(12) STANDARD PATENT (11) Application No. **AU 2018267651 B2**
(19) AUSTRALIAN PATENT OFFICE

(54) Title
Radius filler kits and composite forming method

(51) International Patent Classification(s)
B29C 70/32 (2006.01)

(21) Application No: **2018267651** (22) Date of Filing: **2018.11.22**

(30) Priority Data

(31) Number	(32) Date	(33) Country
15/840,793	**2017.12.13**	**US**

(43) Publication Date: **2019.06.27**
(43) Publication Journal Date: **2019.06.27**
(44) Accepted Journal Date: **2024.02.29**

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(56) Related Art
US 2016/0107432 A1

2018267651 22 Nov 2018

ABSTRACT

A plurality of segments of radius filler (132) is positioned onto a radius filler forming tool (112). The plurality of segments of radius filler (132) is applied to a stringer (124) in a single placement step.

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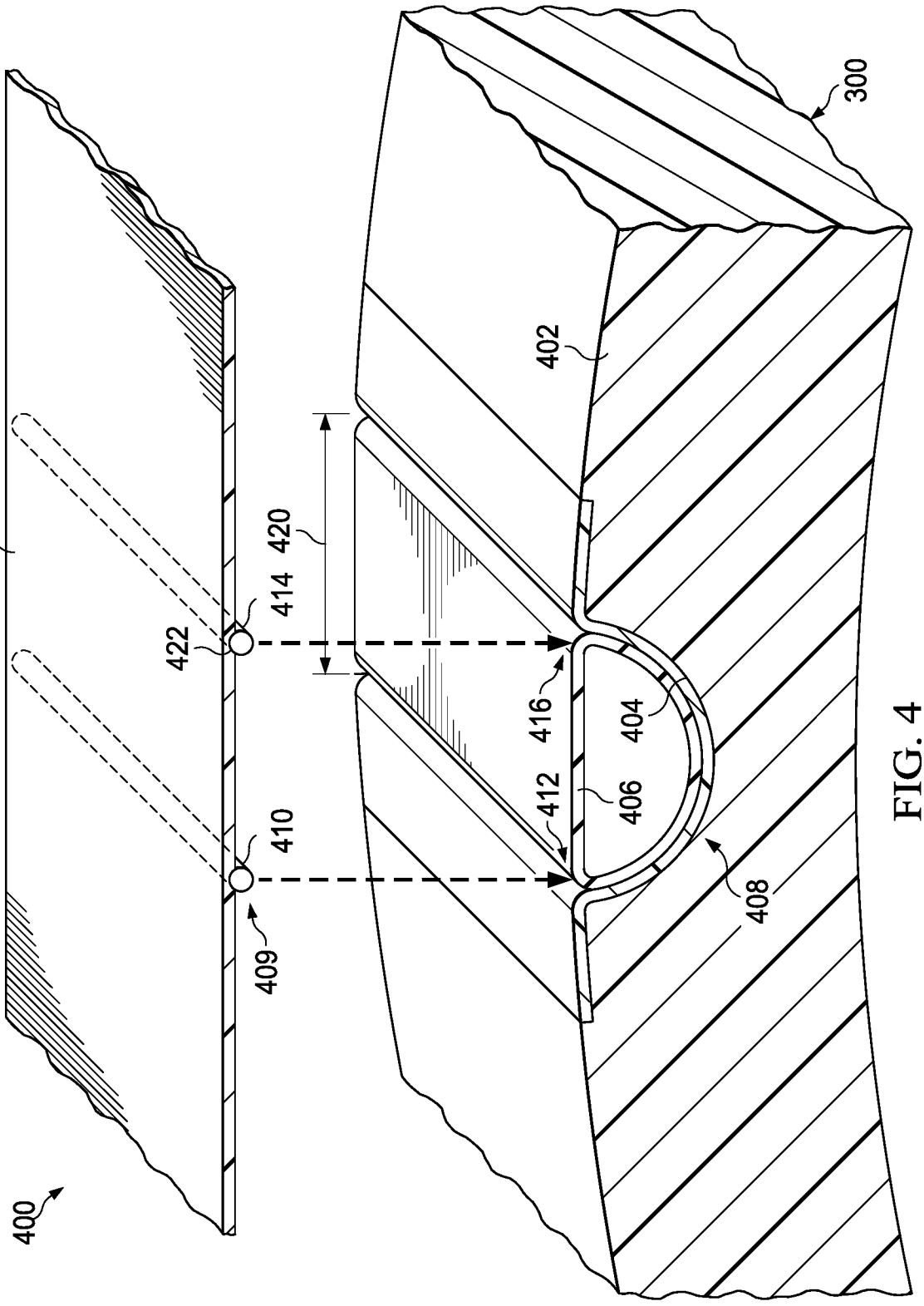

FIG. 4

RADIUS FILLER KITS AND COMPOSITE FORMING METHOD

BACKGROUND INFORMATION

1. Field:

The present disclosure relates generally a composite forming method and a radius filler tool, more specifically, to laying up radius fillers substantially simultaneously. Yet more specifically, the present disclosure relates to forming radius filler kits for application to a composite layup.

2. Background:

Radius fillers, also called "noodles," are used to fill interfaces between plies in composite joints. Radius fillers are commonly used in joints for stiffeners, such as stringers. The radius being filled is created when a composite layup with a particular radius is joined with another composite layup.

Currently, radius fillers are applied to a composite layup directly by hand. Currently, radius fillers are applied individually to the composite layup. Applying radius fillers by hand may take more time than desired. Additionally, applying radius fillers by hand may be a less than desirable use of man power.

Therefore, it would be desirable to have a method and apparatus that take into account at least some of the issues discussed above, as well as other possible issues.

Any discussion of documents, acts, materials, devices, articles or the like which has been included in the present specification is not to be taken as an admission that any or all of these matters form part of the prior art base or were common general knowledge in the field relevant to the present disclosure as it existed before the priority date of each of the appended claims.

SUMMARY

An illustrative embodiment of the present disclosure provides A method. A plurality of segments of radius filler is positioned onto a radius filler forming tool. A ply is applied over the plurality of segments of radius filler. A compression force is applied to the plurality of segments

of radius filler and the ply. The plurality of segments of radius filler is applied to a stringer in a single placement step.

Another illustrative embodiment of the present disclosure provides a method. A ply is applied over a plurality of segments of radius filler. A compression force is applied to the plurality of segments of radius filler and the ply to form a radius filler kit. The radius filler kit is positioned relative to a stringer, the radius filler kit including the plurality of segments of radius filler. The radius filler kit is applied to the stringer in a single placement step to apply the plurality of segments of radius filler to the stringer.

A further illustrative embodiment of the present disclosure provides a method. A plurality of segments of radius filler is positioned onto a radius filler forming tool. A ply is applied over the plurality of segments of radius filler. A compression force is applied to the plurality of segments of radius filler and the ply to form a radius filler kit. The radius filler kit is positioned relative to a stringer. The radius filler kit is applied to the stringer in a single placement step to apply the plurality of segments of radius filler to the stringer.

A yet further illustrative embodiment of the present disclosure provides an apparatus. The apparatus comprises a roller manifold having a vacuum opening and a vacuum bag material connected to the roller manifold. The vacuum bag has an opening interfacing with the vacuum opening.

A yet further illustrative embodiment of the present disclosure provides a radius filler forming tool. The radius filler forming tool comprises a number of grooves in a surface and vacuum channels in the surface surrounding the number of grooves.

