METHOD AND APPARATUS FOR PRODUCING RETICULATED FIBROUS PRODUCT

Filed Nov. 23, 1949

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Application November 23, 1949, Serial No. 129,064

22 Claims. (Cl. 154—1.7)

The present invention relates to method and apparatus adaptable for forming organic or inorganic fiber or strands of fiber into a reticulated configuration or fabric without weaving or interlacing the strands or fibers and to the product so formed, the method embracing overlaying groups of fibers or strands with one or more fibers or strands angularly disposed with respect to the fibers or strands of the group.

The present invention is particularly applicable to the treating and processing of inorganic strands or fibers such as those formed of glass for producing reticulated products having many and varied uses, being especially adaptable for fabrication with other materials as reinforcing mediums.

In processes heretofore employed in preparing and assembling fibers or strands of fibers into composite formation, the apparatus required and the necessary fabricating operations have been costly and the products produced by such processes have not been wholly satisfactory. Woven fabrics have been made of glass fibers or strands of fibers and utilized as reinforcing mediums but the production of such fabrics entails numerous difficulties as in most instances lubricants or other suitable antifriction coatings must be utilized in order to satisfactorily handle the fibers or strands and prevent them from severing one another during weaving operations. The equipment necessary to fabricate an end product of this nature is necessarily expensive because of the elaborate looms or apparatus required and the amount of material that may be produced upon a conventional weaving apparatus or loom in a given length of time is relatively limited rendering the product uneconomical for many purposes.

Other methods have been employed such as the formation and accumulation of glass fibers or strands in random orientation forming a matlike structure which is impregnated with a suitable bonding material to maintain the individual fibers or strands in contiguous relationship, but this method of assembling fibers or strands into a bonded mat results in a product lacking homogeneity and uniformity for superlatives notwithstanding it is possible to orient the fibers in the resultant assemblage or mass to control the strength factors in various directions in the end product.

The present invention embraces a novel method and apparatus for processing and orienting fibers in a manner to produce a reticulated mesh or netlike configuration or fabric by overlaying one or more strands or fibers upon a group of strands or fibers and applying a suitable bonding material or adhesive to retain the strands or fibers in assembled relationship.

Another object of the present invention is the provision of a method for producing a reticulated or netlike structure of continuous glass fibers or strands without interlacing or intertwining of the individual strands or fibers and of utilizing a suitable bonding medium or adhesive to secure the strands or fibers together at their points of intersection.

Another object of the invention is the provision of a method of producing a reticulated or fabric-like product of continuous fibers or strands wherein strands or fibers disposed in different directions are assembled in intersecting relationship without interlacing or weaving in a manner whereby the resultant strength factors in various directions of the composite product may be controlled through directional and symmetrical orientation of the strands or fibers making up the end product.

Another object of the invention resides in the provision of method and apparatus for producing a fabric-like reticulated sheet formed of strands or fibers arranged in symmetrical relationship in which the shape of the mesh or reticulations may be changed or modified by varying the speed and direction of movement of the fill strands or fibers with respect to the speed and direction of movement of the warp strands or fibers during assembly operations.

Another object of the invention resides in the provision of a method of producing a fabric-like product in which the longitudinal and lateral strength factors of the product may be varied by modifying the spacing between juxtaposed strands or fibers of the structure or by varying the sizes of the strands or fibers of both the warp and fill components of the fabric.

Another object of the present invention is the provision of a fabricated product of reticulated nature in which groups of strands or fibers are assembled in linear relationship without undulations as in the case of woven materials or conventional fabrics whereby flexures or stresses in the product are minimized or eliminated in directions normal to the plane of the formed product, the intersections or engaging points of the strands or fibers being joined in a manner to retain the assembly of strands and fibers in fixed orientation whereby desired physical properties in a product of this nature are obtained.

Another object of the invention is the provision of a method and apparatus for producing a lattice-like sheet or composite formed of inorganic fibers or strands in which a maximum strength is imparted to the finished product with a minimum weight of strand or fiber.

Another object of the invention is the provision of a method and apparatus for producing an unwoven fabric-like product in which the thickness of the product will be uniform and which may be economically produced in large quantities.

Still a further object of the invention resides in the method of producing a reticulated unwoven fabric-like product of inorganic fibers or strands in which the equipment or apparatus required to produce the product in mass quantities is simple and inexpensive whereby the cost of manufacturing a product of this nature is greatly reduced as compared with prior methods.

Another object of the invention is the provision of a fabric-like unwoven product formed of strands or fibers of inorganic material in which the physical properties are improved such as flexure endurance and strength in various directions of the plane of the product.

Another object of the present invention is the provision of a fabric-like or reticulated product formed of unwoven intersecting strands or fibers of inorganic material such as glass which is admirably adapted as a reinforcement for incorporation in resin films of all types, molded plastics, laminates formed of vegetable matter or resinous material, calendared or immersed sheet material, reinforcements for paper sheets or reinforcement for laminated papers or other fabricated sheets of fibers or fabricated materials.
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Another object of the invention is the provision of a method and apparatus for producing a fabric-like product in which the reduction in the number of operational steps in manufacturing a product of this nature is effected.

The invention embraces the provision of simple yet effective apparatus for efficiently assembling fibers or strands of fibers into an unwoven fabric-like product wherein a group of fibers or strands is moved in one direction concomitantly with one or more fibers or strands moving in another direction whereby the latter fibers or strands overlay those of the group, the intersections of the overlying strands or fibers with those of the group being adhesively joined together to retain the assembled strands or fibers in a predetermined symmetrical relationship.

This invention further embraces the provision of means for applying a suitable bonding or adhesive material to strands of fibers for bonding the intersections of the strands or fibers together and contemplates means for curing or setting the bonding material.

