Oct. 25, 1949. R. E. SLACK ET AL 2,486,217

METHOD AND APPARATUS FOR EXPANSION OF FIBROUS MATS

Filed July 20, 1945 2 Sheets-Sheet 1

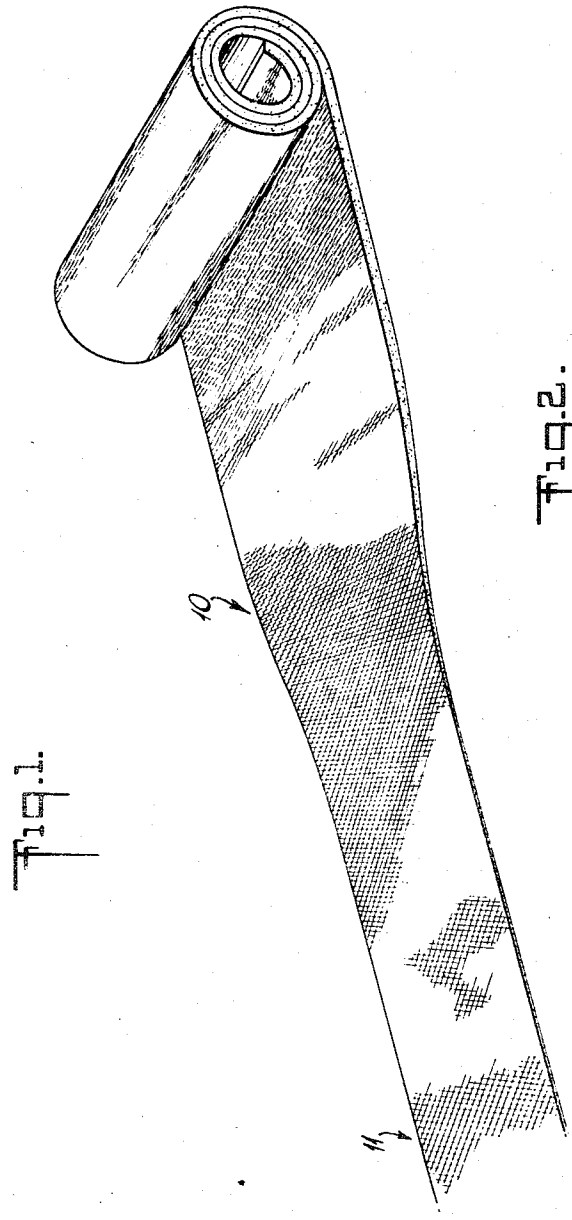


Fig. 1.

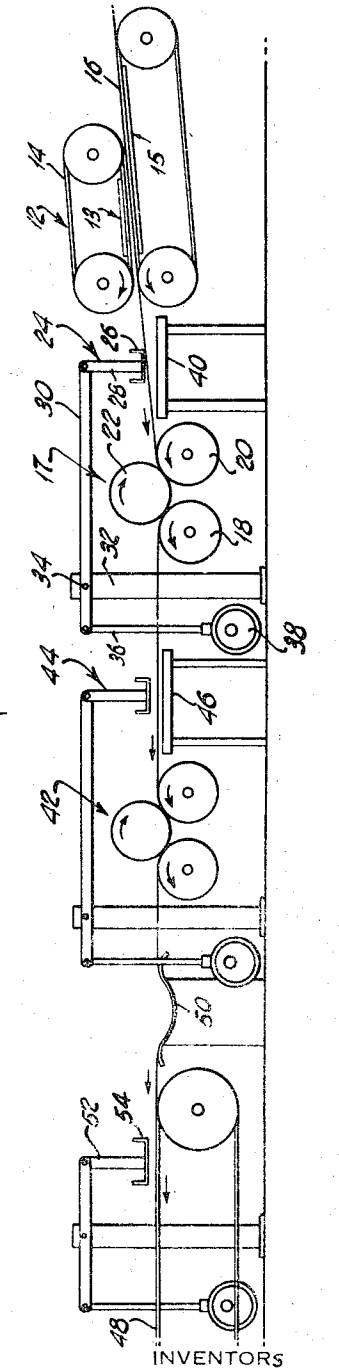


Fig. 2.

