United States Patent

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[54] **HELICOID LAMINATE COMPRISING SEVERAL CONTINUOUS TIERED STRIPS**
10 Claims, 9 Drawing Figs.

[52] U.S. Cl. 161/47, 138/129, 138/130, 138/131, 138/144, 138/150, 156/184, 156/191, 156/195, 156/199, 156/229, 161/145
[51] Int. Cl. F16l 9/14, F16l 59/02
[50] Field of Search 138/129–133, 150, 144; 161/47, 145; 156/184, 191, 192, 195, 199, 544, 143, 144, 229; 264/280, 281, 288

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ABSTRACT: Helicoid products comprising several continuous tiered strips are made by superposing at least two continuous strips with their edges overlapped, incurvating the strips and durably adhering together the contacting faces of the strips. The resulting helicoid product may be conformed to a mandrel and cured, vulcanized or otherwise treated to acquire a durable tubular helicoid form. This technique is particularly useful in making helicoid coverings that may be repeatedly put on and removed from tubes, rods, wires and the like, as coverings, firesleeves, or insulation, for example.

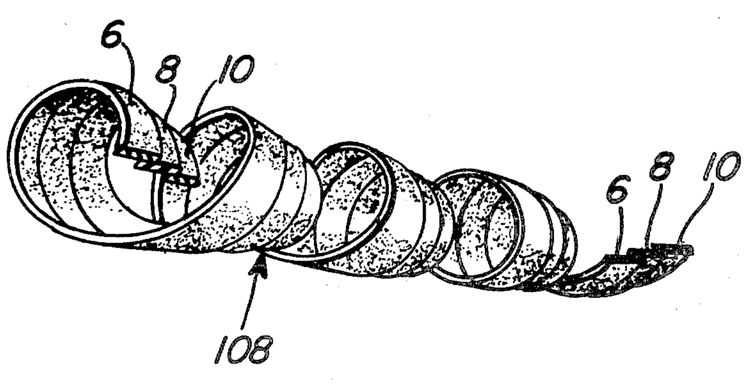

FIG. 1

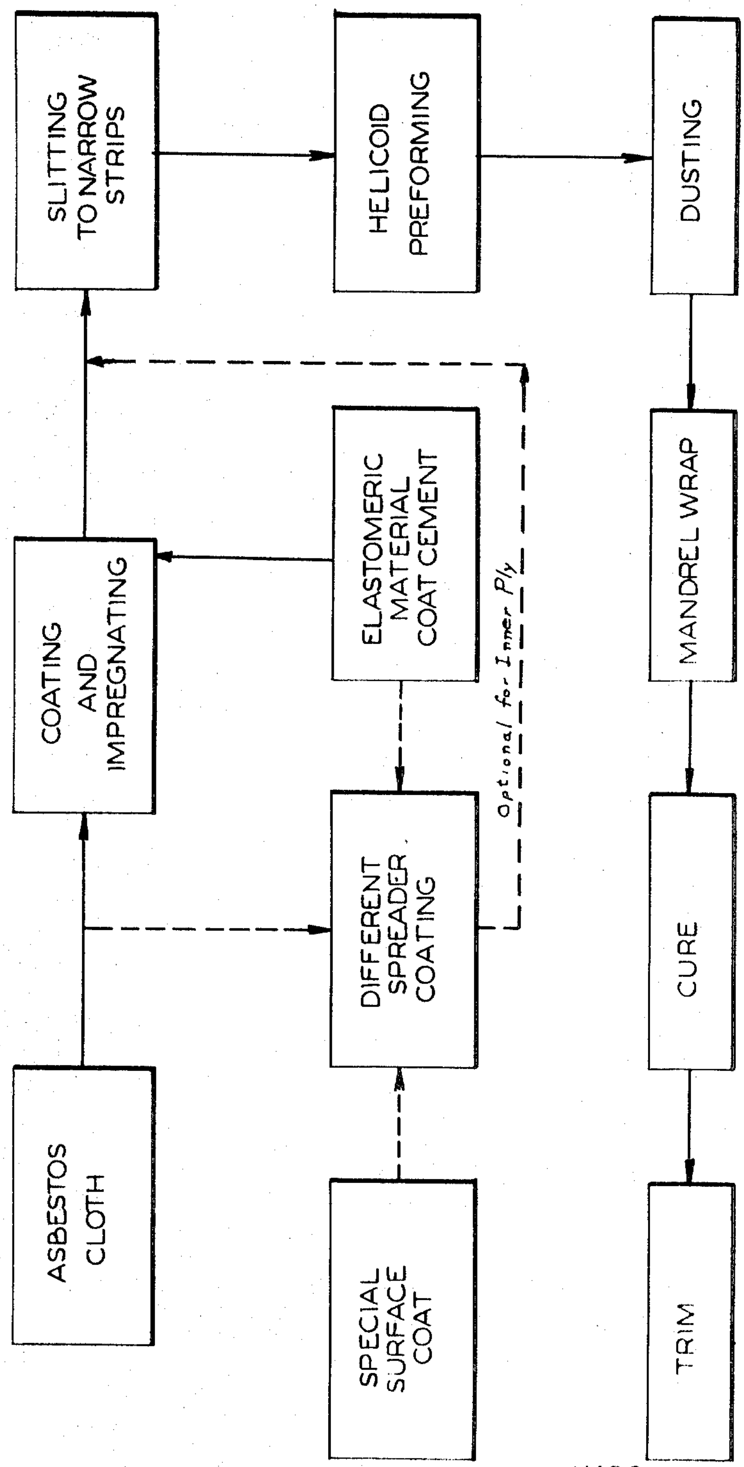

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FIG. 2.

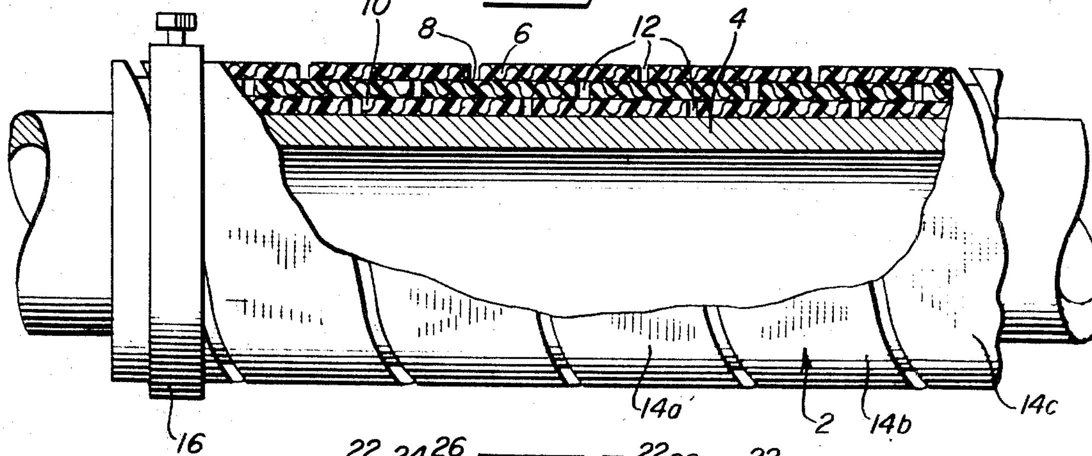

FIG. 3.

