY

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8 Claims. (Cl. 154—92)

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This application relates to the preparation of a mass of glass fibers or filaments in which many or most of the fibers are given a sufficient twist or wave-like curl so that the entire mass has an open fluffy appearance (though rather stiff and resilient to the touch) as distinguished from an ordinary glass mat where the fibers are held together in close contact. Such a mass of fibers has many uses of which the most important now appears to be its use as an air filter medium in air conditioning systems and the like.

This application is based upon our discovery that the fibers can be given this curling effect if they are laid down on a rapidly rotating drum in a series of layers, with each layer made up of a number of strata of parallel fibers but with the fibers in the different layers crossing each other at a very slight angle, and if steps are taken to increase the surface tension or adhesion between the parallel fibers in each layer so that these parallel fibers will tend to resist separation as the mat is expanded.

When this is done, and the fiber mass is cut from the drum and expanded, the parallel fibers within each layer are pulled apart throughout portions of their length but the resistance of this pulling or separating apparently causes the fibers to bend, buckle and wave so that the mass is relatively open and fluffy in appearance. In some cases the surface layers will be flatter than the inside layers, particularly the bottom layer which ordinarily rests on a flat surface while being formed.

Almost any type of binder can be used to increase the adhesion between the parallel fibers in a given layer. In fact, simply adding moisture will give this effect to a limited extent. However, we prefer to use a more permanent binder and preferably this binder is sprayed or otherwise applied on the roller or drum on which the layers of fiber are accumulated. This treatment has the advantage that it is easy to control the amount of binder applied and this can be kept quite uniform through the entire mass.

The binder employed may be any of the binders commonly used with glass fibers and may be of either the soluble or insoluble type. For example the soluble binders are such materials as starch or glue. Ordinarily we prefer to use a binder which can lock the fibers in place such as a thermosetting resin. In this category are the phenolic resins, synthetic latex, urea and melamine resins and the like. Thermoplastic resins such as styrene or polyvinyl compounds may also be employed

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In laying the fibers down on the drum the best method of operating is to draw out a large number of parallel fibers from a single furnace. For example, about 100 parallel fibers may be drawn out from the furnace in a form somewhat like a band with a distance of from 12 to 14 inches between the outside fibers. This furnace is caused to move slowly across the face of the drum as the drum rotates rapidly so that a large number of rotations of the drum will have occurred before the fiber on the back edge of the band from the furnace moves up to the point where the first fiber from the furnace was applied to the drum when the operation started. For example, if the furnace is 14 inches long and advances only about $\frac{1}{4}$ -inch for each rotation of the drum, then at any given point on the drum over which the entire furnace passes, there will be about 56 separate strata of glass fibers laid down all of which are parallel. On the return movement another 56 strata of fibers will be laid down to make another separate layer of parallel fibers. Ordinarily the drum on which the fibers are collected is quite large, say, about 12 feet in circumference and it may rotate at a speed of about 200 revolutions per minute. With a drum of this proportion and this speed a 14-inch furnace can be operated on a traverse ranging anywhere from $\frac{1}{8}$ -inch per revolution up to 3 inches per revolution. We have found in general that it is best to operate with a furnace moving somewhere between $\frac{1}{4}$ to $2\frac{1}{2}$ inches for each revolution of the drum. The number of layers of glass is not critical though in general it should exceed twenty-five. Ordinarily the number will be very much greater as economy demands that a relatively thick mass be built up on the drum, and usually a relatively thick final sheet is desired. It is apparent that the condensed mat formed by the operation described above is composed of a plurality of layers of filaments with the filaments extending in the same general direction across the mat but with filaments of adjacent layers crossing at acute angles.

If the binder is applied to the fibers prior to expansion, by spraying the binder during accumulation on the drum, the amount of binder is not critical but it will ordinarily be found that about from 8% to 15% by weight of binder is the maximum that can conveniently be applied in this manner, for the high speed of rotation of the drum will tend to throw the binder off by centrifugal force. In some cases as little as 2% of binder may be sufficient, but if more is

desired, additional quantities of binder can be applied later as described below.

In place of applying the binder as the glass is accumulated on the drum, we find that the entire mat still in condensed form can be immersed in binder and any excess blown or drawn off, or the mat may be partly expanded, then immersed in or sprayed with binder with the excess sucked off and the expansion continued. In any of these cases at least part of the expansion takes place after the binder is added to increase the adhesion between the fiber bundles.

