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(54) **Method for minimizing inconsistencies appearing on a surface of a composite component and pre-cured composite strip**

Verfahren zum Minimieren von Inkonsistenzen, die auf der Oberfläche eines Verbundstoffs auftreten und vorgehärteter Verbundstreifen

Procédé pour minimiser les inconsistances apparaissant à la surface d'un composant composite et bande composite pré-polymérisée

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(56) References cited:
CA-A1- 2 598 765 **JP-A- H05 156 656**
US-A- 3 865 662 **US-A- 4 331 723**
US-A1- 2005 102 814 **US-B1- 6 284 089**

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Description

BACKGROUND INFORMATION

1. Field:

[0001] The present disclosure relates generally to composite components and in particular to a method and apparatus for manufacturing composite components. Still more particularly, the present disclosure relates to a method and apparatus for improving the appearance of a composite component.

2. Background:

[0002] The aircraft are being designed and manufactured with greater and greater percentages of composite materials. Some aircraft may have more than fifty percent of its primary structure made from composite materials. Composite materials may be used in aircraft to decrease the weight of the aircraft. This decreased weight may improve payload capacities and fuel efficiencies. Further, composite materials may provide longer service life for various components in an aircraft.

[0003] Composite materials may be tough, light-weight materials, created by combining two or more dissimilar components. For example, a composite may include fibers and resins. The fibers and resins may be combined to form a cured composite material.

[0004] Further, by using composite materials, portions of an aircraft may be created in larger pieces or sections. For example, a fuselage in an aircraft may be created in cylindrical sections that may be put together to form the fuselage of the aircraft. Other examples may include without limitation wing sections joined to form a wing or stabilizer sections joined to form a stabilizer. In creating composite components or structures with a curved or circular shape, the composite material may be shaped and/or laid up using a mold that may be placed against an inner mold line (IML) of a composite component. As a result, different features, textures, or appearances may be created on the inner surface of the composite component and/or composite lay up using an inner mold that contacts the inner mold line of the composite component. With a composite component in the form of a fuselage for an aircraft, these features, textures, or appearances may be used on the inside of a passenger cabin. These features, textures or appearances include, for example without limitation, windows, visible lines framing a window for aesthetics, and textures on cabin walls.

[0005] In forming a composite component from composite material, the outer surface or outer mold line (OML) of the composite material may not be subject to an outer mold when an inner mold is used. In the case of a section of a fuselage, this outer mold line may provide the outside appearance of the surface of the fuselage and/or barrel section. With this type of composite component, a smooth surface may be desired.

[0006] Depending on the size of the component, multiple caul plates may be required to be placed on the outer surface of the composite component during curing or forming of the composite component. A caul plate may be a thin gauge sheet that may be made, without limitation, of a metal or a composite material. These caul plates may be used to control the outer mold line and create a smooth surface. Large composite components may require multiple caul plates. When multiple caul plates are used, these plates may be placed next to each other. A gap may be left between adjacent caul plates to accommodate caul plate thermal expansion of the curing and/or heating processes during composite component fabrication.

[0007] At these edges of the caul plates, inconsistencies, such as a visible mark off, fiber waviness and/or fiber distortion may occur. This mark off and fiber distortion may result in a visible line or seam. This type of inconsistency may also occur if a vacuum bag contacts the composite material exposed in the gap between the caul plates and/or if the caul plates overlap during the curing process. Further, fiber waviness may occur with an unacceptable mark off or other type of inconsistency being visible on the cured composite and located in the gap between where the caul plates were during cure. These types of inconsistencies may be undesirable.

[0008] Fillers and surfacing methods may be used to reduce the visibility of these inconsistencies. In other words, the fillers may separate from the composite component prior to the scheduled repainting of the surface of the aircraft. Further, the surface of the composite component may only be lightly sanded in preparation for painting. Excessive sanding may result in an undesirable appearance of the finished aircraft.

[0009] Currently, these types of inconsistencies in the aircraft may be controlled by placing or locating caul plates such that the gaps in which inconsistencies may occur in locations on the aircraft that are not clearly visible in the finished product. These gaps may also be referred to as caul plate seams. For example, inconsistencies from caul plate seams located along a section of the fuselage where a wing is attached to the fuselage or the bottom of the fuselage may not be easily visible. Further, placing caul plates such that caul plate seams are along cut out areas for windows may also minimize inconsistencies.

[0010] US 2005/0102814 discloses a method of transferring an uncured composite laminate skin from a lay-up surface of a male mandrel tool to a female cure tool which includes defining multiple vacuum zones on the lay-up surface, each zone corresponding to one of a multiple of portions into which the skin is to be separated. For example, to separate the skin into two portions, a low profile seal of a first membrane to the lay-up surface is formed at a first vacuum zone and a second low profile seal for a second membrane is formed at a second vacuum zone. The method further includes laying up a composite laminate skin over all the vacuum zone; separating

the composite laminate skin into portions, for example, a first portion over the first vacuum zone and a second portion over the second vacuum zone; and releasing the portions individually into cure tools having an outside mold line surface.

[0011] JPH05156656 discloses a steel pipe pile covered with a corrosion protective material which is covered by a protective cover made of thermoplastic resin and having almost the same form as the outer periphery of the steel pipe pile and having collar portions at both end portions, the collar portions having respective bolt through holes provided therethrough. A butt plate having a curved portion corresponding to the outer periphery of the steel pipe pile and to the inner surface of the protective cover of a flat plate portion is pressed against the anti-corrosives at a position where the rising portion is sandwiched between the collar portions of the protective cover. The protective cover and the butt plate are connected to each other by bolts and nuts.

[0012] Accordingly, there is a need for a method and apparatus for minimizing inconsistencies appearing on the surface of a composite component, which over comes the problems discussed above. Embodiments of the disclosure are intended to satisfy this need.

SUMMARY

[0013] According to the present invention, there is provided a method for applying a pre-cured composite strip to a composite component as claimed in the appended claims.

[0014] An advantageous embodiment of the present disclosure provides a method and apparatus for applying a pre-cured composite strip to a composite component. A pre-cured composite strip having a thermoset resin may be placed on a surface of a portion of the composite component where a caul plate seam may be expected. Caul plates may be placed on the composite component after placing the pre-cured composite strip to form the caul plate seam. The composite component may be cured after placing the caul plates on the composite component.

[0015] Another advantageous embodiment may comprise a pre-cured composite strip, a composite tape layer, and a second composite fabric layer. The first composite fabric layer may have a first width. The composite tape layer may be located on the composite fabric layer and may have a second width that may be smaller than the first width. The second composite fabric layer may be located on the composite tape layer and may have a third width that may be smaller than the second width.