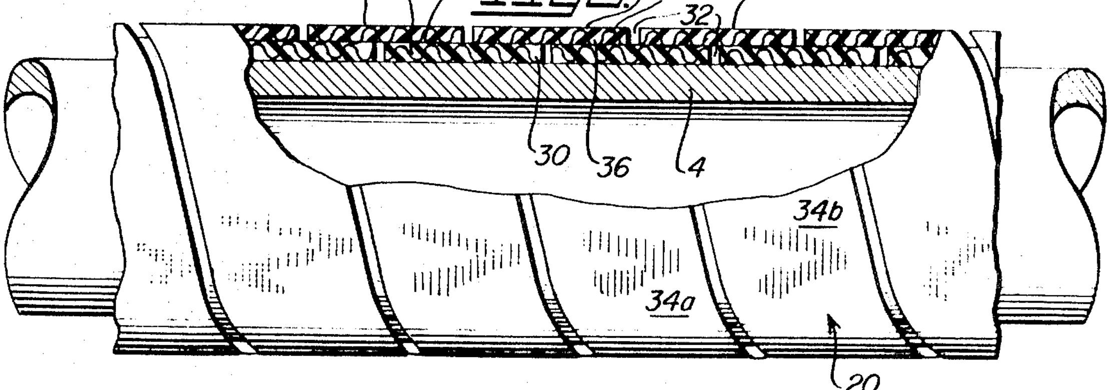

FIG. 4.

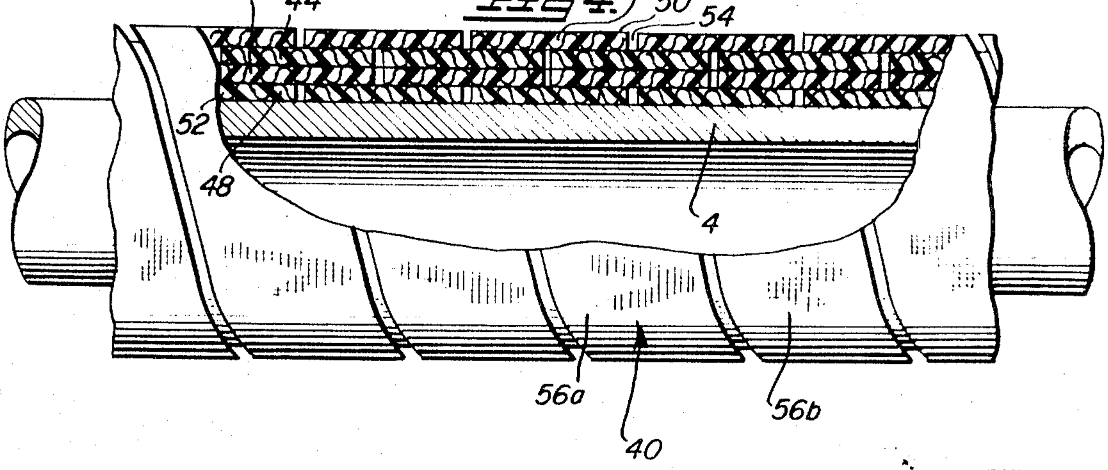

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FIG. 5.

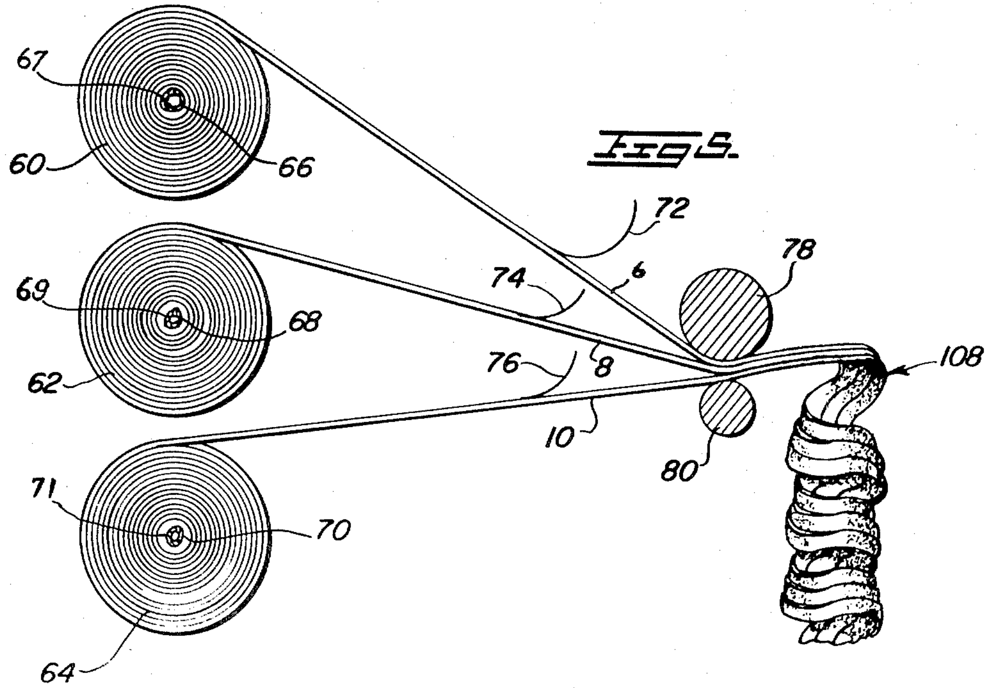

FIG. 6.

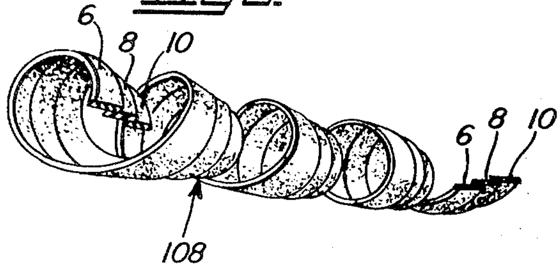

FIG. 7.

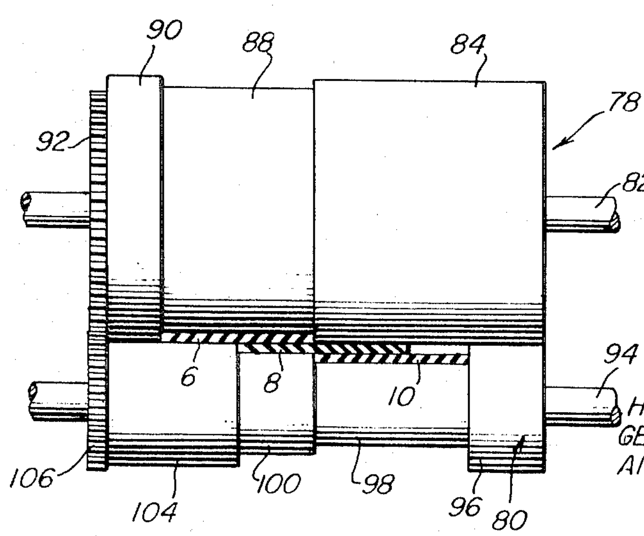

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FIG. 8.

