Sept. 21, 1954 B. LAWRENCE 2,689,813

METHOD FOR MAKING CONTINUOUS TWISTLESS BONDED YARN

Filed Dec. 11, 1951 2 Sheets-Sheet 1

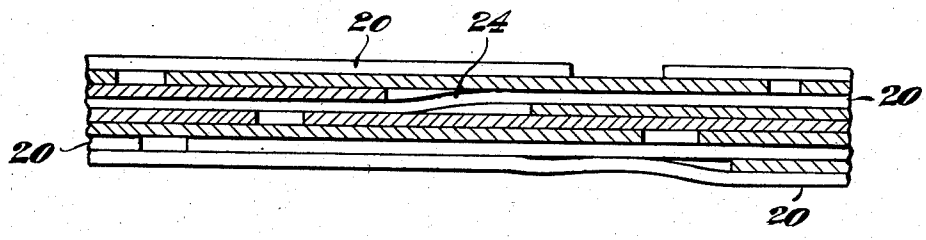


Fig. 1

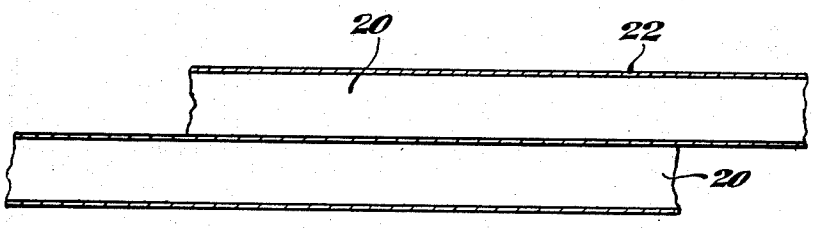


Fig. 2

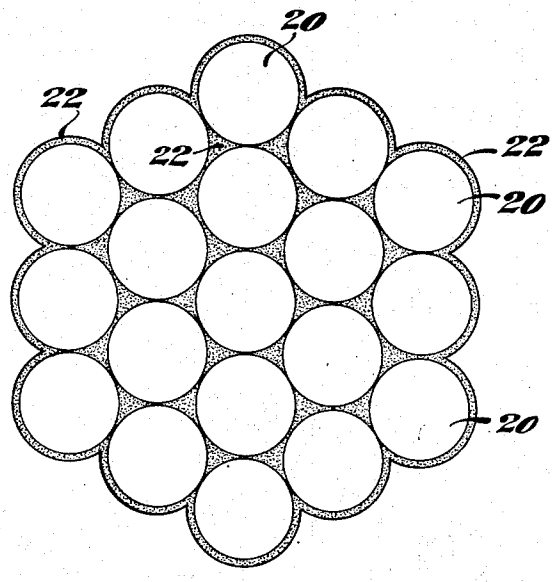


Fig. 3

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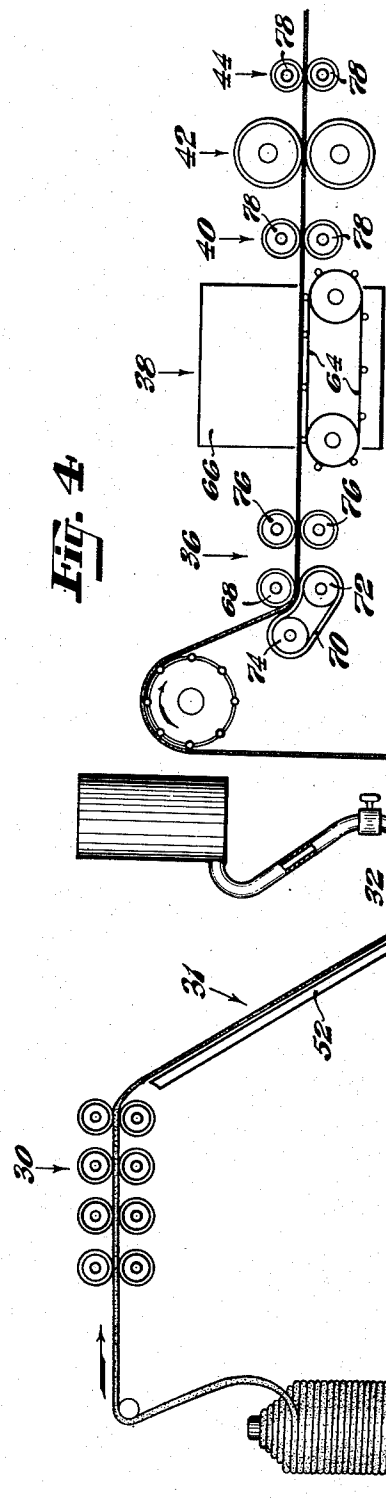