The features and functions 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

The novel features believed characteristic of the illustrative embodiments are set forth in the appended claims. The illustrative embodiments, however, as well as a preferred mode of use, further objectives and features thereof, will best be understood by reference to the following

detailed description of an illustrative embodiment of the present disclosure when read in conjunction with the accompanying drawings, wherein:

Figure 1 is an illustration of a block diagram of a manufacturing environment in which radius fillers are laid up in accordance with an illustrative embodiment;

Figure 2 is an illustration of a perspective view of radius fillers on a radius filler forming tool in accordance with an illustrative embodiment;

Figure 3 is an illustration of a cross-sectional view of a stiffener forming tool for positioning stringers for a layup in accordance with an illustrative embodiment;

Figure 4 is an illustration of a perspective view of a radius filler kit being positioned relative to a stringer in accordance with an illustrative embodiment;

Figure 5 is an illustration of a perspective view of radius fillers and a ply on a radius filler forming tool in accordance with an illustrative embodiment;

Figure 6 is an illustration of a perspective view of a radius filler kit being positioned relative to a stringer in accordance with an illustrative embodiment;

Figure 7 is an illustration of an isometric view of a radius filler placement system having a manifold in accordance with an illustrative embodiment;

Figure 8 is an illustration of a cross-sectional view of a radius filler placement system having a manifold in accordance with an illustrative embodiment;

Figure 9 is an illustration of a radius filler placement system having a manifold sealed to a radius filler forming tool in accordance with an illustrative embodiment;

Figure 10 is an illustration of a radius filler placement system having a manifold sealed to a tool holding a stringer in accordance with an illustrative embodiment;

Figures 11A and **11B** are illustrations of a flowchart of a method for applying more than one segment of a radius filler to a stringer in accordance with an illustrative embodiment;

Figure 12 is an illustration of a flowchart of a method for using a radius filler kit in accordance with an illustrative embodiment;

Figure 13 is an illustration of a flowchart of a method for forming a radius filler kit in accordance with an illustrative embodiment;

Figure 14 is an illustration of an aircraft manufacturing and service method in the form of a block diagram in accordance with an illustrative embodiment; and

Figure 15 is an illustration of an aircraft in the form of a block diagram in which an illustrative embodiment may be implemented.

DETAILED DESCRIPTION

The illustrative embodiments recognize and take into account one or more different considerations. For example, the illustrative embodiments recognize and take into account that composite materials are tough, light-weight materials created by combining two or more functional components. The illustrative embodiments recognize and take into account that a composite material may include reinforcing fibers bound in a polymer resin matrix. The illustrative embodiments recognize and take into account that the fibers may be unidirectional or may take the form of a woven cloth or fabric. The illustrative embodiments recognize and take into account that the fibers and resins are arranged and cured to form a composite material.

The illustrative embodiments recognize and take into account that using composite materials to create aerospace composite structures potentially allows for portions of an aircraft to be manufactured in larger pieces or sections. The illustrative embodiments recognize and take into account that a fuselage in an aircraft may be created in cylindrical sections and then assembled to form the fuselage of the aircraft.

The illustrative embodiments recognize and take into account that in some manufacturing processes for large composite parts, composite materials are laid up on a single large tool. The illustrative embodiments recognize and take into account that the large tool may be a manufacturing time limiting component.

The illustrative embodiments recognize and take into account that radius fillers (noodles) are currently hand installed into the cavities between stringer bladders and web/flange radii. The illustrative embodiments recognize and take into account that a ply, sometimes referred to as an inner mold line (IML) ply, is applied in a separate application step. The illustrative embodiments recognize and take into account that the ply is applied after a compaction step for the radii fillers. The illustrative embodiments recognize and take into account that an additional compaction step is performed for the ply after applying the ply over the radius filler.

The illustrative embodiments recognize and take into account that each application step on a tool adds flow to the assembly work on the tool. The illustrative embodiments recognize

and take into account that each stringer includes radiuses that that are desirably filled. The illustrative embodiments recognize and take into account that applying each radius filler by hand may take an undesirable amount of time.

The illustrative embodiments recognize and take into account that laying radius fillers by hand onto the part may result in inconsistencies. The illustrative embodiments recognize and take into account that the inconsistencies may be introduced by placing unformed noodles into the gaps between a bladder and a stringer.

The illustrative embodiments recognize and take into account that radius fillers (noodles) are currently hand installed into the cavity in manageable (~6ft) increments and then butted. The illustrative embodiments recognize and take into account that this radius filler application process is performed down the length of each stringer twice (one for each side of the stringer). The illustrative embodiments recognize and take into account that the manual radius filler application process may lead to an undesirable amount of on-part inspection (butt/gap requirements). The illustrative embodiments recognize and take into account that the manual radius filler application process adds flow time to the part on the tool.

Referring now to the figures and, in particular, with reference to **Figure 1**, an illustration of a block diagram of a manufacturing environment in which radius fillers are laid up is depicted in accordance with an illustrative embodiment. In this figure, radius filler kit **100** is formed in manufacturing environment **102**.

As depicted, radius filler kit **100** comprises first section of radius filler **104**, second section of radius filler **106**, and ply **108**. First section of radius filler **104** and second section of radius filler **106** are separated by distance **110**. In some illustrative examples, ply **108** is optional.

Distance **110** may be any desirable distance. In some illustrative examples, distance **110** is a single value across the length of first section of radius filler **104** and second section of radius filler **106**. In other illustrative examples, distance **110** includes more than one value along the length of first section of radius filler **104** and second section of radius filler **106.** In some illustrative examples, distance **110** may increase or decrease along the length of first section of radius filler **104** and second section of radius filler **106.** When an increase or decrease is not present, distance **110** includes one value. When an increase or decrease is present, distance **110** includes two or more values**.**

The components of radius filler kit **100** are formed of a composite material. For example, each of first section of radius filler **104**, second section of radius filler **106**, and ply **108** may be formed of composite materials. Radius filler kit **100** may be formed of a thermoplastic composite material or a thermoset composite material.

Radius filler forming tool **112** is used to form radius filler kit **100**. Radius filler forming tool **112** has number of grooves **114** in surface **116**. As used herein, a "number of" items is one or more items. Here, "number of grooves **114**" is one or more grooves. Vacuum channels **118** in surface **116** surround number of grooves **114**. As depicted, number of grooves **114** includes groove **120** and groove **122**.

Each of number of grooves **114** is configured to form a section of radius filler with a length equivalent to a length of a stringer in a layup. As depicted, radius filler forming tool **112** is used to form radius filler kit **100** for stringer **124** in layup **126**. In some illustrative examples, each of number of grooves **114** has a length equivalent to length **128** of stringer **124** in layup **126**. In one illustrative example, groove **120** has length **129** equivalent to length **128** and groove **122** has length **130** equivalent to length **128**.

In some illustrative examples, groove **120** has length **129** greater than length **128,** and groove **122** has length **130** greater than length **128**. In these illustrative examples, groove **120** and groove **122** are used to form sections of radius filler each having length **128**.

In some illustrative examples, length **129** and length **130** are substantially the same. In other illustrative examples, length **129** and length **130** may have different values.

To form radius filler kit **100**, plurality of segments of radius filler **132** is positioned onto radius filler forming tool **112**. Ply **108** is applied over plurality of segments of radius filler **132**. Compression force **134** is applied to plurality of segments of radius filler **132** and ply **108** to form radius filler kit **100**.

In illustrative examples in which ply **108** is not present in radius filler kit **100**, compression force **134** is applied to plurality of segments of radius filler **132** after positioning plurality of segments of radius filler **132** onto radius filler forming tool **112**.

When length **128** is greater than a provided manufactured length of radius filler, positioning plurality of segments of radius filler **132** includes forming joints **136** using plurality of segments of radius filler **132**. For example, radius filler is provided in manufactured lengths. When manufactured length **138** of plurality of segments of radius filler **132** is shorter than length

128, first section of radius filler **104** will include at least one joint **140**. In this illustrative example, at least one joint **140** is part of joints **136**. When manufactured length **138** of plurality of segments of radius filler **132** is shorter than length **128**, second section of radius filler **106** will include at least one joint **142**. In this illustrative example, at least one joint **142** is part of joints **136**.

Joints **136** take any desirable form. In some illustrative examples, joints **136** are butt joints. However, joints **136** may instead be any of at least one of a lap joint, a scarf joint, a step lap joint, or any other desirable type of joint.

