Dec. 29, 1970 J. L. CASADEVALL 3,551,268

CROSS-FIBERED TAPE, AND USES THEREOF

Filed July 7, 1967 3 Sheets-Sheet 1

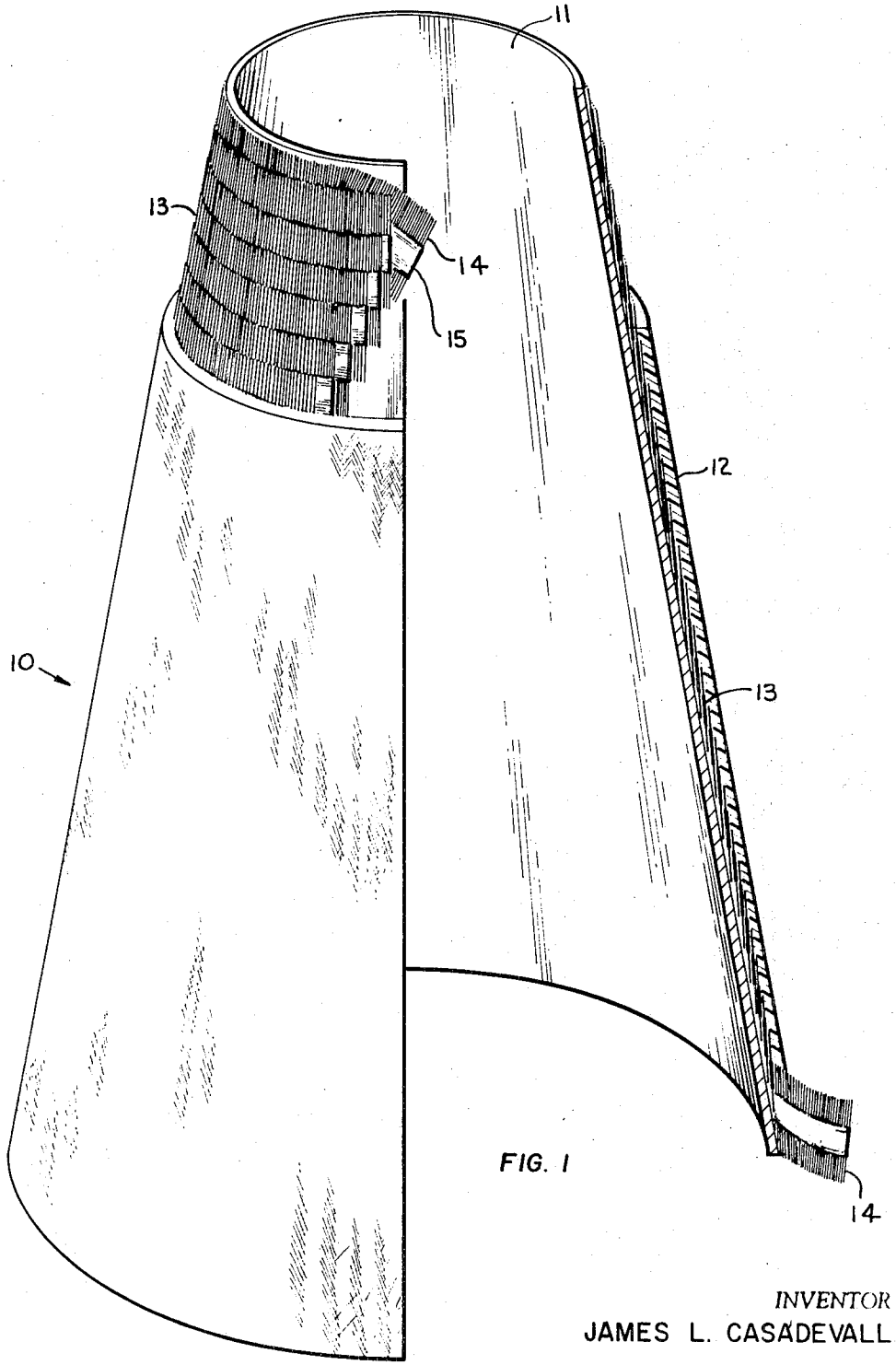


FIG. 1

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CROSS-FIBERED TAPE, AND USES THEREOF