[0016] The features, functions, and advantages can be achieved independently in various embodiments of the present disclosure or may be combined in yet other embodiments in which further details can be seen with reference to the following description and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] The novel features believed characteristic of the advantageous embodiments are set forth in the appended claims. The advantageous embodiments themselves, however, as well as a preferred mode of use, further objectives and advantages thereof, will best be understood by reference to the following detailed description of an advantageous embodiment of the present disclosure when read in conjunction with the accompanying drawings, wherein:

Figure 1 is a flow diagram of aircraft production and service methodology in accordance with an advantageous embodiment;

Figure 2 is a block diagram of an aircraft in accordance with an advantageous embodiment;

Figures 3A-3D are an illustration of a method and apparatus for controlling mark off in fiber migration in a composite structure in accordance with an advantageous embodiment;

Figure 4 is an isometric view of a composite component in accordance with an advantageous embodiment;

Figure 5 is an isometric view of a composite component after trim routing in accordance with an advantageous embodiment;

Figure 6 is a cross-section view of a composite component with a composite strip and caul plates in place in accordance with an advantageous embodiment;

Figure 7 is an illustration of a cross-section view of layers in a composite strip in accordance with an advantageous embodiment;

Figure 8 is a cross-section view of a completed composite strip in accordance with an advantageous embodiment;

Figure 9 is a cross-section view of a composite strip in accordance with an advantageous embodiment;

Figure 10 is an illustration of a cross-section view of another example of a composite strip in accordance with an advantageous embodiment;

Figure 11 is a flowchart of a process for creating a composite strip in accordance with an advantageous embodiment; and

Figure 12 is an illustration of a process for manufacturing a composite component in accordance with an advantageous embodiment.

DETAILED DESCRIPTION

[0018] Referring more particularly to the drawings, embodiments of the disclosure may be described in the context of an aircraft manufacturing and service method **100** as shown in **Figure 1** and an aircraft **102** as shown in **Figure 2**. During pre-production, exemplary method **100** may include specification and design **104** of the aircraft **102** and material procurement **106**. During production, component and subassembly manufacturing **108** and

system integration **110** of the aircraft **102** takes place. Thereafter, the aircraft **102** may go through certification and delivery **112** in order to be placed in service **114**. While in service by a customer, the aircraft **102** is scheduled for routine maintenance and service **116** (which may also include modification, reconfiguration, refurbishment, and so on).

[0019] Each of the processes of method **100** may be performed or carried out by a system integrator, a third party, and/or an operator (e.g., a customer). For the purposes of this description, a system integrator may include without limitation any number of aircraft manufacturers and major-system subcontractors; a third party may include without limitation any number of vendors, subcontractors, and suppliers; and an operator may be an airline, leasing company, military entity, service organization, and so on.

[0020] As shown in **Figure 2**, the aircraft **102** produced by exemplary method **100** may include an airframe **118** with a plurality of systems **120** and an interior **122**. Examples of high-level systems **120** include one or more of a propulsion system **124**, an electrical system **126**, a hydraulic system **126**, and an environmental system **130**. Any number of other systems may be included. Although an aerospace example is shown, the principles of the disclosure may be applied to other industries, such as the automotive industry.

[0021] Apparatus and methods embodied herein may be employed during any one or more of the stages of the production and service method **100**. For example, components or subassemblies corresponding to production process **108** may be fabricated or manufactured in a manner similar to components or subassemblies produced while the aircraft **102** is in service. Also, one or more apparatus, method embodiments, or a combination thereof may be utilized during the production stages **108** and **110**, for example, by substantially expediting assembly of or reducing the cost of an aircraft **102**. Similarly, one or more of apparatus method embodiments, or a combination thereof may be utilized while the aircraft **102** is in service, for example and without limitation, to maintain and service **116**.

[0022] The different advantageous embodiments may provide a method and apparatus for minimizing lines or other types of inconsistencies on the surface of a composite component. In particular, these different advantageous embodiments may control, reduce, or minimize inconsistencies, such as mark off and fiber migration to increase the aesthetic appearance of composite components.

[0023] In the different illustrative examples, inconsistencies caused by a caul plate seam between caul plates may be reduced by using a pre-cured composite. In these examples, the composite may be bonded and/or applied to a substrate, which may be the composite component. The pre-cured composite may be a pre-cured composite strip placed on the outer mold line of the composite component prior to the application and/or placement of the

caul plates. The pre-cured composite strip may be placed where, for example, a caul plate seam may occur between adjacent caul plates.

[0024] In these examples, when cured, the pre-cured composite strip may be sufficiently stiff to prevent the adjacent caul plates from forming an inconsistency in the composite component if these caul plates move or slide over the composite strip during the curing process. As a result, by allowing caul plate movement over the pre-cured composite strip, fiber and resin movement or other changes that may cause inconsistencies may be prevented. As a result, inconsistencies caused by caul plate movement during curing may be eliminated or reduced in extent to produce a surface appearance that meets aesthetic requirements.

[0025] Further, the different illustrative examples may reduce out-of-plane fiber waviness and increase the appearance quality of the surface of the component. Out-of-plane fiber waviness may be an out-of-plane location of fibers in an uncured ply stack up or cured part in which one or more of the plies may be permanently cured into a ridge, depression, or fold not consistent with part geometry. The out-of-plane direction may be either away from or into the part.

[0026] Also, the different embodiments may reduce the need for filling the surface of the component. Also, by using a pre-cured composite strip, a larger gap tolerance may be used in placing caul plates adjacent to each other.

[0027] Turning now to **Figures 3A-3D**, an illustration of a method and apparatus for controlling mark off in fiber migration in a composite structure is depicted in accordance with an advantageous embodiment. In this example, composite component **300** may be a fuselage for an aircraft, such as fuselage **106** in aircraft **100** in **Figure 1**. The construction or assembly of composite component **300** may be performed during component and sub-assembly manufacturing **108** during aircraft manufacturing and service method **100** in **Figure 1**.

[0028] In this example, the materials for composite component **300** are placed around mold **302**, or mold **302** may be placed into the inner mold line portion of composite component **300**. These materials may be, for example without limitation, composite tape and/or composite fabric. Layers of these types and other types of composite materials may be laid down on to mold **302** to form composite component **300**. In this example, mold **302** is an inner mold that may contain features for an inner mold line of composite component **300**. Surface **304** is the surface for the outer mold line of composite component **300**.

[0029] Next, composite strip **306** may be placed onto surface **304** of composite component **300**. In these examples, composite strip **306** may be a pre-cured composite strip. Further, composite strip **306** may be attached to surface **304** of composite component **300** through an adhesive. For example, an adhesive film may be placed onto a surface of composite strip **306**. Curing composite component **300** with composite strip **306** may cause the

adhesive film and composite strip **306** to be integrated and/or attached to composite component **300**.

[0030] After the application of composite strip **306** to composite component **300**, caul plates **308** and **310** may be placed onto composite component **300**. These caul plates may be used to provide a smooth surface and to avoid inconsistencies from occurring that are not desired on surface **304** of composite component **300**.

[0031] Also, caul plate seam **312** may be present between caul plates **308** and **310**. Caul plate seam **312** may be a gap that is present between caul plates **308** and **310**. The size of caul plate seam **312** may be selected to take into account different coefficients of expansion and compaction when composite component **300** is heated along with caul plates **308** and **310**. Composite strip **306** may result in a reduction and/or elimination of inconsistencies in the area of caul plate seam **312** that may reduce the visual aesthetics of composite component **300**.

[0032] More specifically, depending on the material used to form caul plates **308** and **310**, these caul plates may expand at a different rate from composite component **300**. Further, composite component **300** may reduce in diameter during the curing process. As a result, caul plate seam **312**, allows caul plate **308** and caul plate **310** to expand and/slide to avoid buckling or hitting each other. Composite strip **306** may aid in reducing inconsistencies due to the expansion and/or sliding of caul plate **308** and caul plate **310**.

