March 14, 1950 G. M. LANNAN 2,500,690

APPARATUS FOR MAKING FIBROUS PRODUCTS

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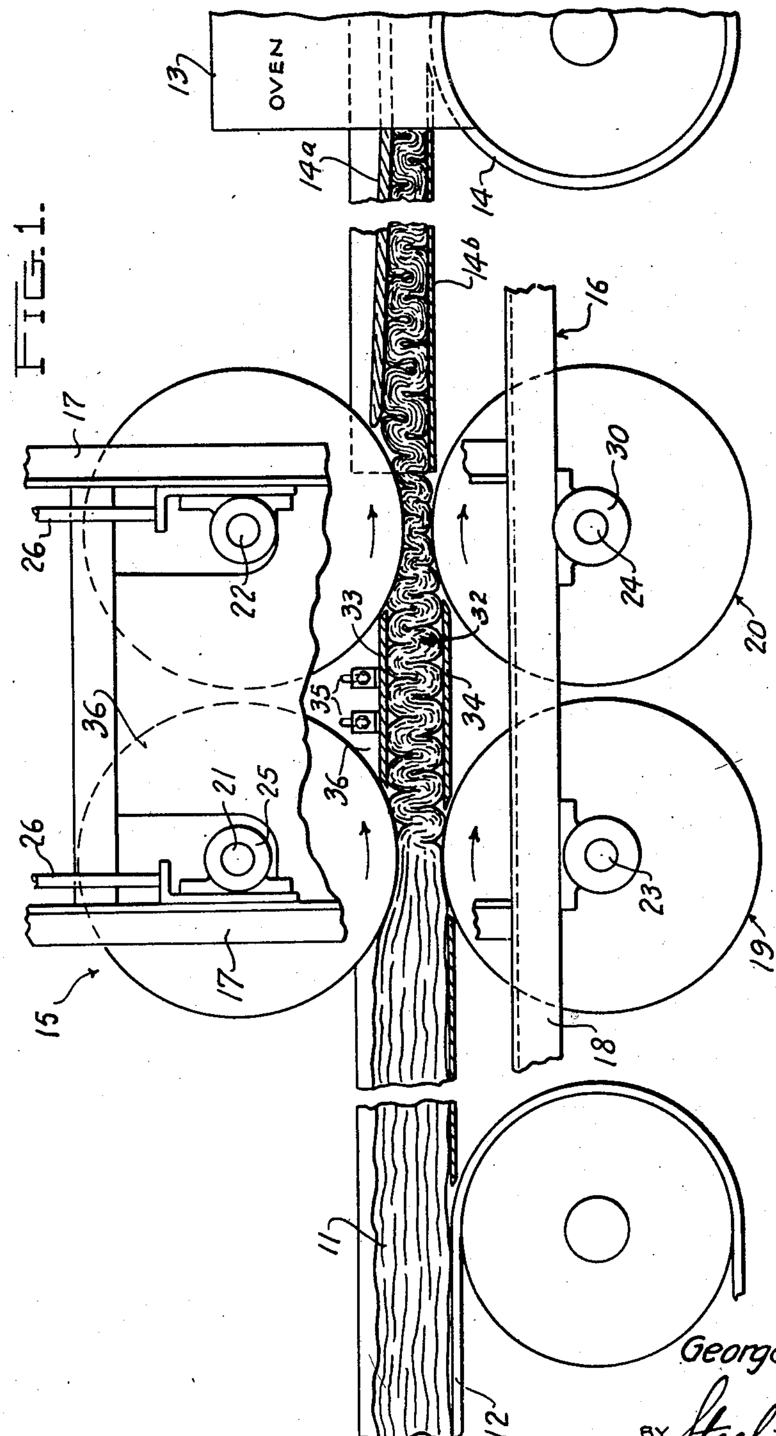
FIG. 1.