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Fig. 3.

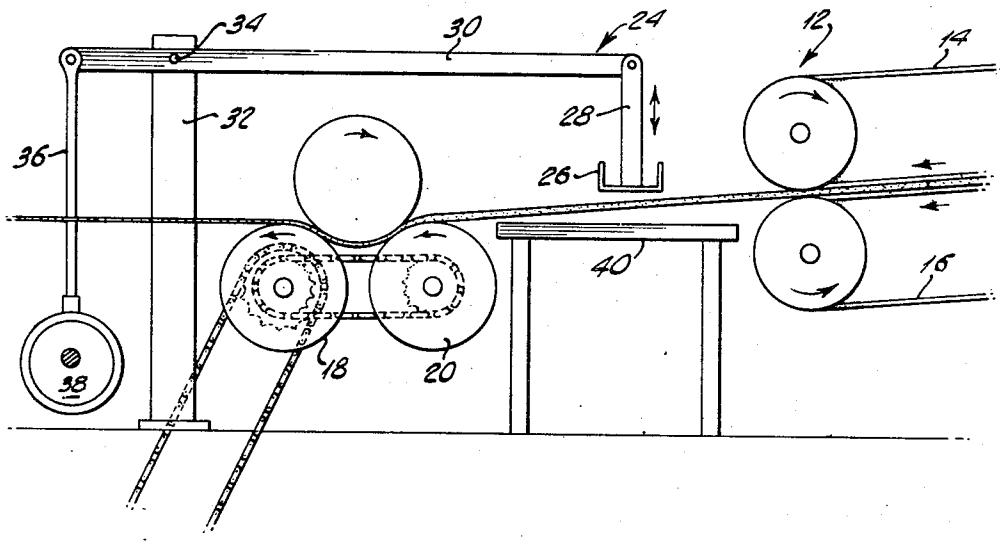
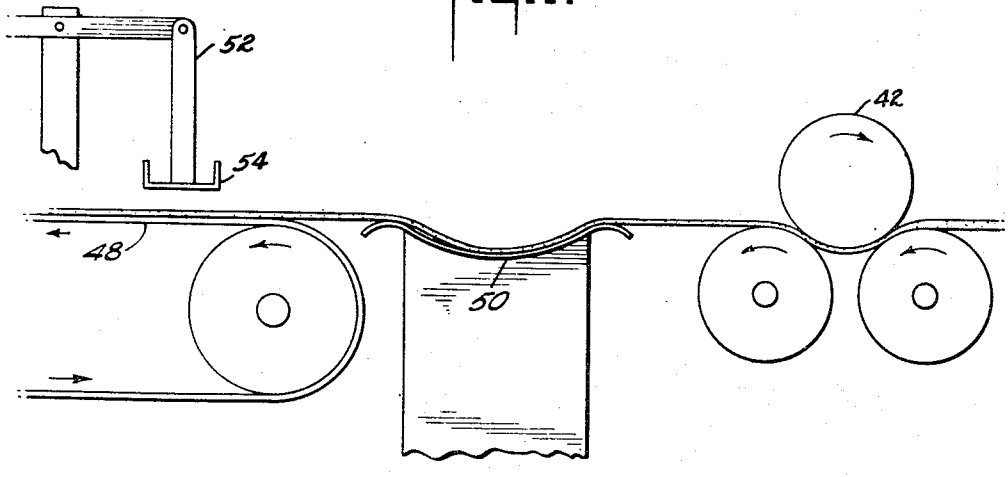


Fig. 4.