The present invention has for a further object the provision of simple yet effective means for initially forming the reticulated product in cylindrical configuration and subsequently subdividing the cylindrical configuration into sheet formation for ease of manipulation, handling and subsequent fabrication with other materials.

Another object of the invention is the provision of an apparatus for fabricating an unwoven fabric from fibrous material which is automatic and continuous in its operation and which requires little or no attention by an operator.

Further objects and advantages are within the scope of this invention such as relate to the arrangement, operation and function of the related elements of the structure, to various details of construction and to combinations of parts, elements per se, and to economies of manufacture and numerous other features as will be apparent from a consideration of the specification and drawings of the invention in which:

Figure 1 is a vertical sectional view of one form of apparatus for carrying out the method of our invention;
Figure 2 is a horizontal sectional view taken substantially on the line 2—2 of Figure 1;
Figure 3 is a horizontal sectional view taken substantially on the line 3—3 of Figure 1;
Figure 4 is a detail vertical sectional view taken substantially on the line 4—4 of Figure 1;
Figure 5 is a horizontal sectional view taken substantially on the line 5—5 of Figure 4;
Figure 6 is a detail sectional view taken substantially on the line 6—6 of Figure 1 illustrating one of the fill strands or yarn carrier devices;
Figure 7 is a detail elevational view showing one of the fill strands and the fill carriers supporting means;
Figure 8 is an enlarged view showing a form of product produced by the method and apparatus illustrated in Figure 1;
Figure 9 is a semidiagrammatic view illustrating a modified form of apparatus for producing a product having a different form of mesh configuration;
Figure 10 is a greatly enlarged plan view showing a mesh configuration of product that may be formed by the method and apparatus illustrated in Figure 9;
Figure 11 is an elevational view partly in section of a modified apparatus for carrying out the process;
Figure 12 is a horizontal sectional view taken substantially on the line 12—12 of Figure 11, and
Figure 13 is a transverse sectional view taken substantially on the line 13—13 of Figure 11.

While we have illustrated a method and apparatus particularly adapted for orienting and assembling fibers or strands of fibers formed of glass or inorganic materials into a reticulated mesh-like product, it is to be understood that we contemplate the utilization of the principles of the present invention for assembling other types of fibers and for other uses wherever the same may be found to be applicable.

Referring now in detail to the drawings in Figures 1, 2 and 21 at each end for securing the post to the frame and ceiling portions respectively of the room in which the apparatus is disposed. The corner posts 11 may be provided with foot or base portions 22 for bolting the frame to the floor or support so as to maintain the frame in fixed relation to the post 19.

Means are provided for supporting a plurality of bobbins of fibers or strands which supply the warp strands for the end product. In the embodiment illustrated there are four supporting means spaced about the rectangular frame 10 and adapted to carry the bobbins or spools of fibers or strands. Each of the supports is inclusive of a pair of upright members or posts 24 mounted upon suitable plates 25 which may be secured to the floor or other supporting surface. The posts 24 form means for supporting a plurality of brackets 26 which extend laterally from the posts in a direction toward the frame 10. Each set of brackets 26 is adapted to receive a bobbin supporting spindle or rod 28.

In the embodiment illustrated and as particularly shown in Figure 2 each spindle 28 supports four bobbins 30 each containing a supply of strands or fibers. As shown in Figure 1 there are eight sets of brackets 26 each supporting a spindle, and as each spindle supports four bobbins, a total of thirty-two bobbins is carried on each support. As there are four supports each carrying the same number of fiber or strand-supply bobbins, there will be supplied to the apparatus a total of 128 warp fibers or strands. It is to be understood that the number of spindles carried by each of the supports 24 and the number of spools carried by each spindle may be varied dependent upon the number of warp fibers or strands desired in fabricating the end product. Each of the spools 30 contains a supply of fiber or strands and forming a warp element in the end product. If yarns are desired for the warp elements then each element 31 may be made of twisted or contiguous strands of fiber.

As particularly shown in Figures 1 and 2 a strand guiding ring 33 is provided to effect a transition in direction of movement of the warp strands or fibers 31. The ring 33 is preferably centered about the axis of the upright or post 19 and is supported by means of struts or bars 34 welded to the ring and annulus 35 and which extend downwardly and outwardly and are welded or otherwise secured at their extremities to the horizontal bars 12 of the frame as particularly shown in Figures 1 and 2. The strands or fibers 31 pass beneath the ring 33 and extend upwardly as shown in Figure 1.

The warp strands are conveyed upwardly, being drawn by means of pulling feed rolls 36 as shown in Figure 1. The rolls 36 are journaled upon suitable brackets 37 mounted upon beams or structural members 38 which are carried upon suitable supports (not shown). The feed rolls 36 are driven by suitable means as for example a chain or belt 39 shown in Figure 4 which is attached to a suitable source of power as for example an electric motor through a gear reduction system (not shown) in order to reduce and control the speed of the feed rolls 36. The finished product of warp and fill yarns designated 32 is divided into two or more sheets or sections in a manner to be hereinafter explained, each section passing beneath a guide roll 40 and to a collecting roll or spool 41 as
shown in Figure 1. The collecting roll 41 may be supported by suitable means as for example rolls 42 and 43 and may be rotated by suitable driving means (not shown) to collect the formed product and at all times maintain the warp threads and the finished composite product in a substantially circular path for the purpose of controlling the locus of revolution of the ring. The inner wall of the ring 66 is suitably configured to fit the peripheral shape of the rollers 70 so that the ring 66 is prevented from vertical displacement and is guided in a circular path. The exterior wall of the ring 66 is formed with a peripheral groove to accommodate a flexible belt 72 which overtakes a pulley 73 driven by an electrically actuated motor 75 or other suitable source of power. The motor 75 is secured to the frame 10 by means of bolts 76.