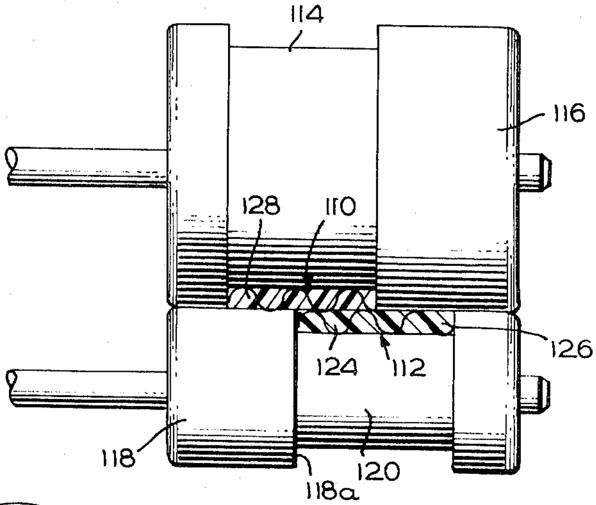
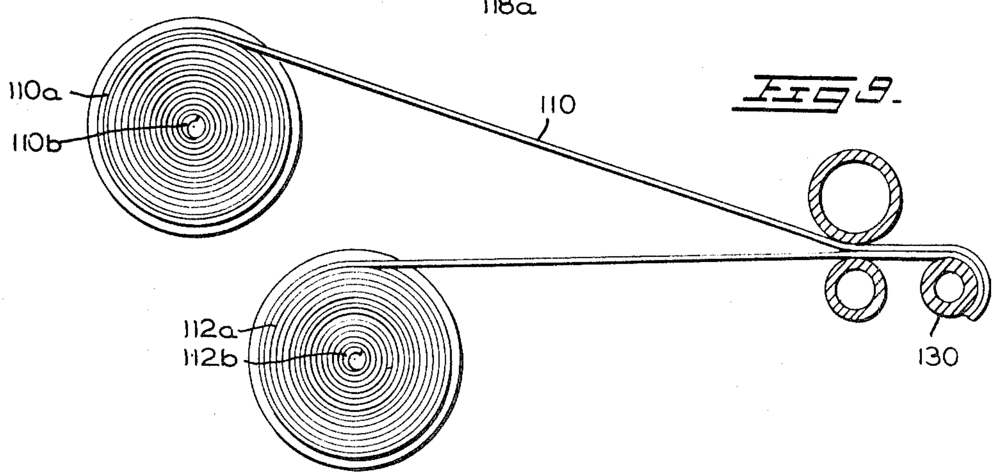


FIG. 9.



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HELICOID LAMINATE COMPRISING SEVERAL CONTINUOUS TIERED STRIPS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a method of forming several strips of material into a unified helicoid form, which can be used for novel covering materials or which upon hardening or curing of an impregnant can be formed into a novel type of conduit. In a specific way, the invention concerns a type of tubular covering that is flexible, fire-resistant and capable of repeated coiling and uncoiling installation and removal without damage about a tube, rod, wire, pipe, hose or the like to function as a firesleeve, packing, and the like.

There are numerous structures which require fluid conduits to be protected against heat and fire by some form of protective covering and yet the fluid conduits must be frequently inspected for possible damage, structural defects or the like while the protective covering is removed. Important examples of this are the hydraulic power-transmitting or fluid-conducting lines of aircraft. Such lines must be protected against fire or other adverse heat conditions, particularly in new high-speed jet aircraft but must be capable of being quickly and frequently inspected for possible structural defects. Flexible metal hose which is employed in such aircraft structures may, for example, be required to withstand an 1,100° C. flame on the surface for 15 minutes without exceeding a temperature of 260° C. on the inside. The flexible metal hose itself is incapable of providing such characteristics and it is necessary for it to be provided with some form of heat-protective covering, i.e., a fire sleeve.

Insulation materials in the form of ribbons or tapes which can be wrapped about a tubular conduct are known. However, the time required to remove and reinstall such insulation coverings to permit inspection of the thermally protected conduit renders this type of product unsuitable for use where easy and frequent inspection of the conduit is required. Some form of insulation covering having a relatively permanent shape and yet which may be readily applied and removed is in demand by the aircraft construction industry and by others.

Use of coverings provided with fasteners such as zippers, hooks, buckles and the like have been investigated. All such removable insulation coverings, however, display poor flexibility when assembled upon a flexible hose and undergo "fish-mouthing" on the compression side of a bend. Zippers and similar closure units which were attached to the insulation covering by machine stitching or the like tend to break loose at the stitch under tension when the enclosed flexible metal conduit is flexed. Also, covers using hooks, buckles and the like are difficult to install.

DESCRIPTION OF THE PRIOR ART

Various techniques are known to make helical wrappings, coverings and conduits. For example, a single strip of material has been spirally wrapped on a conduit so as to be in continuous edge-abutting arrangement and provide an insulation covering for the conduit (U.S. Pat. No. 1,937,561). A modification of this basic concept involves use of a covering strip made to prevent sticking of the tape to the encased pipe or tube so that the tape may be unwound without damage (U.S. Pat. No. 2,353,494).

In addition to limp tapes having no form except the shape to which the tape is applied, it is also known to form insulation tape which is resiliently preformed in a spiral shape so that it can be handled more easily during installation upon or removal from a tubular conduit (U.S. Pat. No. 2,468,589). Such tape offers little or no heat protection at the abutting edges of the coils in the spiral shape.

In terms of prior practices which are not limited to insulation coverings, but generally concern helical products, the formation of structures from rubber, fabric and other materials in a permanent spiral shape or helicoid configuration has been practiced for many years, e.g., formation of piston packing (U.S. Pat. No. 143,705), pneumatic tire inner tubes (U.S. Pat. No. 1,428,382) and rubber tubing (U.S. Pat. No. 1,940,145). It is also common practice to make flexible hose, pipe or other conduits by spiral winding of layers of materials upon a forming mandrel or the like (U.S. Pat. Nos. 2,759,521; 2,913,011, and 3,252,483). Tubing may be formed by the helical winding of strips in combination with shaping wires or other metal inserts upon some form of helix-forming rolls (see U.S. Pat. No. 2,674,298 and 3,191,631).

It is, of course, well known to form tubing by the spiral winding of individual strips of material around a rod (U.S. Pat. No. 3,279,333). The spiral wound product may be a self-supporting pipe or tube (U.S. Pat. No. 2,161,036) or may be a covering for a pipe to protect it against corrosion or for heat insulation purposes (U.S. Pat. No. 2,713,383). In such operations, a plurality of strips may be employed and formed in overlapped or staggered relationship between joints in the resulting tubular structure (U.S. Pat. No. 2,225,026). Moreover, complicated equipment may be used to get a tight telescoping interfitting of the helices by edge crimping (U.S. Pat. No. 2,759,521).

In view of the numerous prior developments as mentioned above, it is apparent many procedures are available for making coverings and other products by helical winding of strip materials. However, in the prior methods, there have been no provision for properly joining several strips of like or unlike materials so as to make a helicoid wrap or to make allowances in the joined strips so that a loose or tight helix can be formed. In the specific case of heat-protective wraps or coverings for metal tubes, pipes and other tubular conduits, moreover, there is a need for improved products that may be installed and removed repeatedly without disassembly of the conduit and without detriment to the conduit or covering.

