I have discovered that I can prepare a glass strand-paper twine by coating a plurality of these glass strands with an adhesive material and superimposing said coated strands on a freshly-formed wet paper-pulp lap in parallel alignment, covering said strand-covered lap with a freshly-formed wet paper-pulp lap to form a unitary assembly, passing said assembly through a dryer, wherein heat is applied to the assembly so as to activate the adhesive and bond the strands to the laps. Thereafter the assembly is cut into strips and is twisted to form a twine. The twine prepared in accordance with the process of the present invention will have greater strength per unit weight than the natural twine and yet can be produced for substantially lower cost than the cost of natural twine. The glass fibrous strands which may be used in the practice of the process of the present invention are made up of a great plurality of individual glass filaments which are combined to form the strand. The process for the preparation of these glass fibrous filaments and strands is well known in the art, as represented by U. S. Patents 2,133,236, 2,133,238 and 2,175,225, among others. These filaments are generally of extremely small diameter, in the order of magnitude of about 0.0002-0.004 of an inch and are combined to form a strand having a diameter of about 0.01", since there are generally about 200 or more filaments used to form a single strand. These glass strands have exceedingly high tensile strength and, in fact, have greater tensile strength than steel wire per unit weight. These strands, on the other hand, cannot be used directly to form a twine because they do not have the flexibility which steel wire has, nor do they have the flexibility which natural fibrous twine has. A further shortcoming of the glass fibrous strands resides in the fact that, if a twine were to be made from glass strands without any protective coating surrounding the strands, the continuous rubbing against the other would result in the breakdown of the individual strands and eventually a breakdown of the entire twine. A still further shortcoming of any glass-strand twine resides in the fact that the flexibility in small arcs is so low, and the attrition is so great, that it is nearly impossible to produce knots having adequate knot strength with such twine without experiencing continuous breaks in the twine. This is due to the sharp, sudden curve through which the twine is bent in knot tying. I have discovered that by coating the glass strands with an adhesive material and superimposing said strands on a freshly-formed wet paper pulp lap, and covering said strand-imbedded lap with a second paper lap of the same type as the first, I can press the components together to form a unitary assembly and dry the same by the application of heat, which heat serves to activate the adhesive material so as to bond the strands to the paper laps. The twine so formed has become fully hermetic. This embodiment is in the nature of a modified cylinder machine adapted to accomplish the purposes as set forth hereinabove. In the drawing the rollers 9, 9a, 10 and 10a serve to carry the papermakers felt 12 in continuous movement. The chambers 5 and 6 are conventional reservoirs for the pulp slurry. 3 and 4 are the pulp slurries contained within the respective reservoirs 5 and 6. The cylinders 1 and 2 serve to pick up thin layers

This invention relates to a process for producing glass strand-paper twine and, more particularly, this invention relates to a process for producing glass strand-paper twine wherein a plurality of glass strands are coated with an adhesive material and are superimposed and imbedded into a freshly-formed wet paper pulp lap in parallel alignment. The strand-imbedded lap is then covered with a freshly-formed paper pulp lap and the components are combined into a unitary assembly and dried with the application of heat so as to activate the adhesive and bond the strands to the laps, thereafter twisting the assembly to form a twine.

One of the objects of the present invention is to produce a glass strand-paper twine which may be used generally as a twine, but which will be particularly useful as a binder twine and binder twine. A further object of the present invention is to produce a glass strand paper twine which can be readily substituted for natural twine, such as that generally referred to as sisal twine. A still further object of the present invention is to produce glass-paper twine by superimposing a plurality of parallel glass fibrous strands which have been coated with an adhesive material on a freshly-formed, wet paper pulp lap and imbedding said strands into the lap, covering the strand-imbedded lap with a freshly-formed wet paper pulp lap to form a unitary assembly, drying the assembly by the application of heat, so as to activate the adhesive and bond the strands to the lap, thereafter twisting the assembly to form a twine.

These and other objects of the present invention will be more fully hereinafter set forth.

Reference is made to my copending application bearing the Serial No. 212,065, filed February 21, 1951, for "Twine and Process of Preparing the Same," in which I have directed claims to the process for producing glass strand-paper twine in which the glass strands are superimposed on a tissue paper web which has been previously coated with an adhesive material, covering the strand-imbedded web with a tissue paper web and uniting these components into a flat assembly, thereafter twisting said assembly into a twine.