[0033] In this example, caul plates **308** and **310** may be placed such that caul plate seam **312** may run longitudinally along composite component **300**. Depending on the particular implementation, a caul plate seam may extend around the circumference of composite component **300**, rather than longitudinally, as depicted with caul plate seam **312**.

[0034] Next, composite component **300** may be prepared for curing and placed into oven **314** with caul plates **308** and **310** in place. This assembly may be cured by heating oven **314** to an appropriate temperature needed to cure the composite materials within composite component **300**.

[0035] In these examples, oven **314** may be a composite curing oven in which heat and pressure may be applied to composite component **300** as the curing process occurs within oven **314**. Oven **314** may provide temperatures of around three hundred fifty degrees to cure composite component **300**. In these examples, oven **314** may be an autoclave that applies pressure and heat. Of course, any type of oven capable of curing composite parts may be used in these different embodiments.

[0036] In addition to using oven **314**, other types of curing processes may be employed. For example, an electron beam system may be used to cure composite components instead of using a thermal curing system, such as oven **314**.

[0037] With reference now to **Figure 4**, an isometric view of a composite component is depicted in accord-

ance with an advantageous embodiment. In this example, composite component **400** is an example of composite component **300** in **Figure 3**. In particular, composite component **400** may be an example of a fuselage section of an aircraft that has been cured in an oven, such as oven **314** in **Figure 3**. In this example, pre-cured composite strips **402**, **404**, and **406** may be present on surface **408** of composite component **400**. Pre-cured composite strips **402**, **404**, and **406** may be located in sections or areas in which caul plate seams were present.

[0038] Turning now to **Figure 5**, an isometric view of a composite component after trim routing is depicted in accordance with an advantageous embodiment. In this example, trim and routing processes may have been performed on composite component **400**. This process may generate windows, such as windows **500**, **502**, **504**, **506**, **508**, **510** and **512**. Additionally, passenger door trims **514** and **516** also may now be present after trim and routing processes have been performed on composite component **400**. Although, in these examples, pre-cured composite strips **402** and **406** may be aligned on the windows, such an alignment may not be necessary.

[0039] Turning now to **Figure 6**, a cross-section view of a composite component with a composite strip and caul plates in place is depicted in accordance with an advantageous embodiment. In this example, composite component **600** may be an example of a cross-section view for composite component **300** in **Figure 3**, taken along lines 6-6. In this example, composite strip **602** may be placed on surface **604** of composite component **600**. Composite strip **602** may be an example of composite strip **306** in **Figure 3**. In this example, surface **604** is an outer surface for an outer mold line of composite component **600**. In this example, caul plates **606** and **608** may be placed onto composite component **600** and composite strip **602**. Caul plates **606** and **608** may be an example of caul plates **308** and **310** in **Figure 3**.

[0040] In this example, caul plate seam **610** may be present between edge **612** of caul plate **606** and edge **614** of caul plate **608**. In this example, caul plate seam **610** may have a ten millimeter gap. The size of the gap for caul plate seam **610** may vary depending on factors, such as, for example, thermal expansion and/or the size of caul plates **606** and **608**.

[0041] Further, in this particular illustrative example, composite strip **602** may taper from center portion **616** to edges **618** and **620** of composite strip **602**. The amount of tapering that occurs may vary depending on the implementation. The tapering in composite strip **602** may allow this strip to transition from enough plies to resist formation of inconsistencies during cure to a single ply. In these examples, each ply may be stepped down in width such that the underlying plies may absorb the change in step without negative effect on the appearance of the composite component. This may be driven by the thickness of the underlying laminate.

[0042] The width of the composite strip may be based on different factors, such as, for example, the gap be-

tween the caul sheets, the method used to align the pre-cured strip, or weight limitations. In these examples, one factor in setting width of the pre-cured strip may be to use a fewest number of plies and a maximum thickness area that may completely support the edges of the caul sheet. Additionally, the thermal expansion and compaction factors may be taken into account.

[0043] Turning now to **Figure 7**, an illustration of a cross-section view of layers in a composite strip is depicted in accordance with an advantageous embodiment. In this example, composite strip **700** may be formed on base plate **702**. Base plate **702** may be a structure on which composite strip **700** may be created. Further, composite strip **700** may be cured to form a pre-cured composite strip on base plate **702** as described above. In this particular illustrative example, composite strip **700** may include peel ply layer **704**, composite fabric layer **706**, composite tape layer **708**, composite fabric layer **710**, and peel ply layer **712**.

[0044] Composite fabric layer **706** and composite fabric layer **710** both may be made of the same type of materials or may be made from different materials depending on the particular implementation. These fabrics may include fibers and resins. The fibers may be, for example, carbon fibers. In these examples, the resins may be thermoset resins. A thermoset resin may be a resin that does not reflow or soften once it has been cured. These composite fabric layers may be implemented using any type of composite fabric in these examples.

[0045] Composite tape layer **708** also may be implemented using any type of composite tape. In these particular examples, resin in composite tape layer **708** also is a thermoset resin. In these examples, tape may consist of a series of unidirectional fibers that may become stiff in an outer mold line direction that may be 90 degrees or perpendicular to the caul plate seam. This stiffness may be utilized to resist the caul sheets forming inconsistencies in the pre-cured strips during the cure. Fibers that run parallel to the caul plate seam may not resist the caul sheets forming inconsistencies although some fibers may be in the direction of the seam to allow for handling of the pre-cured strip. In these examples, the fabric was chosen to match the rest of the surface of the composite component. Other applications may use tape as the outer ply.

[0046] In these examples, peel ply layer **704** and peel ply layer **712** may be used to provide a surface prepared for a mechanical bond. In particular, these layers may provide a rough surface when removed from composite strip **700**. Peel ply layer **704** and peel ply layer **712** may be optional layers. Alternatively, surfaces on composite strip **700** may be prepared for mechanical bonding through other mechanisms, such as sanding or other surface preparation processes to obtain a clean rough surface.

[0047] After curing composite strip **700**, peel ply layer **704** may be removed. After removal of peel ply layer **704**, an adhesive layer may be placed onto surface **714** of

composite fabric layer **706**. Peel ply layer **712** may be removed after curing composite strip **700**, and a surfacer layer may be placed onto surface **716** of composite strip **700**. The surfacer layer may provide a layer that will be sanded during the finishing of the composite component to feather or smooth composite strip **700** into the outer mold line of the composite component. In these examples, composite strip **700** does not require being debulked using a vacuum bagging process prior to cure.

[0048] In this example, composite strip **700** may be tapered with composite fabric layer **706** having a wider width than composite tape layer **708**. Composite fabric layer **710** may have an even smaller width as compared to composite tape layer **708** and composite fabric layer **706**. In these particular examples, peel ply layer **704** and peel ply layer **712** may have a width of around 8cm (3.0 inches). Composite fabric layer **706** may have a width of around 8cm (3.0 inches), and composite tape layer **708** may have a width of around 5.72cm (2.25 inches). Composite fabric layer **710** may have a width of around 3.8cm (1.5 inches) in these examples.

[0049] Turning now to **Figure 8**, a cross-section view of a completed composite strip is depicted in accordance with an advantageous embodiment. In this example, composite strip **700** from **Figure 7** now may include adhesive film layer **802** and surfacer layer **800**. In this form, composite strip **700** may be ready for application to an area or section where a caul plate seam may be expected or planned based on placement of caul plates.