The ring 66 forms a means for supporting one or more supply bobbins of fiber, strand or yarn which form the fill strands or elements of the fabric produced by the apparatus. In the embodiment illustrated in Figure 1, a bobbin 77 is carried by the ring 66 and is mounted upon a bracket 78 secured to the ring by means of the screws 79 or other suitable securing means. Also mounted upon the ring 66 and adjacent the bobbin carrier 78 is a bracket 80 to which is secured an arm 81 carrying strand or thread guide bushings 82 and 83 for guiding the fill strand or yarn 84 in its circular traverse about the group of warp strands or yarns 31. The outer wall of the ring 66 is disposed around the perimeter of the guide ring 54. This arrangement is desirable in order that each individual warp strand or yarn will be spaced from adjacent yarns or strands and thus pass through the bath of bonding agent or adhesive in a manner so that a complete coating of the strands or yarns as well as the desired internal distances between adjacent warp strands or yarns. Disposed within the receptacle 46 is a ring or annulus 58 so positioned as to be immersed in the bonding agent contained within the receptacle 46. The ring 58 is welded or otherwise secured to clips or brackets 59 which are preferably carried by the outer wall 47 of the receptacle 46 as shown in Figure 1. The ring 58 is disposed in the receptacle 46 in a manner such that the warp yarns or strands 31 pass over the guiding ring 54 and beneath and around the ring 58 so that each strand receives an application or coating of the bonding agent or adhesive contained in the receptacle. It is preferable to utilize a thermoplastic adhesive such as asphaltum compound or other suitable binder which is contained in the receptacle 46 is liquid condition. The heated liquid asphaltum compound or other bonding agent is delivered through the receptacle 46 by suitable means (not shown). The purpose of such means is to maintain the asphaltum or bonding agent in a liquid condition to enhance its application to the strands or yarns.

The present invention embraces the provision of a novel method and apparatus for applying one or more fill strands or yarns to the group of warp strands or yarns as the latter are moved in a linear direction by the feed roll rolls 36. In the present embodiment of the invention this means is in the form of a winding mechanism adapted to travel in a substantially circular path about the cylindrical configuration formed by the warp yarns or strands. Journalled upon horizontally disposed stub shafts 63 are antifriction devices or rollers 64, the shafts 63 being supported by the horizontally disposed frame members 14. As shown in Figure 3 there are four rollers 64 illustrated. The antifriction device or rollers 64 support an annularly shaped member or ring 66 which is arranged to revolve about the group of warp strands or yarns, the rollers 64 serving to minimize the friction in yuoring the rotating ring. Mounted upon stub shafts 68 which are mounted in a vertical position upon the frame plate 17 is a plurality of peripherally grooved discs or rollers 70 which are arranged for engagement with the inner wall of the ring 66 for the purpose of controlling the locus of revolution of the ring. The inner wall of the ring 66 is suitably configured to fit the peripheral shape of the rollers 70 so that the ring 66 is prevented from vertical displacement and is guided in a circular path. The exterior wall of the ring 66 is formed with a peripheral groove to accommodate a flexible belt 72 which overtakes a pulley 73 driven by an electrically actuated motor 75 or other suitable source of power. The motor 75 is secured to the frame 10 by means of bolts 76.

The ring 66 forms a means for supporting one or more supply bobbins of fiber, strand or yarn which form the fill strands or elements of the fabric produced by the apparatus. In the embodiment illustrated in Figure 1, a bobbin 77 is carried by the ring 66 and is mounted upon a bracket 78 secured to the ring by means of the screws 79 or other suitable securing means. Also mounted upon the ring 66 and adjacent the bobbin carrier 78 is a bracket 80 to which is secured an arm 81 carrying strand or thread guide bushings 82 and 83 for guiding the fill strand or yarn 84 in its circular traverse about the group of warp strands or yarns 31. The outer wall of the ring 66 is disposed around the perimeter of the guide ring 54. This arrangement is desirable in order that each individual warp strand or yarn will be spaced from adjacent yarns or strands and thus pass through the bath of bonding agent or adhesive in a manner so that a complete coating of the strands or yarns as well as the desired internal distances between adjacent warp strands or yarns. Disposed within the receptacle 46 is a ring or annulus 58 so positioned as to be immersed in the bonding agent contained within the receptacle 46. The ring 58 is welded or otherwise secured to clips or brackets 59 which are preferably carried by the outer wall 47 of the receptacle 46 as shown in Figure 1. The ring 58 is disposed in the receptacle 46 in a manner such that the warp yarns or strands 31 pass over the guiding ring 54 and beneath and around the ring 58 so that each strand receives an application or coating of the bonding agent or adhesive contained in the receptacle. It is preferable to utilize a thermoplastic adhesive such as asphaltum compound or other suitable binder which is contained in the receptacle 46 is liquid condition. The heated liquid asphaltum compound or other bonding agent is delivered through the receptacle 46 by suitable means (not shown). The purpose of such means is to maintain the asphaltum or bonding agent in a liquid condition to enhance its application to the strands or yarns.

Figure 8 illustrates a typical pattern formed on the apparatus hereinbefore described wherein the space between adjacent warp strands 31 is substantially equal to the space between adjacent convolutions of the fill strand 84 after its deposition upon the warp strands resulting in a parallelogrammatically shaped mesh, developing from a rectangle only in the pitch angle of the fill strand. By reducing or increasing the speed of the ring 66 and hence the rate at which the fill strand travels around the warp strands, the vertical dimension of the interstices or meshes of the assembly of the warp and fill strands may be varied as desired. The lateral distance between adjacent warp threads may be varied by increasing or decreasing the number of warp threads utilized in the assembly.