OBJECTS

A principal object of this invention is the provision of new forms of helicoid tubular products.

Further objects include the provision of:

1. New methods of forming helicoid heat protective coverings for conduits.

2. New forms of such coverings for tubular conduits that may be installed and removed repeatedly without disassembly of the conduit and without detriment to the covering.

3. Such coverings of improved type having the further feature of being relatively noncorrosive to metal conduits to which the insulation may be applied.

4. New helicoid coverings that may be used to protect and flameproof wire bundles, tubes, pipes or the like where ease of application of the coverings is important, such as in tight quarters or where repeated inspections of the enclosed conduit are required.

5. Methods of making such new flame protection products from readily available materials with uncomplicated equipment and at relatively low cost.

6. New forms of helicoid coverings that provide good protection to an encased tubular conduit at the junctions between separate coils of the helicoid structure.

7. Heat protection wraps that provide multiple layers of insulation over an encase conduit yet permit a good flexibility to be maintained throughout the entire assembly.

8. New methods of joining two or more strips of like or unlike materials into a laminate, wherein allowances are provided for helicoid winding or wrapping of the laminate.

9. New methods of helically winding two or more strips of like or unlike materials into a loose or tight fitting helicoid arrangement, useful for a covering, or conduit or tube.

10. New forms of apparatus for creating helicoid tubular products for a plurality of continuous strips of binder-impregnated fibrous material or equivalent material.

Other objects and further scope of applicability of the present invention will become apparent from the description given hereinafter; it should be understood, however, that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this description. It should also be understood the foregoing abstract of the disclosure is for the purpose of providing a nonlegal brief statement to serve as a searching-scanning tool for scientists, engineers and researchers and is not intended to limit the scope of the invention as disclosed herein nor is it intended it should be used in interpreting or in any way limiting the scope or fair meaning of the appended claims.

SUMMARY OF THE INVENTION

The foregoing objects are accomplished in accordance with the invention by formation of helicoid products by superposing at least two continuous strips of material in a stepped, overlapping relationship, incurvating the superposed strips and durably adhering together the contacting faces of the strips. The incurvation of the strips may be attained by stretching or tensioning or unequal lengths of strips may be supplied to the superposing that creates the laminate. The emitted laminate thereby curves itself into a continuous helicoid form.

In the specific embodiment of this general technic in which helicoid heat- and fire-protective wraps or coverings are formed, the operation comprises:

a. providing a plurality of strips of fibrous cloth;

b. the strips being impregnated with binder composition, such as an elastomeric material;

c. the strips are assembled in a tiered and staggered configuration with the edge of at least one strip being offset from the edge of at least one other strip; and

d. said staggered configuration is cured into a helicoid integral structure having overlapping butt joints between strips of adjacent coils so that the structure is capable of being repeatedly coiled and uncoiled so that the insulation wrap may be repeatedly installed and removed from a tubular conduit without damage.

In an exemplary form of the helicoid coverings, three strips of equal width of asbestos cloth are used, with one outer strip staggered to one side of the central strip and the other outer strip being staggered to the other side of the central strip. Advantageously, for situations where protection of an encased metal conduit against corrosion are important, the inner face of the insulation wrap may be formed of material different from the remaining structure, e.g., an inner surfacing of ethylene-propylene rubber composition of low-corrosion properties to metal as compared with asbestos fibers and polychloroprene rubber used in forming the remaining portion of the insulation wrap.

In other embodiments, the new helicoid products may be of a double-ply or a quad-ply construction, all of which employ the staggered or overlap edge arrangement which provides ship-lap joints between adjacent coils of the laminate in the helicoid product.

The success in forming helicoid products of this new type is in part due to the discovery that a helicoid configuration can be imparted to laminate strips of elastomer impregnated and coated fibrous cloth by a simple operation of imposing an arcuate configuration to the strips during their contact in the formation of an edge staggered lamination. This principle is employed in the method of forming the new insulation wraps which comprises:

a. providing a plurality of separate strips of fibrous cloth impregnated and covered with uncured, tacky elastomeric material;

b. bringing said separate strips into generally parallel alignment;

c. contacting opposed faces of the strips in a staggered arrangement with the edge of at least one strip being offset from the edge of at least one other strip;

d. imposing an arcuate configuration to the strips during said contacting;

e. recovering from step "d " an uncured open helicoid laminate of said plurality of strips;

f. treating the uncured lamination with a release agent;

g. winding the treated, uncured lamination about a mandrel in a tight helicoid configuration;

h. subjecting the mandrel wound lamination to necessary conditions to cure the elastomeric material contained therein; and

i. removing the cured helicoid lamination from the mandrel.

It has been found that the imposition of an arcuate configuration is advantageously accomplished by passing the parallel aligned separate cloth strips in the uncured, tacky condition through opposed driven rollers which have lands or steps of different diameters which contact different strips or parts of the widths of different strips and drag these strips or parts forward at different angular velocities. The effect of this is to produce incurvation of the laminate which, in turn, causes it to assume an open or loose helicoid configuration. It is then relatively easy to wrap the uncured laminate into a tight spiral about a mandrel and to cure the product upon the mandrel so it acquires a tight permanent helicoid configuration which strongly reverts to a coiled condition when an attempt is made to uncoil the structure.

BRIEF DESCRIPTION OF THE DRAWINGS

A further understanding of the new products, methods and apparatus of the invention may be had by reference to the accompanying drawings in which:

FIG. 1 is a flow sheet diagrammatically illustrating the materials and method steps employed in the formation of preferred new products of the invention;

FIG. 2 is a side view, partially broken away and sectioned, of one form of a helicoid product of the invention having a tri-ply structure;

FIG. 3 is a side view, partially broken away and sectioned, of another form of helicoid tubular covering of the invention;

FIG. 4 is a side view, partially broken away and sectioned, of a further embodiment of helicoid tubular covering of the invention;

FIG. 5 is a diagrammatic side view of apparatus used in the helicoid preforming step of the new methods;

FIG. 6 is a perspective view of loose helicoid uncured preformed material as formed by the new processes;

FIG. 7 is a fragmentary enlarged view of the structure of stepped driven rollers used in accordance with the invention to create the helicoid perform such as shown in FIG. 6.

FIG. 8 is an elevational view, partially in section, of another form of apparatus used in joining two strips of material being fed into opposing rolls in accordance with the invention;

FIG. 9 is a side view of the apparatus of FIG. 8 in which the laminate is wound on a tube.

Referring in detail to the drawings, the tri-ply form of insulation wrap **2** shown in FIG. **2**, as applied to metal pipe **4**, consists of three separate strips **6**, **8** and **10** of asbestos cloth impregnated with an elastomeric material. Inner strip **10** is offset to one side of the central strip **8** while the outer strip **6** is offset to the other side of the central strip **8**. Consequently, there are ship-lap-type joints **12** between the adjacent coils **14***a*, **14***b*, **14***c*, etc., of the helicoid structure. Each turn of the insulation wrap nests into the adjacent turn or coil in the manner of a bell-and-spigot joint. This arrangement provides excellent flexibility without "fish-mouthing" at bends and also gives uninterrupted protection to the encased conduit against external flame or heat.