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METHOD AND APPARATUS FOR EXPANSION OF FIBROUS MATS

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18 Claims. (Cl. 28—71.3)

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The instant invention relates to a method and apparatus for expanding or drafting a condensed fibrous mat to reduce its thickness and to convert it to a more open, porous state. The invention is particularly concerned with the expanding or stretching of condensed mats of the type built up as a plurality of layers or strata of continuous glass filaments on a drawing drum or the like, with the filaments of the layers inter-crossed. The mats are produced by a method which involves the drawing of continuous glass fibers from one or more furnaces reciprocated longitudinally of a drawing drum which is driven at high speed relatively to the rate of reciprocation of the furnace whereby the strands of the several layers intersect at acute angles. When the mat is built up to the desired thickness it is removed by severing it longitudinally of the drum and peeling it from the drum.

Attempts have previously been made to expand such mats to obtain a thinner and more open, fibrous layer. These have required the stretching of the condensed mat between spaced pairs of rolls or belts with the forward pair driven at a higher rate of speed than the rearmost pair. The mat is disposed with the fibers lying generally at right angles to the travel of the mat whereby the mat is drawn or drafted in a direction substantially perpendicular to the original lay of the fibers. These operations expand the mat in a manner similar to that of the expansion of a "lazy tongs," the angles between the fibers opening to increase the porosity and to reduce the density and thickness of the mat. This method, although employed to a substantial extent, has not been entirely satisfactory. It has been found that at various points the fibers resist separation, with the result that the stretched mat contains unexpanded fiber agglomerations termed "ropes." The lack of uniformity of the mat, due to the presence of such ropes and also to the presence of wrinkles and other surface imperfections, has greatly reduced the value of the expanded mats for many uses where uniformity of structure, density and thickness are of primary importance.

A principal object of the invention is the provision of an improved apparatus and method for expanding condensed mats of the type referred to above and, more particularly, to a method and apparatus which will overcome the noted disadvantages of prior methods.

Another object of the invention is the provision of an apparatus and method which will produce an expanded product from a condensed mat of inter-crossed fibers, the product being free from fiber agglomerations or "ropes," and similar defects causing nonuniformity of structure. The product furthermore is of relatively uniform width, thus facilitating subsequent processing and cutting operations.

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A further object of the invention is the provision of a method and apparatus which subjects the mat to vibration during the expanding operation to facilitate the uniform opening of the mat.

A still further object of the invention is the provision of an apparatus and method of the type referred to in which the expanded mat is subjected to a further vibrating action to relieve strains in the mat developed during stretching and which tend to cause wrinkles and other surface imperfections.

Our invention will be more fully understood and further objects and advantages thereof will become apparent when reference is made to the more detailed description of a preferred embodiment thereof which is to follow and to the accompanying drawings in which:

Fig. 1 is a diagrammatic, perspective view of a mat of inter-crossed glass filaments or the like, illustrating the condition of the mat before and after stretching;

Fig. 2 is a diagrammatic view illustrating the preferred apparatus and method of the invention;

Fig. 3 is an elevational view on an enlarged scale of a portion of the apparatus of Fig. 1; and

Fig. 4 is a view similar to Fig. 3 of another portion of the apparatus.

Referring now to the drawings, a condensed fibrous mat of the type employed with the instant invention is illustrated at 10. The mat is that obtained by drawing continuous glass filaments and collecting them on a drum in a multiplicity of inter-crossed strata as referred to above. Mats produced by other apparatus and methods but of similar structure may, of course, be employed. The mat, after removal from the accumulating drum and division into strips of convenient widths, may be transferred, either in rolled form as shown or flat on a pallet, to equipment embodying the instant invention for the stretching operation.

Fig. 1 diagrammatically illustrates the effect of the expanding operation on the condensed fiber mat. As shown, the angular relationship between the fibers is altered as the mat is drawn or stretched to produce the much thinner, open, reticulated structure indicated at 11. The apparatus for producing these results comprises (see Figs. 2, 3 and 4) a feeding means indicated generally at 12 which, in its preferred embodiment, comprises opposed conveyor belts 14 and 16 driven in the direction indicated by the arrows. One or both of the conveyor belts, preferably the upper belt, is carried by an adjustable mounting of suitable type whereby the bight between the belts may be regulated to a width which is somewhat less than the thickness of the mat to be expanded in order that the belts may firmly grasp the mat therebetween. Plates 13 and 15 are preferably supported in substantial contact with the adja-

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cent reaches of the belts to prevent their yielding. Conveyor belts 14 and 16 may be of any conventional belting material which provides smooth, continuous surfaces for contact with the condensed, fibrous mat for a reason to be more fully explained.