Fig. 4

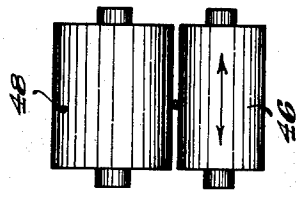


Fig. 6

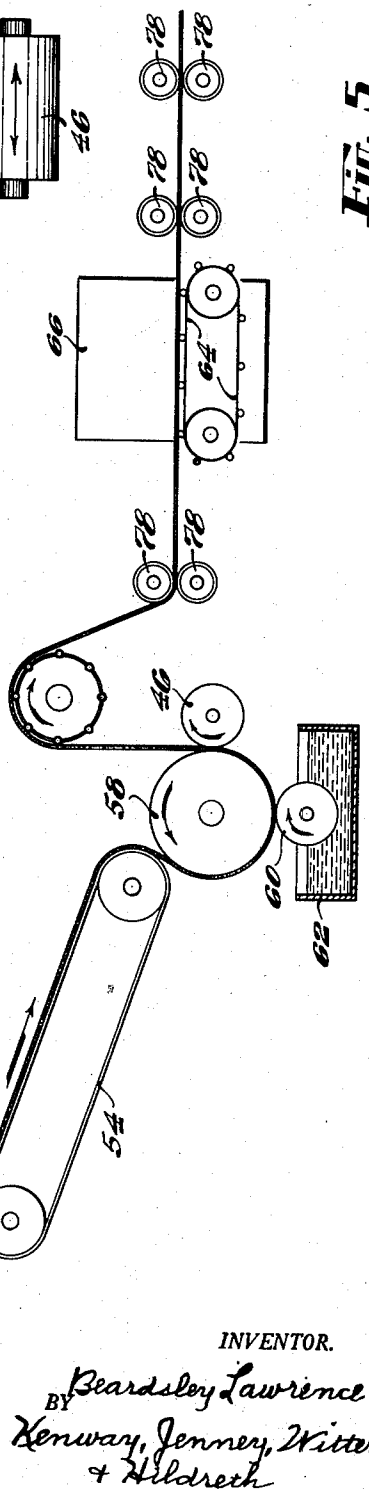


Fig. 5

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METHOD FOR MAKING CONTINUOUS TWISTLESS BONDED YARN

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Application December 11, 1951, Serial No. 261,049

11 Claims. (Cl. 154—91)

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This invention relates to a novel yarn, and more particularly to a yarn or strand wherein the individual fibers are not twisted but rather lie substantially parallel to one another, overlap each other, and are bonded together by an adhesive. In one aspect this invention relates to a yarn or strand wherein the individual fibers bear the load equally. Other aspects of this invention relate to the method for making such a yarn or strand. This application constitutes a continuation in part of my copending application Serial No. 81,851, filed March 17, 1949, now abandoned.

The novel yarn or strand of my invention presents a marked departure from conventional concepts of a yarn or strand. This fact is indicated initially by the absence of any word adequate to describe my product. The terms "yarn" or "strand" are misleading because they connote a twisted product, while the product of my invention has no twist. The word "filament" might be used, but, in as much as it connotes an individual fiber, it would likewise be misleading. Therefore, for lack of better terms, the words "yarn" and "strand" will be employed interchangeably herein and have been selected because they seem best in a functional sense to describe the product of my invention, but wherein they connote a twisted product, it must be understood that they do not apply to my invention.

