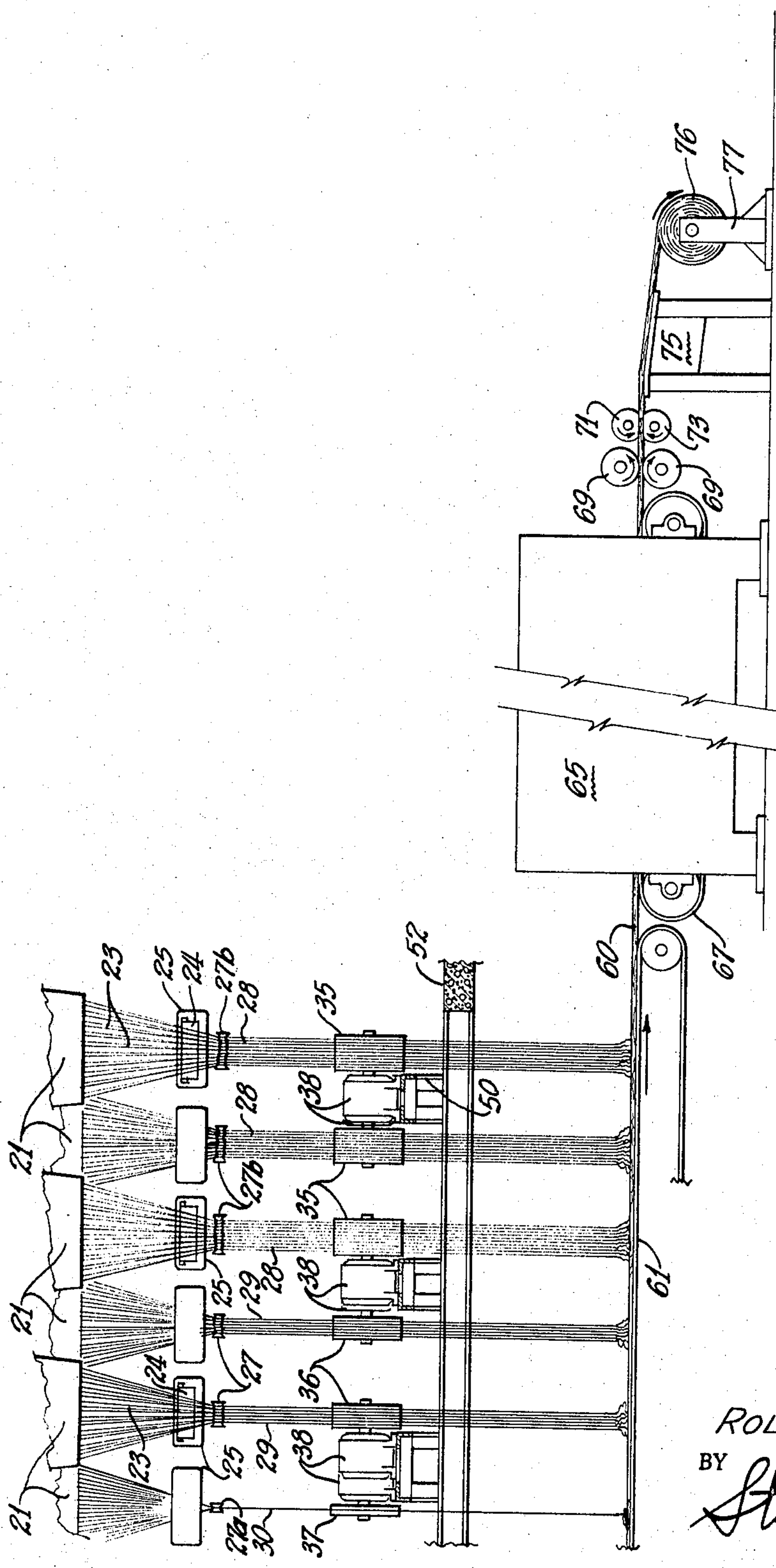

Fig. 1

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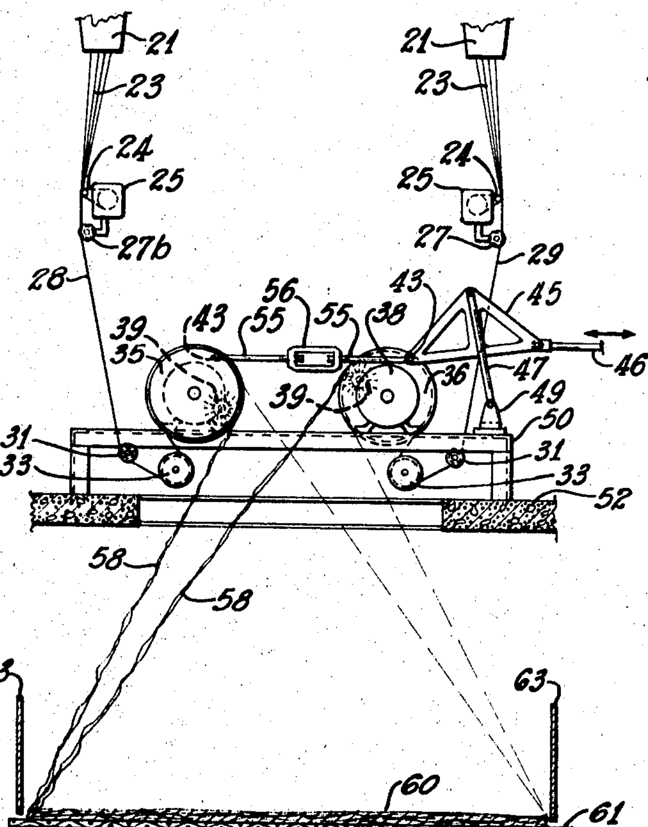