INVENTOR
George M. Lannan
BY Staelin & Overman
ATTORNEYS

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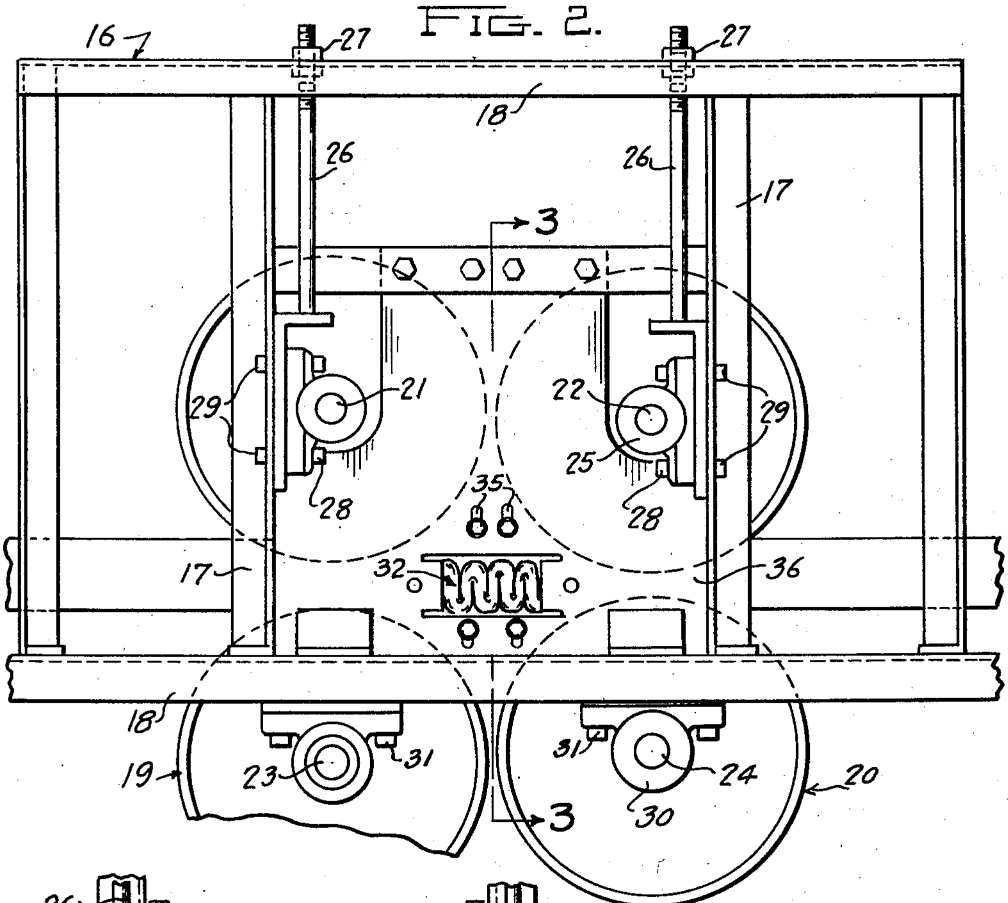
FIG. 2.



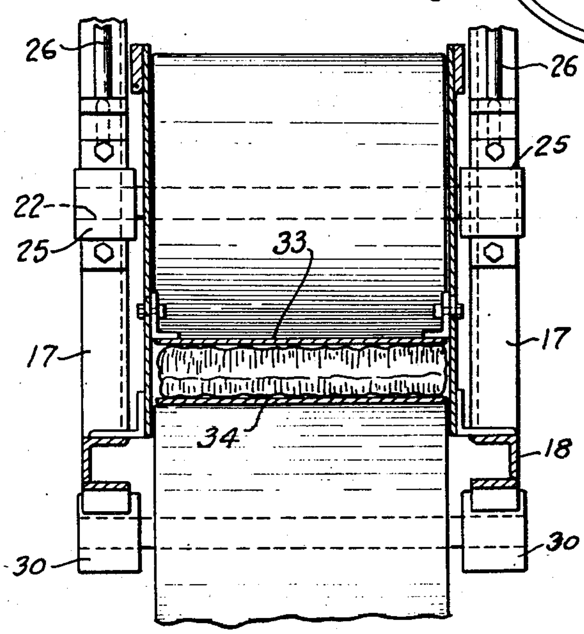


FIG. 3.