In the conventional twisted yarn or strand, tensile strength is a function of fiber strength, and resistance to linear relative motion between fibers. For purposes of analysing the construction of the strand, fiber strength can be looked upon as a constant depending upon the raw material. Resistance to linear relative motion, however, depends upon the surface condition of the fibers, the area of contact between them and the pressure between them; and while surface condition in conventional strands like fiber strength may be looked upon as a constant depending upon the raw material, area of contact and pressure between fibers are functions of fiber length and twist. Thus in conventional yarns or strands, increasing fiber length and increasing the twist up to a certain limit increases the tensile strength.

The tensile strength of conventional strands, however, never approaches the maximum combined strength of the fibers of which it is composed for several reasons. In the first place, the resistance to linear relative motion between fibers cannot be maintained uniform throughout the strand because the pressure between the fibers near the outer edges of the strand is considerably less than at the center of the strand. Secondly,

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twisting the strand subjects certain of the fibers to greater tension than others. And thirdly, the stretching characteristics of a twisted strand are not uniform throughout the strand. Of course the stretching characteristics of the individual fibers may be considered uniform, but there is an additional component of stretch in a twisted strand due to lateral motion of the outer fibers towards the center of the strand. This latter component of stretch varies from the edges to the center of the strand. Thus, when a conventional twisted strand is subjected to tension, parts of it reach the elastic limit of the fibers before others, certain fibers not subjected to substantial pressure slide past each other shifting the load to the fibers held together under pressure, and certain other fibers already subjected to tension will be further stretched, with failure taking place from fiber to fiber.

While these limitations in conventional strands have long been recognized, they have been considered necessary evils, with the result that efforts to improve tensile strength have been largely directed toward increased fiber length and improving conditions of twist. Attempts have been made however, to impregnate conventional strands with an adhesive for the purpose of increasing the resistance to linear relative motion between the individual fibers. These efforts have shown that impregnated twisted strands are stronger than similar conventional strands of the same fiber length and twist ratio. However, a complete and uniform impregnation of a conventional strand is extremely difficult due to the matted thickness of the twisted fibers. And furthermore, due to the twisted construction, the fibers are still subjected to uneven tension, and the non-uniform component of stretch due to twist still is present, rendering progressive failure unavoidable.

Therefore, the general object of my invention, turning attention for the moment particularly to the product thereof, is to provide a continuous strand having a tensile strength substantially equal to the combined tensile strength of the individual fibers which form its cross section. Another object is to provide a strand wherein progressive fiber failure is substantially eliminated and wherein the individual fibers uniformly bear the load. Further objects directed more specifically toward obviating progressive fiber failure are to provide a strand having characteristics of stretch substantially the same as the fibers of which it is composed, to provide a strand in which all of the fibers are substantially free from initial tension, and to provide a strand in which the resistance to linear relative motion between the

fibers of which it is composed is not a function of pressure between the fibers.

In the accomplishment of these objects, I construct a continuous fibrous strand having substantially straight individual fibers disposed in substantially parallel relation, parallel to the axis of the strand, overlapping each other, and being bonded together by an adhesive. The adhesive employed to bond the individual fibers is applied as a thin coating to the fibers uniformly through the strand. It is a feature of the product of my invention that the individual fibers are bonded over substantial portions of their length by the adhesive. This feature is of importance because it means that an inexpensive and weak bonding material may be employed. Being bonded over a considerable area, the total longitudinal resistance of the adhesive exceeds the tensile strength of the fibers themselves although it would not, if bonded only over a small area. Thus the tensile strength of the product is substantially equal to that of the individual fibers forming its cross section. Furthermore, shorter fibers may be employed to achieve the same result so long as the area of bond is large enough to provide a longitudinal resistance as great as the tensile strength of the fibers.