Radius filler placement equipment **144** applies radius filler kit **100** to stringer **124**. Radius filler placement equipment **144** takes any desirable form. Radius filler placement equipment **144** may be operated manually, in an automated fashion, or some combination of the two. Radius filler placement equipment **144** performs at least one of lifting radius filler kit **100** from radius filler forming tool **112,** storing radius filler kit **100,** positioning radius filler kit **100** relative to stringer **124**, and applying radius filler kit **100** to stringer **124.**

In some illustrative examples, radius filler placement equipment **144** is pick and place equipment **146**. When radius filler placement equipment **144** is pick and place equipment **146**, pick and place equipment **146** may be operated manually, in an automated fashion, or some combination of the two. In these illustrative examples, pick and place equipment **146** lifts radius filler kit **100** from radius filler forming tool **112** and places radius filler kit **100** onto stringer **124**. When pick and place equipment **146** is used to lift and place radius filler kit **100**, additional equipment may be present in manufacturing environment **102** to apply compression force **134** to form radius filler kit **100**.

In other illustrative examples, radius filler placement equipment **144** is radius filler forming tool **112**. When radius filler placement equipment **144** is radius filler forming tool **112**, radius filler forming tool **112** comprises flexible material **148**. In some illustrative examples, flexible material **148** is flexible about a line (not depicted) perpendicular to number of grooves **114** in surface **116**.

When radius filler forming tool **112** has flexible material **148**, radius filler forming tool **112** may be bent to apply radius filler kit **100** to stringer **124** and remove radius filler kit **100** from radius filler forming tool **112** substantially simultaneously. For example, compression is applied to at least a portion of radius filler forming tool **112** to press radius filler kit **100** to

stringer **124.** After applying compression, radius filler forming tool **112** is bent away from stringer **124** to "peel" radius filler forming tool **112** from radius filler kit **100.**

In other illustrative examples, radius filler placement equipment **144** takes the form of carrier material **150**. In some illustrative examples, carrier material **150** may be a component of radius filler placement equipment **144.** Carrier material **150** may be used manually, in conjunction with automated or partially automated equipment, or some combination of the two. Carrier material **150** is formed of any desirable material configured to lift radius filler kit **100** and apply radius filler kit **100** to stringer **124**. In some illustrative examples, carrier material **150** is selected to be reusable. In some illustrative examples, carrier material **150** lifts and applies radius filler kit **100** using a mechanical compressive force.

In other illustrative examples, carrier material **150** takes the form of vacuum bag material **152**. When carrier material **150** takes the form of vacuum bag material **152**, a vacuum (not depicted) may be pulled underneath carrier material **150** to lift and apply radius filler kit **100**. Vacuum bag material **152** is formed of any desirable material configured to hold a vacuum, lift radius filler kit **100,** and apply radius filler kit **100** to stringer **124.** In some illustrative examples, vacuum bag material **152** is selected to be reusable.

In some illustrative examples, vacuum bag material **152** is configured to lift a composite material. The composite material may take any desirable form. In some illustrative examples, the composite material includes a ply, such as ply **108** of **Figure 1**. In some illustrative examples, the composite material includes a plurality of segments of radius filler **132** of **Figure 1**. In some illustrative examples, the composite material includes radius filler kit **100** of **Figure 1**.

In some illustrative examples, carrier material **150** and radius filler kit **100** may be transported substantially planar. For example, carrier material **150** and radius filler kit **100** may be transported on a conveyor or on a table. In some illustrative examples, carrier material **150** and radius filler kit **100** are coiled into roll **153**.

In some illustrative examples, carrier material **150** is a component of radius filler placement system **154**. Radius filler placement system **154** may be used manually, in an automated fashion, or some combination of the two. Radius filler placement system **154** comprises roller manifold **156** having vacuum opening **158** and vacuum bag material **152**

connected to roller manifold **156**. Vacuum bag material **152** has opening **160** interfacing with vacuum opening **158**.

In some illustrative examples, vacuum bag material **152** comprises first vacuum bag layer **162** and second vacuum bag layer **164**. First vacuum bag layer **162** creates a vacuum seal with radius filler forming tool **112**. Second vacuum bag layer **164** lifts and holds radius filler kit **100**. First vacuum bag layer **162** and second vacuum bag layer **164** are formed of any desirable type of material. In some illustrative examples, first vacuum bag layer **162** and second vacuum bag layer **164** are formed of the same type of material. In other illustrative examples, first vacuum bag layer **162** and second vacuum bag layer **164** are formed of different materials.

In some illustrative examples vacuum bag material **152** comprises first latex sheet **166**. First latex sheet **166** may be an implementation of first vacuum bag layer **162**. In some illustrative examples, vacuum bag material **152** further comprises second latex sheet **168**. Second latex sheet **168** may be an implementation of second vacuum bag layer **164**.

In some illustrative examples, second latex sheet **168** is bonded to first latex sheet **166**. Second latex sheet **168** is bonded to first latex sheet **166** using any desirable method. Bonds **170** between first latex sheet **166** and second latex sheet **168** may be formed using epoxy, fasteners, welding, or any other desirable method.

As depicted, breather **172** is positioned between first latex sheet **166** and second latex sheet **168**. Breather **172** is in vacuum communication with vacuum opening **158**. Breather **172** distributes vacuum from vacuum opening **158** to edges of first latex sheet **166** to seal first latex sheet **166** against a tool or layup, such as radius filler forming tool **112** or layup **126**.

In some illustrative examples, first latex sheet **166** and second latex sheet **168** are configured to roll around roller manifold **156**. First latex sheet **166** and second latex sheet **168** are configured to form roll **153** with radius filler kit **100**. In these illustrative examples, first latex sheet **166** and second latex sheet **168** are configured to prevent undesirable sticking to roller manifold **156** or radius filler kit **100**.

In some illustrative examples, first latex sheet **166** and second latex sheet **168** each have a respective mesh surface. The respective mesh surface prevents undesirable sticking. For example, a respective mesh surface of first latex sheet **166** prevents first latex sheet **166** from undesirably sticking to roller manifold **156** or radius filler kit **100**. As another example, a

respective mesh surface of second latex sheet **168** prevents second latex sheet **168** from undesirably sticking to first latex sheet **166**.

Roller manifold **156** has any desirable size and shape. In some illustrative examples, roller manifold **156** is cylindrical **173**.

In some illustrative examples, roller manifold **156** has machined surface **174**. When machined surface **174** is present, vacuum bag material **152** is connected to machined surface **174**. For example, first vacuum bag layer **162** is connected to machined surface **174**. Machined surface **174** creates a larger surface area for connecting vacuum bag material **152** to roller manifold **156**.

When roller manifold **156** has machined surface **174**, vacuum opening **158** is within machined surface **174**. Machined surface **174** aids in orienting vacuum opening **158** relative to radius filling forming tool **112** or layup **126**.

Roller manifold **156** forms vacuum chamber **176**. Vacuum equipment **178** provides vacuum to vacuum chamber **176** of roller manifold **156**. Vacuum travels from vacuum chamber **176** through vacuum opening **158** and opening **160** to beneath first vacuum bag layer **162**.

Vacuum beneath first vacuum bag layer **162** seals first vacuum bag layer **162** to one of radius filler kit **100** or layup **126**. Vacuum beneath first vacuum bag layer **162** applies compression force **134** to radius filler kit **100** on radius filler forming tool **112**.

In some illustrative examples, a heating element is associated with radius filler placement system **154**. A heating element may be used to heat composite material of radius filler kit **100**. Heating radius filler kit **100** affects at least one of the flexibility or the tackiness of the composite material of radius filler kit **100**. At least one of flexibility or tackiness of the composite material of radius filler kit **100** affects at least one of adhesion to carrier material **150**, adhesion to stringer **124**, or coiling into or out of roll **153**.

In some illustrative examples, roller manifold **156** has heating element **171**. In other illustrative examples, vacuum bag material **152** has integrated heating elements **179**.

Radius filler placement system **154** may be used as a carrier, a roller, a backing paper, and a compaction bag. Radius filler placement system **154** lifts radius filler kit **100** to act as a carrier. In some illustrative examples, carrier material **150** and radius filler kit **100** form roll **153** and radius filler placement system **154** acts as a roller. Radius filler placement system **154** acts as a backing paper to apply radius filler kit **100** to stringer **124** of layup **126**.

Layup **126** is formed on stiffener forming tool **180**. Stringer **124** is positioned in channel **182** of stiffener forming tool **180**. Bladder **184** is positioned in stringer **124** to maintain the shape of stringer **124**.