[0050] Although composite strip **700** is illustrated with three layers of composite materials, other numbers of layers of composite materials may be used depending on the particular implementation. For example, according to the present invention, composite strip **700** may have two layers comprising a composite fabric layer and a composite tape layer. Alternatively, composite strip **700** may have more layers, such as four or five layers. The number of layers used may depend on the thickness desired with respect to the thickness desired for the composite strip. Typically, a thinner thickness may be desired to reduce weight on the composite component. Also, the width of composite strip **700** also may be selected based on the composite strip **700** weight and gap size requirement.

[0051] In these examples, the composite materials used in composite strip **700** may vary. In these examples, the composite materials used in composite strip **700** may be ones that may not reflow or soften when reheated after curing. In particular, the composite materials may be made with thermoset materials or resins, which will not melt or soften after the initial curing. In this manner, some stiffness may be present when bonding the composite strip to the rest of the composite component. This stiffness may allow the caul plates to slide on the composite strip without causing inconsistencies in the appearance of the surface of the composite component. In this example, composite strip **700** may be pre-cured flat on surface **714** in **Figure 7**. In other embodiments, com-

posite strip 700 may be pre-cured on a curved surface having a radius around the same as the outer mold line for the fuselage section.

[0052] In particular, the different advantageous embodiments may be implemented to reduce or eliminate an appearance of inconsistencies resulting from movement and/or expansion of adjacent caul sheets during the curing of a composite structure or component in an aircraft.

[0053] Turning now to **Figure 9**, a cross-section view of a composite strip is depicted in accordance with an advantageous embodiment. In this example, composite strip **900** may be pre-cured prior to application or use on a composite component.

[0054] In this example, composite strip **900** may include peel ply layer **902**, tape layer **904**, tape layer **906**, fabric layer **908**, and surfacer layer **910**. In this particular illustrative example, tape layer **904** may have the smallest width. Tape layer **906** may have the second smallest width, and fabric layer **908** may have the largest width.

[0055] In this particular example, peel ply layer **902** may have a width of around 8.9cm (3.5 inches). Tape layer **904** may have a width of around 3cm (1.0 inch), and tape layer **906** may have a width of around 5.0cm (2.0 inches). Fabric layer **908** may have a width of around 8cm (3.0 inches) in this example. Surfacer layer **910** may have a width of around 8cm (3.0 inches). Peel ply layer **902** may be removed prior to application to a surface of a composite component with an adhesive layer being added.

[0056] With reference now to **Figure 10**, an illustration of a cross-section view of another example of a composite strip is depicted in accordance with an advantageous embodiment. In this example, composite strip **1000** includes peel ply layer **1002**, tape layer **1004**, tape layer **1006**, fabric layer **1008**, surfacer layer **1010**, and peel ply layer **1012**. In this particular example, peel ply layer **1012** may have a width of around 8.9cm (3.5 inches). Surfacer layer **1010** may have a width of around 8cm (3.0 inches). Fabric layer **1008** may have a width of around 8cm (3.0 inches). Tape layer **1006** may have a width of around 5cm (2.0 inches), and tape layer **1004** may have a width of around 3cm (1.0 inch). Peel ply layer **1002** may have a width of around 8.9cm (3.5 inches) in this example.

[0057] The different types of layers and widths illustrated in **Figures 7-10** are provided for purposes of illustrating some different configurations that may be implemented. These examples are not meant to limit the manner in which layers may be selected or the widths. The different examples illustrate one embodiment of layers of different widths to provide a tapered composite strip for use in areas in which caul plate seams may be expected.

[0058] In these illustrative examples, the length of these composite strips may be around 152.4cm (60 inches). Further, the zero degree ply direction may be parallel to the length of the composite strips in these examples.

In these examples, one optimal utilization of the tape materials may be when they are used with the fiber direction in the outer mold line plane that is 90 degrees or perpendicular to the length of a caul plate seam.

[0059] Some examples of materials that may be used in fabric and tape layers include, for example, without limitation, carbon, fiberglass, boron, ceramic, and aramids. The resins that may be found in these types of layers may include, for example, alkyd polyester, epoxy, ureaformaldehyde, liquid-crystal, polytetrafluoroethylene, polyetheretherketone, and polyethersulfone. Adhesive film layers used in the depicted examples may take the form of epoxy. With some resin/prepreg systems, an adhesive film is not required because the resin in the prepreg may be considered to be self-adhesive. Peel ply layers may be formed using nylon or polyester in the different examples.

[0060] In these examples, the fabric and tape may be prepreg components. In other examples, the composite strips may be fabricated with resin infusion of dry fabric and/or tackified fabric.

[0061] Turning now to **Figure 11**, a flowchart of a process for creating a composite strip is depicted in accordance with an advantageous embodiment. The process illustrated in **Figure 11** may be used to create a composite strip, such as composite strip **604** in **Figure 6** or composite strip **700** in **Figure 7** or **Figure 8**.

[0062] The process begins by selecting a composite material for a layer in the composite strip (operation **1100**). Operation **1100** may include a selection of the type of material and the dimensions for the material. A selection of a fabric, tape, peel ply, or other material may be made. The dimensions selected may include length, width, and thickness.

[0063] In this example, the first layer may take the form of a composite fabric. Of course, other types of composite materials may be used, depending on the implementation. In this example, the base may be a base, such as base plate **702** in **Figure 7**. Depending on the implementation, the strip may be placed onto a strip or layer of peel ply that is already present on the base. The selected strip of the composite material is placed onto a base to form a layer (operation **1102**). The strip may be placed on top of another layer on the bases for layers subsequent to the initial layer.

[0064] Next, the process determines whether additional layers may be needed for the composite strip (operation **1104**). If additional layers are needed, the process returns to operation **1100** to select another material for the next layer of the composite strip. In selecting another layer, a selection of a fabric, tape, peel ply, surfacer, or other material may be made. This selection may also include dimensions for this next layer. The width of this next layer may be narrower than a previous layer to taper the composite strip.

[0065] With reference again to operation **1104**, if additional layers are not needed, the process then cures the composite strip (operation **1106**). Thereafter, the

process terminates. Turning now to **Figure 12**, an illustration of a process for manufacturing a composite component is depicted in accordance with an advantageous embodiment. The process illustrated in **Figure 12** may be used to create a composite component, such as composite component **300** in **Figure 3**. The process begins by positioning a pre-cured composite strip over a surface of a composite component where a caul plate seam may be expected (operation **1200**). Next, the pre-cured composite strip is bonded to the surface of the composite component (operation **1202**). The bonding may be achieved through the use of an adhesive layer, in these examples. The caul plate seam may be an area or section where a gap may be expected between adjacent two caul plates placed onto the composite component. Next, the process places the caul plates onto the composite component (operation **1204**). Then, process cures the composite component (operation **1206**) with the process terminating thereafter.

[0066] The different steps illustrated in **Figure 12** only depict some of the steps involved in manufacturing a composite component with a desired amount of surface finish or appearance. Of course, other steps may be involved in preparing the composite component both in forming the composite component and preparing the composite component for curing.