It is a feature of the product of my invention that the adhesive coating of the fibers is very thin, and therefore, the displacement of the adhesive, when the strand is subjected to tension, is negligible. Thus the stretching characteristics of the strand are substantially the same as those characteristics of the individual fibers.

It is an additional feature of the product of my invention that all of the fibers in the strand are substantially free from initial tension either longitudinally or torsionally. This feature, combined with the fact that the stretching characteristics of the strand are substantially the same as the individual fibers throughout the strand, provides a substantially uniform fiber elongation, and a substantially simultaneous fiber failure.

Turning attention now to the objects and features of the method of my invention, a brief discussion of the major difficulties encountered in the production of the strand of my invention will best serve as an introduction. Uniform impregnation or saturation of a fiber mass with adhesive, and forming parallel fibers into a continuous strand without initial fiber tension constitute the most important obstacles. Uniform impregnation of thickly matted fibers with an adhesive is extremely difficult. Highly penetrative volatile liquid mediums for the adhesive have been employed with moderate success with thickly matted fibers, but the coating is not truly uniform and the cost of such liquids is prohibitive. Also, heat and pressure improve impregnation of thickly matted fibers, but still fall far short of uniformity. On the other hand, uniform impregnation is possible if the fibers are dispersed to airy thinness, but hitherto, it has been thought impossible to handle fibers in such a state of dispersion, much less to form them into a continuous untwisted strand.

Therefore, it is an important object of my invention to provide a method for uniform coating of fibers and for forming them, after being coated, into a continuous untwisted strand. Other objects include the provision of a method for aligning the fibers in parallel relation in a strand without subjecting some of the fibers to initial tension, and the provision of a method for bonding the fibers to each other over substantial portions of their length.

In the method of my invention, I draw the fibers of a continuous roving into substantially parallel relation with a thickness of only several fibers. In this state, the fiber group is without coherence and easily falls apart. If the fiber group were sufficiently compact to cohere without support during processing prior to saturation, thorough and uniform saturation could not thereafter be obtained. After drafting, I pass the fibers continuously between two opposed surfaces upon which an adhesive has been deposited. A controlled pressure is exerted upon the fibers while being saturated, in order to prevent excess adhesive from coagulating unevenly between them and to distribute the adhesive uniformly. Thereafter the fibers are formed into a composite strand by a reciprocal rubbing action which serves to gather the fibers near the edge of the fiber group toward the center, and to roll the fibers back and forth into a composite group. In this latter state, the fibers form a strand with substantially parallel fibers uniformly coated with an adhesive.

Further features of the method of my invention include subjecting the strand to a slight draft before the adhesive has been allowed to set, removing a substantial portion of volatile liquid or water from the adhesive and thereafter compressing the strand. These features ensure absence of initial fiber tension, and the maximum bonding area.

These and other objects and features of my invention will be best understood and appreciated from a detailed description of a preferred embodiment thereof, selected for the purposes of illustration and shown in the accompanying drawings in which:

Fig. 1 is a diagrammatic sectional view in side elevation of the strand of my invention,

Fig. 2 is a diagrammatic sectional view in side elevation illustrating a normal bond between two individual fibers,

Fig. 3 is a diagrammatic view in end elevation of the strand of my invention,

Fig. 4 is a diagrammatic illustration of the process of my invention,

Fig. 5 is a diagrammatic illustration of a variation of the process of my invention, and

Fig. 6 is a diagrammatic plan view of the axially reciprocating forming roll.

The product

In the product of my invention as shown in Fig. 1, I employ cotton fibers 20, aligned in parallel relation, overlapping each other, and bonded together by an adhesive 22 (see Fig. 2). The fibers 20 are cotton in this preferred embodiment but it is to be noted that the invention is not limited to the use of cotton fibers. The fibers 20 may comprise other staples such as hemp, flax, sisal, etc. or synthetic fibers such as rayon, nylon, fortisan, spun glass, etc. The adhesive 22 employed in this preferred embodiment, is conventional rubber latex, but here again it may readily comprise other bonding agents having suitable properties of viscosity and adhesiveness.