In order to hold the wrap **2** tightly upon the metal pipe **4** and prevent accidental movement or unwrapping, straps or clamps **16** may be applied at opposite ends of the insulation wrap **2** or at any other appropriate position.

In the embodiment shown in FIG. **3**, the insulation wrap **20** is of a bi-ply construction formed of an outer strip of elastomeric impregnated asbestos fiber cloth strip **22** and an inner strip **24**. Strips **22** and **24** are laminated to one another along an interface **26** so that the two strips **22** and **24** form an integral unit. The edge **28** of the strip **22** is offset from the edge **30** of the strip **24** in a staggered arrangement. Ship-lap joints are provided between adjacent coils of the laminate, with the joints in between coils of single strips being in a butt arrangement **32**.

In the form of insulation wrap shown in FIG. 4, which is of quad-ply construction, the insulation wrap **40** comprises an outer strip **42**, a pair of central strips **44** and **46** and an innermost strip **48**. The central pair of strips are in full register with their longitudinal edges aligned thus creating the central section in the insulation wrap of this embodiment of double thickness. The edge **50** of the outer strip **42** is offset to one side of the central ply while the edge **52** of the inner strip **48** is offset to the opposite side of the central ply. As a result, the ship-lap joints **54** between adjacent coils **56*a*** and **56*b***, etc., of the insulation wrap are fully overlapping at all points throughout the entire area of the wrap when installed upon the metal pipe or tubing **4**.

Referring now to FIG. 5, there is illustrated a preferred method of forming insulation wrap such as tri-ply wrap (FIG. 2).

Separate reels **60**, **62** and **64** of asbestos fiber cloth impregnated and covered with uncured, tacky, elastomeric material are mounted for free rotation upon supporting shafts **66**, **68** and **70**. Spring loaded retainers **67**, **69** and **71** are used, the tensions of which may be adjusted to control the relative unrolling of strips **6**, **8** and **10**. In order to prevent sticking of separate convolutions in the rolls of cloth strips, they have coverings of thin separator strips **72**, **74** and **76** which are pulled from the respective strips **6**, **8** and **10** as they are unrolled and carried to the opposed driven rollers **78** and **80**.

As seen in FIG. 7, the top roll **78** is carried on a driven shaft **82** and has a series of steps or faces **84**, **88**, **90** and a gear **92**. Similarly, the roller **80** carried upon the driven shaft **94** is formed with a series of steps **96**, **98**, **100**, **104** and a gear **106**, the latter meshing with gear **92**. Face **90** is of the same diameter as face **84**, while on roll **80**, face **104** is of the same diameter as face **96**. Face **90** and a portion of face **84** mate with steps **96** and a portion of step **104** of the roll **80** which serves to align and limit the two rolls **78**, **80** in operation when the rolls are biased toward each other under spring-loaded pressure by spring means (not shown). Power is provided from a source (not shown) through the meshing gears (not drawn to scale) **92**, **106**.

In roll **78**, face **88** is of lesser diameter than faces **84**, **90**. Roll **80** has a three-step arrangement, in that step **100** is of smaller diameter than step **104**, while step **98** is of smaller diameter than step **100**.

Step **88** is equal in width to the upper strip **6**; step **100** is equal in width to one-half of strip **8**, and step **98** is equal in width to the width of strip **10**. In a three-ply arrangement, the widths of the three strips are preferably the same, so that if step **88** has a width x, step **100** has a width of $x/2$, and step **98** has a width of x.

The relationship of the diameters of the two rolls **78**, **80** is such that the smaller step **88** is always larger than the diameter of step **98**. Actually, the step from the larger face **84** to the smaller **88** is quite small, and the stepping down from step **104** to step **100** to step **98** is quite small. The opening between the rolls **78** and **80** is exaggerated for purposes of clarity. The diameter of steps **84**, **90** compared to the diameter of steps **96**, **104** is in the order of 1.6:1, so that roughly the diameters of steps **88**, **98** are in a similar ratio. This ratio can be altered depending upon the degree of curvature desired to be applied to the formed laminate **6**, **8** and **10**.

Steps **88** and a portion of steps **84** of roll **80** create the pressure to force opposing faces of the strips **6**, **8** and **10** into contact with one another into a staggered arrangement as illustrated in FIG. 7 and cause the tacky faces of the strips which are in contact with one another to stick together. At the same time, the differences in diameters of the steps of the driven rolls **78** and **80** impose an arcuate configuration to the strips during the contacting because more of the length of one strip, e.g., strip **6**, is fed per unit time past the point of contact than the length of strip **8**. Similarly, more of strip **8** is fed past the point of contact per unit time than of strip **10**. Unequal feeding from the rolls **60**, **62**, **64** is evidenced in that reel **60** is the first to unwind completely, reel **62** is the next to be unwound completely, and reel **64** is the last to unwind its material. The relative rates of unwinding which in turn is usually indicative of the degree of curvature imparted to the laminate **6**, **8**, **10**, is controlled by the relative tensions of retainers **67**, **69** and **71**, the diameter of roll **78** relative to the diameter of roll **80**, the pressure loading on the two rolls **78**, **80** and the speeds of rotation of the two rolls. Consequently, the laminated strips as they issue from the contacting rolls **78** and **80** form an uncured open helicoid lamination **108**. This open lamination is illustrated in more detail in FIGS. 5, 6.

Referring to FIGS. 8 – 9, two separate strips of impregnated materials, **110** and **112**, are fed from reels **110*a***, **112*a*** to between two sets of opposed cylindrical rolls **114**, **116** and **118**, **120**; reels **110*a*** and **112*a*** have joined thereto springs **110*b*** and **112*b*** which control the tension of unreeling. The spring tension of each is adjustable to control the relative rates of feed of strips **110**, **112**. FIG. 8 depicts the exit of the materials from between the rolls. The materials are in a stepped, overlapped relationship, in that a side end portion **122** of strip **110** mates with side end portion **124** of strip **112**. Roll **116** is larger in diameter relative to adjacent roll **114**, and roll **118** is larger in diameter than adjacent roll **120**. Roll **116** is also larger in diameter than the larger roll **118**. Roll **114** is also larger in diameter than the diameter of roll **120**.

In passing through the opposed rolls, overlapped portions **122**, **124** are under compression, and in addition, the free side end portions **126**, **128** are also under compression. The degree of compression is related to the spacings between the opposed rolls, the loading on the rolls, the tension of springs **110*b***, **112*b***, and the relative thickness of the two strips of materials.

It is believed that the principles of incurvation of the joined strips are as follows. Strips **110** and **112** are fed in constant feed through the opposed rolls, being drawn through by the rate of rotation and relative diameters of the rolls. However, the rate of feed from reel **110*a*** is greater than the rate from reel **112*a***. The overlapped portions **122**, **124** have a tendency to be drawn through linearly. Since the diameter of roll **114** is larger than the diameter of roll **120**, side portion **128** has a tendency to be pulled through faster for example when the rate of rotation of roll **114** is greater than the rate of rotation of roll **120**. Depending upon the type of material used for strip **110**, the tension on springs **110*b***, **112*b***, and also strip temperature or the temperature of the rolls, side portion **128** is either stretched, calendered to a greater degree than adjacent portion **124**, or placed in tension relative to side end **126**, or simply its strip is drawn through faster than adjacent strip **112**.