[0067] Thus, the different advantageous embodiments provide a method for applying a pre-cured composite strip to a composite component. A pre-cured composite strip having a thermoset resin may be placed on a surface of a portion of the composite component where a caul plate seam is expected. Caul plates may be placed on the composite component after placing the composite strip to form the caul plate seam. The composite component may be cured after placing the caul plates on the composite component.

[0068] In this manner, different advantageous embodiments may reduce inconsistencies on a finished composite component. The different examples depict features that may be found in some of all of the advantageous embodiments. Different combinations of these features may be used to reduce inconsistencies in the appearance of the surface of composite components. The description of the different advantageous embodiments has been presented for purposes of illustration and description, and is not intended to be exhaustive or limited to embodiments in the form disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art, in accordance with the appended claims. For example, the depicted embodiments may apply the method and apparatus to the production of a composite fuselage. The different advantageous embodiments may be applied to reducing blemishes on other components or parts. For example, some advantageous embodiments may be applied to other components, such as, without limitation, a wing or a tail of an aircraft. Further, different advantageous embodiments may provide different advantages as compared to other advantageous em-

bodiments. The embodiment or embodiments selected are chosen and described in order to best explain the principles of the disclosure, the practical application, and to enable others of ordinary skill in the art to understand the various embodiments with various modifications as are suited to the particular use contemplated.

Claims

1. A method for applying a pre-cured composite strip (306, 700) to a composite component (300), the pre-cured composite strip comprising a first composite fabric layer (706) having a first width and a composite tape layer (708) on the first composite fabric layer having a second width that is smaller than the first width, the method comprising:

placing (1200) the pre-cured composite strip on a surface (304) of a portion of the composite component where a caul plate seam may be expected;

placing (1202) caul plates (308, 310) on the composite component (300) after placing the pre-cured composite strip (306, 700) to form the caul plate seam; and
curing (1204) the composite component (300) after placing the caul plates on the composite component.

2. The method of claim 1, wherein the placing step (1202) comprises:
adhering the pre-cured composite strip (700) with a layer of adhesive (802) to the surface of the portion of the composite component where the caul plate seam is expected.

3. The method of claim 1, wherein the placing step (1202) comprises:

removing a peel ply layer (712) from the pre-cured composite strip (700);
adhering the pre-cured composite strip (700) to the surface of the portion of the composite component where the caul plate seam is expected with a layer of adhesive between a surface of the pre-cured composite strip and the surface of the portion of the composite component where the caul plate seam is expected.

4. The method of claim 3, wherein the peel ply layer is a first peel ply layer (712) and wherein the placing step further comprises:

removing a second peel ply layer (704) from the pre-cured composite strip to expose a second surface; and
placing a surfacer layer (800) on the second sur-

face.

5. The method of any preceding claim, wherein the precured composite strip further comprises:
a second composite fabric layer (710) on the composite tape layer (708) having a third width that is smaller than the first width.

6. The method of any preceding claim further comprising:

forming a composite strip set; and
curing the composite strip set to form the precured composite strip (306, 700).

7. The method of claim 6, wherein the forming step further comprises:

placing a first layer of peel ply (704) over the first layer of composite fabric (706); and
placing a second layer of peel ply (712) under the layer of composite tape.

Patentansprüche

1. Verfahren zum Aufbringen eines vorgehärteten Verbundstreifens (306, 700) auf ein Verbundbauteil (300), wobei der vorgehärtete Verbundstreifen eine erste Verbundgewebeschiicht (706) mit einer ersten Breite und eine Verbundbandschiicht (708) auf der ersten Verbundgewebeschiicht mit einer zweiten Breite, die kleiner als die erste Breite ist, umfasst, wobei das Verfahren umfasst:

Anordnen (1200) des vorgehärteten Verbundstreifens auf einer Oberfläche (304) eines Teils des Verbundbauteils, wo eine Deckplattennaht zu erwarten ist;
Anordnen (1202) von Deckplatten (308, 310) auf dem Verbundbauteil (300) nach dem Anordnen des vorgehärteten Verbundstreifens (306, 700), um die Deckplattennaht auszubilden; und
Aushärten (1204) des Verbundbauteils (300) nach dem Aufsetzen der Deckplatten auf das Verbundbauteil.

2. Verfahren nach Anspruch 1, bei dem der Schritt des Anordnens (1202) umfasst:

Anbringen des vorgehärteten Verbundstreifens (700) mit einer Klebstoffschicht (802) an der Oberfläche des Teils des Verbundbauteils, auf dem die Deckplattennaht erwartet wird.

3. Verfahren nach Anspruch 1, bei dem der Schritt des Anordnens (1202) umfasst:

Entfernen einer Abziehschiicht (712) von dem

vorgehärteten Verbundstreifen (700);
Ankleben des vorgehärteten Verbundstreifens (700) an die Oberfläche des Teils des Verbundbauteils, an dem die Deckplattennaht erwartet wird, mit einer Klebstoffschicht zwischen einer Oberfläche des vorgehärteten Verbundstreifens und der Oberfläche des Teils des Verbundbauteils, an dem die Deckplattennaht erwartet wird.

4. Verfahren nach Anspruch 3, wobei die Abziehschiicht eine erste Abziehschiicht (712) ist und wobei der Schritt des Anordnens ferner umfasst:

Entfernen einer zweiten Abziehschiicht (704) von dem vorgehärteten Verbundstreifen, um eine zweite Oberfläche freizulegen; und
Anbringen einer Spachtelschiicht (800) auf der zweiten Oberfläche.

5. Verfahren nach einem der vorstehenden Ansprüche, bei dem der vorgehärtete Verbundstreifen ferner umfasst:

eine zweite Verbundgewebeschiicht (710) auf der Verbundbandschiicht (708) mit einer dritten Breite, die kleiner als die erste Breite ist.

6. Verfahren nach einem der vorhergehenden Ansprüche, wobei das Verfahren weiterhin umfasst:

Bilden eines Satzes von Verbundstreifen; und
Aushärten des Satzes von Verbundstreifen, um den vorgehärteten Verbundstreifen zu bilden (306, 700).

7. Verfahren nach Anspruch 6, bei dem der Schritt des Bildens weiter umfasst:

Anordnen einer ersten Abziehschiicht (704) über der ersten Verbundgewebeschiicht (706); und
Anbringen einer zweiten Abziehschiicht (712) unter der Verbundbandschiicht.