Forwardly of conveyor belts 14 and 16 a drafting or drawing device 17 is provided comprising in its preferred embodiment driven rolls 18 and 20 and idler roll 22. Rolls 18 and 20 are supported on parallel, substantially horizontal shafts spaced apart sufficiently to define a gap between the rolls, the mat passing over rolls 18 and 20 and the gap therebetween. Roll 22, which is a free roll, rests on the mat over the gap to maintain the mat in frictional contact with rolls 18 and 20 and is rotated by its contact with the mat.

An apparatus indicated generally at 24 for vibrating the mat is mounted for operation on the mat intermediate the feeding and drafting devices 12 and 17 respectively. In its preferred embodiment vibrator 24 comprises a device for subjecting the mat to repeated impacts on one or both faces. In the construction shown the vibrator includes a flat blade 26 extending the width of the mat and mounted for reciprocating or oscillating movement into and out of contact with the mat at close intervals. Blade 26 may be carried by an arm 28 fixed to an arm 30 which in turn is pivotally mounted on post 32 supported from the frame of the machine. Arm 30 is rocked on its pivot 34 by means of connecting rod 36 and eccentric 38 or other suitable device. A plate 40 extends substantially the distance between the feeding device 12 and the drafting rolls and for the full width of the mat. Preferably the plate is at an angle to the plane of the mat, the end of the plate adjacent the drafting rolls being relatively close to the mat, say, about ¼'' below the level of the mat, and the opposite end being a substantially greater distance from the mat, say, 1½''–2''. The spacing of plate 40 from the bottom of the mat when the latter is out of contact with the blade is correlated with the length of stroke of spanker arm 28. That is, plate 40 is positioned so that when blade 26 is in its lowermost position the mat is carried or driven into contact with the plate. The plate thus serves, in effect, as a member for impacting the under surface of the mat.

The drafting or expanding operation may be performed in a single stage between feeder 12 and drafting device 17 but preferably a multiple stage operation is employed as illustrated particularly in Fig. 2. For this purpose a second drafting device 42, preferably of the same type as device 17, is mounted on the frame structure and a second vibrating apparatus 44, preferably of similar type to apparatus 24, is mounted for operation on the fibrous mat intermediate the two drafting devices. A plate 46 underlies the mat at the position of the second vibrator and is spaced from the mat a sufficient distance to be contacted by the mat when the latter is thrown or forced downwardly by the blade of the vibrator.

A conveyor belt 48 is located forwardly of the second drafting device. Conveyor 48 is mounted on suitable driven rolls for travel in the direction indicated by the arrow and leads to or through equipment for further processing the mat, such equipment forming no part of the instant invention.

A supporting table 50, preferably concave in cross section and extending the width of the mat, is located between drafting device 42 and conveyor 48, the table allowing the mat to form a shallow loop on its way to the conveyor.

A third vibrator 52 is mounted to operate on the expanded mat supported on conveyor 48. Vibrator 52 is preferably of the same type as vibrators 24 and 44 and includes a blade 54 which subjects the mat to rapidly repeated impacts. The reciprocation of the blade is preferably controlled to contact the mat and depress it slightly but not to the extent achieved by the other vibrators where a more vigorous spanking action is desired.

The drives for the conveyors, drafting rolls, and vibrators have not been shown in detail but it will be appreciated that they may take any usual form and may comprise independent drives for each device or, alternatively, a single prime mover may be employed with appropriate drive connections. In any event, the driving arrangement is such that the different devices will operate at predetermined relative speeds.