Fig. 2

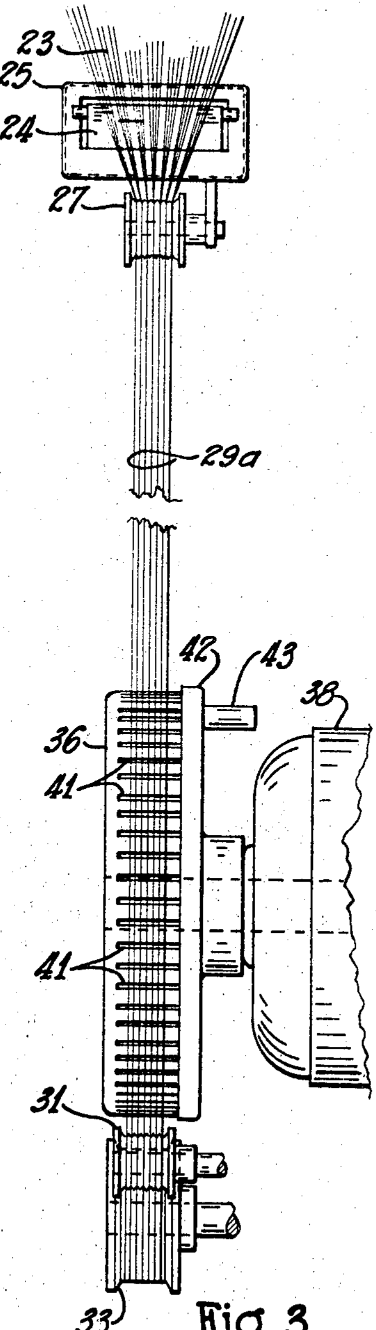

Fig. 3

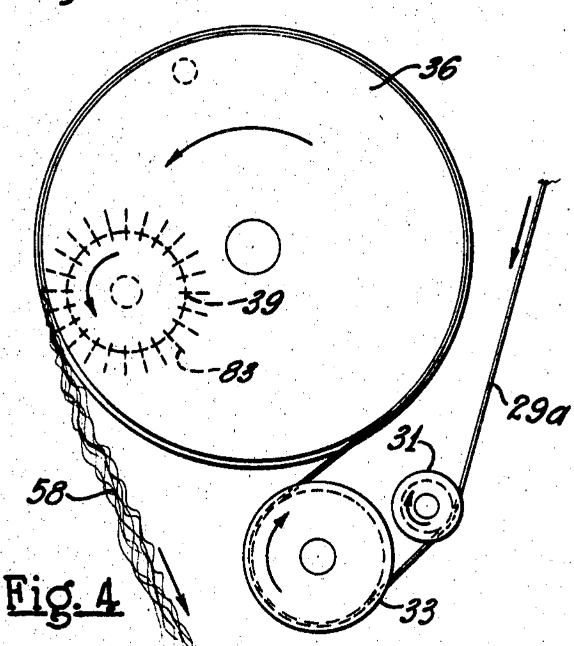

Fig. 4

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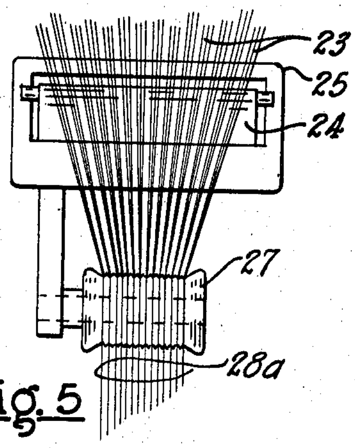