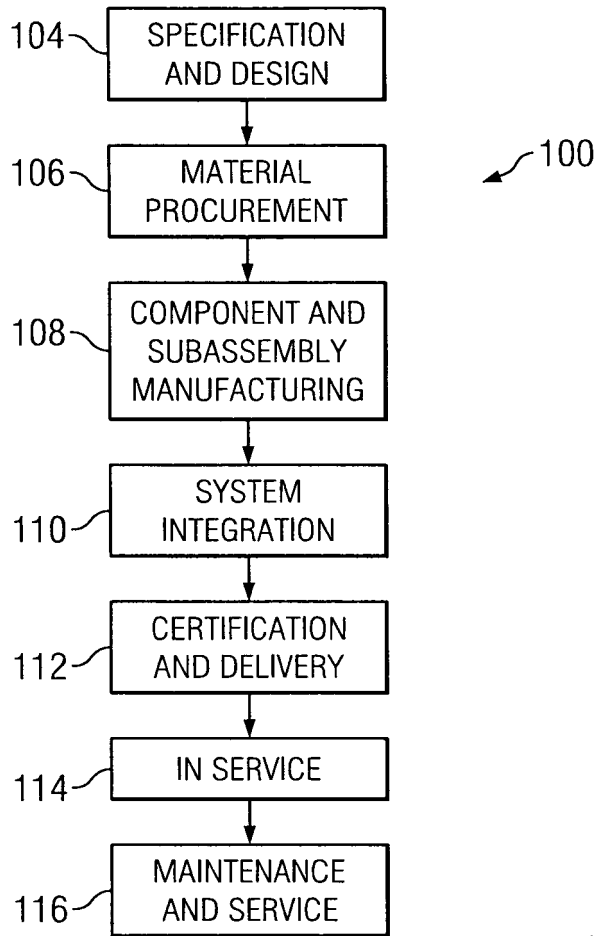
Revendications

1. Procédé pour appliquer une bande composite pré-durcie (306, 700) à un composant composite (300), la bande de composite pré-durcie comprenant une première couche de tissu composite (706) ayant une première largeur et une couche de ruban composite (708) sur la première couche de tissu composite ayant une deuxième largeur qui est inférieure à la première largeur, le procédé comprenant les étapes consistant à :

placer (1200) la bande composite pré-durcie sur une surface (304) d'une partie du composant composite où une jointure de plaques de con-

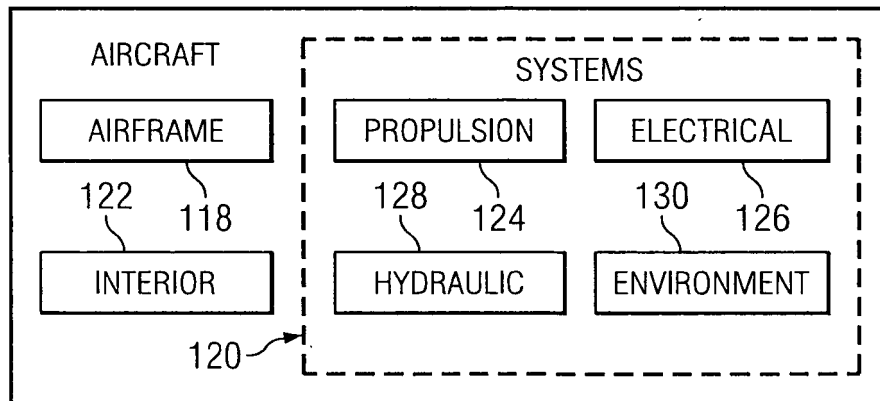
- formation peut être attendue ;
 placer (1202) des plaques de conformation (308, 310) sur le composant composite (300) après avoir placé la bande composite pré-durcie (306, 700) pour former la jointure de plaques de conformation ; et
 durcir (1204) le composant composite (300) après avoir placé les plaques de conformation sur le composant composite.
2. Procédé selon la revendication 1, dans lequel l'étape de placement (1202) comprend l'étape consistant à : faire adhérer la bande composite pré-durcie (700) à l'aide d'une couche d'adhésif (802) à la surface de la partie du composant composite où la couture de plaques de conformation est attendue.
3. Procédé selon la revendication 1, dans lequel l'étape de placement (1202) comprend les étapes consistant à :
- retirer une couche en pli pelable (712) à partir de la bande composite pré-durcie (700) ;
 faire adhérer la bande composite pré-durcie (700) à la surface de la partie du composant composite où la jointure de plaque de conformation est attendue à l'aide d'une couche d'adhésif entre une surface de la bande composite pré-durcie et la surface de la partie du composant composite où la jointure de plaques de conformation est attendue.
4. Procédé selon la revendication 3, dans lequel la couche en pli pelable est une première couche en pli pelable (712) et dans lequel l'étape de placement comprend en outre les étapes consistant à :
- retirer une seconde couche en pli pelable (704) de la bande composite pré-durcie pour exposer une seconde surface ; et
 placer une couche d'apprêt surfaçant (800) sur la seconde surface.
5. Procédé selon l'une quelconque des revendications précédentes, dans lequel la bande composite pré-durcie comprend en outre :
- une seconde couche de tissu composite (710) sur la couche de ruban composite (708) ayant une troisième largeur qui est plus petite que la première largeur.
6. Procédé selon l'une quelconque des revendications précédentes, comprenant en outre les étapes consistant à :
- former un ensemble de bandes composites ; et
 durcir l'ensemble de bandes composites pour former la bande composite pré-durcie (306,
- 700).
7. Procédé selon la revendication précédente, comprenant en outre les étapes consistant à :
- placer une première couche de pli pelable (704) sur la première couche de tissu composite (706) ; et
 placer une seconde couche de pli pelable (712) sous la couche de ruban composite.

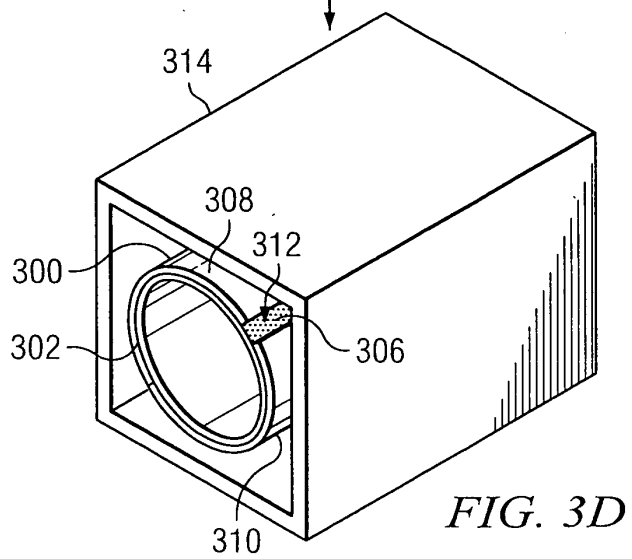
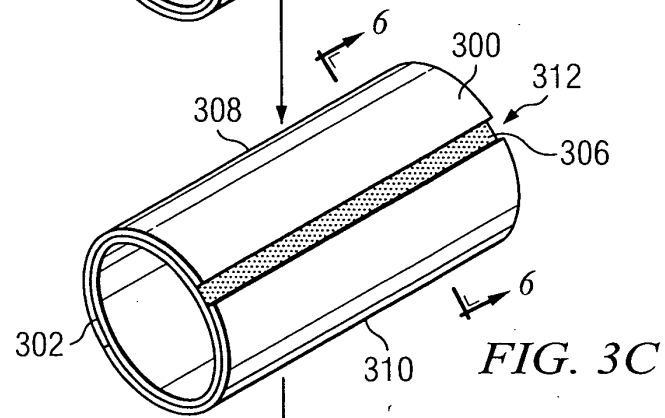
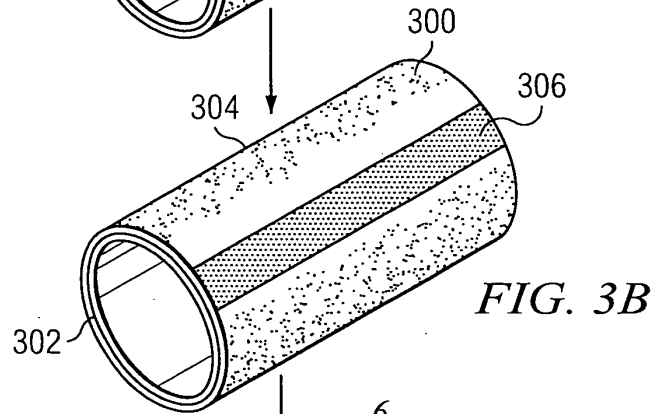
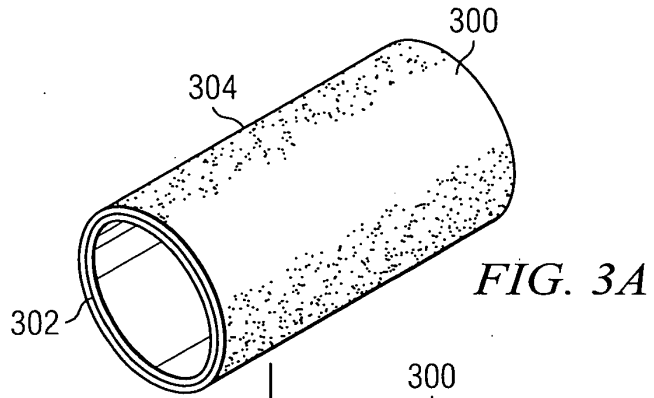
FIG. 1