It will be seen from Fig. 1 that the fibers substantially overlap each other, and with reference to Fig. 2, the overlapping has the effect of greatly augmenting the area contact of the bond. In Fig. 3, furthermore, it will be seen that all the fibers other than those at the extreme peripheries of the strand will be largely surrounded by

adhesive and that only a short overlapping will have the effect of producing a bonding area substantially greater than the cross sectional area of the fibers themselves. Thus an inexpensive adhesive may be employed having a per square inch bonding strength considerably less than the tensile strength of the fibers, but by being bonded over a large area still ensure that the fibers will bear the load.

It is further to be noted that there is little air space between the fibers within the strand. This feature is concomitant with the fact that the fibers are bonded together over substantial portions of their area.

The adhesive coating **22** is extremely thin and therefore its displacement when the strand is subjected to tension will be extremely small. Thus, the stretching properties of the strand will be substantially the same as those properties of the fibers **20**, and when the strand of my invention is subjected to tension, all of the fibers will elongate uniformly and rupture simultaneously when their elastic limit is reached. Thus, the rupture of the strand herein shown is accompanied by a resounding snap, with the fibers near the break remaining substantially unfrayed.

The strand of my invention will substantially approach the maximum strength of the fibers which compose its cross section; and it is to be noted that neither expensive adhesives nor long staple fibers need be employed in the strand herein shown to achieve results vastly superior to conventional twisted strands. Tests have shown that the strand of my invention, employing inexpensive adhesives and short staple cotton fibers achieves a tensile strength upwards of 35,000 lb./sq. in. as compared to 16,000 lb./sq. in. in a twisted strand composed of the same fibers.

In the preliminary analysis, outlined above, of the limitation of a twisted strand, tensile strength of individual fibers was regarded as a constant regardless of fiber length. However, in actual practice the longer cotton fibers, besides being better for reasons of promoting friction, also have greater individual tensile strength. Thus, the strand of my invention when constructed with inexpensive short staple cotton fibers, will have a tensile strength substantially greater than that of a twisted strand composed of expensive long staple fibers, but if long staple fibers are employed in my strand, the resultant tensile strength will be vastly superior to that of the expensive twisted strand.

In addition to being arranged in substantially parallel relation, and bonded over large portions of their area, substantially all of the individual fibers are free from initial tensions or torsions. A certain small amount of random slight misalignment as indicated at **24** cannot be eliminated in actual practice, but it will be seen that no initial tensions or torsions such as exist in the conventional strand are present in the strand of my invention. Furthermore, stretching the strand of my invention will not cause greater pressure to be exerted upon some fibers and not on others, either through variance of stretching characteristics within the strand or through variations in alignment as in a twisted strand. Therefore, the maximum fiber strength is substantially obtained.

While no twist is normally employed in the strand of my invention, it may be desirable to impose a twist upon the strand for the purpose of giving it an additional factor of stretch. This may be desirable in reinforcing rubber where strands having varying properties of stretch are required. It will be noted in this connection that, although twisting the strand of my invention may slightly reduce its strength, conventional strands cannot be given varying degrees of twist without drastically altering their tensile strength.

The method

The characteristics of the strand of my invention are highly dependent upon the method of constructing the strand. Thus it might be supposed that a twisted strand could be unravelled and bonded to produce the strand of my invention. Such an assumption, however, would be false because in that case the individual fibers would be subjected to initial tensions and torsions inherent in the original strand and caused by the untwisting process.

The preferred method of constructing the strand of my invention is illustrated in Fig. 4 and includes a first step of drawing the fibers into substantially parallel relationship at **30**, conveying them as an extremely thin ribbon incapable of sustaining its own weight at **31**, saturating them under pressure between surfaces with an adhesive at **32**, forming them into a composite strand at **34** by a reciprocal rubbing action across the surface upon which the fibers are saturated, subjecting the composite strand to a slight draft at **36**, substantially drying the strand at **38**, subjecting the strand to a second forming step at **40**, subjecting it to pressure at **42**, and a third forming step at **44**.