It has been found that satisfactory bonding of the intersections of the warp and fill strands may be attained through the utilization of various thermosetting or thermoplastic adhesives or bonding agents. In order to cure, set or fuse the bonding agent, a zone is provided for applying heat to the formed product subsequent to the application of the bonding agent. As illustrated in Figure 1, this may be accomplished by disposing a plurality of spaced heating units or burners 87 about the cylindrical configuration of the formed product so that it moves away from the fill strand applying zone. The heating units 87 illustrated are of the gas burning type but it is to be understood that other fuels may be utilized or electrical units be provided if desired. In order to minimize the amount of heat energy required for curing or setting the bonding agent, an annular well 89 fabricated of heat resistant material may be advantageously employed which is supported upon a metallic wall or plate 90. By controlling and directing the application of heat from the burners 87 upon the coated warp strands at the zones of intersections of the fill strands therewith, the bonding agent may be rapidly cured, set or fused as the formed product moves to a collecting zone.

Means are provided for guiding the formed fabric to
the feed or draw rolls 36. As particularly shown in Figures 1 and 5, the diameter of the cylindrical configuration of the formed fabric is determined by the size of the rings 58 and 92, the latter being arranged at the upper end of the cylindrical strand assemblage. The ring 92 is suitably supported upon the post 19 by means of brackets 93. Arranged in spaced intervals above the ring 92 are additional gripping members 95 and 97 each of a different shape for accomplishing progressive or gradual transition of the cylindrical configuration of strand formation to a flat sided configuration as the latter approaches the draw or feed rollers 36. The guide members 95, 96 and 97 are suitably supported upon the centrally positioned post 19 by means of brackets or struts 98. As the strand assemblage approaches a flattened shape the strand fabric may be severed or subdivided by any suitable severing means to form two or more sheets which are conveyed to the collector or accumulator rolls 40. A satisfactory severing of the fill strands of the assemblage may be accomplished by utilizing electrically energized resistance wires 99 such as nichrome wire which is heated to a temperature sufficient to molt and thus quickly sever the fill strands so that the resultant strips 38 may be conveyed to the motor or collector rolls 40.

The warp fibers or strands may be grouped in any predetermined shape or configuration to receive an overlay of fill strands. For example, the warp strands may be grouped or disposed in a polygonal shape, elliptical, rectangular or even substantially flat. If desired the warp strands or elements may be arranged in a single plane during the application of the fill strands or elements. It is to be understood that the principles of the present invention embrace the fabrication of an unwoven fabric-like product in which the fill elements traverse a path around or crosswise of a group of warp elements and joining the intersections of the elements together to form a symmetrical reticulated or mesh like product. If the warp strands are arranged in a single plane and the fill strands conveyed around the warp strands, the fill strands lie on each side of the group of warp strands providing an assembled product involving three layers of strands. In this form of product, the width of the formed strip may be predetermined by the width of the group of warp strands and the severing operation may be eliminated. This form of product eliminates the presence of the severed ends of fill strands.

Figure 9 illustrates a modified form of apparatus for applying fill strands to the warp strands in more than one direction. As illustrated diagrammatically in Figure 9 the warp strands 31' are caused to move upwardly by a first pair of rolls 38 and 39 as shown in the drawings. A pair of rings 66 and 66' each carrying one or more bobbins containing a supply of fill strands 84 and 84' are arranged to travel around or circumscribe the group of warp strands 31' to deposit two or more layers of fill strands disposed in angular relationship both with respect to each other and to the warp strands of the product. Due to the angular positioning when several fill strands from supply bobbins carried by the rings 66' and 66" utilized the resultant reticulated product or pattern is of the character illustrated in Figure 10. In this figure it is to be noted that the warp strands 31' are overlaid by a row of fill strands 84' and the fill strands 84" overlaid with another layer of fill strands 84". Thus by varying the angularities at which the fill strands may be disposed upon the warp strands, which may be done by varying the speed of the ring or rings carrying the bobbins of fill strands, the magnitude and direction of the strength factors of the resultant end product may be varied and controlled. This feature is extremely desirable in connection with various products and fabrications incorporating the unwoven fabric of the present invention. Thus for the reinforcement of the pattern or mesh illustrated in Figure 8 may be desirable while for other types of fabricated materials the pattern or strand formation exemplified in Figure 10 may be desired.

By utilizing the method of the present invention, the size of mesh, the number of warp and fill strands and their assemblage may be accomplished while the number of both warp or fill strands, and the grouping of the warp strands, and the speed and direction of movement of the warp and fill strands during their assemblage.

The operation of the apparatus in carrying out the method of the invention as follows: The supports 24 are each provided with a plurality of bobbins carrying supplies of fibers, strands or other form of linear material to form the warp elements for the product. The fibers or strands 31 from each of the bobbins are threaded beneath the ring 93 and over the ring 54, the individual strands or fibers being spaced apart, commonly on the ring 54 by means of the spacing fingers or projections 56. The strands or fibers 31 are then threaded beneath the ring 58 immersed in the bonding agent in the receptacle 46 and are led upwardly over the spreading ring 92 and in engagement with the guides 95, 96 and 97 over the feed or draw rolls 36, there being tension on the warp elements setting up sufficient friction between the warp elements 31 and the feed rolls 36 to cause the threads to be drawn upwardly. It should be pointed out that due to the circumferential spacing of the warp strands by means of the guides or fingers 86, 86' the warp strands between the rings 58 and 92 assume a generally cylindrical configuration. Asphaltum compound or other bonding agent or adhesive is supplied to the annular receptacle 46 in a liquid condition. The asphaltum compound may be heated in a separate heater 72. The asphaltum compound is then led through the medium of the belts 72, 72" to rotate the rings 66 and the bobbin or bobbins 77 carrying a quantity of fill strand or fiber 84. The rotation of the ring 66 conveys or winds the fill strand or element 84 around the cylindrical configuration of the upwardly moving warp strands or elements 31. As the fill element or strand moves around the group of warp strands or fibers, the fill strand or element progressively contacts or engages the individual warp strands, the bonding agent on the warp strands or fibers causing the fill thread or thread to adhere or be bonded or joined to the warp threads at their intersections, thus forming an unwoven reticulated or mesh-like product of intersecting threads or strands. The bonding agent forms a suitable means for maintaining the warp and fill elements in their assemblage and the fact that the warp threads are moving upwardly continuously the winding of the fill strand or strands thereon, the fill strands are disposed at a slight angle away from a perpendicular to the warp threads, the angle or pitch of the fill strand being equal to the space between adjacent convolutions of a single fill strand. Thus the finished unwoven fabric or product embodies substantially rectangular mesh configuration although actually the fill strands are not at right angles to the warp strands as above pointed out.