Radius filler placement equipment **144** applies plurality of segments of radius filler **132** to stringer **124**. Radius filler placement equipment **144** applies plurality of segments of radius filler **132** to first gap **186** and second gap **188** of stringer **124**. First gap **186** and second gap **188** are separated by distance **110**.

As depicted, applying plurality of segments of radius filler **132** to first gap **186** and second gap **188** comprises applying plurality of segments of radius filler **132** to first gap **186** and second gap **188** simultaneously. In some illustrative examples, applying radius filler kit **100** to stringer **124** comprises placing first section of radius filler **104** of radius filler kit **100** into first gap **186** of stringer **124** and second section of radius filler **106** of radius filler kit **100** into second gap **188** of stringer **124**.

In some illustrative examples, radius filler placement system **154** acts as backing paper to position and apply radius filler kit **100** to stringer **124**. After applying radius filler kit **100** to stringer **124**, radius filler placement system **154** acts as a compaction bag to apply pressure to radius filler kit **100**.

As used herein, the phrase "at least one of," when used with a list of items, means different combinations of one or more of the listed items may be used, and only one of each item in the list may be needed. In other words, "at least one of" means any combination of items and number of items may be used from the list, but not all of the items in the list are required. The item may be a particular object, a thing, or a category.

This example also may include item A, item B, and item C, or item B and item C. Of course, any combination of these items may be present. In other examples, "at least one of" may be, for example, without limitation, two of item A, one of item B, and ten of item C; four of item B and seven of item C; or other suitable combinations.

The illustration of manufacturing environment **102** in **Figure 1** is not meant to imply physical or architectural limitations to the manner in which an illustrative embodiment may be implemented. Other components in addition to or in place of the ones illustrated may be used. Some components may be unnecessary. Also, the blocks are presented to illustrate some

functional components. One or more of these blocks may be combined, divided, or combined and divided into different blocks when implemented in an illustrative embodiment.

For example, although radius filler placement system **154** is described for use with radius filler kit **100**, radius filler placement system **154** may be used to place any desirable type of composite material. For example, radius filler placement system **154** may instead be referred to as a composite placement system or composite placement apparatus. In some illustrative examples, radius filler placement system **154** may be used to position and place plies of composite material (not depicted). In some illustrative examples, radius filler placement system **154** may be used to coil and store plies of composite material (not depicted).

Turning now to **Figure 2**, an illustration of a perspective view of radius fillers on a radius filler forming tool is depicted in accordance with an illustrative embodiment. Radius filler forming tool **200** is a physical implementation of radius filler forming tool **112** of **Figure 1**. Plurality of segments of radius filler **202** has been positioned onto radius filler forming tool **200**. Plurality of segments of radius filler **202** is a physical implementation of plurality of segments of radius filler **132** of **Figure 1**.

In this illustrative example, plurality of segments of radius filler **202** has been placed into number of grooves **204** in surface **206** of radius filler forming tool **200**. As depicted, plurality of segments of radius filler **202** include radius filler **208** placed into groove **210** of number of grooves **204** and radius filler **212** placed into groove **214** of number of grooves **204**.

Groove **210** and groove **214** are separated by distance **216**. As depicted, radius filler **208** and radius filler **212** are separated by distance **216**. Distance **216** is equivalent to a distance between a first gap and a second gap of a stringer, such as stringer **402** of **Figure 4** or stringer **602** of **Figure 6**. As depicted, distance **216** has a constant or substantially constant value. However, in other non-depicted illustrative examples, distance **216** has multiple values. When distance **216** has multiple values, radius filler **208** and radius filler **212** are not parallel.

In some illustrative examples, number of grooves **204** in surface **206** is configured to shape plurality of segments of radius filler **202**. In one illustrative example, number of grooves **204** in surface **206** is configured to shape plurality of segments of radius filler **202** to a domed cross-sectional shape. In another illustrative example, number of grooves **204** in surface **206** is configured to shape plurality of segments of radius filler **202** to a triangular cross-sectional

shape. Number of grooves **204** in surface **206** may shape plurality of segments of radius filler **202** when compressive force is applied to plurality of segments of radius filler **202**.

Vacuum channels **218** in surface **206** surround number of grooves **204**. Vacuum channels **218** are used to form a seal around number of grooves **204** to apply vacuum to plurality of segments of radius filler **202**.

Turning now to **Figure 3**, an illustration of a cross-sectional view of a stiffener forming tool for positioning stringers for a layup is depicted in accordance with an illustrative embodiment. Stiffener forming tool **300** is a physical implementation of stiffener forming tool **180** of **Figure 1**. As depicted, stiffener forming tool **300** has plurality of channels **302**.

A stringer is laid up in each of plurality of channels **302**. After laying up a stringer in a respective channel of plurality of channels **302**, radius fillers are applied to gaps of the respective stringer.

Laying up stringers and radius fillers in each of plurality of channels **302** of stiffener forming tool **300** by hand is a time-limiting step. Applying radius fillers as a radius filler kit will reduce the time spent applying radius fillers to stiffener forming tool **300**. For example, applying plurality of segments of radius filler **132** of **Figure 1** as radius filler kit **100** to stiffener forming tool **300** will reduce the time spent applying plurality of radius filler **132** to stiffener forming tool **300**.

The illustration of stiffener forming tool **300** in **Figure 3** is not meant to imply physical or architectural limitations to the manner in which an illustrative embodiment may be implemented. Other components in addition to or in place of the ones illustrated may be used. Some components may be unnecessary. Also, the blocks are presented to illustrate some functional components. One or more of these blocks may be combined, divided, or combined and divided into different blocks when implemented in an illustrative embodiment.

For example, although stiffener forming tool **300** has a circular cross-section, a stiffener forming tool may have any desirable shape. As another example, although stiffener forming tool **300** has channels **302**, a stiffener forming tool may have any desirable size, quantity, or shape of channels.

Turning now to **Figure 4**, an illustration of a perspective view of a radius filler kit being positioned relative to a stringer is depicted in accordance with an illustrative embodiment. In **Figure 4**, stringer **402** has been placed in one of plurality of channels **302** of stiffener forming

tool **300** of **Figure 3**. More specifically, stringer **402** is within channel **404** of stiffener forming tool **300**. Radius filler kit **400** is a physical implementation of radius filler kit **100** of **Figure 1**. Radius filler kit **400** is positioned relative to stringer **402**. Stringer **402** is a physical implementation of stringer **124** of **Figure 1**.

Bladder **406** is positioned within stringer **402**. Bladder **406** maintains shape **408** of stringer **402** during curing.

Radius filler kit **400** is positioned relative to stringer **402**. Radius filler kit **400** comprises plurality of segments of radius filler **409**. Plurality of segments of radius filler **409** form first section of radius filler **410** and second section of radius filler **414**. Radius filler kit **400** is positioned such that first section of radius filler **410** will be placed into first gap **412** of stringer **402.** Radius filler kit **400** is positioned such that second section of radius filler **414** will be placed into second gap **416** of stringer **402**.

Radius filler kit **400** is applied to stringer **402** by lowering carrier material **418** towards stringer **402**. Radius filler kit **400** is lowered such that plurality of segments of radius filler **409** is applied to first gap **412** and second gap **416** of stringer **402**. First gap **412** and second gap **416** are separated by distance **420.** First section of radius filler **410** and second section of radius filler **414** on carrier material **418** are separated by distance **420** prior to application to stringer **402**.

Plurality of segments of radius filler **409** is applied to first gap **412** and second gap **416** simultaneously. Radius filler kit **400**, including first section of radius filler **410** and second section of radius filler **414**, is lowered such that first section of radius filler **410** is applied to first gap **412** and second section of radius filler **414** is applied to second gap **416** simultaneously.

Carrier material **418** and radius filler kit **400** are lowered towards stiffener forming tool **300** to apply radius filler kit **400** to stringer **402**. In some illustrative examples, carrier material **418** holding radius filler kit **400** may be transported in a substantially planar state. In other illustrative examples, carrier material **418** holding radius filler kit **400** may be transported in a rolled state. In some illustrative examples, applying plurality of segments of radius filler **409** comprises unrolling carrier material **418** and radius filler kit **400**. In other illustrative examples, carrier material **418** and radius filler kit **400** are unrolled after transportation but prior to application of radius filler kit **400** to stringer **402**.