In the operation of the apparatus described above and in carrying out the method of the instant invention, the condensed mat as received from the mat-forming equipment, and suitably in the form of a roll or the like, is delivered to feeding device 12 and its end inserted between the adjacent reaches of conveyors 14 and 16. At the start of the operation the mat, as it issues from conveyors 14 and 16, may be stretched by hand and threaded through the machine. In the apparatus shown, expansion of the mat takes place in two stages, between the feeding device and the first set of stretching rolls and between the two sets of rolls. Conveyor 48 is driven at a speed corresponding to the rate of travel of the mat through the second set of stretching rolls so that substantially no further stretching or expansion of the mat takes place after the mat leaves the stretching device. The shallow loop which the expanded mat assumes as it travels over table 50 between stretching device 42 and conveyor 48 provides sufficient slack in the mat to prevent momentary variations in the relative speeds of the two from tensioning and further stretching the mat. At the same time the table prevents the mat from sagging to such an extent as to be stretched by its own weight.

The unexpanded mat is fed at a relatively low speed by conveyors 14 and 16, the feed being either continuous or intermittent. Drafting device 17 is driven continuously at a much higher speed. As the drafting rolls exert tension on the mat, due to their increased speed relative to the feed of the mat, the mat is drawn out and expanded as it leaves the bight between the feeding conveyors, the fibers of adjacent layers being rearranged from their position at relatively acute angles to one another to assume wider angles as illustrated diagrammatically in Fig. 1. It has been found that the drafting operation exerts a drawing force on the fibers before they leave the bight between the feed conveyors, partial rearrangement of the fibers tending to take place at this point. The smooth surfaced conveyors described above are essential to permit the slippage of the layers of fibers, one over the other, required for this operation.

A second stretching or expanding operation takes place between the two stretching devices, the forward device 42 being operated at a higher speed than device 17. The tension exerted on the mat between the two devices causes an additional expansion of the mat and a further rearrangement of the fibers. The operational speeds of the drawing or stretching devices relative to

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each other and to the feed device may be proportioned as desired to secure the desired total expansion of the mat and to divide such total between the two stages. It will be appreciated that the extent to which the mat is to be expanded will depend upon the character and thickness of the original unexpanded mat and of the character and thickness of the product to be made. For purposes of example it may be stated that to produce a commercial type expanded material, say, 65 mils in thickness, for certain uses, a condensed mat is expanded about 50 times its original length.

During both stages of the stretching operation the mat is subjected to the repeated impacts of the blades of the vibrators 24 and 44 which are operated to strike the mat at close intervals. For example, the vibrator blades may be reciprocated or oscillated approximately 300 times per minute. The stroke of the vibrator blades is adjusted so that the blades carry or drive the mat into contact with the plates below the mat whereby the lower surface of the mat is also subjected to what is in effect a spanking operation.

The vibration or spanking action causes fiber bunches or bundles which resist opening and expansion to separate into their individual fibers and become expanded and opened in substantial conformity with the remainder of the mat and assists in the general expanding operation. In addition the frictional contact between the mat and the plates contributes to the uniform opening or expansion of the mat.

Vibrator 52, positioned forwardly of the sets of stretch rolls and overlying conveyor 48, is operated in the same way as vibrators 24 and 44 to exert a spanking action on the surface of the stretched mat. The stroke of the blade is adjusted to provide a lighter tapping or spanking of the mat as compared to the operation of the other vibrators. This action, together with the support provided by conveyor 48, serves to smooth out wrinkles and other imperfections in the mat caused particularly by strains set up during the drafting operation and to confine surface fibers to the plane of the mat. After the mat passes beneath vibrator 52 it is carried by conveyor 48 to or through equipment for further processing.