Filed July 7, 1967 3 Sheets-Sheet 2

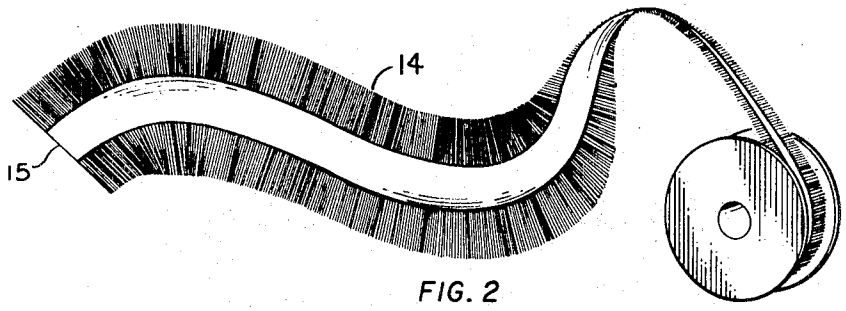


FIG. 2

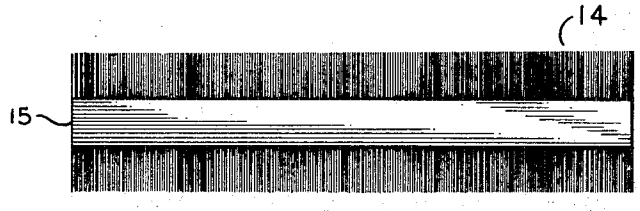


FIG. 3

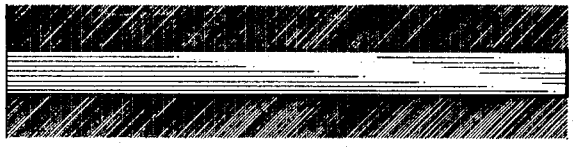


FIG. 4

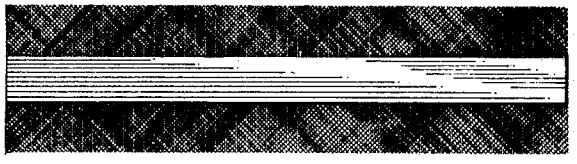


FIG. 5

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CROSS-FIBERED TAPE, AND USES THEREOF