I make further reference to my copending application bearing the Serial No. 227,768, filed May 25, 1951, for "Twine and Process of Preparing the Same," in which I have directed claims to a process for producing a twine comprising the steps of coating a tissue paper web with an adhesive material and superimposing and imbedding on said web, a plurality of glass strands and organic fibrous strands in parallel alignment and in alternate traverse arrangement, covering the strand-imbedded, adhesive-coated web with a tissue paper web and uniting these components into a flat assembly, there-after twisting said assembly into a twine.

Natural twine, generally referred to as sisal twine, is becoming increasingly short in supply and the price of said natural twine is increasing steadily, so that it is becoming a virtual necessity to find a synthetic twine which will be satisfactory for all of the general applications to which the natural twine is put.
of the paper pulp and apply it to the felt 12. The squeeze rollers 7 and 8 serve the dual function of forcing the freshly formed paper pulp lap to adhere to the felt in order that the laps may be conveyed thereby and further serves to squeeze out part of the excess water contained in the lap. The symbol 13 indicates the felt 12 carrying one thickness of the pulp lap as applied to the felt by the applicator roll 1. The glass strands 14 are directed through a comb-like guide or reed 15 containing a plurality of dents through which the individual strands are passed in parallel alignment. The strands, in parallel alignment are passed over the guide roller 19 into the adhesive reservoir 20 containing a heat-sealable thermoplastic resinous adhesive such as poly-vinyl acetate in aqueous dispersion, 21. In the adhesive reservoir the strands are passed around the applicator roll 22 and are directed out of the adhesive chamber around the roller 23 which serves to squeeze off any excess of adhesive and up through the drying chamber 24 through the aperture contained therein, 25. Upon emerging from the drying chamber the adhesive coated strands 27 are passed under tension around the combining roller 26 wherein the strands 17 are superimposed upon the freshly formed paper pulp lap 13 in parallel alignment resulting in the strand covered lap 15. As the strand covered lap 15 passes between the applicator roll 22 and the squeeze roll 7, a second freshly formed paper pulp lap is superimposed thereupon to form the sandwich-like structure of two freshly formed paper pulp laps with the heat sealable thermoplastic resinous adhesive coated glass strands in parallel alignment therebetween. The unitary structure 16 thus produced around the roller 9 and is conveyed toward the roller 10 as indicated by the symbol 11 which represents the felt conveying the unitary structure 16. As the unitary structure 16 passes over the roller 10 it is separated from the felt 12 and is lead to the press section and dries where the heat sealable resin adhesive bonds the webs together upon the application of heat. Although the wet pulp laps are seemingly separate individual structures at the outset they appear to be a single lap with the glass strands imbedded therebetween after the two laps are combined, dried and heated. The drying chamber 24 containing the channel 25 through which the resin coated glass strands are conveyed to the paper making machine as shown in the drawing, is not an essential part of the process as one may readily dispense with this embodiment. However, if one makes use of an aqueous solution or dispersion of a heat sealable resinous adhesive one may well wish to drive off the moisture from the glass strands before said strands are applied to the freshly formed pulp lap. If one wished to use the resinous adhesive as a hot-melt one would dispense with the drying chamber 24 completely as cooling would be desired after the strands have left the roller 23 in their approach to the roller 25. As a further embodiment of the present invention one could make use of a cooling medium in the nature of blasts of air applied to the resin coated strands if a hot-melt adhesive is used. There are many obvious modifications which may be applied to the fundamental process of my invention some of which have been mentioned hereinafore. Additionally, amongst these modifications is the concept of making use of more than two pulp applicator rolls in which one could set up an arrangement identical with that appearing between the paper pulp chambers 5 and 6 wherein the glass strands could be applied, in addition, to the pulp lap after the chamber 6 and subsequently covered with a third layer of freshly formed paper pulp and combined as indicated above to form a unitary structure. A further modification of the fundamental process can be accomplished by applying the glass material to the glass strands over an applicator roll without adopting the concept of leading the strands through the resins suspension or hot-melt.

It should be further obvious that the adhesive material can be applied to the glass strands by spraying the strands with the adhesive material in any means of adhesive application. These and other modifications of the fundamental concept of my invention will be completely obvious to any one skilled in the art once having seen my fundamental process and further specific discussion of these departures is not deemed necessary. These modifications are however intended to be included in the appended claims. When the unitary structure 16 leaves the felt 12 and is lead to the press section and dries, the tape-like structure is processed in substantially the same manner as a paper web would be processed on a conventional cylinder papermaking machine. Thereafter, the wide web may be slit to strips of the desired width and each strip may then be twisted to form the twine. It will be further obvious to anyone skilled in the art that the concept as disclosed in the accompanying drawing may be applied with slight modification to other papermaking machines than the cylinder machine such as the Fourdriner machine amongst others.