The method and apparatus described above have been found to produce a smooth, uniform, expanded mat, free of ropes or other fiber clusters. The extent of expansion of the mat may be readily controlled to produce the desired finished product. The thickness of the final product is more dependent on the nature of the condensed mat (i. e., weight and angle of lay of the fibers) than on the degree of expansion. Greater or less expansion in the apparatus tends to affect the width of the final product more than the thickness. Although the desired degree of expansion may be obtained by either a single or two-stage stretching operation, two stages of expansion become increasingly necessary as the thickness of the final product increases, thereby making it more difficult to break up the fiber clusters. The primary reason for the use of the second stage of expansion is to remove fiber clusters (ropes) that pass the first stage of expansion. Reconstruction of the apparatus for a single stage operation requires merely the elimination or non-operation of the second set of stretching rolls and the second spanker.

Having thus described our invention in rather full detail, it will be understood that these details need not be strictly adhered to, but that various changes and modifications thereof may suggest themselves to one skilled in the art, all falling within the scope of the invention as defined by the subjoined claims.

What we claim is:

1. In an apparatus for expanding a condensed mat of fibers in which the fibers lie in intercrossing relationship, means engaging opposite faces of the mat for feeding the mat forwardly, means for exerting stretching tension on said mat and means intermediate said first and second mentioned means for vibrating said mat.

2. In an apparatus for expanding a condensed mat of glass fibers in which the fibers lie in intercrossing relationship, means engaging opposite, flat faces of the mat for feeding the mat forwardly, drafting rolls for exerting tension on said mat to stretch the same and means intermediate said feeding means and drafting rolls for vibrating said mat.

3. In an apparatus for expanding a condensed mat of fibers in which the fibers lie in inter-crossing relationship, means for feeding said mat forwardly, means for exerting tension on said mat to stretch the same, and means intermediate said first and second means and operable to subject said mat to repeated impacts.

4. In an apparatus for expanding a condensed mat of fibers in which the fibers lie in intercrossing relationship, means for stretching said mat and moving the same forwardly and means for subjecting said mat to repeated impacts on both faces while said mat is carried forwardly by said stretching means.

5. In an apparatus for expanding a condensed mat of fibers in which the fibers lie in inter-crossing relationship, means for feeding the mat forwardly, means for exerting tension on said mat to stretch the same, means located intermediate said feeding means and tensioning means to subject said mat to repeated impacts and means forwardly of said stretching means operable to subject said mat to repeated impacts.

6. In an apparatus for expanding a condensed mat of fibers in which the fibers lie in inter-crossing relationship, means for feeding the mat forwardly, means for exerting tension on said mat to stretch the same, means intermediate said first and second-mentioned means for vibrating said mat, said last-named means including a vibrator positioned to subject said mat to repeated impacts, and a plate below said mat and normally spaced therefrom for intermittent contact by said mat during said vibrating action.

7. In an apparatus for expanding a condensed mat of fibers in which the fibers lie in intercrossing relationship, means for feeding the mat forwardly, means for exerting tension on said mat to stretch the same, means intermediate said first and second-mentioned means for vibrating said mat, means forwardly of said tensioning means for further tensioning said mat to stretch the same and means intermediate said first and second-mentioned stretching means to vibrate the mat.

8. In an apparatus for expanding a condensed mat of fibers in which the fibers lie in intercrossing relationship, means for feeding the mat forwardly, means for exerting tension on said mat to stretch the same, means intermediate said first and second-mentioned means for vibrating said mat, means forwardly of said tensioning means for further tensioning said mat to stretch the same, means intermediate said first and second-mentioned stretching means to

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vibrate the mat and means forwardly of said second-mentioned tensioning means to vibrate said mat.

9. In an apparatus for expanding a condensed mat of fibers in which the fibers lie in inter-crossing relationship, means for feeding the mat forwardly, means for exerting tension on said mat to stretch the same, vibrator means intermediate said first and second-mentioned means and comprising a blade operable to subject said mat to repeated impacts, a second means for exerting tension on said mat positioned forwardly of said first tensioning means, vibrator means intermediate said first and second-mentioned tensioning means comprising a blade operable to subject said mat to repeated impacts, and members beneath said mat and normally spaced therefrom to be intermittently contacted by said mat when vibrated by said vibrator means.