The raw material employed in one example of the method of my invention herein shown is a No. 4 American upland cotton roving with a staple length of $1\frac{1}{16}$", conditioned in the conventional manner for drawing and straightening. In drawing the fibers into parallel relationship at **30**, I subject them to an 8 to 1 draft and form them into an extremely thin ribbon being only several fibers thickness. In this state the fiber mass is so weak that it cannot support its own weight across a gap during processing and for this reason it is guided to the saturating rolls by a chute **52** or belt **54** and more or less deposited thereon. On the other hand the thinness of dispersion of the fibers permits thorough saturation, and by subjecting the ribbon to pressure between rolls during saturation, substantial uniformity of saturation may be attained. After saturation, however, it is extremely difficult to handle the fibers and practically impossible to withdraw them directly from the saturating aparatus. Therefore I gather them together by a reciprocal rubbing action at **34**. The reciprocal rubbing may disrupt the true parallel alignment of the fibers slightly by giving them a mild undulation from one side to the other, and therefore, I preferably subject the strand so formed to a slight draft at **36** while the adhesive is still wet, and will permit the fibers to slide one past the other. The resulting "yarn" is equivalent to a 32^s yarn.

In referring to the extreme thinness of the fiber group or "ribbon" after drafting, I have stated that it is of only several fibers thickness and cannot support its weight across a gap during processing. It will be understood, however, that these terms must be read in the light of the context as a whole and that the conditions of processing must be taken into consideration. The fiber ribbon of the specific example described above employed in producing a 32^s yarn is so light after drafting that it will only support its weight for a few inches when held vertically under ideal

conditions. Of course, processing conditions are of necessity more rigorous than a simple lifting test, and in my preferred embodiment the ribbon is substantially continuously supported throughout its passage from the drafting element to the saturating roll, and is not permitted to pass a horizontal gap at any point. An additional factor to be considered, of course, is the fiber length. Extremely long staple length fibers would probably support their weight over a longer gap. Also under processing conditions the gap might not be so great as to cause a complete rupture in the ribbon but yet disrupt it unevenly and render the resulting yarn non-uniform. As a further illustration of the thinness of the ribbon employed herein prior to saturation, it is significant to note that under actual production conditions, I have been obliged to put an air screen alongside the ribbon between the drafting element and the saturating element in order to prevent casual air drafts from disrupting the fiber group.

It will be noted that the surface of the saturating rolls is slightly roughened. This factor is of importance in eventually disengaging the formed yarn from the saturating roll. If the surface of the saturating roll is absolutely smooth, forming becomes difficult and apparently the surface tension of the roll is increased thereby rendering it more difficult to withdraw the yarn from the roll.

The adhesive employed in this example of the process of my invention is a curable neoprene latex and contains roughly 100 parts by weight of water and 40 parts by weight of solid matter. Therefore, it will be seen that when the strand dries, there will be substantial space between the fibers and the illustration of the strand of my invention in Fig. 1 would be inaccurate. To compensate for this, I dry the strand as indicated at 38 to substantially eliminate the water, being careful, however, to leave the adhesive in a slightly tacky state. Thereafter, for the purpose of consolidating the strand and creating a uniform bond, I subject the strand to an additional forming action indicated at 40, press it at 42 and again form it by a reciprocal rubbing action at 44. It will be seen that other proportions of water or volatiles may be employed and the ensuing steps varied to suit the difference.

It is to be noted that the composite strand formed at 34 is the basic product of my invention. Its fibers are substantially parallel and are bonded together well enough to produce a strand comparable in strength to the conventional cotton strands. The steps 36 through 44 are merely for the purpose of perfecting the strand to approach the theoretical maximum, but it is not intended to limit the invention to them.