After applying radius filler kit **400** to stringer **402**, a compression force is applied to create a greater adhesive force between radius filler kit **400** and stringer **402** than between radius

filler kit **400** and carrier material **418**. When the adhesive force between radius filler kit **400** and stringer **402** is greater than the adhesive force between radius filler kit **400** and carrier material **418**, carrier material **418** may be removed from radius filler kit **400**. When carrier material **418** is removed from radius filler kit **400**, first section of radius filler **410** remains in first gap **412** and second section of radius filler **414** remains in second gap **416**.

In some illustrative examples, carrier material **418** is a vacuum bag material. When carrier material **418** is a vacuum bag material, the vacuum bag material may be sealed to stiffener forming tool **300** holding stringer **402** after applying radius filler kit **400** to stringer **402**. In these illustrative examples, a vacuum may be applied to plurality of segments of radius filler **409** and stringer **402** to apply the compression force to plurality of segments of radius filler **409**. After applying the vacuum, carrier material **418** is removed.

In some illustrative examples, plurality of segments of radius filler **409** and stringer **402** may be cured prior to removing carrier material **418**. In other illustrative examples, plurality of segments of radius filler **409** and stringer **402** are cured after removing carrier material **418**. For example, plurality of segments of radius filler **409** and stringer **402** may be components of a larger composite layup. In this example, after positioning the other components of the larger composite layup, the composite layup is co-cured as a whole. For example, plurality of segments of radius filler **409** and stringer **402** may be components of a barrel section of an aircraft. In this illustrative example, the barrel section may be cured after a composite skin is placed over plurality of segments of radius filler **409** and stringer **402.**

The illustration of radius filler kit **400**, carrier material **418**, and stiffener forming tool **300** in **Figure 4** are not meant to imply physical or architectural limitations to the manner in which an illustrative embodiment may be implemented. Other components in addition to or in place of the ones illustrated may be used. Some components may be unnecessary.

As discussed, channel **404** is a portion of stiffener forming tool **300**. In other illustrative examples, channel **404** may be a portion of a stiffener forming tool having a different size, shape, or quantity of channels. Radius filler kit **400** is depicted as having two radius filler sections. In other illustrative examples, radius filler kit **400** may have greater than two radius filler sections.

As another example, first section of radius filler **410** and second section of radius filler **414** have domed cross-sectional shape **422**. In other non-depicted illustrative examples, first section of radius filler **410** and second section of radius filler **414** may have other desirable

shapes. For example, first section of radius filler **410** and second section of radius filler **414** may have a triangular cross-sectional shape.

Radius filler kit **400** may be positioned and applied to stringer **404** in any desirable fashion such as manually, in an automated fashion, or some combination of the two. For example, carrier material **418** may be maneuvered manually or using automated equipment. In some illustrative examples, a compression force is applied to radius filler kit **400** manually. In some illustrative examples, a compression force is applied to radius filler kit **400** in an automated fashion.

Turning now to **Figure 5**, an illustration of a perspective view of radius fillers and a ply on a radius filler forming tool is depicted in accordance with an illustrative embodiment. Radius filler forming tool **500** is a physical implementation of radius filler forming tool **112**. Plurality of segments of radius filler **502** have been positioned onto radius filler forming tool **200**. Plurality of segments of radius filler **502** is a physical implementation of plurality of segments of radius filler **132** of **Figure 1**.

Radius filler forming tool **500** is a physical implementation of radius filler forming tool **112** of **Figure 1**. Plurality of segments of radius filler **502** have been positioned onto radius filler forming tool **500**. Plurality of segments of radius filler **502** is a physical implementation of plurality of segments of radius filler **132** of **Figure 1**.

In this illustrative example, plurality of segments of radius filler **502** have been placed into number of grooves **504** in surface **506** of radius filler forming tool **500**. As depicted, plurality of segments of radius filler **502** include radius filler **508** placed into groove **510** of number of grooves **504** and radius filler **512** placed into groove **514** of number of grooves **504**.

As depicted, radius filler **508** includes three portions of radius filler joined by joint **516** and joint **518**. As depicted, radius filler **512** includes three portions of radius filler joined by joint **520** and joint **522**.

Groove **510** and groove **514** are separated by distance **524**. As depicted, radius filler **508** and radius filler **512** are separated by distance **524**. Distance **524** is equivalent to a distance between a first gap and a second gap of a stringer, such as stringer **602** of **Figure 6**. As depicted, distance **524** has a constant or substantially constant value. However, in other non-depicted illustrative examples, distance **524** has multiple values. When distance **524** has multiple values, radius filler **508** and radius filler **512** are not parallel.

In some illustrative examples, number of grooves **504** in surface **506** is configured to shape plurality of segments of radius filler **502**. In one illustrative example, number of grooves **504** in surface **506** is configured to shape plurality of segments of radius filler **502** into a domed cross-sectional shape. In another illustrative example, number of grooves **504** in surface **506** is configured to shape plurality of segments of radius filler **502** into a triangular cross-sectional shape. Number of grooves **504** in surface **506** may shape plurality of segments of radius filler **502** when a compressive force is applied to plurality of segments of radius filler **502**.

As depicted, ply **526** is being laid over plurality of segments of radius filler **502**. After applying ply **526** over plurality of segments of radius filler **502**, a compression force is applied to plurality of segments of radius filler **502** and ply **526** to form a radius filler kit. After forming the radius filler kit, the radius filler kit is applied to a stringer, such as stringer **402** of **Figure 4** or stringer **602** of **Figure 6**. A compression force may be applied in any desirable way. In some illustrative examples, the compression force is a mechanical compression force. In other illustrative examples, the compression force is a pneumatic compression force, such as applying a vacuum.

In some illustrative examples, the radius filler kit, including ply **526** and plurality of segments of radius filler **502**, is positioned and applied onto a stringer using radius filler forming tool **500**. In these illustrative examples, radius filler forming tool **500** includes a flexible material. In these illustrative examples, the flexible material is flexible about a line perpendicular to number of grooves **504** in surface **506**. In other illustrative examples with different curvatures, the flexible material may be flexible in any desired direction.

In other illustrative examples, the radius filler kit, including ply **526** and plurality of segments of radius filler **502**, is removed from radius filler forming tool **500** using a carrier material (not depicted). In some illustrative examples, the carrier material is a vacuum bag material. In these illustrative examples, the vacuum bag material may be used to apply a vacuum to the radius filler kit on radius filler forming tool **500** and to apply the radius filler kit to a stringer.

Vacuum channels **528** in surface **506** surround number of grooves **504**. Vacuum channels **528** are used to form a seal around number of grooves **504** to apply vacuum to ply **526** and plurality of segments of radius filler **502**.

In some illustrative examples, the carrier material may be a component of a radius filler placement system, such as radius filler placement system **154** of **Figure 1**. In other illustrative examples, a pick and place machine is used to remove the radius filler kit from radius filler forming tool **500** and place the radius filler kit onto a stringer.

Turning now to **Figure 6**, an illustration of a perspective view of a radius filler kit being positioned relative to a stringer is depicted in accordance with an illustrative embodiment. Radius filler kit **600** is a physical implementation of radius filler kit **100** of **Figure 1**. Radius filler kit **600** is positioned relative to stringer **602**. Stringer **602** is a physical implementation of stringer **124** of **Figure 1**.

As depicted, stringer **602** is within channel **604** of stiffener forming tool **605**. Stiffener forming tool **605** may be a physical implementation of stiffener forming tool **180** of **Figure 1**. Stiffener forming tool **605** may be a portion of stiffener forming tool **300** of **Figure 3**. When stiffener forming tool **605** is a portion of stiffener forming tool **300**, stringer **602** has been placed in one of plurality of channels **302** of stiffener forming tool **300** of **Figure 3**.

Bladder **606** is positioned within stringer **602**. Bladder **606** maintains shape **608** of stringer **602** during curing.