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FIG. 2





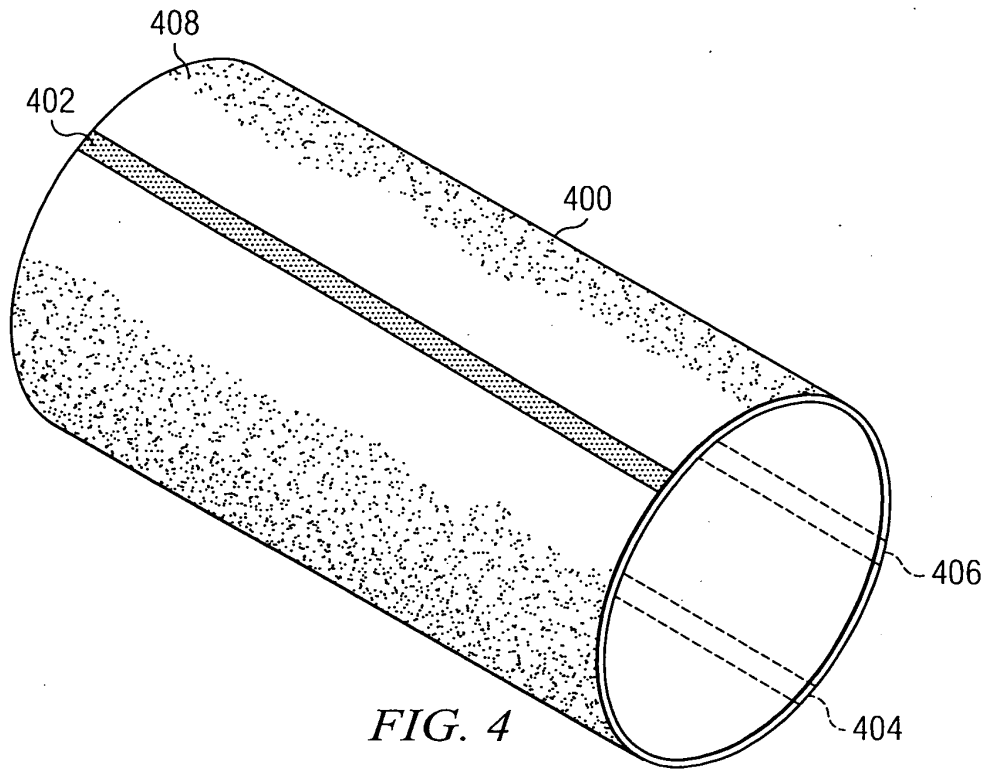


FIG. 4

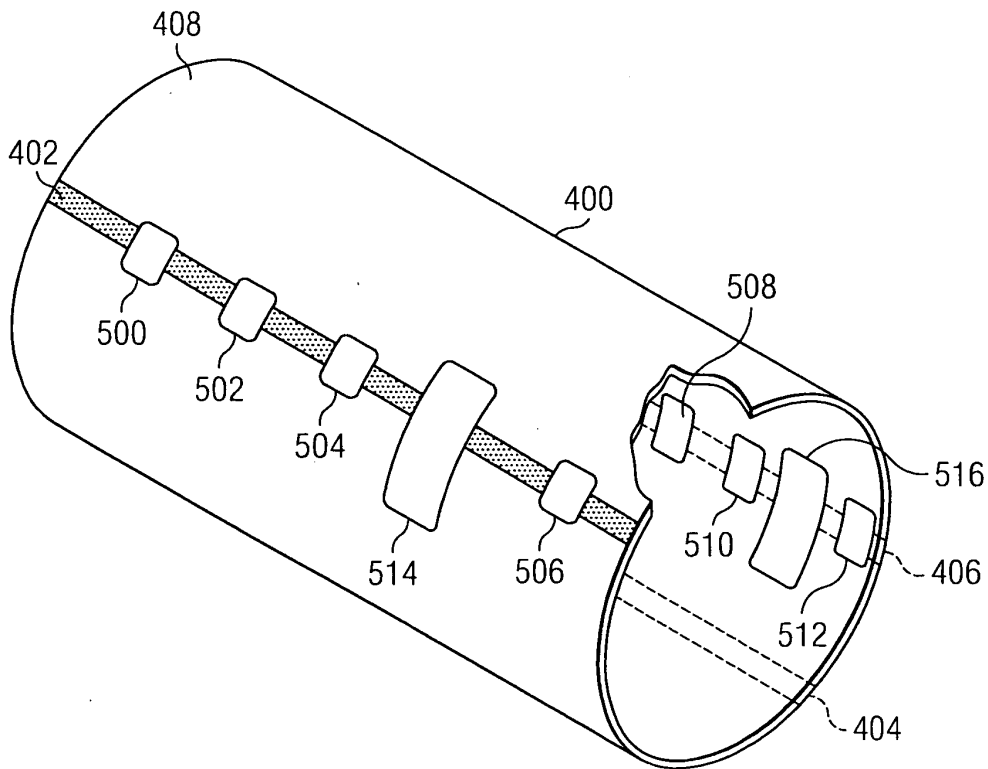


FIG. 5

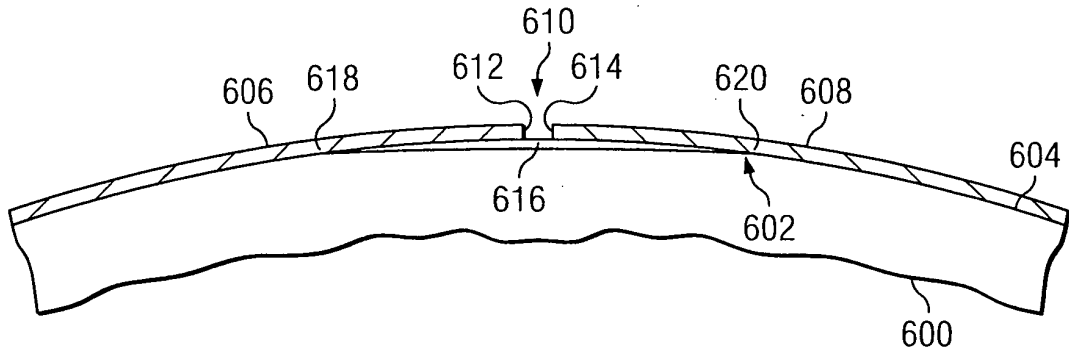


FIG. 6

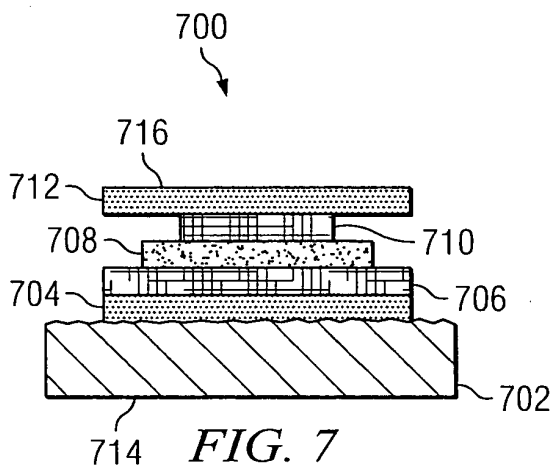


FIG. 7

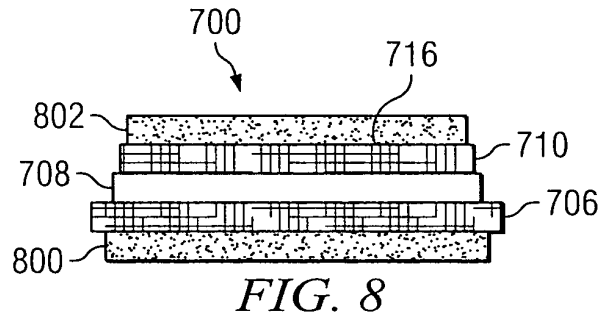