INVENTOR
George M. Lannan

BY Staelin & Overman
ATTORNEYS

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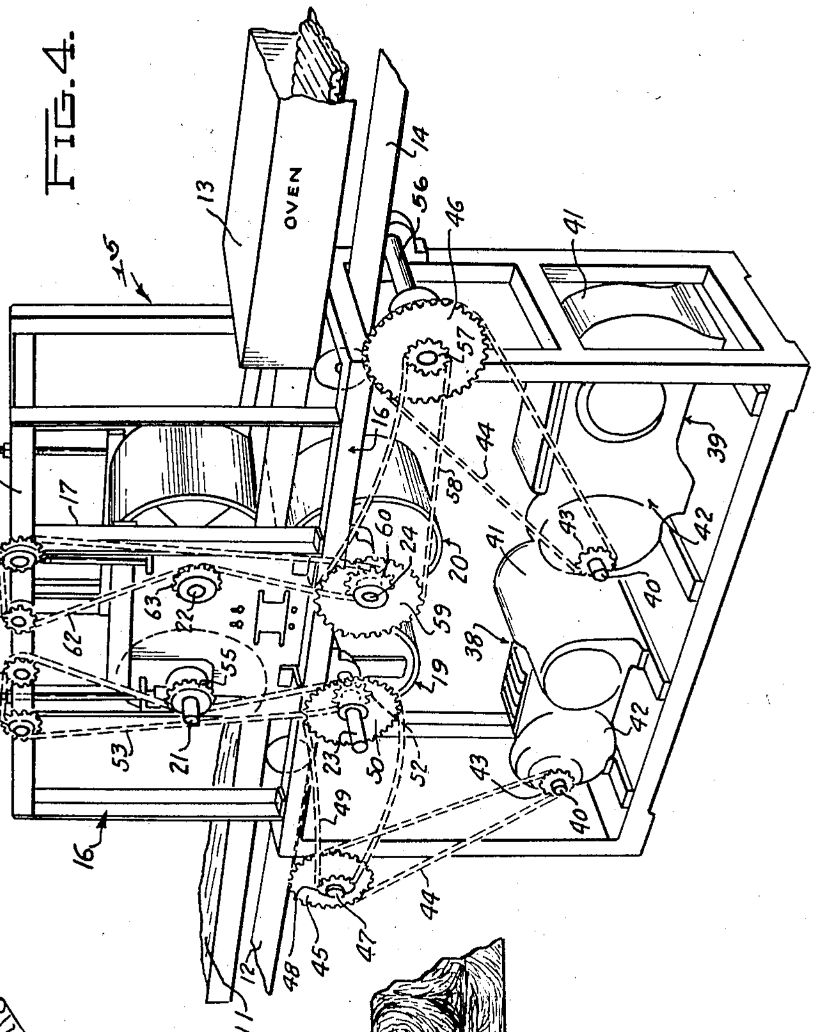

FIG. 4.

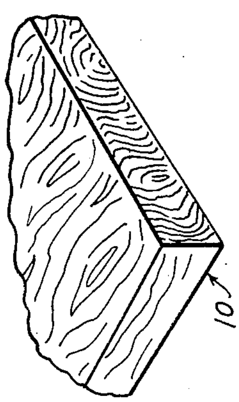

FIG. 5.

FIG. 6.

INVENTOR
George M. Lannan

BY Staelin & Overman

ATTORNEYS

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APPARATUS FOR MAKING FIBROUS PRODUCTS

George M. Lannan, Newark, Ohio, assignor to Owens-Corning Fiberglas Corporation, a corporation of Delaware

Application November 21, 1945, Serial No. 630,091

5 Claims. (Cl. 154—1)

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This invention relates to apparatus for producing mineral wool mats, especially those comprising fibrous glass, slag wool, rock wool and the like. Although the invention is not limited to any particular type of mineral wool, it is described herein in connection with the production of fibrous glass mats because it has been found superior in this connection.

One process for producing bonded fibrous glass mats on a production basis is to continuously deposit the glass fibers as they are formed in a haphazardly arranged mass on a travelling conveyor and to spray or otherwise apply a suitable binder or stiffening agent onto the fibers as the latter are built up on the conveyor. The resulting loose, fluffy mass of fibrous glass is delivered by the conveyor in mat formation to a station such as a heating chamber where the mat is compacted to the desired thickness and density and the resin or binder is polymerized or dried to a hard state.

When producing fibrous glass mats in accordance with the above process, the fibers are of great lengths and are rained down onto the conveyor at high speed. Because of this, the fibers substantially all lie in planes parallel to the conveyor and to the major surfaces of the mat but are haphazardly arranged with respect to other directions. A mat of fibers so produced may be compared to a book with the leaves of the book representing the planes parallel with the conveyor and each leaf being considered as composed of haphazardly arranged fibers.