Radius filler kit **600** is positioned relative to stringer **602**. Radius filler kit **600** comprises plurality of segments of radius filler **609**. Plurality of segments of radius filler **609** forms first section of radius filler **610** and second section of radius filler **614**. Radius filler kit **600** is positioned such that first section of radius filler **610** will be placed into first gap **612** of stringer **602**. Radius filler kit **600** is positioned such that second section of radius filler **614** will be placed into second gap **616** of stringer **602**.

Radius filler kit **600** further comprises ply **617**. As depicted, ply **617** is positioned between plurality of segments of radius filler **609** and carrier material **618**. After application of radius filler kit **600** to string **602**, ply **617** forms an "inner mold line (IML) ply" of a resulting stiffener.

As depicted, radius filler kit **600** is being carried on carrier material **618**. Carrier material **618** is formed of any desirable material. In some illustrative examples, carrier material **618** is a vacuum bag material. In some illustrative examples, carrier material **618** is a portion of a radius filler placement system, such as radius filler placement system **154** of **Figure 1**.

Radius filler kit **600** is applied to stringer **602** by lowering carrier material **618** towards stringer **602**. Radius filler kit **600** is lowered such that plurality of segments of radius filler **609** is applied to first gap **612** and second gap **616** of stringer **602**. First gap **612** and second gap **616** are separated by distance **620**. First section of radius filler **610** and second section of radius filler **614** on carrier material **618** are separated by distance **620** prior to application to stringer **602**.

Plurality of segments of radius filler **609** is applied to first gap **612** and second gap **616** simultaneously. Radius filler kit **600**, including first section of radius filler **610** and second section of radius filler **614**, is lowered such that first section of radius filler **610** is applied to first gap **612** and second section of radius filler **614** is applied to second gap **616** simultaneously.

Carrier material **618** and radius filler kit **600** are lowered towards stiffener forming tool **605** to apply radius filler kit **600** to stringer **602**. In some illustrative examples, carrier material **618** holding radius filler kit **600** may be transported in a substantially planar state. In other illustrative examples, carrier material **618** holding radius filler kit **600** may be transported in a rolled state. In some illustrative examples, applying plurality of segments of radius filler **609** comprises unrolling carrier material **618** and radius filler kit **600**. In other illustrative examples, carrier material **618** and radius filler kit **600** are unrolled after transportation but prior to application of radius filler kit **600** to stringer **602**.

After applying radius filler kit **600** to stringer **602**, a compression force is applied to create a greater adhesive force between radius filler kit **600** and stringer **602** than between radius filler kit **600** and carrier material **618**. When the adhesive force between radius filler kit **600** and stringer **602** is greater than the adhesive force between radius filler kit **600** and carrier material **618**, carrier material **618** may be removed from radius filler kit **600**. In some illustrative examples, carrier material **618** is pulled or peeled off of radius filler kit **600**. In some illustrative examples, carrier material **618** is rolled onto a manifold to remove carrier material **618** from radius filler kit **600**. In some illustrative examples, carrier material **618** is removed from radius filler kit **600** as a whole. When carrier material **618** is removed from radius filler kit **600**, first section of radius filler **610** remains in first gap **612** and second section of radius filler **614** remains in second gap **616**.

In some illustrative examples, carrier material **618** is a vacuum bag material. When carrier material **618** is a vacuum bag material, the vacuum bag material may be sealed to stiffener forming tool **605** holding stringer **602** after applying radius filler kit **600** to stringer **602**.

In these illustrative examples, a vacuum may be applied to plurality of segments of radius filler **609** and stringer **602** to apply compression force to plurality of segments of radius filler **609**. After applying the vacuum, carrier material **618** is removed.

In some illustrative examples, plurality of segments of radius filler **609** and stringer **602** may be cured prior to removing carrier material **618**. In other illustrative examples, plurality of segments of radius filler **609** and stringer **602** are cured after removing carrier material **618**. For example, plurality of segments of radius filler **609** and stringer **602** may be components of a larger composite layup. In this example, after positioning the other components of the larger composite layup, the composite layup is co-cured as a whole. For example, plurality of segments of radius filler **609** and stringer **602** may be components of a barrel section of an aircraft. In this illustrative example, the barrel section may be cured after a composite skin is placed over plurality of segments of radius filler **609** and stringer **602.**

The illustration of radius filler kit **600**, carrier material **618**, and stiffener forming tool **605** in **Figure 6** is not meant to imply physical or architectural limitations to the manner in which an illustrative embodiment may be implemented. Other components in addition to or in place of the ones illustrated may be used. Some components may be unnecessary. Also, the blocks are presented to illustrate some functional components. One or more of these blocks may be combined, divided, or combined and divided into different blocks when implemented in an illustrative embodiment.

Channel **604** may be a portion of a stiffener forming tool having any desirable size, shape, or quantity of channels. Channel **604** may have any desirable size or shape. Radius filler kit **600** is depicted as having two radius filler sections. In other illustrative examples, radius filler kit **600** may have greater than two radius filler sections.

As another example, first section of radius filler **610** and second section of radius filler **614** have domed cross-sectional shape **622**. In other non-depicted illustrative examples, first section of radius filler **610** and second section of radius filler **614** may have other desirable shapes. For example, first section of radius filler **610** and second section of radius filler **614** may have a triangular cross-sectional shape.

Radius filler kit **600** may be positioned and applied to stringer **604** in any desirable fashion such as manually, in an automated fashion, or some combination of the two. For example, carrier material **618** may be maneuvered manually or using automated equipment. In

some illustrative examples, a compression force is applied to radius filler kit **600** manually. In some illustrative examples, a compression force is applied to radius filler kit **600** in an automated fashion.

Turning now to **Figure 7**, an illustration of an isometric view of a radius filler placement system having a manifold is depicted in accordance with an illustrative embodiment. Radius filler placement system **700** is a physical implementation of radius filler placement system **154** of **Figure 1**. In some illustrative examples, carrier material **418** of **Figure 4** is a component of radius filler placement system **700** of **Figure 7**. In some illustrative examples, carrier material **618** of **Figure 6** is a component of radius filler placement system **700** of **Figure 7**.

Radius filler placement system **700** has roller manifold **702** and carrier material **704**. Carrier material **704** is bonded to roller manifold **702**. Vacuum is supplied to a vacuum chamber (not depicted) of roller manifold **702** through vacuum supply **706** connected to first end **708** of roller manifold **702**. Second end **710** of roller manifold **702** is sealed to create the vacuum chamber (not depicted) inside roller manifold **702**.

Carrier material **704** may be used to lift a radius filler kit from a radius filler forming tool, such as lifting radius filler kit **100** from radius filler forming tool **112** of **Figure 1**. Carrier material **704** may be used to lift a radius filler kit from at least one of radius filler forming tool **200** of **Figure 2** or radius filler forming tool **500** of **Figure 5**.

To lift a radius filler kit, a vacuum is pulled between carrier material **704** and a radius filler forming tool. After lifting the radius filler kit, the radius filler kit and carrier material **704** may be wrapped in a roll around roller manifold **702**. A radius filler kit may be transported in a rolled state on radius filler placement system **700**.

Carrier material **704** may also be used as a backing paper and a compaction bag when applying a radius filler kit to a stringer. To apply a radius filler kit to a stringer, carrier material **704** and the radius filler kit are unrolled from roller manifold **702**. Afterwards, a vacuum is pulled beneath carrier material **704** to compact the radius filler kit and remove the radius filler kit from carrier material **704**.

Radius filler placement system **700** may reduce at least one of manufacturing time or manufacturing cost. Radius filler placement system **700** is reusable. Further, radius filler placement system **700** may replace disposable manufacturing materials. For example, radius

filler placement system **700** may replace disposable vacuum bagging materials. Radius filler placement system **700** may reduce manufacturing waste.

Radius filler placement system **700** may be operated in any desirable manner. Radius filler placement system **700** may be placed and operated manually, in an automated fashion, or some combination of the two. In some illustrative examples, radius filler placement system **700** is positioned manually. In other illustrative examples, radius filler placement system **700** is positioned using an automated system. In some illustrative examples, radius filler placement system **700** is rolled manually. In other illustrative examples, radius filler placement system **700** is rolled in a completely or partially automated fashion.