As the warp and fill strands in assembled relationship move upwardly away from the receptacle 46 they are subjected to the heating devices 77 which cure, set or fuse the bonding agent or adhesive so as to impart permanence to the product. The group of warp strands and fill strands bonded thereto move upwardly in the form of a cylindrical configuration and after passing the circular ring 92, the transition guides 95, 96 and 97 progressively reshape the cylindrical configuration to a flattened configuration as shown in Figure 5. As the flattened configuration approaches the feed rolls or draw rolls 36 the severing devices 99 in the form of electrically heated resistance units engage and fuse the fill threads thus severing the same so as to divide the formed product into two sheets, each sheet being conveyed over a roll 36.
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to the collector or accumulator rolls 40. It is to be understood that the formed product may be subdivided into any number of sheets or strips by utilization of the required number of properly spaced strand severing devices in each roll position.

The bonding agent may be applied to the strands by spraying or other suitable method. It is to be understood that while we have illustrated the apparatus positioned so as to convey the warp strands or elements in a vertical direction, the apparatus may be utilized in a horizontal or other roll position. If other positions are employed, the bonding agent or adhesive may be sprayed on the warp strands in lieu of the dip method illustrated in Figure 1.

The operation of the apparatus of Figure 9 is substantially as described in respect to the form illustrated in Figure 1 with the ring or bobbin carrier 66 traveling in a direction opposite to that of the ring or bobbin carrier 66.

It is to be understood that the utilization of the method and apparatus is contemplated for producing an assemblage of linear materials of various types and kind. Thus the warp components may be of vegetable fiber such as cotton strands or yarns on which a layer of synthetic fibrous material such as acetate rayon or fiber-forming linear polymeric amide (nylon) may be applied as the fill component of the assemblage, the warp and fill components with their interlocking adhesive. Materials of which the above are typical examples may be utilized for warp or fill components as desired. The invention may be advantageously utilized to form an assemblage of glass fibers, strands or yarns as warp or fill components with materials of the character above enumerated in conjunction with a joining or bonding means for maintaining the warp and fill components in assembled relationship. In practicing the invention in connection with the formation of reticulated products from certain materials, the step of applying an independent bonding agent may be dispensed with when a readily heat softenable or fusible material is employed in assembly with a relatively heat resistant material. By way of example, a fill constituent of acetate rayon may be assembled with a warp constituent of glass fibers, strands or yarns and sufficient heat applied to the intersections of the constituents during assembly to partially fuse the acetate rayon causing it to adhere to or bond with the glass constituent providing a relatively permanent assembly.

It has been found that many different adhesives or bonding materials may be employed for joining the assembled warp and fill elements together. Thus adhesives such as starch, sugar, gum or various glutinous materials may be advantageously used. Thermoplastic bonding agents other than asphaltum compounds may be used such as vinyl chloride, vinyl acetate, copolymers thereof, methyl methacrylate or other resins of this nature capable of establishing a bond. Thermosetting resins may also be employed such as urea-formaldehyde and phenol-formaldehyde. It is to be understood that the enumerated materials as bonding agents may be used alone or in combination as many other readily obtainable materials may be successfully employed for the purpose.

Figures 11, 12 and 13 illustrate a further modification of apparatus for carrying out various phases of the method of our invention of producing a wovensheet fabric-like material. The arrangement of this form of apparatus is particularly adaptable to the production of a wovensheet fabric wherein the fill fibers or strands may be formed from molten material simultaneously with the operation of assembling the fill strands or fibers with the warp strands or rolls.

The apparatus illustrated in Figures 11 through 13 is inclusive of a frame structure or base 125 upon which is mounted a tube or member 127 which is maintained in proper position on the frame 125 by means of supporting struts 128. A plurality of strand or fiber guiding means in the form of rings are designated in Figure 11 by numerals 130, 131, 132 and 133. Each of the strand or fiber guiding rings is supported from the tube or member 127 by means of radially arranged units 135. These units may be welded or otherwise secured to the rings, the inner ends of the struts being secured to the tube 127 by means of bolts 137 or other suitable securing means.

Extending through the hollow interior of the tube 127 is a shaft 139, one extremity of the shaft being formed with a tenon portion 140 upon which is secured a rotatable element or cap member 141. The cap member 141 is mounted on a tenon portion 140 of the shaft 139 by means of a key 142, a nut 143 being threaded on the extremity of the tenon portion 140 to hold the cap member 141 on the tenon portion 140. The shaft 139 is revolvably supported at its ends by means of anti-friction or ball bearings 145 and 146. The other extremity of the shaft 139 extends into a housing 148 which encloses suitable gearing 149, the gearing being connected to the shaft 150 of a motor 151 or other suitable power source for rotating the shaft 139. Through the medium of the gearing 149, the shaft 139 may be driven at a desirable speed to obtain a required rate of rotation of the cap or rotatable element 141.