In certain applications of the fibrous mat, there is a tendency for the mat to delaminate, or in other words, adjacent areas of the layer-like formation of the mat tend to separate from one another along planes parallel with the major faces of the mat. This is, of course, objectionable, and it is one of the principal objects of this invention to overcome this tendency.

It is another object of the invention to provide apparatus for rearranging or reorienting the glass fibers so that a large proportion of the latter extend generally perpendicular to the major surfaces of the mat instead of parallel to the latter as is the case with the process briefly outlined above. Thus, many fibers are disposed to resist delamination or separation of the mat, and also to resist compressive forces applied to the mat to thereby provide a more rigid and board-like mat.

Another object of this invention is to provide apparatus in advance of the binder-setting station for piling the mat or portions of the mat of fibrous material upon itself in directions parallel with its major faces while allowing some expansion of the mat in directions transverse to its major faces. In this operation the fibers of the mat buckle and take the general form of closed loops extending successively in opposite directions transversely of the path of travel of the mat. The effect is to force the fibers out of their predominant parallel relationship, and rearranging many of them to extend generally perpendicular to the mat surfaces. As the mat of rearranged fibers passes to the binder-setting station the binder is rigidified to permanently set the fibers in this new relation.

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Still another object of this invention is to provide apparatus of the above type adaptable to the production of fibrous glass mats of various thicknesses and densities.

It is a still further object of the invention to provide apparatus of this type that will operate continuously and at high speed on a mat of fibrous material to process the mat in the way described at rates comparable to the rates of forming the fibers and the mats.

The foregoing as well as other objects will be made more apparent as this description proceeds, especially when considered in connection with the accompanying drawings, wherein:

Figure 1 is a semi-diagrammatic side elevation of apparatus constructed in accordance with this invention;

Figure 2 is also a side elevation of the apparatus showing some of the parts more in detail;

Figure 3 is a sectional view taken substantially on the plane indicated by the line 3—3 of Figure 2;

Figure 4 is a perspective view of the apparatus showing the driving means for the corrugating rolls;

Figure 5 is a fragmentary diagrammatic perspective view of a bonded fibrous glass mat produced by the apparatus shown in Figures 1 to 4 inclusive; and

Figure 6 is a similar view to Fig. 5 but shown in cross-section and on an enlarged scale.

A bonded fibrous glass mat produced by the apparatus forming the subject matter of this invention is indicated in Figures 5 and 6 of the drawings by the reference character 10. The characteristics of this mat are such as to enable its use as heat or sound insulation and for other numerous and diversified applications. For example, the bonded fibrous glass mat 10 may be advantageously used as wall or ceiling board or panels, lining for air ducts, wall panels for refrigerator cabinets or the like, coverings for stoves, pipes, industrial ovens, and for boiler insulation.

Of course, fibers other than glass may be employed in forming the mat 10, but glass fibers are preferred because they enable producing a bonded mat or board having densities ranging from less than one pound to more than nine pounds or more per cubic foot, according to the particular purposes to which the mat is to be put. Furthermore, boards of fibrous glass may be produced having sufficient rigidity to enable handling and assembling the mats without reinforcing the mat with cardboard, paper or other reinforcing elements.

Referring to Figure 1 of the drawings, a loose, fluffy bat 11 of fibrous material such as mineral fibers, for instance, fibrous glass, produced in accordance with any suitable fiber-forming process and deposited on a belt-type conveyor 12 in mat formation is advanced along a predetermined path of travel by the conveyor 12. The glass fibers are deposited on the conveyor to a thickness and at a density predetermined to provide the required density of the finished mat or board 10, and this density may vary from two or three pounds per cubic foot to nine to twelve or more pounds per cubic foot, depending on the particular use of the board.

As the glass fibers are built up in mat formation on the conveyor 12, a suitable binder or stiffening agent may be sprayed or otherwise applied to the fibers. Numerous different binders such as furfural, lignin, asphalt, may be used for this purpose, but it is preferred to employ a thermosetting condensation product, such for example, as phenol formaldehyde, urea formaldehyde, or various modifications and variations of these synthetic materials, which may be originally in liquid state, and finally in a hard, strong, solid mass. For most applications of the mat or board, it has been found that an aldehyde condensation product is a very satisfactory binder or stiffening agent.

The deposition of the fibers and the application of the binder thereto may be in accordance with the disclosure of the Simison and Collins Patent 2,189,840 or in any other suitable fashion.