Fig. 5

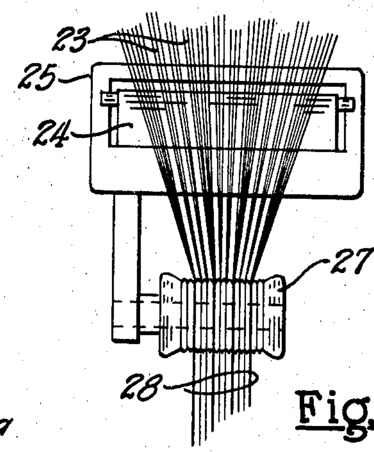

Fig. 6

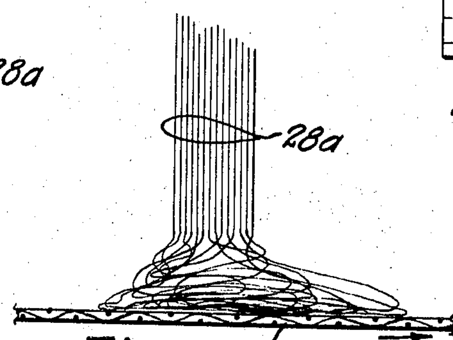

Fig. 7

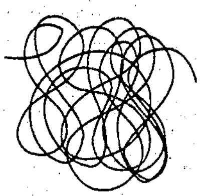

Fig. 8

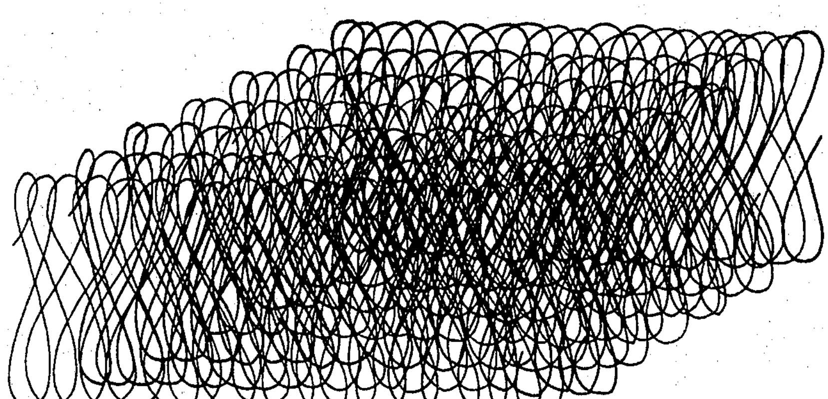

Fig. 9

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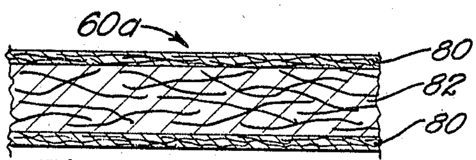

Fig. 10

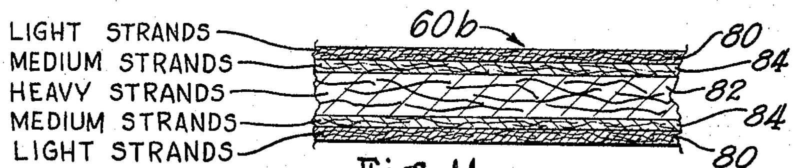

Fig. 11

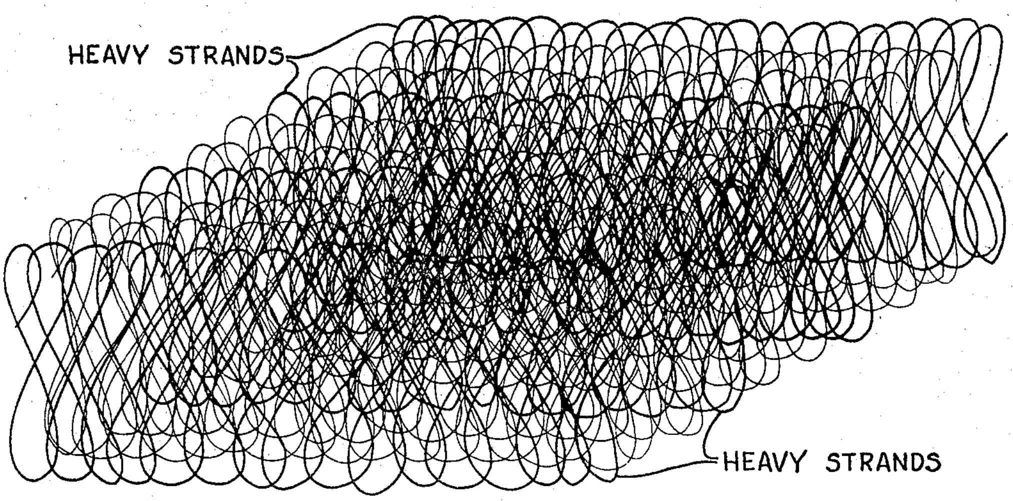

Fig. 12

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3,442,751
FIBROUS BODIES INCLUDING STRANDS AND METHODS OF PRODUCING SUCH BODIES

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Int. Cl. B32b 17/02, 31/30
U.S. Cl. 161—72 11 Claims

ABSTRACT OF THE DISCLOSURE

Fibrous bodies including laterally looped and interengaging strands of continuous glass filaments, the filaments being generally of uniform size but differing in number in different strands as in the strands of one layer compared to the strands in another layer, and methods of producing such fibrous bodies by gathering filaments from a forming source in substantially different numbers into strands and projecting the strands in close array and interengaging loops upon a receiving surface.