Meanwhile, free side end portion **126** of strip **112** appears to pass between opposed rolls **116** and **120** so that it is either in compression, or under slight tension but much less than the tension within side end **126**, or neither under tension nor compression. The joined strips **110**, **112** emitted from between the rolls incurvated to the right in FIG. 8 in a continuous arc.

If the same amount of material is placed on reels **110*a***, **112*a*** at the start of a forming operation, at the end of the cycle reel **110*a*** will have unwound before reel **112*a***. This clearly indicates of course that although a constant feed from each separate reel is used, the rate of feed from one reel to the next is different. The amount of material left on reel **112*a*** when reel **110*a*** is unwound is a function of the factors mentioned, that is, tension of springs **110*b***, **112*b***, temperature of the strips, the type of material used for the strips, the relative sizes of the rolls, and the loading on the rolls.

If a length of joined strips is cut off, it freely assumes the shape shown in FIG. 6, being that of a continuous, loose helicoid. The laminate may be used as is, or it may be wound on a mandrel or rod 130 (FIG. 9). In FIG. 8, it is seen that sidewall 118*a* of roll 118 acts as an end guide for strip 112, while sidewall 116*a* of roll 116 acts as an end guide for strip 110. This guide arrangement controls in precision the continuous overlap of the two strips 110, 112. When the produced helicoid is wound on a mandrel 130 (FIG. 9), not only are the adjacent strips 110 of the laminate in abutment, but the adjacent strips 112 are also in abutment relative to each other. In addition, a joint between adjacent strips 112 (FIG. 3) is superimposed by a solid portion of superimposed strip 110 so that the laminate itself produces ship-lap joints between adjacent coils of the laminate.

The laminate may be wound on a core so that a solid or continuous covering 112 is applied on the core, and a second continuous covering 110 is superimposed over the covering 112.

If desired, the tight abutment or tight helix arrangement may be a loose helix, so that spacings exist between adjacent strips 110 and adjacent strips 112. This, of course, depends upon the type of covering desired to be formed or the type of product desired to be produced.

The impregnant in the strips may thereafter be cured or hardened. The resultant product is either a solid tube or a wrap or covering which can be wound and unwound. Generally, heat is applied to cure or harden the impregnant, using techniques that are well known. If a polyester resin, for example, is the impregnant, fusion of the resins in the strips occurs so that a hard, unified product results.

The laminate veers to the right in arcuate form (FIG. 8). An end of the laminate is applied to a rotating core 130 so that a helicoid wrap is formed directly adjacent the exit end of the opposed sets of rolls. On the core 130 the individual strips 110, 112 are in abutment with adjacent strips. All helicoid strips (actually being one continuous strip) are in abutment with each other to provide a solid covering; all strips 110 are in abutment with each other to provide a solid covering over strip 112. The coils of the complete laminate form ship-lap joints between each other.

The laminate on the core 130 may thereafter be subjected to heat to provide a cure or hardening of the impregnant. Depending upon the product desired to be produced, the strips may be only amalgamated to each other to form the helicoid laminate or the impregnated may be fused throughout to form a solid tube upon removal of the core 130.

DISCUSSION OF THE METHOD

An advantageous sequence of steps which may be used to produce new heat protective coverings of the invention is outlined in the flow diagram constituting FIG. 1. A first stage of the operation is the provision of a plurality of separate strips of asbestos fiber cloth impregnated and covered with uncured, tacky, elastomeric or other binder material. Such strips could be obtained from a commercial source, but in a fully integrated operation, the attainment of such strips would advantageously begin by the coating and impregnating of woven fabric made from asbestos fibers with an elastomeric material composition, e.g., a solvent solution of the material known as "coat cement". Any suitable method of applying the elastomeric material coating may be employed, such as knife coating, roller coating, spraying, dipping and the like. A preferred method is the so-called divine coating technique which results in a major portion of the coating material being retained on the surface of the cloth and only a minor amount of the coating penetrating into the interstices of the cloth.

Each of the separate strips which are to be plied together to form the lamination may be coated with the same elastomeric composition. However, in special cases, such as where maximum protection against corrosion of metal conduit by the insulation wrap at elevated temperatures is required, one or more surfaces of the strips may be coated with an elastomeric composition having very low corrosive characteristics. Thus, a preferred form of the new insulation wraps may employ ethylene-propylene rubber compound (EPDM) to coat the surface of the insulation wrap and would be in contact with the metal pipe (e.g., the inner surface of strip 10 in FIG. 2). In such a preferred tape, the remaining surfaces of the strips would be coated with a polychloroprene composition. Such a procedure is illustrated in FIG. 1 by a portion of the flow diagram which shows in dotted flow lines the optional different spreader coating step which can be employed where special surface coatings are used. In the procedure as illustrated in FIG. 1, one surface of a strip of asbestos cloth would be coated upon one side with elastomeric coat cement and on the other surface with a special surface coat.

The coating and impregnating operation will advantageously be accomplished using drying ovens or comparable equipment to evaporate solvents and other volatile material from the coating composition and leave the asbestos cloth impregnated and covered with an uncured, tacky, elastomeric coat. Normally, the resulting coated asbestos cloth will be rolled into a jumbo roll for subsequent processing. As this is accomplished, a release sheet of polyethylene film, holland cloth or comparable separator sheet will be applied to one surface of the coated asbestos cloth so that the cloth may be formed into rolls without convolutions adhering to each another.

The cloth is next slit into narrow widths, e.g., about 1 to 5 cms. These are then rolled into separate rolls of suitable diameter, e.g., 10 to 50 cms., for ease of handling in subsequent operations, such as reels 60 to 64 of FIG. 5.

The next stage of the operations is the helicoid preforming which has generally been described previously in connection with FIG. 5. Basically, the operation involves bringing the separate strips of whatever desired number, advantageously between 2 to 4 separate strips, into generally parallel alignment, contacting opposed faces of the strips in a staggered, tiered arrangement with the edge of at least one strip being offset from the edge of at least one other strip. Such staggered arrangements may take various forms, as illustrated in FIGS. 2 through 4. With a two-ply construction such as in FIG. 3, little variation is possible except in the amount of overlapping at the edge between the separate strips. Where the three-ply construction is employed, equal overlap between the top and bottom strips relative to the central strip (see FIG. 7) is advantageous. In a four-ply construction (see FIG. 4) two central strips may be fully aligned with no overlap to provide a double-thickness central ply. An alternative to this would be to use a three-ply construction with the asbestos cloth for the central portion being heavier in weight or of different woven construction than the strips for the two outer plies.

The strips are incurvated as described hereinbefore. As the strips contact under such conditions, the resulting laminated structure assumes an open loose helicoid form as illustrated in FIG. 6. This loose helicoid product may be produced and handled in continuous length or suitable measured lengths may be cut from the product issued from forming rolls for handling in subsequent steps of the operation.