The binder-impregnated fibrous glass mat on the conveyor 12 is advanced through a heating chamber 13 by a conveyor 14 and the mat is compacted to desired thickness at the entrant end of the heating chamber by the sloping end of a skid plate 14ª cooperating with a supporting plate 14ᵇ and held compacted while in the chamber between the skid plate and the conveyor 14. The temperature within the heating chamber 13 is sufficient to cure, set, or dry the binder into a final set and this is accomplished while the mat is held to the predetermined desired thickness. Prior to setting of the binder and during the interval the mat passes from the conveyor 12 to the conveyor 14, the fibers are rearranged or are oriented to have a large proportion of them extend predominantly perpendicular to the mat surfaces, instead of parallel to the latter. In general, this is accomplished by piling the mat up on itself by what is roughly a corrugating or successive looping in opposite directions of the mat, with the loop or corrugations extending transversely of the path of advancement of the mat.

In detail, the fibers of the fibrous glass mat are rearranged by apparatus indicated generally in the several figures of the drawings by the reference character 15 and situated between the delivery end of the conveyor 12 and the entrant end of the conveyor 14. The apparatus

comprises a frame structure 16 having upright frame members 17 supported at opposite sides of the path of travel of the mat and connected together by cross braces 18. Two pairs of rolls 19 and 20 are journalled on the frame 16 with the axes of the rolls of one pair lying in a common vertical plane and with the axes of the rolls of the other pair lying in a parallel vertical plane. The distance between the two planes is preferably determined to provide the minimum clearance between the peripheries of the rolls. Also the top roll of each pair is positioned above the path of travel of the mat and the bottom roll of each pair is supported below the path of travel of the mat.

The top rolls are respectively secured on shafts 21 and 22 and the bottom rolls are respectively secured on shafts 23 and 24. The opposite ends of the shafts 21 and 22 are respectively journalled in bearings 25 supported on the upright members 17 of the frame 16 for vertical sliding movement. The bearings 25 are independently adjustable by threaded members 26 having the lower ends respectively secured to the bearings 25 and having the upper ends projecting through the cross braces 18 at the top of the frame 16. Suitable nuts 27 are threaded on the upper ends of the members 26 and are seated on the upper and lower faces of the cross braces 18 so that rotation of the nuts effects a vertical movement of the bearings 25 in an upward or downward direction, depending upon the direction of rotation of the nuts. The bearings 25 are secured in their various adjustable positions by means of bolts 28, which project through elongated slots formed in the upright member 17 and are threaded for receiving clamping nuts 29. Thus, it will be noted that provision is made for vertically adjusting the top rolls of each pair toward and away from the bottom rolls to vary the space between the rolls for receiving the mat 18. The opposite ends of the shafts 23 and 24 for the bottom rolls of each pair are respectively journalled in bearings 30 secured to the upright member 17 by means of the fastener elements 31. The adjustment of the rolls of both pairs is such that the fibrous material passing through the bite of each pair is gripped sufficiently tightly to be fed at approximately the rate of peripheral speed of the rolls.

The rolls are rotated in the general direction of movement of the mat along its path of travel and the rolls of the pair 20 are rotated at a slower peripheral speed than the rolls of the pair 19. In actual practice, the conveyor 14 for advancing the mat through the heating chamber 13 travels at a rate slower than the rate of movement of the forming conveyor 12 and the rolls of the pair 20 are rotated at a peripheral speed which corresponds to the rate of travel of the conveyor 14, while the rolls of the pair 19 are rotated at the faster rate which corresponds to the rate of travel of the conveyor 12. Thus, the pair of rolls 20 retards the rate of advancement of the mat 18 relative to the pair of rolls 19, and as a result, the mat is piled up on itself between the pairs of rolls. In the present instance, movement of the mat upwardly or downwardly out of its path of travel is limited so that the piling up of the mat between the two pairs of rolls results in a tendency of the mat to buckle on itself and assume the form roughly of corrugations or loops, as at 32, between the two pairs of rolls.

As shown particularly in Figure 1 of the drawings, this control of the piling up action is effected by a pair of plates 33 and 34 respectively located at opposite sides of the path of travel of the mat. These plates extend for the full width of the mat and for the full length of the space between the two pairs of rolls and the opposite sides of the plates are removably supported by brackets and bolts in slots 35 formed in side plates 36 respectively secured to opposite sides of the frame 16 (Figures 1 and 2). The opposite ends of the plates 33 and 34 extend in proximity to the respective rolls, so that the fibrous material cannot escape around the edges of the plates.