There are a plurality of ways in which this twine may be fabricated. Each of the minor departures from the essential concept of the applicant are mere modifications, a few of which are set forth hereinafter. One could superimpose a great plurality of the coated strands on a wide, wet, freshly-formed paper lap and thereafter superimposing a second wet paper pulp lap on the strand-imbedded lap and pressing the components together to form a unitary assembly. This wide assembly may then be split into a plurality of narrower webs of desired width, which one could twist into the desired paper twine. Still further, and as a preferred embodiment of the present invention, one could prepare the unitary assembly, as indicated hereinafore, and one could make use of a pressing device, in the nature of a pair of rollers covered with a resilient material, which would force the upper and lower paper laps together to form corrugations with the glass strands. Care must be taken in the selection of the pressure rollers to insure that the fibrous strands are not damaged while the unitary assembly is being pressed into a corrugated form. For this reason, it is advisable to use a combing wheel which is firm and resilient, and yet sufficiently pliable so as to avoid damaging the strands. Still other embodiments of this invention will become obvious to any one skilled in the art and, further specific enumeration of details as a consequence is unnecessary. Each of these embodiments, however, is intended to be included within the scope of the appended claims.

In the practice of the process of the present invention any adhesive material may be used to bond the paper web and glass strands together such as natural adhesives and synthetic resinous adhesives both thermosetting and thermoplastic. Amongst the thermosetting resinous adhesives which may be used in the practice of the process of the present invention are the aminoplast resins such as those produced when an aldehyde is reacted with amino compounds such as urea, dicyandiamide and aminotriazines such as melamine, benzoguanamine, formoguanamine, acetoguanamine, halo substituted triazines such as 2-chloro-4,6-diamino-1,3,5-triazine, mono, di or trialkyl melamines, for instance, 2,4,6-triethyl triazine, 1,3,5-triazine, the mono, di or trialkyl or mono, di, or triaryl melamines such as 2,4,6-triphenyl, trimino 1,3,5-triazine and the like. Other thermosetting resins which may be used are those produced by the corocation of an aldehyde with phenols such as hydroxy benzene, resorcinol, bisphenol and the like, or aldehydes reacted with ketones such as acetone, methyl ethyl ketone, ethyl propyl ketone, cyclohexanone and the like. Amongst the aldehydes which may be used in corocation with any of the resin forming materials set forth hereinafore are...
acetalddehyde, propionaldehyde, crotonic aldehyde, crocolin and aromatic or heterocyclic aldehydes such as benzaldehyde, furfural and the like. Formaldehyde is generally the most commonly used aldehyde in connection with these resin forming materials and is actually generally preferred.

Paper adhesives, both natural and synthetic, may be used, such as the polymers of butadiene or copolymers of butadiene and styrene.

Amongst the natural adhesives which may be used are casein, soya protein and other proteins, starch, animal glue, gelatin, blood, asphalt, pitch and the like.

The practice of the process of the present invention, the thermoplastic, heat-sealable adhesive resins are preferably used to coat the glass strands which are subsequently activated by the application of heat in the course of the drying operation, so as to bond the web and the glass strands together. Amongst the thermoplastic heat-sealable resin adhesives which may be used are polyvinyl acetate, the alkyd esters of the alpha, beta-unsaturated carboxylic acids, such as polymethyl acrylate, polymethyl methacrylate, polybutyl acrylate, polybutyl methacrylate, polybutyl fumarate, polybutyl maleate and the like. Still further, there may be used allyd resins of the unsaturated or saturated type, either oil-free or oil-containing, modified with styrene, acrylonitrile or other vinylidene, vinyl, or vinylene compounds, polyesters such as glycol succinate or glycol sebacates, amide esters and the like.