In this form of apparatus the warp strands 31" are supplied from bobbins or spools 30" carried upon suitable supports 26". The warp strands or fibers 31" are directed in a straight line beneath and around the lowermost ring 30 so as to engage the inner peripheral area of the ring 130, the fibers or strands being maintained in suitable spaced relation by suitable means as, for example, spacing fingers 129 disposed circumferentially around the ring 130. The strands 31" are then directed upwards adjacent the inner surface areas of the rings 131, 132 and 133, the strands passing over the upper surface of the uppermost ring 133 thence downwardly on the outside thereof as illustrated in Figure 11. In this form of apparatus the fill fibers or strands are laid over the warp fibers or strands as the latter progress along the exterior peripheral zones of the rings 132 and 131. In this form of the invention the fill fibers or strands may be readily continuously formed or fabricated immediately prior to their application to the warp fibers or strands 31".

In the embodiment illustrated we have employed a fill strand composed of several fibers formed and attenuated from molten glass or other suitable fiber-forming material. As illustrated a bushing or feeder 155 is adapted to contain a body of molten glass 157 or other fiber forming material, the bottom of the feeder or bushing being formed with a series of orifices 156 through which the molten glass flows in the form of a corresponding number of streams 157 of molten glass. The streams 157 are continuously attenuated to form fibers, the latter being caused to pass over an applicator roll 158, the fibers being gathered into a strand 84", the formed strand passing through a suitable guiding means in the form of an eye 160. The strand 84" is directed to a guide member 161 in the form of a roller 161 journaled upon a suitable stub shaft 162 carried by the cap member 141. It is to be understood that one or more strands 84" may be applied to the warp strands and hence one or more guide rollers 161 may be carried by the cap member 141. Even though a single strand 84" forms a fill element in the finished product, it is desirable in order to obtain a perfect dynamic balance of member 141 that a roller 161' or equivalent counterbalance weight be mounted diametrically opposite to the guide roller 161 to accomplish this purpose. It is desirable to apply an adhesive or bonding agent to the strand 84" through the medium of the applicator roll 158. As illustrated there is provided a receptacle 164 provided with a tube 165 terminating adjacent the applicator roll 158. The tube 165 is provided with a valve 167 for regulating the rate of flow of adhesive or bonding agent through the tube 165 to be applied to the roll 158. In this manner the
amount of adhesive or bonding agent applied to the strand 84'' may be controlled by regulating the amount of adhesive or agent applied to the roll 158.

As previously stated the streams 157 of molten glass issuing from the feeder 155 are attenuated to form fibers and this is accomplished through the tension of winding the fiber strand 84'' formed from the fibers onto the exterior of the cylindrical or circular configuration or formation of warp strands passing downwardly on the exterior peripheries of the rings 133, 132 and 131. Means are provided for conveying the warp strands 31'' for movement in the directions shown in the drawings particularly in Figure 11. As illustrated the finished fabric 32'' formed by the assemblage of warp and fill strands passes downwardly exteriorly of the rings 131 and 132. It is desirable to sever the fill strands at one or more points in order to form one or more strips of finished fabric. As illustrated in Figures 11 and 13 the fabric 32'' is adapted to be severed at diametrically disposed points to form two strips of finished material. To this end we have provided fill strand severing means in the form of electrically heated resistance wires or elements 170, there being two such means. The apparatus is illustrated arranged on opposite sides of the cylindrical configuration of finished fabric. Each severing element 170 is adapted to be energized by a suitable electric current and is heated through internal resistance of the wire itself to a temperature such as will readily sever the fill strands of the fabric as it moves downwardly. Other fiber or strand severing means may be employed such as a gas flame or mechanical cutting devices.

Arranged at diametrically spaced zones with respect to the cylindrical fabric formation are pairs of feed rolls 171 and 172 through which the respective strips of finished fabric are drawn by movement of the feed rolls. The rolls may be actuated by any suitable source of power (not shown) in order to establish a uniform movement of the fabric. The fabric, after passing through the feed rolls, may be collected upon accumulator rolls 174, one of which is shown in Figure 11. Thus under the friction of the engagement of the moving feed rolls with the strips of fabric, the warp strands 31'' are tensioned throughout their movement and are thus drawn upwardly on the interior of the rings 130, 131, 132 and 133 thence downwardly on the exterior of the rings through the zone where the warp strands 31'' are applied to form the fabric 32''. The strand severing devices 170 sub-divide the fabric into strips which are conveyed by the pairs of feed rolls to the accumulator rolls. It is to be understood that any suitable motivating means may be used for conveying the strands 31'' and the finished fabric 32'' in the process of our invention. For example, the feed rolls may be dispensed with and power applied through suitable power transmitting devices directly to the accumulator rolls 174 whereby the latter serve as means to move the strands and finished strips of fabric.

While there are various adhesives or bonding agents that may be employed for joining the fill fibers or strands to the warp fibers or strands as hereinbefore mentioned, certain bonding agents require a curing operation. In order to effect a curing operation, the apparatus is inclusive of a plurality of heating elements 176 spaced around the exterior of the cylindrical configuration of formed fabric. The heating elements may be in the form of gas flame or electrically energized units for applying heat to the fabric after the application of the fill strands 31'' in order to effect the curing. The heating units 176 may be surrounded by a wall of suitable refractory material 178 mounted upon a metal annulus or backing plate 179. The refractory material 178 serves to reflect heat onto the fabric and thus minimize the amount of heat energy required to effect the curing operation.