Following the formation of the helicoid preform, it is treated by dusting with release or antitack material to prevent exposed surfaces from sticking together or sticking to the mandrel in the subsequent operations. Any suitable material known to the rubber-processing art as satisfactory dusting agent may be employed for this purpose including powdered mica, soapstone, chalk, calcium carbonate, or the like. Such dusting may be accomplished in wind tunnels, by spraying, in tumbling barrels or other suitable equipment.

Following the dusting, the loosely coiled helicoid preform is wound upon a mandrel having a suitable outside diameter to form an inside diameter to the insulation wrap of approximate size to encase the tubing or conduit to be covered by the wrap. Metal rods or pipes are advantageously used as mandrels, high-carbon steel or stainless steel being examples, although any other suitable materials including ceramics, glass, or the like, may be used for the mandrel. Application of a release coat upon the surface of the mandrel prior to wrapping the helicoid preform is recommended in order to insure easy and clean removal of the finished product from the mandrel after the cure.

The curing step is performed using curing conditions as recommended by the manufacturer of the elastomeric material used in the initial coating stage of the operation. As is known to those associated with curing or vulcanizing of rubber of comparable curable elastomeric materials, such conditions may be varied. In some special cases, air curing at ambient temperature over substantial lengths of time may be used, e.g., with silicone elastomers. Normally, however, curing is accomplished by heating the mandrel-wrapped product to an elevated temperature, e.g., 150–250° C. for about 1 to 72 hours. Induction heating, infrared heating, or the like may be employed instead of the more common heating in electrical resistance or gas fired ovens. Where hollow mandrels are employed, heat exchange liquids may be circulated through the interior of the mandrel in order to provide all or part of the heat.

Following the curing, the cured helicoid lamination is removed from the mandrel and may be used for intended purposes without further treatment. Normally, however, the product will be trimmed at the edges to provide sharp, neat product or may be cut to smaller lengths as required by the trade or special purchaser. Additionally, the subsequent handling may involve wrapping, packaging and the like.

EXAMPLES

The following details of operations in accordance with the invention and reported data illustrate the further principles and practice of the invention to those skilled in the art. In these examples and throughout the remaining specification and claims, all parts and percentages are by weight and all temperatures are in degrees centigrade unless otherwise specified.

EXAMPLE 1

This example illustrates the production of a three-ply construction insulation wrap having a low corrosion internal surface in various sizes.

A standard GR-M rubber cement consisting of about 85 percent volatile haloalkane solvent and 15 percent elastomeric mix was used as the principal elastomeric coating material for the production run. The elastomeric mix in the cement was formed of rubber (100 parts), benzothiazyl disulfide (1 part), plasticizer (2 parts), stearic acid (0.5 parts), zinc oxide (5 parts), magnesium carbonate (4 parts), antioxidant (2 parts), carbon black (5 parts) and hard clay (40 parts).

A standard plain weave cloth made of asbestos fiber yarn having a thickness of about 2.5 mm. was doctor-blade coated with the above coating cement at a rate of about 20 percent on each side based upon the weight of the cloth. The coated cloth was dried in a hot air oven and polyethylene film was applied to one surface as a masking. The cloth was slit into tapes of 2 cm. width and the tapes were wound into small rolls of about 15 meters in length with the polyethylene masking between convolutions.

In another operation, the same cloth was coated upon one side at the 20 percent rate with the GR-M cement and upon the other side at a 20 percent rate with a similar standard coating cement used EPDM rubber as the elastomer base rather than the GR-M rubber. This different surfaced cloth was also slit into 2 cm. tapes and wound into 15 meter length rolls with a polyethylene film separator.

Two rolls of the first tape and one roll of the second tape were mounted on a helicoid preform machine of the type described hereinbefore. Before the tape from each roll was passed through the lamination rollers, the polyethylene masking strip was peeled from the tape. The driven rollers of the machine were operated at about 35 r.p.m. and a helicoid preform of tri-ply construction was formed at a rate of about 2.5 meters per minute. As the preform emerged from the forming rolls, it was dusted with powdered mica.

The dusted preform was tightly wrapped upon a 5/16 in. O.D. mandrel formed of "Teflon" coated aluminum tubing on an arbor-type lathe maintaining about 1 to 2 mm. space at the joints while wrapping. The mandrel wrapped material was then vulcanized in a circulating air oven for 1 hour at about 160° C. The vulcanized product was removed from the oven and cooled to ambient temperature, removed from the mandrel and end trimmed.

The resulting insulation wrap was installed upon black iron pipe and subjected to a standard heat transmission test in which the outer surface of the wrap is subjected to a flame maintained at a temperature of approximately 1,100° C. conducted for a period of 16 minutes while the temperature of the surface of the encased iron pipe was measured at 2-minute intervals. The mean temperature did not exceed 260° C.

In similar runs, preforms for larger size mandrels were formed on larger forming rolls and vulcanized on the required-size mandrels. In still further runs, even larger size insulation wraps were made using tapes of 2.5 cm. width rather than the 2 cm. size.

EXAMPLE 2

The process of example 1 was repeated except that the small amount of carbon black in the standard polychloroprene rubber cement was replaced with aluminum pigment. When the resulting product was subjected to the heat transmission test, satisfactory heat insulation properties were recorded. However, these properties were not as good as for the product of example 1, apparently due to the added conductivity through the metal particles.

In another run, perlite was substituted for the magnesium carbonate in the elastomeric coating composition of example 1.

In a further run, titanium dioxide was substituted for the magnesium carbonate. The resulting insulation wraps using these alternate fillers exhibited acceptable heat insulation properties although they were inferior to the product of example 1.

DISCUSSION OF DETAILS

The materials used for the continuous strips may be varied depending upon the helicoid product produced. The materials may be paper, plastic, sponge rubbers, foamed plastics, glass fiber cloths, and metals. Materials of a fibrous or spongelike nature may utilize impregnants, which preferably are in a nonhardened or uncured stage when passing through the rolls. Moreover, it is evident that the materials of the strips may be different, as for example, in wrapping electrical conduits a variety of insulation materials are desirable. In addition to elastomeric compounds, silicones, thermoplastic resins, thermosetting resins such as polyester, epoxy and phenols, may be used as impregnants for one or more of the strips. Nonhardened or uncured impregnants are particularly useful in providing a good bond between the overlapping portions upon subsequent cure. For example, the elastomer of one strip may temporarily combine or fuse with the elastomer of the adjacent strip. Upon curing of the elastomer, the fusion is fixed to such an extent that the materials act as an original composite rather than joined strips. Curing or hardening may be effected by an air cure or by oven cure.

After hardening or curing of the impregnant, the material may be left on the core as a protective covering, as for example, as a wire insulation. In another embodiment, it may be removed from the core and cut in lengths or wound upon itself, such as in B-X cable.

Where the helicoid product is a heat protective tubular covering in accordance with a preferred embodiment of the invention, the strip material is formed of asbestos fibers. Plain weave fabric of about 1–3 mm. thickness made of threads or yarns of asbestos fibers is particularly suitable. However, any other flexible webs such as nonwoven felts, knit fabrics or the like of good strength characteristics are contemplated for use as the base for the strips in the laminated products. Use of asbestos fibers only in the webs is preferred, but inclusion of other heat-resistant fibers, e.g., glass fibers, in various amounts, e.g., up to 25 percent is contemplated as an alternative.