Filed July 7, 1967 3 Sheets-Sheet 3

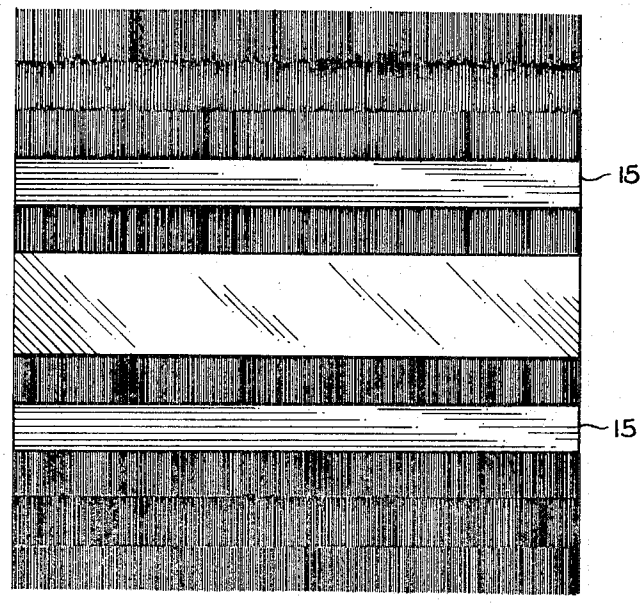


FIG. 6

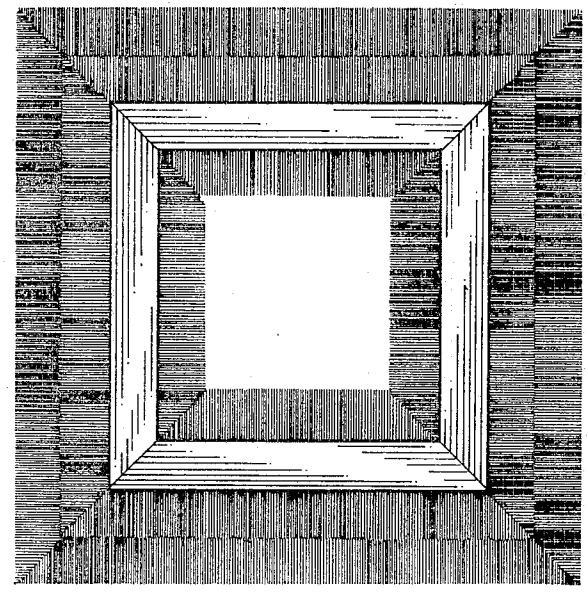


FIG. 7

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3,551,268

CROSS-FIBERED TAPE, AND USES THEREOF

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Int. Cl. D03d 1/00; B32b 25/02
U.S. Cl. 161—89 8 Claims

ABSTRACT OF THE DISCLOSURE

This invention relates to the use of a novel cross-fibered tape by the use of which a wide variety of structural or temperature-resistant materials can be joined together. This tape can consist of a large number of short fibers, such as of fiber glass, that are held together by a center member extending the length of the tape, but leaving both ends of the fibers free and therefore available to be joined such as by adhesive means to the two materials that are to be secured together. Even though relative motion takes place between the two materials, due for example to heating effects, the tiny fibers serve in a highly advantageous manner to prevent complete separation of the two materials.

This invention relates to an arrangement for securing together materials that may have widely different coefficients of thermal expansion, and more particularly to a cross-fibered tape, and to the use of the tape for securing an item such as ablative material to a material as dissimilar thereto as a metallic substructure.

The use of ablative heat shield materials in the manufacture of missiles has proven highly advantageous, but nevertheless such ablative materials have been secured to the missile substructures only with great difficulty. One procedure has been to secure the ablative material to the substructure at room temperature, and this joinder has been successful as long as the assembly remains at relatively low temperature. However, if the bond line is heated, expansion of the metal substructure may generate sufficient force to cause failure in the form of longitudinal or circumferential splitting of the heat shield material, such failure often occuring at temperatures as low as 250° F. to 350° F.

High temperature bonds are much more economical to accomplish, and the quality is generally much higher. However, upon cooling of the assembly to room temperature, shrinking of the metal substructure often produces sufficient bond line stresses that catastrophic failure can thereafter occur, with the result that a complete loss of bond takes place at the adhesive to ablative interface, or at the interface of the substructure to the adhesive.

It is an object of this invention to provide a novel method for securing of ablative type materials to a metal substructure, as well as to a novel tape usable in accordance with this method whereby a joint is provided that will allow for a desirable degree of relative motion, thus making the resulting arrangement predictable and reliable over a wide range of thermal conditions.

The cross-fibered tape I provide in accordance with this invention is utilized in sufficient length that it can be wrapped in an overlapping relationship about the metallic substructure of a warhead, for example. This tape is composed of a very large number of short fibers of fiber glass, quartz, silica or the like, or even of metal, that in one embodiment are held in essentially parallel relationship by a center member disposed perpendicular to the fibers. The center member is continuous for the length of the tape, and preferably of a width that is approximately ⅓ that of the length of the fibers, although it could be wider or narrower. As a result of this arrangement, the ends of the tiny fibers extend both above and below the center member used to secure these fibers into a tape, which ends are available to be secured to the members to be fastened together.