The fibers of the strand formed at 34 are substantially free from initial tensions or torsions, and it will be seen that if thermo-plastic resins not containing substantial percentages of volatiles are employed, the steps 36 to 44, although they doubtless would add strength, may be eliminated and the strand produced at 34 will have satisfactory properties of bond. The mild undulation in such a strand will not substantially reduce its strength nor cause progressive fiber failure, and may even be beneficial making the strand slightly more resilient.

The reciprocal rubbing action employed in the method of my invention herein shown is performed by a composition cork and neoprene surfaced roll 46 adapted to rotate in unison with a saturating roll 48 having a slightly roughened surface. The cork surfaced roll 46 is further adapted to reciprocate axially, bearing lightly against the saturating roll 48. Actually the method herein shown is not dependent upon any specific surface of the rolls 46 and 48 because the strand may be thus gathered by rubbing one's finger back and forth over it while it is disposed in a thin ribbon-like condition on the saturating surface so long as the saturating surface is not slippery. The essential factor with respect to the surfaces of the rolls 46 and 48 is that they must be capable of traction against a freshly saturated fiber mass. Furthermore, it is important not to apply too much pressure in rubbing the ribbon into a strand because excessive pressure causes the ribbon to shred into many small strands. While it may be theoretically possible to perform the reciprocal rubbing by hand, in practice, the production of a uniform and continuous strand is only feasible with a roll such as the roll 46.

Conveying the thin ribbon to the saturator may be accomplished by a chute 52 or a conveyor belt 54 (see Fig. 5) as desired.

Saturation is accomplished by opposed saturating rolls 47 and 48 with the adhesive held between them by dams 56, or by saturating rolls 58 and 60 (see Fig. 5) wherein the roll 60 is partially immersed in adhesive in a pan 62. Pressure is applied between these rolls to ensure uniformity of saturation and to prevent local coagulation of adhesive.

Consolidation may be accomplished by pressing the strand in a mold, by rolling it between two hard surfaces, by passing it through a continuous press, or by passing it between rolls adapted to force the strand into a narrow groove, the latter method being illustrated diagrammatically at 42.

Drying and heating may be accomplished by carrying the strand along an endless belt 64 within a heated chamber 66. The slight draw step indicated at 36 may be accomplished by holding the strand lightly over a wide arc of a first roll 68 by means of an endless belt 70 driven by two rolls 72 and 74 disposed adjacent to the roll 68 but separated by a wide arc around the said roll 68; and drawing the strand between two draw rolls 76 closely associated to the former holding rolls 68, 72 and 74, but rotating at a slightly greater speed. In this embodiment I only subject the strand to a supplemental draft of approximately 6%.

The forming steps indicated at 40 and 44 may be accomplished by axially counter-reciprocating rolls 78, or even by rubbing the strand between two relatively hard surfaces.

The process of my invention may be varied as desired to meet the characteristics of various resins or bonding agents employed. For instance thermal setting resins may be employed in which case provision for application of heat is made concurrent with the steps indicated at 32—44. Furthermore, the strand may be passed through a trumpet or grooved rolls for the purpose of altering its cross sectional shape.

While these and other variations will be evident to those skilled in the art, it is not intended to limit the invention to the precise form of the preferred embodiments herein shown but rather to measure it in terms of the appended claims.

Having thus disclosed and described an illustrative embodiment of my invention, what I claim as new and desire to secure by Letters Patent of the United States is:

1. The method of making a continuous twistless strand from staple fibers comprising the fol-

lowing steps: aligning the fibers in straight parallel relationship overlapping each other in an extremely thin ribbon of only several fibers' thickness said fibers being so extremely dispersed in said ribbon that said ribbon cannot sustain its own weight across a substantial gap under processing conditions, placing the ribbon upon a surface having a thin coating of adhesive thereon, subjecting the ribbon to uniform pressure to distribute the adhesive uniformly among the fibers thereof, and thereafter gathering the fibers into a composite strand by a reciprocal rubbing action in which the lateral fibers are gathered towards the central fibers.

2. The method of making a continuous untwisted strand as defined in claim 1 having the additional step of compressing the strand after it has been gathered together by the rubbing action.