The plates 33 and 34 coact with the rolls to control to some extent the arrangement of the mat as it piles up on itself under influence of the difference in speed of the pairs of rolls. The space between the plates determines the size of the loops measured in directions transverse to the direction of travel of the mat. Since the fibrous material leaving the pairs of rolls is often compressed to a thickness less than that of the material in the space between the pairs of rolls, very large loops or corrugations will be flattened out, bent over, and otherwise distorted by the compressing action to such extent as to partly obliterate the loop or corrugation pattern. This of course is not deleterious in most cases because there will remain a rearrangement of the fibers with a large portion of the fibers extending in directions transverse to the major faces of the mat. Where, however, it is desired to retain more of the original loop pattern in the finished board, it is desirable to have the plates 33 and 34 closer together, say spaced about twice the thickness of the finished board. While with this relation of the plates there will also be some flattening and other distorting of the loop pattern when the fibrous material is compressed to the desired final thickness, the pattern will be preserved to greater extent. Of course, the plates may be set closer than twice the thickness of the finished mat if desired, but best performance of the apparatus has been had with the mentioned setting of the plates.

An increase in density of the fibrous mat as it passes through the rolls is ordinarily obtained due to the difference in speed of the two pairs of rolls. In the cases where the mat entering between the first pair of rolls is the same thickness as the finished mat or board of rearranged fibers, the increase in density of the fibrous material is directly proportional to the ratio of the speeds of the two pairs of rolls. Where the entering fibrous mat and the finished mat are different in thickness then the change in density of the fibrous material will also be directly proportional to the ratio of the two thicknesses.

As an illustration of this, the fibrous mat entering between the first pair of rolls may be about 2 pounds per cubic foot and 2 inches thick. The rolls of the first pair may be rotated at 50 R. P. M. and the rolls of the second pair at 10 R. P. M. The density of the finished mat if 4 inches thick will be 5 pounds per cubic foot and if 2 inches thick will be 10 pounds per cubic foot. Other densities and thicknesses may be obtained as desired by varying the thickness or density or both of the entering mat, or by varying the ratio of the speeds of the pairs of rolls, or by variation in all these respects.

Upon reference to Figure 4 of the drawings, it will be noted that the two pairs of rolls 19 and 20 are driven independently of one another by power units 38 and 39. Each power unit comprises a drive shaft 40 connected to an electric motor 41 through the medium of gear reduction mechanism 42. A sprocket wheel 43 is keyed or otherwise secured to each drive shaft 40 and chains 44 serve to respectively connect the sprockets 43 to the sprockets 45 and 46. The sprocket 45 is secured to a shaft 47 carried by the frame 16 and having a relatively small sprocket 48 secured thereto adjacent the sprocket 45. The sprocket 48 is connected by means of a chain 49 to a relatively large sprocket 50 keyed to the bottom roll shaft 23 for rotation as a unit with the latter. A second sprocket 52 is secured to the shaft 23 at the inner side of the sprocket 50 and is connected by a chain 53 to a pair of idler sprockets 54 journalled on the top cross bar 18 of the frame in spaced relation to each other. A sprocket wheel 55 corresponding to the sprocket wheel 52 is secured to the shaft 21 and meshes with the inner side of the chain 53. Inasmuch as the top roll of the pair 19 is secured to the shaft 23, it follows that these rolls are rotated in opposite directions by the power means 38.

Referring again to Figure 4 of the drawings, it will be noted that the sprocket 46 is secured to a shaft 56 having a relatively small sprocket 57 secured thereto at the outer side of the sprocket 46. The sprocket 57 is connected by a chain 58 to a relatively large sprocket 59 fixed to the shaft 24, which also supports the bottom roll of the pair of rolls 20. A sprocket 60 is also secured to the shaft 24 at the inner side of the sprocket 59 and is connected to a pair of idler sprockets 61 by means of a chain 62. The idler sprockets are journalled on the top of the cross brace 18 on the frame 16 in spaced relationship and the inner side of the chain 62 meshes with a sprocket 63. The sprocket 63 corresponds to the sprocket 60 and is keyed to the shaft 22 which also supports the top roll of the pair of rolls 20. Thus, the top roll of the pair of rolls 20 is rotated in a direction opposite the direction of rotation of the bottom roll by the power unit 39.