In order to obtain abutment of each layer in a three-ply system, the three strips of material are preferred to be of equal widths. However, the thicknesses and impregnants may vary, depending upon the materials used.

Normally, the temperatures of the individual strips are at ambient and the rolls are unheated. There may be a slight temperature rise above ambient at the rolls, depending upon the compression upon the materials. With metals and with certain impregnants, the rolls and/or the strips of material may be heated to improve the drawing effect or to assist in the hardening or cure of the impregnant.

One of the particular advantages of the invention from a production viewpoint is that the feed reels are in a general planar position on fixed bearings. This arrangement not only provides for ease in substituting a full reel for an empty one, but also facilitates adjustments of the apparatus, such as the tensions on springs, without stopping the machine operation. Where the reels are wound around the core, as in wire-wrapping apparatus, such simple adjustments cannot be made without stoppage. Moreover, with the reels rotating but fixed relative to each other, visual inspection is readily made of all portions of the apparatus in relative safety.

An important feature of the new heat-protective coverings is the overlap configuration provided along edges between separate coils or turns of the helicoid structures. This has been discovered to provide good flexibility without allowing "fish-mouthing" at bends or creation of other openings when the encased conduit is bent or flexed. The degree and nature of the overlapping can be varied by selection of sizes for individual tapes forming the laminations of the product, degree or edge overlap and the like. Simplicity of construction and manufacture, however, make it advantageous to use all tapes of equal width and to use an equal amount of edge overlap at each side of the product.

Any suitable number of strips of elastomer coated cloth may be used to form the insulation covering. As indicated previously in describing a four-ply product, a plurality of strips may be manifolded to form a single "step" of the covering. This permits production of the new products to be varied for special end uses employing a minimum number of basic fabricating elements.

A wide variety of elastomers are available for use in forming the elastomeric coating compositions used in the new insulation coverings Elastomers having the highest degree of heat and oxidation resistance at a reasonable cost are advantageously used. Polychloroprene and ethylene-propylene rubbers are preferred elastomers. Silicone rubbers are another useful class of elastomers. Elastomers of acrylic type polymers, e.g., 1–6 carbon atom alkyl esters of acrylic and methacrylic acids, chlorinated polyethylenes, and other elastomers of high-temperature resistance known to the art are contemplated for use in the invention. Mixtures of two or more elastomers may be employed.

The elastomeric coating compositions are prepared for coating of the flexible asbestos fiber webs according to industry-recognized procedures and formulations. Suitable compositions may contain from 5 to 50 percent solids and 50 to 95 solvents or dispersants, although other proportions may also be used in special cases. Solvent solutions or emulsions may be employed. Nonflammable solvents are preferred in forming the elastomeric solutions or so-called "cements", e.g., haloalkane like tetrachloroethylene, dichlorotetrafluoroethane, carbon tetrachloride and the like.

The nonvolatile portion of the coating compositions, in addition to an elastomer, will advantageously include antioxidants vulcanizing agents, fillers, pigments, plasticizers, accelerators and similar additives known to the rubber industry. Fillers are usually employed in amounts of 15 to 60 parts filler per 100 parts elastomer. The other additives advantageously amount to 0.01 to 10 percent, especially 0.5 to 5 percent, of the elastomer content.

Examples of fillers, which may be of the reinforcing type, as well as inert type, include magnesium carbonate, zinc oxide, carbon blacks, hard clays, calcium silicates, blanc fixe, whiting, talc, slate four, infusional earth and the like.

Examples of pigments include carbon black, iron oxide red and yellows, titanium dioxide and comparable inorganic pigments.

Examples of accelerators include mercaptobenzothiazole, benzothiazyl disulfide, metal dialkyl dithiocarbamates, alkylene thiuram tetrasulfides and the like.

Examples of antioxidants hydroquinone, monobenzyl ether, p-isopropoxy diphenylamine, phenylnaphthylamine, styrinated phenols, octylated diphenylamines and the like.

Examples of plasticizers and softeners include hydrocarbon oils, polyolefins, aromatic oils and the like.

Examples of vulcanizing agents include sulfur, tetra methylthiuramdisulfide, zinc oxide, magnesium oxide, organic peroxides and the like.

In final analysis, the elastomeric coating compositions are prepared and formulated according to commercial practice for rubber compounding and use. Future improvements in this art, therefore, should be adapted to continually upgrade products, basically designed in accordance with the invention, to give the highest possible values for all desirable qualities in the final product.

The embodiments of the invention in which an exclusive property or right is claimed are defined as follows:

1. A helicoid laminate comprising:
   a. two or more strips of material joined in overlapping relationship with each other along a longitudinal edge to provide a staggered and tiered arrangement;
   b. the joined strips being bonded to each other to form a unified laminate;
   c. the strips being coiled in a helicoid construction by an incurvation of the joined strips;
   d. the incurvation of the joined strips being imposed therein by at least one strip being of unequal length with that of an adjacent joined strip; and
   e. adjacent helicoid portions of a strip are in a butt joint relationship with each other while adjacent portions of the laminate are in a ship-lap joint with respect to each other.

2. A covering material as recited in claim 1 wherein adjacent coils of the laminate are not bonded to each other so that the helicoid laminate can be wound and unwound at will.

3. A covering material as recited in claim 1 wherein the adjacent coils of the laminate in the helicoid construction are bonded to each other at the ship-lap joint portions so that the helicoid laminate is a unified tubular product.

4. A helicoid laminate according to claim 1 in which at least two of said strips are silicone strips in contact with one another.

5. A helicoid flexible covering for tubular conduits to provide heat and flame protection to the conduit, comprising:
   a. a plurality of strips of fibrous cloth;
   b. a bonding agent impregnated into and covering said strips;
   c. said strips being joined in a staggered configuration with the edge of at least one strip being offset from the edge of at least one other strip;
   d. at least one of said joined strips being of unequal length with an adjacent strip thereby providing an incurvature in the joined strips forming a helicoid;
   e. said staggered configuration being cured into the helicoid, integral structure, having ship-lap joints between adjacent coils, said structure being capable of being repeatedly coiled and uncoiled so the insulation wrap may be repeatedly installed and removed from a tubular conduit without damage.

6. A helicoid flexible covering as claimed in claim 5 wherein the fibrous cloth is asbestos cloth and the bonding agent is an elastomeric material.

7. A helicoid flexible covering as claimed in claim 5 formed of three strips of equal width of asbestos cloth, the inner strip being offset to one side of the central strip and the outer strip being offset to the other side of the central strip.

8. A helicoid insulation wrap as claimed in claim 7 wherein the elastomeric material covering the innermost face of said inner strip is an ethylene-propylene rubber composition and the remaining elastomeric material of the wrap is a polychloroprene rubber.

9. A helicoid insulation wrap as claimed in claim 5 formed of two strips of equal width of asbestos cloth.

10. A helicoid insulation wrap as claimed in claim 5 formed of four strips of equal width of asbestos cloth, the two central strips being plied in full edge-to-edge contact, the inner strip being offset to one side of said plied central strips and the outermost strip being offset to the other side of the plied central strips.