When the fiber is cut from the drum and expanded in a direction generally transversely of the lay of the fibers, it will be found that the curling tendency starts almost as soon as the layers of parallel fibers start to open up, but the best effects are had when the mat is given a relatively large expansion, say to a length in excess of twenty times its original length and preferably as much as fifty times its original length. For example a good expansion is one where a mat having an initial length of 6 feet in the direction of expansion is expanded to a total length of from 300 to 540 feet. If too much expansion is applied, the total area will not be materially increased but the mat will tend to narrow to compensate for increased length. In general, it will be found that the area of the initial mat cannot be expanded much more than 30 times its original area.

When the mass has been expanded, it will be noted that the glass appears to form a series of superimposed wavy layers which give the desired resiliency but are sufficiently entangled to hold the mass together. In fact, the mat can, if desired, be split rather uniformly between its faces by stripping off separate layers. We believe that this structure results from the fact that the fibers are laid down in layers with each layer made up of many strata of parallel fibers and that the peculiar curly effect is largely the result of expansion and relative movement of the parallel fibers within each layer.

As stated, we prefer to apply binder to the fibers while they are being laid down on the drum, as this gives a uniformity of application. Ordinarily, however, it will be found that it is not feasible to apply sufficient binder in this way to give the finished mat its desired characteristics. In such case it ordinarily will be found desirable to increase the stiffness of the mat by adding additional binder after expansion has taken place and before the final drying operation. This can be done by any of the methods ordinarily used for applying binder to expanded glass mats, as by spraying on the binder or by immersing the mat in solution or suspension in the binder and removing excess binder in any desired manner. A good final product for use in air filters may have anywhere from 8% to 60% by weight of binder (based on the weight of the glass) included in it. The principal thing is to have enough binder to lock the fibers together where they cross and contact each other. If this additional binder is applied by spraying after expansion it tends to increase the concentration on the top surface, which stiffens this surface against collapse. The bottom surface which rests on a stationary or moving support naturally tends to be flat.

After the mat has been expanded it is taken through a drier to drive off any excess moisture and if a thermosetting resin has been used, it can be cured or set at this time. It is understood

that the resin used in liquid form either for spraying on the mat or for immersing the mat is an unset resin.

Some idea of the density of our mat can be had from the fact that a mat prepared for use as an ordinary air filter will be so light and open that it may weigh only from 1½ to 8 ounces per cubic foot.

Our invention may be understood from the following example, reference being had to the accompanying drawings in which Fig. 1 is a plan view of a mat made in accordance with our invention; Fig. 2 is a side view of this mat with a group of layers separated; Fig. 3 is a perspective view of the mat; Fig. 4 is a section through a drum on which the glass fibers are wound; Fig. 5 is a face view of this drum; Fig. 6 is a plan view of an expander for expanding the mat wound on the drum and Fig. 7 is a side view of such expander.

Referring to Figs. 4, 5, 6 and 7, the glass was accumulated on a drum 10 four feet in diameter and six feet long rotating at a speed of 200 revolutions per minute. A furnace 12 with 100 glass fibers (as indicated at 14) running from it traversed the face of the drum 10 at a speed such that it advanced 1½ inches for each revolution of the drum. In the drawings this movement is greatly exaggerated to indicate the nature of the movement. Actually the glass fibers on the drum were substantially parallel as indicated by the figures stated above. The formation of glass on the drum 10 was maintained until the mat 16 on the drum weighed about 100 pounds and during all this time spray nozzles 18 were moved slowly back and forth across the face of the drum spraying on the accumulated glass a light spray of a standard form of liquid phenolic resin (a resin which was maintained in a water-soluble state and kept relatively fluid with the water present). After sufficient fiber had accumulated on drum 10, mat 16 was cut across the face of the drum and laid out flat to form a mat measuring approximately 6 feet across the fibers by 12 feet in the direction of the fibers. An unexpanded portion of this mat is indicated at 20 in Figs. 6 and 7. This mat was then expanded along a line running approximately at right angles to the fibers as indicated in Figs. 6 and 7 to give a mat approximately 450 feet long. A space of from 10 to 15 feet was provided between the point of pull on the fibers as indicated at 22 and the unexpanded portion 20, so that the mat could expand progressively. A moving screen 24 supported the fibers at this time and during this expansion additional binder was sprayed on the top surface as indicated at 26 in an amount sufficient so that the final weight of binder was between 40% and 60% of the weight of the glass. The expanded mat was then taken up by conveyor 28 to a drier 30 where it was dried at a temperature of about 300° F. and cut into separate pieces of desired size.