This invention relates to fibrous bodies containing continuous filaments with some or all of the filaments in bundles or strands. More particularly the invention pertains to fibrous glass bodies including strands of varying quantities of filaments. Methods of producing such fibrous bodies are also encompassed by this invention.

An important aspect of the invention is that its practice is preferably but not necessarily closely associated with apparatus for forming and drawing continuous glass filaments, gathering the filaments in strands, and depositing the strands as a continuous mat upon a belt conveyor.

The fibrous bodies or mats thus created are intended primarily as reinforcing media in molded synthetic resin plastic structures, such as airplanes, rockets, automobiles, boats, tanks, recreational equipment, electrical devices and appliance parts. However, they may also be utilized very effectively for filtering, acoustical and thermal insulation, roofing sheets and non-woven fabrics.

Fibrous mats for reinforcing plastic products contribute strength, impact resistance, dimensional stability and temperature resistance and usually improve electrical properties, chemical inertness, weathering and fabrication ease.

The above cited benefits gained through the inclusion in such plastic structures of fibrous glass have been thoroughly demonstrated. However, there have been problems in obtaining thorough and fast wetting out of the fibrous insert by the molten plastic and in securing, without undue labor, a highly finished surface on the molded product.

There have also been difficulties involved in the fabrication of fiibrous strand bodies or mats. Because of the comparative greater bulk of standard fibrous glass strands, they are not inclined to become easily entangled to form an integrated mass. They also are not disposed to lie in a flat formation. A further objection has been that the production of such mats has been costly due to the requirement of special equipment and slow and involved processing.

Then, too, in fibrous mats of conventional types there is a lack of integrity, irregular or insufficient strength, deficiencies in porosity, and lack of uniform thickness. Also, to meet the ever increasing demands for greater strength, improvement in the effectiveness of the fibrous reinforcement is of concern.

Accordingly, it is a prime object of this invention to provide fibrous bodies which are responsible for better physical properties in the final composite molded structure, to facilitate the fabricating procedures, and to pre-

pare fibrous bodies helpful in forming a smoother, more attractive finished surface.

An additional object of the invention is a method simultaneously projecting strands having different quantities of continuous filaments upon a receiving surface.

A further object is the production of fibrous bodies having surface layers of strands lighter in weight and with a lower quantity of filaments than strands in the intermediate portions of the bodies.

Another object is a method carrying along with heavier strands, strands or groups of filaments too light to be independently projected in a controlled manner.

An additional object is to provide an integrated mat or other body of bonded strands in which the strands are associated in a particularly orderly and prearranged manner providing a high degree of strength and porosity.

Another supplemental object is a method of forming a mat of fibrous strands upon the foraminous surface of a conveyor by projecting strands thereagainst without enmeshing the strands in the foraminous surface.

A general object is the provision of a continuous, efficient process for dependably and economically producing bodies of fibrous glass.

More particularly, an object of this invention is to provide a process involving drawing continuous filaments of glass, variously gathering the filaments into a plurality of strands, and projecting the plurality of strands in parallel and planar formation back and forth across a conveyor to form a mat of strands thereon.

These and other objects and advantages are secured, at least in part, through the use and particular arrangement of a plurality of production units as disclosed herein incorporating pull wheels for drawing continuous glass filaments, grooved gathering and guide shoes for dividing them into a plurality of strands in a variety of sizes, directing the strands in closely aligned formation in a reciprocating path across a traveling conveyor, and collecting the strands as an integrated mat upon the conveyor.

A better understanding of the invention may be obtained from the following description and by reference to the drawings, in which:

FIGURE 1 is a side elevation of a portion of a production line including equipment adapted for the practice of the invention;

FIGURE 2 is a somewhat enlarged vertical cross section of the production line of FIGURE 1 showing two pull wheels and associated apparatus for gathering filaments into strands and projecting the strands upon a conveyor;

FIGURE 3 is a further enlarged side view of one of the wheels of FIGURE 2 receiving strands from a gathering shoe;

FIGURE 4 is a front view, on the same scale as FIGURE 3, of the pulling wheel thereshown;

FIGURES 5 and 6 are enlarged views of the gathering shoe and the associated size applicator illustrating two different filament gathering arrangements;

FIGURE 7 is a somewhat diagrammatic illustration of a group of strands being received upon the conveyor;

FIGURE 8 indicates how a single strand usually loops back and forth as it is deposited in a path angularly crisscrossing the conveyor;

FIGURE 9 is a diagrammatic and fragmental illustration of the pattern of deposit derived from a band of seven strands projected in a crosswise path upon the conveyor;

FIGURES 10 and 11 are sections of two different fibrous bodies constructed according to the invention; and

FIGURE 12 is a diagrammatic illustration of the pattern of deposit of a group of ten strands of which four are larger than the remaining six.