In actual practice, the top rolls are rotated in a counterclockwise direction while the bottom rolls are rotated in a clockwise direction with the result that the peripheral portions of the rolls adjacent the mat move in the general direction of advancement of the mat by the conveyors 12 and 14. Furthermore, the pair of rolls 19 are rotated by the power unit 38 at a peripheral speed which corresponds to the rate of travel of the conveyor 12 and the pair of rolls 20 are rotated by the power unit 39 at a slower rate, which corresponds to the rate of travel of the conveyor 14.

In operation, the pair of rolls 19 are relatively adjusted to feed the mat 11 into the space between the pairs of rolls and the pair of rolls 20 are relatively adjusted to compact the piled-up portion of the mat to a thickness approximating the desired thickness of the finished mat 10. The two pairs of rolls effect the feeding and discharge of the mat by the rolls and the piling up of the mat is the natural result of such action. In this connection, it will be noted that as the looped portion of the mat leaves the pair of rolls 20, it is held to the proper thickness by a pair of plates 14^a and 14^b. The bottom plate 14^b extends from the delivery side of the apparatus 15 to the conveyor 14 and is located in a common plane with the top side of the conveyor. The top plate 14^a extends through the heating chamber 13 and cooperates with both the plate 14^b and the top side of the conveyor 14 to hold the mat to the proper thickness during polymerization of the thermosetting resin.

It follows from the foregoing that piling up of the mat on itself between the two pairs of rolls rearranges the fibers in the mat so that a large portion of the fibers extend predominantly perpendicular to the surfaces of the mat and this arrangement is maintained during advancement of the mat through the heating chamber 13. As the binder applied to the mat is set as the mat progresses through the heating chamber 13, the fibers are permanently bonded together and retain their rearranged position in the finished mat. Thus, the fibers resist any tendency for the mat to delaminate and, in addition, the resistance of the mat to compression is improved.

As shown in Figure 6, a large portion of the fibers in the mat 10 extend predominantly perpendicular to the top and bottom surfaces of the mat. The glass fibers forming the mat are of relatively great length and may extend continuously through one or several of the loop formations. Moreover, the above distribution of the fibers in the mat imparts an appearance to the mat surfaces that simulates wood graining, as shown in Figure 5, especially if the surfaces are sanded or otherwise smoothed, and this appearance may be enhanced by coating the surfaces of the board with a clear lacquer or Bakelite varnish.

In Figure 6 of the drawings an attempt has been made to illustrate generally the distribution of the fibers in the finished mat 10. It has previously been stated that as the mat piles up on itself under the influence of the difference in speed of the two pairs of rolls a series of closed loops 32 or corrugations are formed in the portion of the mat between the two pairs of rolls. If the mat is compacted to reduced thickness by the pair of rolls 20 the loops are flattened to an extent depending upon the degree of compression. As the loops are flattened the fibers forming opposite sides of the loops buckle, usually toward each other, providing adjacent loops with relatively flat head portions at opposite sides of the mat which, in effect, interlock with one another. In instances where the degree of compression of the mat is relatively great, it is possible that the loops may be flattened to such an extent as to practically lose their identity in the completed mat. In fact during the stage the mat is piled up between the two pairs of rolls it is possible that some of the fibers will not follow a well defined looped pattern but, on the other hand, will assume a haphazard arrangement in the mat. However, large groups of fibers still actually lie transversely of the mat surfaces and, in general, a number of these fibers may be considered to extend from one surface of the mat to the other. Moreover, due to the substantial length of the glass fibers, the majority of the fibers extend continuously through one or several of the loop or near loop formations.

It will be understood, of course, that the illustration of the fibers and the arrangement of the fibers in the drawings must be highly diagrammatic because of the great fineness of the fibers and the infinite minor variations in the loop pattern into which the fibers will be rearranged.

Various modifications may be resorted to within the spirit of the invention and the scope of the claims.

I claim:

1. Apparatus for producing fibrous glass mats comprising means for advancing a resin impregnated mat of glass wool along a predetermined path of travel, means for advancing the resin impregnated mat through a heating zone at a slower rate of speed to polymerize the resin, pairs of rolls respectively engageable with opposite sides of the mat between the two advancing means, means for rotating the rolls in the direction of travel of the mat at peripheral speeds corresponding substantially to the rate of travel of the separate advancing means, the space between said pairs of rolls defining a forming zone in which the mat is formed into overlapping loops and held under compression, one pair of rolls being spaced apart a lesser distance than the initial thickness of the mat, and means for maintaining pressure on said mat subsequent to forming the loops therein.