The resulting product was a resilient, open mass of stiffened glass fiber having a weight of between 1½ and 8 ounces per cubic foot adapted for use in air filters and the like consisting of a plurality of superimposed layers of waved, entangled but non-compacted glass fibers with the fibers of the various layers sufficiently entangled with each other to hold the mass together. This mass contained plastic binder amounting to between 30% and 60% of the weight of the glass which served to lock the fibers together at their intersection and stiffen them to give resilience to

the mass. In cases where the binder was applied only as the glass fibers were first being accumulated on the drum the amount of fiber ranged down to 8% of the weight of the glass. The fibers in the product were relatively long, that is, a major proportion of them would run from one edge of the cut piece to another edge either adjacent or opposite and only a minor proportion (as where fibers had been broken) would show ends within the mass.

In Figs. 1 to 3 we have endeavored to illustrate a mat made in accordance with our invention in the accompanying drawing but have found the article exceedingly difficult to depict since the details of the construction are represented by myriads of tiny fibers which cannot be shown separately. However, we have endeavored in the drawing to give some indication of the nature of the product.

The representation in Fig. 2 is more or less diagrammatical, as in fact the layers do not separate quite as clearly as indicated in that drawing, as the entanglement between the layers is caused by the very fine fibers which are hard to illustrate.

It is understood that the examples given are intended to be illustrative only and not to limit the nature of our invention.

What we claim is:

1. The method comprising forming a mat of a plurality of layers of filaments, with the filaments extending generally transversely of the mat and with the filaments of adjacent layers crossing at acute angles, drawing the mat in a direction at right angles to the general lay of the filaments to expand the mat, applying a minor proportion of an unset binder to the mat between the time that the mat is partly formed and the time when it has been partly expanded, continuing the drawing of the mat wet with such binder on it until the layers of the mat assume a corrugated or undulatory form, applying additional unset binder to the mat and setting the binder.

2. A product comprising a plurality of superposed layers of glass filaments, with the filaments of adjacent layers in crossing relationship, the layers lying substantially parallel to one another and each layer being approximately uniform, contiguous undulations projecting above and below the median plane of the layer and extending at an angle to the filament directions, superposed layers being tied together by a multiplicity of interconnecting filaments, a binder bonding said filaments into a substantially unitary body, with the concentration of binder being greater at the top of such product than at the bottom whereby the top surface of the structure is stiffened against collapse.

3. A method comprising forming a condensed mat of a plurality of layers of filaments with the filaments of all layers extending in the same general direction across the mat but with filaments

of adjacent layers crossing at slight angles, expanding the mat in a direction transversely of the general lay of the filaments in the condensed mat until an open fluffy mass of waved filaments is formed, applying an unset binder to the open fluffy mass and setting the binder.

4. A method comprising forming a condensed mat of a plurality of layers of filaments with the filaments of all layers extending in the same general direction across the mat but with filaments of adjacent layers crossing at slight angles, expanding the mat in a direction transversely of the general lay of the filaments in the condensed mat until an open fluffy mass of waved filaments is formed, applying an unset binder to the mat during expansion thereof, and setting the binder after expansion is completed.

5. A method comprising forming a condensed mat of a plurality of layers of filaments with the filaments of all layers extending in the same general direction across the mat but with filaments of adjacent layers crossing at slight angles, applying a liquid to the filaments of the condensed mat, expanding the mat in a direction transversely of the general lay of the filaments in the condensed mat until an open fluffy mass of waved filaments is formed, applying an unset binder to the open fluffy mass and setting the binder.

6. A method comprising forming a condensed mat of a plurality of layers of filaments with the filaments of all layers extending in the same general direction across the mat but with filaments of adjacent layers crossing at slight angles, applying a liquid to the filaments of the condensed mat, expanding the mat in a direction transversely of the general lay of the filaments in the condensed mat until an open fluffy mass of waved filaments is formed, applying an unset binder to the mat during expansion thereof, and setting the binder after expansion is completed.

7. The method specified in claim 5 wherein said liquid comprises an unset binder.

8. The method specified in claim 6 wherein said liquid comprises an unset binder.

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