10. In an apparatus for expanding a mat of glass fibers in which the fibers lie in inter-crossing relationship, means for feeding the mat forwardly, drafting rolls for exerting tension on said mat to stretch the same between said drafting rolls and said feeding means, a second set of drafting rolls forwardly of said first-mentioned drafting rolls for exerting tension on said mat to further stretch the same between said first and second-mentioned drafting rolls and vibrator means positioned intermediate said first-mentioned drafting rolls and said feeder, between said first and second-mentioned drafting rolls, and forwardly of said second-mentioned drafting rolls, each of said vibrator means comprising a blade operable to subject said mat to repeated impacts.

11. In an apparatus for expanding a mat of glass fibers in which the fibers lie in inter-crossing relationship, means for feeding the mat forwardly, drafting rolls for exerting tension on said mat to stretch the same between said drafting rolls and said feeding means, a second set of drafting rolls forwardly of said first-mentioned drafting rolls for exerting tension on said mat to further stretch the same between said first and second-mentioned drafting rolls, a vibrator means positioned intermediate said first-mentioned drafting rolls and said feeder, a second vibrator means between said first and second-mentioned drafting rolls, and a third vibrator means forwardly of said second-mentioned drafting rolls, each of said vibrator means comprising a blade operable to subject said mat to repeated impacts, and members below said mat at the position of said first and second vibrator means and normally spaced from said mat for intermittent contact by said mat during said vibratory action.

12. In an apparatus for expanding a condensed mat of fibers in which the fibers lie in inter-crossing relationship, a mat feeder, drafting rolls operable at greater speed than the feeder to exert tension on said mat and stretch the same, and vibrator means intermediate said drafting rolls and feeder, said vibrator means comprising a flat blade operable to subject said mat to repeated impacts and means for rapidly reciprocating said blade toward and away from said mat.

13. In an apparatus for expanding a condensed mat of fibers in which the fibers lie in inter-crossing relationship, mat feeding means, drafting rolls operable at greater speed than the feeding means to exert tension on said mat and stretch the same, vibrator means intermediate said drafting rolls and feeder, said vibrator means comprising a flat blade operable to subject said mat to repeated impacts, means for rapidly reciprocating said blade toward and away from said mat and a second, similar vibrating means forwardly of said drafting rolls.

14. In an apparatus for expanding a condensed mat of fibers in which the fibers lie in inter-crossing relationship, mat feeding means comprising parallel, smooth surfaced conveyors having adjacent reaches spaced apart sufficiently to exert a holding action on the unexpanded mat, means for driving said conveyors at one speed, drafting rolls operable to move said mat at a speed substantially greater than the rate of movement of said conveyors and means intermediate said feeding means and drafting rolls for vibrating said mat.

15. In the method of expanding a condensed fiber mat in which the fibers lie approximately transversely of the mat and in inter-crossing relationship at relatively acute angles to one another, the steps comprising expanding the mat in a direction substantially perpendicular to the lay of the fibers and in the plane of the mat, and continuously therewith subjecting said mat to repeated vibrations, to break up fiber clusters.

16. In the method of expanding a condensed fiber mat in which the fibers lie approximately transversely of the mat and in inter-crossing relationship at relatively acute angles to one another, the steps comprising expanding the mat in a direction substantially perpendicular to the lay of the fibers and in the plane of the mat, and continuously therewith subjecting said mat to repeated impacts.

17. In the method of expanding a condensed fiber mat in which the fibers lie approximately transversely of the mat and in inter-crossing relationship at relatively acute angles to one another, the steps comprising expanding the mat in a direction substantially perpendicular to the lay of the fibers and in the plane of the mat, and continuously therewith subjecting said mat to repeated impacts during and after the expanding operation.

18. In the method of expanding a condensed fiber mat in which the fibers lie approximately transversely of the mat and in inter-crossing relationship at relatively acute angles to one another, the steps comprising expanding said mat in a direction substantially perpendicular to the lay of the fibers and in the plane of the mat, subjecting said mat to repeated impacts during the expanding operation, again expanding said mat and subjecting said mat to repeated impacts during and after said second expanding operation.

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