Referring to the drawings in more detail, the fibrous mat production apparatus of FIGURE 1 includes a portion of a series of molten glass feeding bushings **21** depending from conventional glass melting tanks which are not illustrated.

Continuous filaments **23** are drawn from the minute orifices of the bushing **21**. For the purpose of being specific in describing the invention in connection with this apparatus, it will be considered that there are 405 orifices in each bushing and the filaments drawn therefrom have an average diameter of fifty, hundred thousandths of an inch.

Size or binder is applied to the filaments as the latter pass over the traveling belts or aprons **24** of the conventional size applicators **25**. The size may merely be water to reduce friction between filaments as they are subsequently joined together in strand form. A more complex size or binder is however desired to promote coherence of the filaments when combined as strands, and adherence of the strands of filaments to the surface of the pulling wheels. Where the mat produced is to be ultimately combined with a plastic resin, it is also desirable to include a coupling agent in the size which facilitates wetting of the strands by the resin.

A preferred form of binder is one retaining sufficient cohesive properties when cured to contribute to the bonding of the strands in the mat in which they are collected on the conveyor or other receiving surface. Such a binder has the dual purpose of holding the filaments together as strands, and bonding the strands into an integrated body.

As applied by a belt applicator the liquid binder can be wiped on the descending strand-forming filaments in an even and metered manner. Good results have been attained with a liquid binder having about five percent by weight of a resin or other basic bonding ingredient dispersed in a water vehicle, the latter comprising practically all of the other ninety-five percent of the composition with allowance for a comparatively small quantity of coupling and lubricating ingredients. Resins of polyesters, phenolics, acetates and acrylics have proved satisfactory as the basic ingredient of the binder.

Other coating means may be employed for applying the binder to the filaments. Some alternate methods involve spray devices, dipping reservoirs, and stationary felt applicators, Also dry binder particles may be shaken down into the mat.

It is however important that the binder coating or film be uniform, continuous, and not excessive in quantity. The various lubricating, coupling and bonding functions of the binder are thus uniformly effective throughout the lengths of the continuous filaments and the strands in which they are combined. A belt applicator is considered most practical for securing the desired continuous and uniform characteristics in the binder coating.

In the event that the bonding together of the body strands is dependent alone on the liquid binder coating on the strands, the proportion of the solid resin component left on the strands should be about three percent by weight of the strand assembly even for binder material of the highest effectiveness. For other less active materials the proportion may be five or more percent.

As the mats are produced immediately below the glass filament forming stations, a commonly used lubricant component of the size may be omitted. The inclusion of such a lubricating material has been found necessary for improving the handleability of the strands where the strands go through subsequent operations such as plying and twisting, but it is not otherwise necessary and in fact interferes with effective wetting of the strands by a plastic resin.

The filaments from each bushing, after the binder is applied thereto, are grouped together to form a number of strands which are individually segregated as they travel within grooves over the respective gathering shoes **27*b***, **27** and **27*a***. The primary division of the filaments into strand groups is here accomplished manually at the start of production.

In the method of the invention as portrayed in FIGURE 1, the filaments from the last three bushings **21**, on the right hand of the observer, are gathered into ten groups which are brought together as strands in separate grooves of the gathering shoes **27*b***. With an even division of the filaments from the 405 orifices of each bushing, each of the ten strands contain forty or forty-one filaments.

The filaments from the next two bushings are gathered in six groups on gathering shoes **27**, as illustrated, and each of the resulting strands would be of heavier gauge containing approximately sixty-seven filaments.

From the last bushing of the portion of the series shown, all of the filaments are combined on shoe **27*a*** in a single strand. Such a strand is quite conventional in size as far as prior practice is concerned, but approaches a probable maximum weight for the preferred procedures of this invention.

Various numbers of additional bushings and various groupings of the filaments therefrom may be involved in the unillustrated portion of the series of bushings of FIGURE 1. One probable arrangement would be six bushings with the filaments gathered in the same divisions shown in connection with the six described bushings but with the group divisions in reverse order.

The sets of strands **28** from the final three bushings of the series, toward the right side of FIGURE 1, pass down around grooved guide or aligning shoes and idler wheels before being drawn over the pulling wheels **35** and projected downwardly therefrom.

Similarly the sets of strands **29** and the single strand **30** from the remaining bushings of FIGURE 1 respectively reach pull wheels **36** and **37** and are projected therefrom. The pull wheels are driven by motors **38** arranged in pairs between adjacent pull wheels longitudinally of the production line.

The traction between the strands and the surface of a pull wheel furnishes the pulling force that attenuates the glass filaments formed from the minute molten glass streams issuing from the orifices of the furnace bushing. This adherence of the strands to the pull wheel is evidently due to the cohesive effect of the binder carried by the strands supplemented by other air and surface forces of attraction.