3. The process of making a twistless staple length fiber strand comprising the following steps: aligning a multiplicity of straight fibers in parallel relation in a thin ribbon in which said fibers are so loosely dispersed that said ribbon cannot sustain its weight across a substantial gap during processing, thoroughly saturating the fibers with an adhesive while in said extremely dispersed condition by applying said ribbon to a surface having a coating of said adhesive thereon and then subjecting the ribbon to pressure, and then gathering the fibers under pressure into a strand by a transverse motion reciprocated so as not to impart a twist to the strand.

4. The method of making a continuous twistless strand comprising the following steps: drafting a roving into a flat ribbon of only several fibers' thickness wherein the individual fibers are so loosely dispersed that said ribbon cannot sustain its own weight across a substantial horizontal gap during processing, said fibers being straight and lying substantially in parallel relationship overlapping each other, passing the fibers continuously between two opposed surfaces upon which a liquid adhesive has been deposited, exerting a light pressure upon the said fibers between the two said surfaces, and thereafter gathering the fibers into a composite strand by a reciprocal rubbing in which the lateral fibers are gathered towards the central fibers.

5. The method of making a twistless yarn comprising the following steps: drafting the fibers into substantially straight and parallel relationship overlapping each other, disposing the fibers in an extremely thin flat ribbon of not more than a few fibers' thickness said fibers being so extremely dispersed in said ribbon that said ribbon cannot sustain its own weight across a substantial gap under processing conditions, uniformly coating the fibers with a liquid adhesive while the said fibers are disposed in the thin ribbon, subjecting the ribbon to uniform pressure to distribute the adhesive uniformly among the fibers thereof, and thereafter gathering the fibers into a composite strand by reciprocal rubbing, again drafting the fibers, and subjecting them thereafter to substantial pressure, whereby the individual fibers will be bonded together over substantial portions of their length and will be subjected to a substantially uniform initial tension.

6. The method of making a continuous strand defined in claim 5 further characterized by substantially drying the strand after the second drafting stage but before the compression stage whereby the major portion of volatiles present in the adhesive will be eliminated prior to consolidation.

7. The method of making a continuous twistless strand comprising the following steps: drawing fibers into straight and parallel relationship substantially overlapping each other, forming them into an extremely thin flat ribbon of only a few fibers' thickness said fibers being so extremely dispersed in said ribbon that said ribbon cannot sustain its own weight across a substantial gap under processing conditions, uniformly coating the fibers with an adhesive while the fibers are in the said thin state by applying said ribbon to a surface having a coating of said adhesive thereon and then subjecting the ribbon to pressure, thereafter gathering the fibers into a strand by reciprocal rubbing action, further consolidating the fibers by a reciprocal rolling between two opposed surfaces, and subjecting the strand to pressure whereby the individual fibers are securely bonded over substantial portions of their area.

8. The method of making a continuous twistless strand described in claim 7 further characterized by subjecting the strand to a second rolling stage after the final compression stage.

9. The method of making a continuous twistless strand comprising the following steps: aligning a plurality of fibers in straight and parallel relationship substantially overlapping each other, arranging the fibers in an extremely thin ribbon of only several fibers' thickness said fibers being so extremely dispersed in said ribbon that said ribbon cannot sustain its own weight across a substantial gap under processing conditions, uniformly coating the fibers with an adhesive while the fibers are in the said arrangement by applying said ribbon to a slightly roughened surface having a coating of said adhesive thereon and then subjecting the ribbon to pressure thereafter gathering the fibers into a composite strand by a reciprocal rubbing action, subjecting the strand so formed to a minor draft under light pressure, and applying radial pressure thereto.

10. The method of making a continuous twistless strand defined in claim 9 further characterized by subjecting the strand to heat concurrently with the said radial compression.

11. The method of making a continuous twistless strand defined in claim 10 further characterized by substantially drying the strand after the said minor draft and before applying the said radial compression whereby substantially all of the volatiles in the adhesive will be eliminated prior to the compression step.

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