FIG. 8

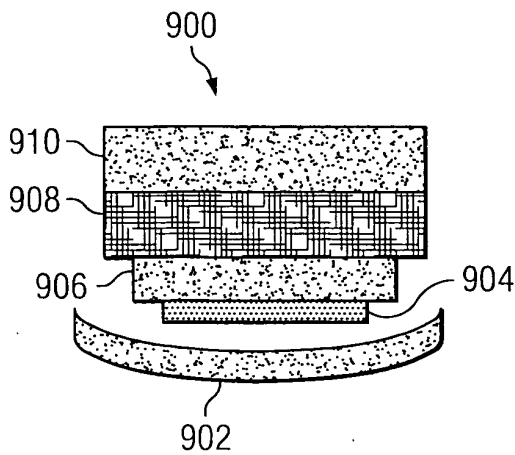


FIG. 9

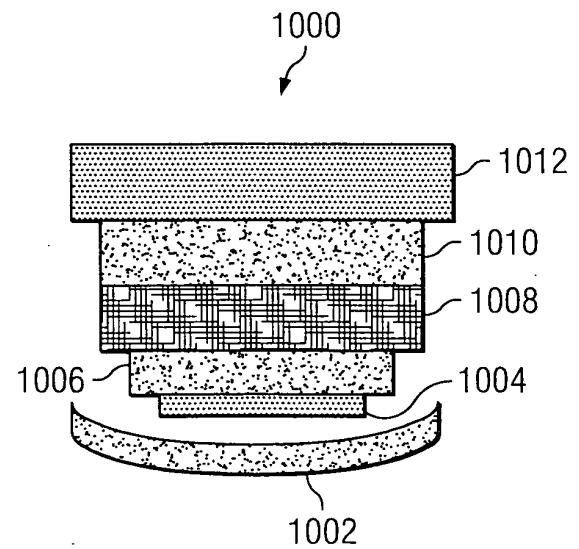


FIG. 10

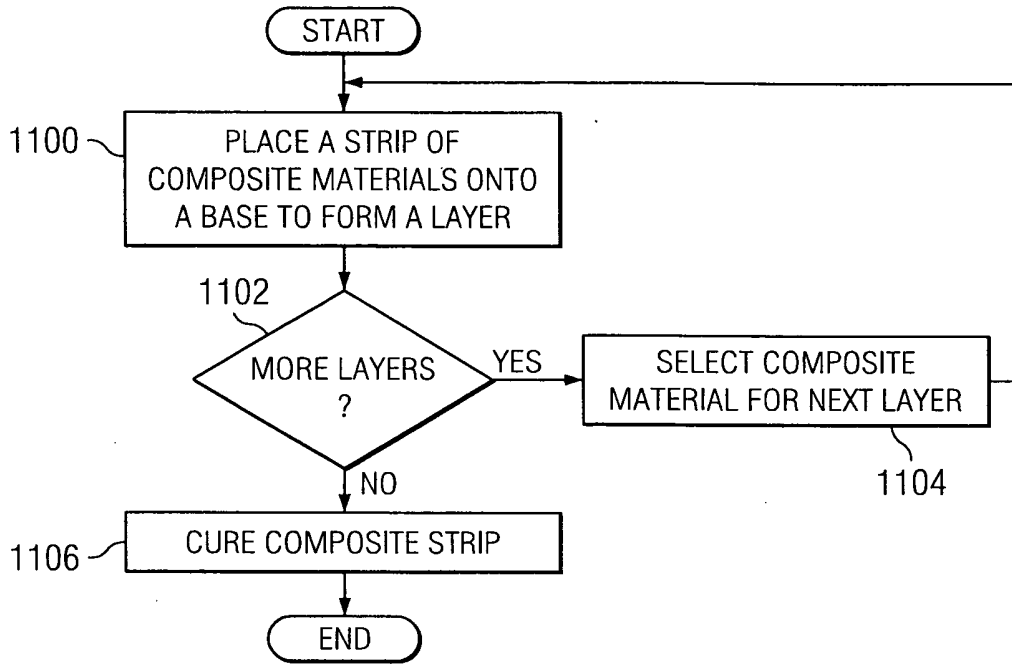


FIG. 11

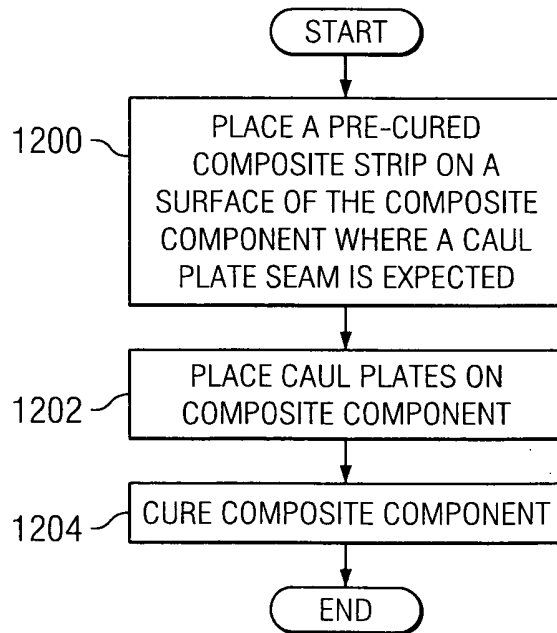


FIG. 12

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 20050102814 A [0010]