The strands projected from the pull wheels are deposited upon the chain conveyer **61** and accumulate to form a continuous mat **60**. This is carried through oven **65** upon conveyor **67** for curing of the binder component, the latter being derived from applicators **25**, from a powdered binder subsequently introduced into the mat or from a combination of binders from the two sources.

The mat **60** is drawn from the oven by pull rolls **69**, and after having its edges trimmed by a pair of discs **71** and cooperating grooved wheels **73**, passes over inspection table **75** and is wound in a roll **76** on the windup stand **77**.

Details of the pull wheels, aligning shoes, and idler wheels and the manner in which the strands are driven downwardly by the pull wheels for collection on the conveyor will be described with special reference to the enlarged views of FIGURES 2, 3 and 4.

In the vertical cross section of FIGURE 2 there is shown in elevation the center pair of bushings **21** of FIGURE 1 and the apparatus associated therewith including one each of the pull wheels **35** and **36** for depositing the strands on the conveyor. The pull wheel **36** with elements of the apparatus cooperating therewith is shown in enlarged form in FIGURES 3 and 4. As the two wheels and their associated apparatus are quite identical in structure and function description of the wheel **36** will generally apply to the apparatus including wheel **35**.

From guide or aligning shoe **31**, which is grooved similarly to the gathering shoe **27** for maintaining the strands separate and in spaced relation, the strands **29** are led around the idler wheel **33** and over and around pull wheel **36**. The strands are released from the pull wheel at a moving point reciprocating along an arc of the peripheral path of the wheel. This release is effected by the successive projection of fingers **83** of the oscillating spoke wheel **39**, located within the wheel, through slots **41** in the cylindrical surface of the wheel. The strands are thus kinetically projected downwardly tangentially from the wheel and in a path moving back and forth across the conveyor **61**.

The rear side of each pull wheel is covered by an independently mounted, oscillatable back plate **42** (see FIGURE 3) on which the associated spoke wheel is carried. Back plate **42** of the assembly including pull wheel **36** is arcuately oscillated through rearwardly projecting post **43**. The latter is driven by functioning of a fluid cylinder or other mechanism (not illustrated) which acts through the triangular link **45**, which pivots upon bar **47** on the base **49** as shown in FIGURE 2. The piston rod extending from the cylinder or a similar member from other mechanism is joined to the triangular link **45** by linking rod **46**. The base **49** is positioned on the platform **50** which also supports the other pull wheel **35**, motor **38** and other equipment associated therewith. Platform **50** rests upon the operator's floor **52**.

Through the connecting assembly **55**, including the turnbuckle **56**, the transverse movement of the triangular link **45** is transmitted to a post **43** to also arcuately oscillate the back plate and spoke wheel **39** within the pull wheel **35**. This oscillation is preferably in an arc of approximately fifty-seven degrees. With the single means effecting the oscillation of both spoke wheels their action may be closely synchronized.

The group of strands **58** thrown down by the pull wheels, and the strands from any other pull wheels preceding or following this pair are accumulated in mat form **60** upon the traveling conveyor **61**, which is preferably of carbon steel chain construction. Side shields **63** define the edges of the mat **60** and prevent undesirable lateral overreaching of the strands. A two foot height for these shields is generally sufficient.

The width of the conveyor covered by the mat in this case is four and one half feet, but this may be varied through a wide range by changing the oscillating arc length of the spoke wheels and the distance of the pull wheels above the conveyor. The side shields **63** are adjustably mounted so that their spacing may be altered to match the width of the deposited material. Ordinarily the width utilized would be between extreme limits of two and nine feet.

In a preferred embodiment the pull wheels are twelve inches in diameter and have a series of peripheral cross slots **41**, approximately one and one-eighth inches long, three-sixteenths of an inch wide and spaced five-sixteenths of an inch apart. For a high number of strands or for receiving a fan of filaments in conjunction with strands the pull wheels may be considerably wider and the slots proportionately longer. To reduce the wear, the strand receiving surface of the pull wheels is given a hard surface such as an electrolytic deposit of aluminum oxide or a coating of nickel phosphate.

The main body of the spoke wheel **30** is in this instance about three and three-quarter inches in diameter with fingers **83**, twenty-seven in number, radially extending slightly more than thirteen-sixteenths of an inch from the periphery of the main body. The exterior portions of the fingers are generally of rectangular blade form one inch wide with a thickness of .024 of an inch. About one-eighth of an inch of the outer end of the fingers extend out of the pull wheel slots at the point of their greatest projection.

The movement of the fingers **83** into the slots **81** and their momentary projection through the slots to release the strands is synchronized through a timing drive between the pull wheel and the spoke wheel. This may include a toothed pulley fixed upon the hub of the pull wheel, a cog timing belt running between this pulley and a pulley on the shaft upon which the spoke wheel is journaled.