2. Apparatus for producing fibrous glass mats comprising separate means for advancing a resin impregnated resilient mat of long glass wool fibers along a predetermined path of travel, a heating zone in said path of travel, means for advancing the resin impregnated mat through the heating zone at a slower rate of speed to polymerize and cure the resin, a pair of rolls respectively engageable with opposite sides of the mat between the two advancing means, and rotatable in the direction of travel of the mat at a peripheral speed corresponding substantially to the rate of travel of the first advancing means, a second pair of rolls respectively engageable with opposite sides of the mat between the first pair of rolls and the heating zone, the distance between said second pair of rolls being substantially less than the distance between said first-named rolls, means for rotating the second pair of rolls in the direction of travel of the mat at a peripheral speed corresponding substantially to the rate of travel of the second advancing means, and a pair of stationary plates adjustably mounted on opposite sides of the path of travel of the mat and between said pairs of rolls, said plates coacting with said pairs of rolls to regulate the pattern of the mat passing therebetween and spaced apart a distance substantially twice that of the initial thickness of the mat.

3. Apparatus for producing fibrous glass mats comprising separate means for advancing a resin impregnated mat of long glass wool fibers having a tendency to resist deformation along a predetermined path of travel, a heating zone in said path of travel, means for advancing the resin impregnated mat through the heating zone at a slower rate of speed to polymerize and cure the resin, a pair of rolls respectively engageable with opposite sides of the mat between the two advancing means, and rotatable in the direction of travel of the mat at a peripheral speed corresponding substantially to the rate of travel of the first advancing means, a second pair of rolls respectively engageable with opposite sides of the mat between the first pair of rolls and the heating zone, the distance between said second pair of rolls being substantially less than the distance between said first-named rolls, means for rotating the second pair of rolls in the direction of travel of the mat at a peripheral speed corresponding substantially to the rate of advancement of the mat by the second advancing means, and a pair of parallelly disposed plates respectively positioned on opposite sides of the mat between the two pairs of rolls and spaced apart a distance substantially twice the initial thickness of the mat, said first-named rolls cooperating with the second pair of rolls to form a succession of loops in a defined pattern in the mat between the plates, and means for con-

tinuously holding the formed mat under compression after it leaves said second pair of rolls and during passage through said heating zone.

4. Apparatus for producing glass fiber mats comprising means for advancing a mat of long glass fibers along a predetermined path of travel, a pair of rolls respectively engageable with opposite sides of the mat and rotatable in the direction of travel of the mat at a peripheral speed corresponding substantially to the rate of advancement of the mat, a second pair of rolls respectively engageable with opposite sides of the mat beyond the first pair and rotatable in the direction of travel of the mat at a peripheral speed less than the peripheral speed of the first pair of rolls, said pairs of rolls defining between them a forming zone in which the mat is folded upon itself by the relative movement of said rolls, the distance between the rolls of said second pair being less than the initial thickness of the mat and less than the transverse dimension of said forming zone, and means for maintaining the folded mat under both transverse and longitudinal compression after it is formed.

5. Apparatus for producing fibrous glass mats comprising means for advancing a resin impregnated highly resilient mat of fibrous material in which the fibers are present in the form of long glass fibers substantially parallelly disposed in the plane of the mat along a predetermined path of travel, a pair of rolls respectively engageable with opposite sides of the mat and rotatable in the direction of travel of the mat at a peripheral speed corresponding substantially to the rate of advancement of the mat, a second pair of rolls respectively engageable with opposite sides of the mat beyond the first pair and rotatable in the direction of travel of the mat at a peripheral speed less than the peripheral speed of the first pair of rolls, a pair of parallelly disposed plates respectively adjustably supported at opposite sides of the path of travel of the mat between the two pairs of rolls and spaced apart a distance substantially twice the initial thickness of the mat, said first-named rolls cooperating with the second pair of rolls to form and compress a succession of folds in a defined pattern in the mat between said plates, said second pair of rolls spaced apart a distance at least equal to the final thickness of the mat and exerting compression on the formed mat transversely of the direction of travel thereof, means for continuously maintaining the formation of the mat as it leaves said second pair of rolls, and means for curing the mat in said formation.

GEORGE M. LANNAN.

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