Glass and glass strands are formed in a unitary structure, these structures or assembly will resemble tape-like products. These tapes may be treated in a plurality of ways prior to the twisting operation, after they have been heat-treated to bond the strands to the paper webs, for instance, the tape may be passed through a water bath and then run directly to the twisting machine, or the tapes may be merely passed between additional heated rolls and directly twisted; or, as a further modification, the tapes may be passed between a pair of parallel hotplates, and twisted directly. A still further modification can be accomplished by applying heat, such as in the manner indicated hereinabove, passing the tapes through a water bath and then twisting to form the twine or, still further, the tapes may be passed through a water bath, twisted to form the twine and then heated. A still further modification resides in the embodiment in which the tapes pass through a steam box, wherein both heat and moisture could be applied to the tapes and then, upon removal therefrom, the tapes could be twisted in a moist, warm condition. A still further modification resides in the embodiment in which a water bath is used wherein a sizing material, such as glue, flour, wax emulsions, metallic soaps, such as sodium stearate, resin dispersions and the like is incorporated into the water bath. These sizing materials may be added to improve water and/or scuff resistance. Still further, one could apply to the paper web a softener in the nature of an oil, such as mineral oil, vegetable oil, animal oil and the like. A still further modification of the general process resides in the use of a third freshly-formed wet paper pulp layer, wherein there is superimposed on the first formed layer a plurality of coated strands, a second layer is superimposed thereupon, followed by a superimposition of a second layer of coated strands, followed by the superimposition of the third layer, in which the ultimate unitary structure is sandwich-like, being composed of layers of paper layer, adhesive-coated strands, paper layer, adhesive-coated strands, and paper layer. The number of strands used across any given lap is in no way critical. It is possible to vary the number of strands rather substantially, depending on the number of the twine and ultimately the thickness of the twine desired, and depending further on the strength of the twine desired.

In the manufacture of the glass filaments, molten glass, maintained at a temperature of about 2500° F. is allowed to pass through about 204 dies to form glass threads which are drawn downwardly at about 6,000-10,000 feet per minute. A size coating is applied to the individual filaments. This coating serves to protect each individual filament from its companions in the strand, whereby loss due to attrition is reduced to a negligible factor.

In practicing the process of this invention any paper pulp slurry may be used but best results will be realized when the paper pulp slurry used is that type of slurry which is conventionally used in the production of tissue paper sometimes referred to as twisting tissue paper.

I claim:

1. A process for producing glass strand-paper twine comprising coating a plurality of glass strands with an adhesive material, superimposing said coated strands on a freshly-formed wet paper pulp layer in parallel alignment, covering said strand-covered layer with a freshly-formed wet paper pulp layer to form a unitary assembly, passing said assembly through a dryer, wherein heat is applied to the assembly so as to activate the adhesive and bond the strands to the lap, thereafter twisting the assembly to form a twine.

2. A process for producing glass strand-paper twine comprising coating a plurality of glass strands with a thermoplastic, heat-sealable adhesive resin, superimposing said coated strands on a freshly-formed wet paper pulp layer in parallel alignment, covering said strand-covered layer with a freshly-formed wet paper pulp layer to form a unitary assembly, passing said assembly through a dryer, wherein heat is applied to the assembly so as to activate the adhesive and bond the strands to the lap, thereafter twisting the assembly to form a twine.

3. A process for producing glass strand-paper twine comprising coating a plurality of glass strands with a thermoplastic, heat-sealable adhesive resin and superimposing said coated strands on a freshly-formed wet paper pulp layer in parallel alignment, covering said strand-covered layer with a freshly-formed wet paper pulp layer to form a unitary assembly, passing said assembly through a dryer, wherein heat is applied to the assembly so as to activate the adhesive and bond the strands to the lap, thereafter twisting the assembly to form a twine.

4. A process for producing glass strand-paper twine comprising coating a plurality of glass strands with a thermoplastic, heat-sealable adhesive resin and superimposing said coated strands on a freshly-formed wet paper pulp layer in parallel alignment, covering said strand-covered layer with a second freshly-formed wet paper pulp layer and uniting the components to form a unitary assembly, passing said assembly through a dryer, wherein heat is applied to the assembly so as to activate the adhesive and bond the strands to the lap, thereafter twisting the assembly to form a twine.

5. A process for producing glass strand-paper twine comprising coating a plurality of glass strands with a thermosetting adhesive resin, superimposing said coated strands on a freshly-formed wet paper pulp layer in parallel alignment, covering said strand-covered layer with a freshly-formed wet paper pulp layer to form a unitary assembly, passing said assembly through a dryer, wherein heat is applied to the assembly so as to activate the adhesive and bond the strands to the lap, thereafter twisting the assembly to form a twine.

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