With the high peripheral speed of the pull wheels, which may be driven at 2000 revolutions per minute, the strands are forcefully projected in straight tangential lines from the oscillating point of disengagement effected by the fingers of the spoke wheel. The kinetic energy the strands thus acquire carries them in straight courses to the region of the conveyor surface. Here they are self-positioning in whirl formation with each strand assuming an individualistic pattern, as indicated in FIGURE 8, but disposed in interengaging and interleaving relation with the other strands of the set, as portrayed in FIGURE 7 and the purely diagrammatic presentation of FIGURE 9.

The distance of the pull wheels above the conveyor, and the rotational speed of the wheels are so selected, in relation to the specifications of the strands being deposited, that the strands are projected with sufficient force to carry them as a band of generally constant form and in substantially regular paths to the surface of the conveyor or other collection surface.

Each group of strands is thus deposited in a reciprocating strip across the conveyor in a constant repeating pattern and with substantially stable dimensions.

A large range of relationships can be established between the strips laid by various pull wheels in the system, but any one product may be reproduced uniformly by locking the system into the dynamic relationship which has been found to produce the particular mat structure desired.

While a balance of the various factors involved is required to establish the proper kinetic energy for carrying the strands in a dependable, regular fashion to the conveyor surface, the projection of the strands in close array helps prolong the integrity of the band formation. Evidently each strand aspirates air during its high speed descent and this tends to pull or hold adjacent strands together. The group of strands will travel further than a single strand before losing momentum and directional regularity since the retarding effect of the thin wall of air separating strands is reduced by the joint pull of such strands upon the air.

The total resistance opposing the group is thus materially less than the total resistance that would be encountered by the same number of strands projected individually.

When the strands reach the proximity of the conveyor surface, their kinetic energy has been quite completely dissipated through air drag and possibly by a braking effect transmitted upwardly by the immediately preceding deposited strand portions. As linearly the strands greatly exceed the length of the course upon which they are laid, the strands must assume a looping formation. This irregular coiling is initiated above the surface of the conveyor and is characterized by irregularly shaped, figure eights with loops extending laterally as much as an inch or more from the preceding, comparatively straight path of each strand. The loops of adjacent strands and possibly of all the strands of a strip are variously interleaved to integrate the deposited strip.

In the mat production line of FIGURE 1 it will be assumed that the full series of bushings and strand gathering apparatus is double that shown with the six assemblies not shown duplicating the six illustrated but in reverse order in regard to numbers of strands.

With such an arrangement three bands of ten strands each are first deposited upon the conveyor. There are only forty or forty-one filaments in such strands. With the filaments having a nominal diameter of fifty hundred-thousandths of an inch the individual strands are roughly five-thousandths of an inch in diameter. These are comparatively fine strands and provide a lower surfacing portion to the mat which contributes to a smoother finish to a molded product in which the mat is utilized as a reinforcing element.

Being light in weight these strands do not travel with great energy as they are projected from the pull wheels and therefore are deposited upon the conveyor with little force. Entanglement with the mesh of the conveyor is thus avoided. More conventional heavier strands are apt to enter openings of the conveyor when impinged thereon and to cause the mat to be disrupted when removed from the conveyor.

The next two bands of strands are heavier as they each contain approximately sixty-eight filaments and have a diameter of about six-thousandths of an inch. These strands together with the two extra heavy, singly projected center strands **30** and the subsequent two bands **29** of sixty-eight filaments furnish superior strength and moldability to the mat and form a more open structure for easy penetration by the fluidized resin in a molding operation. The final sets of lighter strands **28** provide the smooth surface texture to the upper side of the mat.

In FIGURE 11 is shown a fragmental section of a mat **60*b*** such as produced by the apparatus of FIGURE 1. The surface layers **80** incorporate the light strands **28** while the center portion **82** contains the singly projected strands **30**. The layers **84** adjacent the surface layers are composed of the medium weight strands **29**.

The mat **60*a*** of FIGURE 10 incorporates only surface layers **80** of light strands and a central body portion **82** of heavier strands.

In practicing this invention on the basis of a large and continuous volume a production mat line incorporating a series of twenty bushings is feasible. All or a portion only of the bushings may be operated according to the thickness and nature of the mat to be produced. The quantity and size of the strands in which the filaments from each bushing are gathered may be altered to provide different combinations. Wide pull wheels, gathering shoes, and aligning shoes are adapted for handling one or numerous strands as desired.

When a group of light strands required for fine texturing either in surface portions or throughout a mat structure have insufficient weight to be projected efficiently, without drifting, for deposit in a controlled pattern, a number of heavy strands may be incorporated in the band of strands. The kinetic force of such heavy strands entrains and guides the lighter strands in a straight course for the proper deposit of the whole group or band of strands. Such an arrangement, on a rather minimal and unlikely scale, is illustrated in FIGURE 6. The ten strands **28** there involved include four with six filaments and six with three filaments.