Turning now to **Figure 8**, an illustration of a cross-sectional view of a radius filler placement system having a manifold is depicted in accordance with an illustrative embodiment. View **800** is a cross-sectional view of radius filler placement system **700** of **Figure 7**.

Radius filler placement system **700** has roller manifold **702** having vacuum opening **801**. Carrier material **704** takes the form of vacuum bag material **802**. Vacuum bag material **802** is connected to roller manifold **702**. Vacuum bag material **802** has opening **803** interfacing with vacuum opening **801**.

As depicted in view **800**, carrier material **704** comprises multiple layers. As depicted, carrier material **704** is formed from first layer **804** and second layer **806**. First layer **804** is formed of a vacuum bagging material. In some illustrative examples, first layer **804** is formed of a latex material. In some illustrative examples, first layer **804** may be referred to as a first latex sheet.

Vacuum bag material **802** is configured to lift a composite material. The composite material may take any desirable form. In some illustrative examples, the composite material includes a ply, such as ply **108** of **Figure 1**. In some illustrative examples, the composite material includes the composite material includes plurality of segments of radius filler **132** of **Figure 1**. In some illustrative examples, the composite material includes radius filler kit **100** of **Figure 1**.

First layer **804** has first surface **808** and second surface **810**. First surface **808** is configured to have a tackiness desirable to form a vacuum seal between first surface **808** and tooling. Second surface **810** is configured to be substantially non-adhesive. For example, second surface **810** is configured to prevent second surface **810** from sticking to roller manifold

702. As another example, second surface **810** is configured to prevent second surface **810** from sticking to a composite material of a radius filler kit.

Second layer **806** is formed of a vacuum bagging material. In some illustrative examples, second layer **806** is formed of a latex material. In some illustrative examples, second layer **806** may be referred to as a second latex sheet.

Although not depicted, second layer **806** is bonded to first layer **804**. The second latex sheet is bonded to the first latex sheet in any desirable fashion. In some illustrative examples, one of epoxy, mechanical fasteners, or welding connects first layer **804** and second layer **806** in selected locations.

Second layer **806** has first surface **812** and second surface **814**. First surface **812** is configured to have a tackiness desirable to adhere to a composite material of a radius filler kit. First surface **812** has a tackiness desirable to act as a carrier for the radius filler kit.

Second surface **814** is configured to be substantially non-adhesive. For example, second surface **814** is configured to prevent second surface **814** from sticking to first surface **808** of first layer **804**. As another example, second surface **810** is configured to allow for distribution of vacuum between first layer **804** and second layer **806**.

Breather **816** is positioned between first layer **804** and second layer **806**. Breather **816** distributes vacuum to the edge of first layer **804**. Breather **816** is in vacuum communication with vacuum opening **801**.

In some illustrative examples, when first layer **804** and second layer **806** are a first latex sheet and a second latex sheet, each have a respective mesh surface. In some illustrative examples, second surface **810** of first layer **804** is a mesh surface. In some illustrative examples, second surface **814** of second layer **806** is a mesh surface.

As depicted, roller manifold **702** has machined surface **818**. As depicted, vacuum bag material **802** is connected to machined surface **818**. Machined surface **818** may ease positioning of vacuum opening **801** relative to a tool. As depicted, vacuum opening **801** is positioned within machined surface **818**.

The illustrations of radius filler placement system **700** in **Figures 7** and **8** are not meant to imply physical or architectural limitations to the manner in which an illustrative embodiment may be implemented. Other components in addition to or in place of the ones illustrated may be used. Some components may be unnecessary. Also, the blocks are presented to illustrate some

functional components. One or more of these blocks may be combined, divided, or combined and divided into different blocks when implemented in an illustrative embodiment.

Although not depicted, in some illustrative examples, radius filler placement system **700** may include at least one heating element. For example, vacuum bag material **802** may have integrated heating elements. As another example, roller manifold **702** may have a heating element.

Turning now to **Figure 9**, an illustration of a radius filler placement system having a roller manifold sealed to a radius filler forming tool is depicted in accordance with an illustrative embodiment. In view **900**, radius filler placement system **700** of **Figures 7** and **8** is sealed to radius filler forming tool **902**. In view **900**, first layer **804** is transparent to more easily view radius filler forming tool **902**. Radius filler forming tool **902** is a physical implementation of radius filler forming tool **112** of **Figure 1**. In some illustrative examples, radius filler forming tool **902** may be radius filler forming tool **200** of **Figure 2** or radius filler forming tool **500** of **Figure 5**.

As depicted, first layer **804** of carrier material **704** is sealed to vacuum channel **904** of radius filler forming tool **902**. Second layer **806** extends across radius filler kit **906**. In view **900**, first layer **804** is transparent to more easily view second layer **806**. As depicted, radius filler kit **906** has first section of radius filler **908**, second section of radius filler **910**, and ply **912**. Each of first section of radius filler **908**, second section of radius filler **910**, and ply **912** are present between radius filler forming tool **902** and second layer **806.** Each of first section of radius filler **908**, second section of radius filler **910**, and ply **912** are shown in dashed lines to depict placement below second layer **806.**

After releasing vacuum from beneath carrier material **704**, radius filler kit **906** is carried by second layer **806**. In some illustrative examples, after releasing vacuum from beneath carrier material **704**, radius filler kit **906** and carrier material **704** are rolled onto roller manifold **702**.

Radius filler placement system **700** may be operated to lift radius filler kit **906** in any desirable manner. Radius filler placement system **700** may be placed and operated manually, in an automated fashion, or some combination of the two. In some illustrative examples, radius filler placement system **700** is positioned relative to radius filler kit **906** and radius filler forming tool **902** manually. In other illustrative examples, radius filler placement system **700** is positioned relative to radius filler kit **906** and radius filler forming tool **902** using an automated

system. Radius filler placement system **700** may apply a compressive force using vacuum based on operator supplied or system supplied commands.

After applying a compression force, radius filler placement system **700** is used to lift radius filler kit **906** from radius filler forming tool **902**. In some illustrative examples, radius filler placement system **700** is removed from radius filler forming tool **902** manually. In other illustrative examples, radius filler placement system **700** is removed from radius filler forming tool **902** using completely or partially automated equipment.

In some illustrative examples, after applying a compression force, radius filler placement system **700** is rolled. In some illustrative examples, radius filler placement system **700** holding radius filler kit **906** is rolled manually. In other illustrative examples, radius filler placement system **700** holding radius filler kit **906** is rolled in a completely or partially automated fashion.

Turning now to **Figure 10**, an illustration of a radius filler placement system having a manifold sealed to a stiffener forming tool having a stringer is depicted in accordance with an illustrative embodiment. In view **1000**, radius filler placement system **700** of **Figures 7** and **8** is sealed to bladder **1002** and stiffener forming tool **1004**. More specifically, first layer **804** of carrier material **704** is sealed to bladder **1002** and stiffener forming tool **1004**. In view **1000**, first layer **804** is transparent for ease of viewing stringer **1006** and bladder **1002**.

More specifically, radius filler placement system **700** is sealed around stringer **1006** to receive radius filler kit **906** of **Figure 9**. Stringer **1006** is positioned on stiffener forming tool **1004**.

By applying vacuum beneath carrier material **704**, radius filler kit **906** is pressed against stringer **1006**. After releasing the vacuum from beneath carrier material **704**, radius filler placement system **700** is removed from stiffener forming tool **1004**. After removing radius filler placement system **700**, radius filler kit **906** remains on stringer **1006**.

In view **1000**, a cutaway is present to depict the positioning of second layer **806** of carrier material **704** and radius filler kit **906** relative to stringer **1006**. This cut-away view is present only for illustrative purposes of the positioning of second layer **806** and radius filler kit **906** and is not intended to imply limits as to the length of carrier material **704** and radius filler kit **906.** For example, although a cut-away is depicted, radius filler kit **906** may extend to the edge of stringer **1006**.