When used in the manufacture of nose cones, the tape is typically wrapped starting from the small diameter portion of the conical structure, so that the lower ends of the fibers are in contact with the surface of such structure, with the upper ends of the same fibers being available, because of the overlapping relationship employed, to be bonded to ablative material being utilized to form the outer surface of the nose cone. By virtue of this arrangement, as relative motion would tend to take place between the metallic structure and the ablative material, such can occur without loss of bond integrity, inasmuch as the fibers can continue to form the connection between the substructure and the ablative material, even when these members are somewhat separated. At most, only some lifting away of the fibers in the central area of the tape is involved. The center member of the tape utilized for holding the fibers together can be of such construction that it can stretch to allow for expansion of the metallic member, so at all times an effective juncture is preserved. This center strip may be made of such material as silicone rubber, Teflon, or epoxy in either solid or cellular form, and possibly other material having sufficient elongation and thermal properties suitable for the environment to which it would be exposed. This center strip can vary from ¼ to ½ of the tape width.

My invention is not limited to use with warheads, or even conical members, for obviously my novel tape and my novel method may be utilized for securing materials of a variety of thermal coefficients to a relatively flat surface, to a domed structure, and to many other shapes. When working with basically flat shapes, I prefer to start laying the tape from two or possibly four outer edges. More specifically, such tape is applied parallel to a given outer edge, with successive pieces of tape placed parallel to and overlapping the first piece, until at or near the center of the structure, the various buildups of tape intersect. Such an arrangement is resorted to in order to prevent separation, by a form of hinging movement, of the outer material away from the structure, such as might be prone to occur if tape was utilized on a basically flat member, with all pieces of tape applied in a given manner.

Also, I am not to be limited to tape having a 90° relationship between the fibers and the central member, for obviously the fibers could for example be placed at a 45° angle to the centerline of the tape if such was desired. By using a form of weave wherein some of the fibers lie crosswise to other fibers, the tape can "lock" the upper material to the lower material so that shifting, or any form of relative sideways movement cannot occur.

In use, my preferred method involves the steps of disposing several adjacent layers of cross-fibered tape on a first member, with each successive layer substantially overlapping the preceding one such that the fiber ends of one edge of each layer of tape can be secured to the first member, and thereafter securing a second member to the fiber ends of the other edge of said layers of tape, with the fibers of said layers of tape serving to secure said members together, while still allowing relative motion between the members.

My invention is not limited to those composite structures operating in a high thermal environment such as that experienced in re-entry conditions, for my novel concepts can be advantageously used for the attachment of dissimilar materials operating at extremely low temperatures, such as experienced in areas where super cooled cryogenic materials such as liquid oxygen or liquid hydrogen are used. These materials must be contained in and have contact with structural members such as tanks,

piping, and valves, which benefit by the use of insulating materials that prevent heat input and rapid volatilization of the contained gases.

There are also areas of application for this unique material and method in which both extremes of thermal range may be experienced by the same bonded assembly. Examples of this would be those insulating or heat shielding materials used within the blast area of liquid propelled missiles. In this environment the assembly may be subjected to an initial impact of unignited liquid fuels of extremely low temperature followed by direct flame blast on ignition. The outer space environment also subjects assemblies to a similar extreme which in this case may change repeatedly as in a day to night exposure on the lunar surface from approximately +400° F. to −200° F.

A further important advantage provided by this unique contribution is the manner in which an elastomeric center strip forms a continuous shock absorbing layer separating the two adherends. This layer is beneficial in that it performs as a vibration damping medium preventing the full transfer of externally applied vibration or shock forces to the inner structural unit. The continuous shock absorbing elastomeric layer is particularly advantageous in the environment resulting from a nearby nuclear blast. Under this condition, a combination of extremely high heat input and severe shock waves can be expected, which would be extremely damaging to normal, direct bonded assemblies.