The process carried out upon the apparatus illustrated in Figures 11 through 13 inclusive is similar to that hereinafter described. In operating this process, the motor 151 is energized to rotate the shaft 139 and the winding device or winding cap 141. The warp strands 31'' are guided upwardly and interiorly of the guide rings 130, 131, and 132 and over the upper surface of the ring 133, thence downwardly exteriorly of the rings 132 and 131. This movement of the warp strands takes place by reason of the movement or rotation of the feed rolls 171 and 172 or other means for establishing movement of the warp strands. Simultaneously with the movement of the warp strands in the manner hereinafter described, the glass fibers are attenuated from the bushings 156 and assembled together to form a strand 84''. During the formation of the strand, the fibers passing over the roll 158 acquire a coating of adhesive or bonding agent applied to the roll through the tube 165 from the receptacle 164. The fill strand 84'' is carried by the guide means or roller 161 on the winding device 141 circumferentially around the warp strands 31'' as they move downwardly as indicated in Figure 11. After the fill strand has been superposed or laid upon the warp strands 31'' the assembled fabric moves through the curing zone and, under influence of the temperature 176, the adhesive or bonding agent is cured or "set" so as to join the intersec-
sions of the warp and fill strands together to form a fabric. The cured fabric moves downwardly and upon reaching the strand severing devices 170, the fill layer is severed subdividing the fabric into strips which are conveyed by the feed rolls to the accumulator rolls and will be noted that this form of process, as in the other forms hereinbefore described, is continuous in operation. One of the advantages of this form of apparatus and process is the substantially simultaneous formation of the fill strand 84'' from inorganic fibers 157, this step in the process being carried out at the time the winding device 141 attenuates the fibers and concomitantly winds the fill strands upon the warp strands.

It is to be understood that any number of strand severing devices 170 may be utilized to form a corresponding number of strips of the finished product and a pair of feed rolls may be utilized for each strip severed from the composite fabric in its initial formation. It is to be also understood that the fill strand 84'' may have been previously fabricated from fibers and may be fed to the winding device 141 directly from a bobbin or spool in the same manner that the warp strands 31'' are fed to the apparatus. It is apparent that, within the scope of the invention, modifications and different arrangements may be made other than as herein disclosed, and the present disclosure is illustrative merely, the invention comprehending all variations thereof.

We claim:
1. The method of producing a reticulated fibrous product including the steps of moving a group of spaced mineral fibers in one direction, moving a fiber in a different direction and depositing it upon the fibers of the group to cause the fiber to be overlaid upon and intersecting engagement with the fibers of the group, and joining the fibers together at their zones of intersection.
2. The method of producing a product of strand material including the steps of moving a group of spaced strands disposed in side by side relationship in the intersection, moving a strand of mineral fibers in a different direction and depositing it upon the strands of the group to cause the strand to be overlaid upon and in intersecting engagement with the spaced strands of the group, and joining the engaging strands together at their zones of intersection.
3. The method of producing an unwoven mesh of warp and fill elements formed of glass fibers including the steps of feeding the warp elements in spaced relation in one direction, concomitantly overlaying the group of warp elements with one or more fill elements moving in a dif-


fertent direction to form therewith a mesh-like configuration, and joining the elements at their intersections by a bonding medium to impart integrity to the mesh-like configuration.

4. The method of producing a reticulated product of strands of inorganic fibers including the steps of moving a group of strands arranged in spaced relation in a direction of their length in predetermined spaced formation, applying a bonding agent to the moving group of strands, concomitantly causing an independent strand or strands to circumscribe the group of strands and overlay and engage the individual spaced strands of the group to form a reticulated pattern, the bonding agent joining the strands together at their zones of intersection.

5. The method of forming an unwoven product of warp and fill elements including orienting a plurality of warp elements in spaced relation for movement in substantial parallelism in a linear direction, immersing the warp elements in a supply of adhesive whereby the elements acquire a coating of adhesive, and winding one or more fill elements in a direction circumscribing the spaced warp elements in a manner whereby the fill element or elements are joined to the warp elements through the medium of the adhesive coating.

6. The method of producing an unwoven fabric of strands of mineral fibers including the steps of feeding a group of strands arranged in generally circular formation in the direction of their length, concomitantly mov- ing a strand in a generally circular path circumscribing the group of strands whereby the circularly moving strand overlies and engages the strands of the group, and securing the strands to one another at their points of intersection.

7. Apparatus of the character disclosed including in combination, a frame, strand guiding means including a plurality of strand spacing projections supported upon the frame, means for supplying a plurality of strands to the strand guiding means, said guiding means being configured and arranged to dispose the plurality of strands in spaced relation in a substantially parallel group, a strand conveying member, means for actuating the strand conveying member to deposit an independent strand of material across the group of spaced strands in overlying engagement therewith, and an applicator for applying a bonding agent for securing the strands in assembled relationship.

8. Apparatus of the character disclosed including in combination, means including guide members for positioning a group of warp elements in spaced substantially parallel relationship, a relatively movable fill element supporting member; means for driving said fill element supporting member for depositing one or more fill elements on said group of warp elements in angular relation thereto, means including an applicator for applying a bonding agent to establish a juncture of the fill elements with the warp elements at their zones of intersections, and means for applying heat to cure the bonding agent.

9. Apparatus of the character disclosed including in combination, a frame, warp element guiding means including a plurality of projections associated with the frame for positioning a group of warp elements in spaced substantially parallel relationship, an applicator for applying an adhesive to the warp elements, a relatively movable fill element carrying member; means for driving the member for depositing one or more fill elements on said group of warp elements in angular relation thereto in a manner whereby the adhesive joins the intersections of the warp and fill elements, and means for applying heat to set the adhesive.

10. Apparatus of the character disclosed, in combination, means including a guide member for orienting a group of strands in spaced parallel relation; for movement in a linear direction, a relatively movable strand carrying member; means for moving the strand carrying member in a different direction relative to the direction of move- ment of the group of strands for depositing a strand layer upon the group of strands, and means for applying a bonding agent to join the group of strands and strand layer in assembled relationship.

11. Apparatus of the character disclosed, in combination, means for moving a group of spaced warp elements in a rectilinear direction in substantially circular formation, a plurality of guide members arranged to engage and maintain the warp elements in circular formation; means including an applicator for applying a coating to said warp elements, a relatively movable fill element supporting member; means for driving the fill element supporting member in a circular path around the cylindrical formation of warp elements for superposing a fill element thereon and in engagement therewith, said coating joining the warp and fill elements together at their points of intersection.