Positioning the pull wheel at the distance above the conveyor and driving it at a speed to deliver the heavier strands uniformly to the conveyor surface, will also propel the interventing lighter strands in accompanying relation therewith. A diagrammatic illustration of a portion of a deposited strip of such a band of strands may be seen in FIGURE 12. Not indicated in this theoretical showing is the propensity of the lighter strands to move closer and around the heavy strands.

Very fine strands and even loosely grouped filaments may thus be incorporated in a projected band or bundle for depositing upon a receiving surface. While fibrous glass is best suited because of its weight for the heavy strands, the lighter filamentary material may be either organic or inorganic, including wool, cotton, acrylics, rayon, saran, nylon, aluminum silicate, asbestos and glass.

A combination of light and heavy strands from each of a series of pull wheels has an advantage over a series in which most of the wheels are individually restricted to strands of a certain size, as failure or shut down of one or more wheels does not then seriously affect the proportion between light and heavy strands in the deposited mat. Should for instance, a wheel projecting only fine strands for a mat surface fail, heavy strands from

the next wheel would then constitute the surface material. However, if several successive wheels deliver a similar combination of light and heavy strands, interruption of the operation of one of them would have a quantitative and not a qualitative effect.

An important feature of the invention is the attraction and commingling of the light strands or other filamentary elements around and with the larger strands. The latter are thus at least partly covered by the lighter material. While effective in their capacity of providing strength and moldability the larger strands may then be utilized in surface portions of mats due to their insheathing by the light strands. An extreme degree of such coaction comprises a single bulky strand with a heavy strand as a core and light strands or other filamentary elements continuously entangled therewith and forming an outer fuzzy covering, simulating a wooly effect yarn. For conventional textile use, particularly in the category of coarse fabrics such as upholstery, drapes and carpeting, filamentary elements of wool, nylon, or of other fibers would be desirable to provide an attractive and soft surface finish.

In summary, it may be seen that the invention provides composite fibrous bodies with distinct layers, and not only various sizes or weights of strands or other filamentary elements in different layers but also in combination in the same layer.

As shown, the invention further encompasses methods of producing such fibrous bodies, including the step of entraining floatably inclined, light filamentary material with forceably projected comparatively heavy strands, and mergeably entangling such light material of various compositions with core strands.

While pull wheels are considered the most satisfactory means for projecting the multi-filament strands, entraining air nozzles would also serve the purpose to at least a limited degree. Such projection would bring the strands and other filamentary elements into a more compacted grouping and would therefore not be as adaptable for depositing controlled layers as would the pull wheels when the latter are arranged to project planar bands of strands.

While it is economically desirable to position the strand depositing apparatus adjacent the filament forming source, strands and other filamentary bodies may be delivered from spools or other packaging devices.

In view of the foregoing description of basic aspects of the invention, it will be understood that modifications and variations may be effected in the methods and products of the invention without departing from the scope and spirit thereof.

I claim:

1. A method of producing a fibrous body containing strands of different sizes which comprises delivering continuous filaments from a glass filament forming source, gathering the filaments in substantially different numbers into strands and projecting the strands in close array and in interengaging loops upon a receiving surface.

2. A method according to claim **1** in which a minority of the strands contain a considerably larger number of filaments than the remaining strands.

3. A method of producing a fibrous body which comprises delivering a substantial number of continuous glass filaments from a forming source, gathering the filaments into strands with more filaments in some of the strands than in others whereby there are relatively heavy and light strands and, projecting the strands in a substantially planar band for deposit in laterally looped, interengaging relation upon a receiving surface.

4. A method according to claim **3** in which the size of the strands alternate across the band.

5. A method according to claim **3** in which there are relatively heavy strands at the lateral edges of the band.

6. A fibrous body which includes successive layers of entangled strands of continuous filaments, one of said layers containing a greater number of strands and strands of a fewer number of continuous filaments than that of strands in a second layer.

7. A fibrous body which includes successive overlying groups of fibrous glass strands of uniform size, continuous filaments with one group including strands of varied numbers of filaments.

8. A fibrous planar body containing strands of continuous filaments, the weight of the strands being progressively heavier and the number of filaments in the strands being progressively greater inwardly from the upper and lower surfaces of the planar body.

9. A method of producing a fibrous body which comprises delivering continuous filaments from a first source, gathering the filaments into a first set of strands, depositing the strands upon a receiving surface, delivering continuous filaments from a second source, gathering the filaments from the second source into a second set of strands with the number of strands in the second set differing from that of the strands in the first set and the average number of filaments in the strands of the second set differing from that of the filaments in the strands of the first set, and then depositing the second set of strands upon the receiving surface over the first set of strands.

10. A method according to claim 9 in which the filaments delivered from the second source are substantially of the same size as those delivered from the first source.

11. A method of producing a fibrous body which comprises delivering continuous filaments from a source, gathering the filaments into strands with the number of filaments in at least one of the strands differing substantially from the number of filaments in at least one of the other strands, and depositing the strands in close array upon a receiving surface.

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U.S. Cl. X.R.

28—72, 75; 156—167, 180; 161—93, 155