These and other objects, features and advantages will be more apparent from a study of the enclosed drawings in which:

FIG. 1 shows a perspective view, partly in section, revealing how my novel tape can be wrapped in overlapping relation about an inner member, and thereafter serve as a highly effective means to which an outer member can be secured;

FIG. 2 is a drawing illustrating my novel tape as it may extend from a spool or reel;

FIG. 3 illustrates a length of tape in which in accordance with one embodiment of this invention, the fibers are disposed in a longitudinal array, with a central member disposed substantially in the mid portion of the tape and serving to secure the fibers in a desirable configuration, while leaving the ends of the fibers free;

FIG. 4 illustrates a length of tape of somewhat different construction, in that the fibers are disposed at an angle to the length of the tape;

FIG. 5 is a view similar to FIGS. 3 and 4 but which differs in that approximately one-half of the fibers of the tape are disposed at one angle, and interwoven with the other half of the fibers, which are disposed at a different angle;

FIG. 6 illustrates a procedure that may be utilized with flat material, in which several layers of tape may be disposed in overlapping relationship, commencing from opposite edges of the flat material; and

FIG. 7 is a view generally like FIG. 6, but in which cross-fibered tape in accordance with this invention is utilized, beginning from each edge of a piece of structural material.

Referring to FIG. 1, it will be noted that a portion of a nose cone **10** is shown, with a portion thereof removed so as to reveal an important utilization of my novel cross-fibered tape. In this embodiment of my invention, a conically shaped metal substructure **11** is provided, in surrounding relationship about which, ablative material **12** is to be secured. In accordance with this invention, a joinder layer **13** is made up, utilizing a number of layers of my cross fibered tape **14**, an exposed end of which is shown at the uppermost and lowermost portions of the nose cone. The procedure associated with the construction of a nose cone in accordance with this invention will be discussed hereinafter.

Turning to FIG. 2, it will be noted that my novel cross-fibered tape is of such a nature that it can be stored or wrapped upon drums or spools, and dispensed when the tape is to be utilized. As will be noted in this figure, as well as FIGS. 3 through 5, my tape comprises a large number of fibers disposed in a longitudinal array, with the center member **15** extending the length of the array of fibers and serving to hold them in the desired configuration. Although I prefer to dispose this center member substantially in the mid portion of the tape, I could if conditions warrant, place the center member closer to one edge of the tape than the other. The center member is of a width corresponding to approximately ¼ to ½ of the overall width of the tape, with a center member width of ⅓ of the overall width being typical.

When utilizing the tape for securing ablative material to the metallic substructure of a nose cone, for example, I prefer the center member to be an elastomeric member such that the tape can remain in close contact with the substructure despite the expansion or contraction of the substructure. This elastomeric material may for example be one of several silicone rubbers such as the DC–90–092 one part system available from the Dow Corning Corporation of Midland, Mich.

As to the length of the fibers, they may for example be 1″ long when utilized in nose cones, but say 3″ long when securing insulating material to a gas storage bottle, large rocket engine, or the like.

I prefer the use of high strength glass fibers in the construction of my tape, such as fiber glass fibers manufactured by Owens-Corning Fiberglas Corporation of Santa Clara, Calif. For example, such fibers may be .00012″ to .00075″ in diameter, which fibers may be wound with 204 such fibers per strand. These strands may be bundled to form a roving that utilizes 12 to 60 of such strands, with say 20 strands per roving being typical. In the latter instance, if say 10 rovings are utilized per inch of tape, this means that approximately 40,800 fibers or filaments would be disposed in each lineal inch of tape. Considering the fact that a substantial overlap of one tape layer with respect to the next is preferred, a very large number of fibers are being utilized to hold the ablative material onto the substructure of the nose cone.

It should be noted that the fibers or filaments could also be of nylon, polypropylene, or even of suitable metals. In latter instance, the metal fibers could even be welded or brazed if the two materials being joined are metallic.