12. Apparatus of the character disclosed including in combination, a frame, means associated with the frame for guiding a plurality of warp elements in spaced relation, a receptacle adapted to contain adhesive material, means including a bar for carrying warp elements through the adhesive whereby the warp elements acquire a coating of adhesive, a fill element supporting member; means for moving the fill element supporting member relative to the warp elements for depositing a continuous fill element on the warp elements forming a layer of fill material engaging the warp elements, a plurality of heating elements, the assemblage of warp and fill elements being movable through a zone adjacent the heating elements for setting the adhesive to join the layer of fill material to the warp elements.

13. Apparatus of the character disclosed in combination, a frame, guiding means associated with the frame, means for supplying a plurality of warp elements to the guiding means, an annularly shaped receptacle adapted to contain a supply of bonding material, means for moving the warp elements, means for directing the moving warp elements through the bonding material in the receptacle, said warp elements arranged to move away from the receptacle in a generally circular formation, a rotatably supported ring mounted on the frame, said ring adapted to support a supply of fill element, means for rotating the ring to wind the fill element around the circular formation of warp elements, the bonding material on the warp elements securing the layer of fill element thereto, and heating means for curing the bonding material.

14. The method of producing a reticulated product of fibrous material including the steps of continuously moving a group of warp strands arranged in predetermined spaced relationship, fabricating a fill strand from fibers being formed concomitantly from molten mineral material and depositing the fill strand on the group of spaced warp strands in a manner whereby the warp and fill strands are joined at their zones of intersection, and continuously collecting the reticulated product as it is formed.

15. The method of producing an unwoven fabric-like product including the steps of moving a group of fibers of mineral material arranged in predetermined spaced relationship, simultaneously supplying a continuous fiber to a zone adjacent the group of fibers, conveying the fiber in a direction to deposit same upon the group of spaced fibers forming an overlayer thereon in a manner whereby the group of fibers and overlying fiber are joined together at their zones of intersection.

16. The method of forming a reticulated product of fibrous material including the steps of moving a group of fibers in one direction interiorly of a fiber guiding means, reversing the direction of movement of the group whereby they are caused to move exteriorly of the guiding means, overlaying the group of fibers with a fill fiber material while the group of fibers are moved exteriorly of the guiding means in a manner to cause the fill fiber
material to adhere to the fibers of the group at their zones of intersection.

17. Apparatus of the character disclosed, in combination, a plurality of annular members in axially spaced relation forming guiding means for linear warp material, an element revolvable around the warp material, means for supplying a linear fill material to said revolvable element, driving means for rotating said element around the warp material for depositing the linear fill material upon the linear warp material, and means for applying a bonding agent to one of said materials for joining the intersecting fill and warp materials together.

18. Apparatus of the character disclosed, in combination, guiding means including a pair of spaced annular members for directing linear warp material for movement in one direction, a second guiding element for directing and conveying linear fill material in a different direction, means for effecting relative movements of said materials in their respective directions whereby one of said materials is caused to be deposited upon the other, and means for adhesively joining the warp and fill materials at their zones of intersection.

19. Process of manufacturing a non-woven fabric, comprising the steps of moving along a predetermined path a layer composed of longitudinal threads arranged next and parallel to each other and extending in the direction of said predetermined path; applying an adhesive to said layer of longitudinal threads during movement thereof along said predetermined path; continually winding, along a path substantially transverse to said predetermined path, at least one transverse thread about said moving layer of longitudinal threads after said adhesive has been applied thereto so that adjacent turns of said wound transverse thread adhere to said layer of longitudinal threads extending adjacent and transverse to the same to constitute a layer of transverse threads forming together with said layer of longitudinal threads, to which they adhere, a non-woven fabric.

20. Process of manufacturing a non-woven fabric, comprising the steps of moving along a predetermined path a layer composed of longitudinal threads arranged next and parallel to each other and extending in the direction of said predetermined path; applying an adhesive to one face of said layer of longitudinal threads during movement thereof along said predetermined path; continually winding, along a path substantially transverse to said predetermined path, at least one transverse thread about said moving layer of longitudinal threads after said adhesive has been applied thereto so that adjacent turns of said wound transverse thread adhere to said layer of longitudinal threads extending adjacent and transverse to the same to constitute a layer of transverse threads forming along their portions which adhere to said layer of longitudinal threads together with the same a non-woven fabric and along their portions which do not adhere free transverse thread portions; and severing said free transverse thread portions from said layer of longitudinal threads.

21. Process of manufacturing a non-woven fabric, comprising the steps of arranging a plurality of longitudinal threads next and parallel to each other so as to form a layer of said longitudinal threads; continually moving said layer along a first path in the direction of the length of said longitudinal threads; applying an adhesive to said layer of longitudinal threads at a first part of said first path; continually moving at least one transverse thread repeatedly along an endless second path extending about said first path along and against one side of said layer of longitudinal threads at a second part of said first path located adjacent to and after said first part of said path in the direction of movement of said layer of longitudinal threads so that said transverse thread will adhere to said layer of longitudinal threads and be carried therewith along said first path to form a non-woven fabric with said layer of longitudinal threads.

22. Process of manufacturing a non-woven fabric, comprising the steps of arranging a plurality of longitudinal threads next and parallel to each other so as to form a layer of said longitudinal threads; continually moving said layer along a first path in the direction of the length of said longitudinal threads; applying an adhesive to said layer of longitudinal threads at a first part of said first path; continually moving a plurality of transverse threads located next to each other respectively and repeatedly along a plurality of endless second paths extending about said first path along and against one side of said layer of longitudinal threads at a second part of said first path located adjacent to and after said first part of said path in the direction of movement of said layer of longitudinal threads so that said transverse threads will adhere to said layer of longitudinal threads and be carried therewith along said first path to form a non-woven fabric with said layer of longitudinal threads.

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