With reference again to FIG. 1, although in securing one cylindrical member about the exterior (or interior) of another such member it would generally be immaterial from which end the tape wrap is commenced, when securing one conical member about another, it is generally desirable to start at the smaller end of the inner member in laying up the wrap of tape inasmuch as this in effect locks the outer layer to the inner layer. That is, the outer member cannot move in one direction because of the geometrical configurations involved, and cannot move in the other direction because of the fibers themselves. Therefore, in the construction of a nose cone, for example, I prefer to start wrapping the tape from the smaller end of the metallic substructure, with the overlap being such that the central portion **15** of one layer of the tape is closely adjacent the central portion of the next layer, with the lower ends of the fibers of each section of tape being in physical contact with the metallic substructure **11**, and the upper ends of each layer of tape being free to be secured to the interior portion of the outer member **12**. It is for an adhesion reason rather than a structural reason that I prefer to wrap the tape with the center portion of one layer closely adjacent the center portions of the preceding and succeeding layers, the reason being that in this manner the undesirable condition of the members **11** and **12** being secured directly together is prevented. In other words, it is desirable to adhesively bond,

in an instance such as this, the lower ends of the tape to the inner member, and the upper ends to the outer member, but it is not desirable for the adhesive used in conjunction with one of these members to also bond directly to the other member, for to do so would defeat the very purpose of this invention which normally permits a degree of relative motion between the inner and outer members as a result one of these members in effect being able to pull somewhat away from the other one, with, however, the fibers of the tape still extending firmly between both members despite such relative motion.

As to a typical procedure for constructing a nose cone in accordance with my invention, I first degrease the metallic substructure **11**, which step is followed by grit blasting to provide a clean surface to which the adhesive may be applied. Although I may use adhesive in either liquid or film form, I prefer the use of a film material such as HT–424, manufactured by Bloomingdale Rubber Company, or the equivalent. Such material is sufficiently tacky as it comes from the manufacturer that it can easily retain itself upon the cleaned metallic substructure. Typically, I apply this material either by use of a roller or by hand working it so that air is not included between the film and the substructure.

I am now ready to begin the application of my novel cross fibered tape, and as previously indicated, I prefer to begin at the small end of the conical substructure so that as the various overlapped layers are created, the lower end of the fibers of the tape will be in contact with the adhesive, which is sufficiently tacky to retain them in the position as applied. There are available mechanical devices for performing this wrapping function with a high degree of overlap accuracy. It should be noted, however, that if an error is made in the wrapping procedure, the machine can be stopped and the tape can be pulled away from either the film or the liquid adhesive and then restarted correctly.

Although I can now place the wrapped nose cone in an oven so as to cure the adhesive before proceeding further, in most instances I prefer now to apply the ablative material, so that the curing of the adhesive as well as the ablative material can be accomplished in one operation. The ablative material is applied usually in tape form on similar equipment to that used in applying the attachment tape in accordance with this invention. The width of the ablative material tape varies according to whether a flat wrap or a shingle wrap is to be made. The equipment is sufficiently accurate that either layup method can at this time be performed.

It should be noted that the majority of the ablative wrapping materials are sufficiently high in resin content that direct bond can be made to the exposed fiber ends of the cross-fibered tape without the use of secondary adhesives. However, where required, a liquid or film adhesive may be applied over the fiber ends to insure bonding of the drier or nonresinous ablative materials. When the wrapping of the ablative material has been completed, the unit is subjected to sufficient temperature and pressure, as in an oven or autoclave, to insure complete cure of all adhesives and resins used. A typical temperature would be 325° F. and typical curing time would be one hour per ¼" of ablative material thickness, under pressures of from 15 to 500 lbs. per square inch. Lower pressures are used in many of the rubber modified ablative materials; higher pressures may be required for full density of the conventional phenolic resin type materials.

Upon removal of the finished assembly from the oven, an external machining cut may be performed as on a lathe or grinder to provide the finish thickness of the ablative material to be say ¼". The ablative materials may be composed of fibers of asbestos, glass, silica, graphite, carbon, nylon, resinous materials of epoxies, phenolics, and the like. This material is available in any width required of either warp or bias cut. I typically prefer the bias cut in which all fiber ends are bonded to the basic adhesive used, passing completely through the ablative thickness for end grain exposure.

It should be noted that there is no flow in either direction of adhesive material through the layers of cross fibered tape, for if such should occur, this would minimize the highly advantageous result sought in accordance with this invention, that is, the permissible amount of relative motion between substructure and ablative material.

If it is decided to perform a flat wrap of the ablative material upon the nose cone, I prefer to begin at the small end of the nose cone and to overlap in each instance the preceding layer to a sufficient degree to provide the thickness required. However, if a shingle wrap is utilized, the wrap begins at the aft or larger end so that the shingle angle lies at approximately 20° in the direction of air flow over the nose cone. An external coating may be applied to the finished heat shield ablative material to prevent moisture pickup or contamination during assembly and handling. The nose cap can be made of similar material and is installed in the forward end to complete this portion of the assembly. The aft end is similarly joined to the adjacent section of the missile, which may for example be the center section.

As previously mentioned, I prefer on conical surfaces to begin at the small end so that the locking type action is such that the ablative material cannot move forward on the structure because of the literally millions of small fibers that serve to restrain it in that direction. However, this type of locking is not present in a cylinder of substantially constant diameter, and for that reason it is preferred to begin wrapping from both ends towards the center, in which case lateral movement in either direction is prevented.

In the flat plane embodiment revealed in FIG. 6, layup of the pieces or sections of cross-fibered tape proceeds from each edge toward the center. In FIG. 7 it will be noted that in instances in which sideways motion of the ablative material is to be prevented, I can begin the layup from all four sides, terminating at the center.

It is obvious from the preceding description of this invention that my novel cross-fibered tape provides a directional attachment method with the major strength in the fiber direction. It is therefore possible to provide for the major attachment in the direction of the separating forces expected in the particular design involved. The layups as shown in FIGS. 6 and 7 may therefore be modified or adjusted to provide the maximum strength in any desired direction.

Other embodiments and uses of my invention will be apparent to those skilled in the art, and I am not to be limited to those described herein except as required by the scope of the appended claims.

I claim:

1. A cross-fibered tape for use in securing together materials which may have dissimilar coefficients of expansion, said tape comprising a large number of fibers disposed in a longitudinal array while generally oriented at an angle to the longitudinal axis, and a center member of elastomeric material extending the length of the array of fibers, said center member being disposed substantially in the mid portion of the tape and covering approximately ¼ to ½ the overall width of the tape, and serving to secure such fibers in the desired array.

2. The tape as defined in claim **1** in which said fibers are generally parallel to each other, and perpendicular to the length of said tape.

3. The tape as defined in claim **1** in which said fibers are generally parallel to each other, but disposed at an angle to the length of said tape.

4. The tape as defined in claim **1** in which said fibers are principally disposed at one or the other of two angles with respect to said center member, with approximately

one-half of the fibers of the tape being at said one angle, and interwoven with the other half of the fibers, which are disposed at the other of said angles.

5. A cross-fibered tape for use in securing together materials which may have dissimilar coefficients of expansion, said tape comprising a large number of similar length fibers disposed in a longitudinal array while generally oriented at an angle to the longitudinal axis, and a center member extending the length of the array of fibers, said center member being of elastomeric material covering approximately ¼ to ½ the overall width of the tape and serving to secure such fibers in the desired array, while leaving the ends of the fibers free.

6. The tape as defined in claim 5 in which said fibers are generally parallel to each other, and perpendicular to the length of said tape.

7. The tape as defined in claim 5 in which said fibers are generally parallel to each other, but disposed at an angle to the length of said tape.

8. The tape as defined in claim 5 in which said fibers are principally disposed at one or the other of two angles with respect to said center member, with approximately

one-half of the fibers of the tape being at said one angle, and interwoven with the other half of the fibers, which are disposed at the other of said angles.

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U.S. Cl. X.R.

161—38, 93, 144; 156—304