Radius filler placement system **700** may be operated to position and apply radius filler kit **906** in any desirable manner. Radius filler placement system **700** may be placed and operated manually, in an automated fashion, or some combination of the two. In some illustrative examples, radius filler placement system **700** is positioned relative to stringer **1006** manually. In other illustrative examples, radius filler placement system **700** is positioned relative to stringer **1006** using an automated system. Radius filler placement system **700** may apply a compressive force using vacuum based on operator supplied or system supplied commands.

After applying a compression force, radius filler placement system **700** is removed from radius filler kit **906** and stringer **1006**. In some illustrative examples, radius filler placement system **700** is removed from radius filler kit **906** and stringer **1006** manually. In other illustrative examples, radius filler placement system **700** is removed from radius filler kit **906** and stringer **1006** using completely or partially automated equipment.

The different components shown in **Figures 2-10** may be combined with components in **Figure 1**, used with components in **Figure 1**, or a combination of the two. Additionally, some of the components in **Figures 2-10** may be illustrative examples of how components shown in block form in **Figure 1** can be implemented as physical structures.

Turning now to **Figures 11A** and **11B**, illustrations of flowcharts of a method for applying more than one segment of a radius filler to a stringer is depicted in accordance with an illustrative embodiment. Method **1100** may be implemented to form and apply radius filler kit **100** of **Figure 1**. Method **1100** may be implemented using radius filler forming tool **112** and radius filler placement equipment **144** of **Figure 1**. Method **1100** may be implemented using radius filler forming tool **200** of **Figure 2**. Method **1100** may be implemented to apply a plurality of segments of radius filler to a stringer, on a stiffener forming tool, such as stiffener forming tool **300** of **Figures 3** and **4**. Method **1100** may be implemented using radius filler forming tool **500** of **Figure 5**. Method **1100** may be implemented using a radius filler placement system having a roller manifold such as radius filler placement system **700** of **Figures 7-10.**

Method **1100** positions a plurality of segments of radius filler onto a radius filler forming tool (operation **1102**). Method **1100** applies the plurality of segments of radius filler to a stringer in a single placement step (operation **1104**). Afterwards, the method terminates.

In some illustrative examples, positioning the plurality of segments of radius filler comprises forming joints using the plurality of segments of radius filler (operation **1106**). In

some illustrative examples, positioning the plurality of segments of radius filler comprises forming a plurality of butt joints. In some illustrative examples, by forming joints, the plurality of segments of radius filler are formed into a smaller quantity of sections of radius filler, each section having a greater length than the provided length of the plurality of segments of radius filler. In one illustrative example, the plurality of segments of radius filler may have a manufactured length in the range of four feet to six feet. In this illustrative example, the plurality of segments of radius filler are joined to form at least one section of radius filler that is greater than the manufactured length of the plurality of segments of radius filler. For example, the at least one section of radius filler may be 10 feet long, 20 feet long, 25 feet long, or any other desirable length.

In some illustrative examples of method **1100**, the plurality of segments of radius filler are joined to form more than one section of radius filler. In some illustrative examples, the resulting sections of radius filler are each greater than the manufactured length of the plurality of segments of radius filler. In some illustrative examples, the resulting sections of radius filler are all the same length.

In some illustrative examples of method **1100**, positioning the plurality of segments of radius filler comprises placing the plurality of segments of radius filler into two grooves in the radius filler forming tool, wherein the two grooves are separated by a distance (operation **1108**). By positioning the plurality of segments of radius filler into two grooves in the radius filler forming tool, at least two sections of radius filler are formed. By positioning the plurality of segments of radius filler into two grooves in the radius filler forming tool, a first section of radius filler and a second section of radius filler are created separated by the distance.

In some illustrative examples of method **1100**, applying the plurality of segments of radius filler to the stringer comprises applying the plurality of segments to a first gap and a second gap of the stringer, wherein the first gap and the second gap are separated by the distance (operation **1110**). In some illustrative examples of method **1100**, applying the plurality of segments of radius filler to the first gap and the second gap comprises the plurality of segments of radius filler to the first gap and the second gap simultaneously (operation **1112**).

In some illustrative examples, the plurality of segments of radius filler are applied to the stringer using the radius filler forming tool. In some illustrative examples of method **1100**, applying the plurality of segments of radius filler comprises bending the radius filler forming

tool to press the plurality of segments against the stringer and remove the plurality of segments of radius filler from the radius filler forming tool (operation **1114**). In some illustrative examples, method **1100** further comprises co-curing the plurality of segments of radius filler and the stringer to form a portion of an aircraft (operation **1115**).

In other illustrative examples, radius filler placement equipment other than the radius filler forming tool is used to apply the plurality of segments of radius filler to the stringer. In some illustrative examples, method **1100** lifts the plurality of segments of radius filler from the radius filler forming tool using a carrier material, wherein applying the plurality of segments of radius filler is performed using the carrier material (operation **1116**). The carrier material takes the form of any desirable type of material.

In some illustrative examples, the carrier material is a vacuum bag material, and method **1100** seals the vacuum bag material to a stiffener forming tool holding the stringer (operation **1118**). In some illustrative examples, method **1100** also applies a vacuum to the plurality of segments of radius filler and the stringer to apply compression force to the plurality of segments of radius filler (operation **1120**). The compression force applied is sufficient to create an adhesion between the plurality of segments of radius filler and the stringer that is greater than the adhesion between the plurality of segments of radius filler and the vacuum bag material. After applying the vacuum to apply the compression force, the vacuum bag may be removed from the stringer, leaving the plurality of segments of radius filler in contact with the stringer.

In some illustrative examples, the vacuum bag material is a component of a radius filler placement system, and method **1100** rolls the plurality of segments of radius filler and the carrier material around a manifold of a radius filler placement system (operation **1122**). In some illustrative examples, applying the plurality of segments of radius filler to the stringer comprises unrolling the plurality of segments of radius filler from the roller manifold (operation **1124**).

Turning now to **Figure 12**, an illustration of a flowchart of a method for using a radius filler kit is depicted in accordance with an illustrative embodiment. Method **1200** may be implemented to position and apply radius filler kit **100** of **Figure 1**. Method **1200** may be implemented using radius filler placement equipment **144** of **Figure 1**. Method **1200** may be implemented to apply a plurality of segments of radius filler to a stringer, on a stiffener forming tool, such as stiffener forming tool **300** of **Figures 3** and **4**. Method **1200** may be implemented

using a radius filler placement system having a roller manifold such as radius filler placement system **700** of **Figures 7-10.**

Method **1200** positions a radius filler kit relative to a stringer (operation **1202**). Method **1200** applies the radius filler kit to the stringer in a single placement step (operation **1204**). Afterwards, the method terminates.

In some illustrative examples, the radius filler kit is transported in a rolled state. For example, the radius filler kit may be rolled on a carrier material for at least one of transportation or storage purposes. In these illustrative examples, applying the radius filler kit to the stringer comprises unrolling the radius filler kit to contact the stringer (operation **1206**).

In some illustrative examples, applying the radius filler kit to the stringer comprises placing a first section of a radius filler of the radius filler kit into a first gap of the stringer and a second section of the radius filler of the radius filler kit into a second gap of the stringer (operation **1208**). Further, in some of these illustrative examples, applying the radius filler kit to the stringer places the first section of the radius filler and the second section of the radius filler simultaneously (operation **1210**).

In some illustrative examples, the radius filler kit is transported using a radius filler forming tool. In some of these illustrative examples, the radius filler kit may be applied to the stringer using the radius filler forming tool. In one illustrative example, applying the radius filler kit to the stringer comprises bending a radius filler forming tool to press the plurality of segments against the stringer and remove the plurality of segments of radius filler from the radius filler forming tool (operation **1212**).

In some illustrative examples of method **1200**, applying the radius filler kit comprises simultaneously applying a first section of radius filler, a second section of radius filler, and a ply to a stringer (operation **1214**). By simultaneously applying the first section of the radius filler, the second section of the radius filler, and the ply to the stringer, the application time to the stringer is reduced.

In some illustrative examples, method **1200** applies a compression force to the radius filler kit (operation **1216**). By applying a compression force to the radius filler kit, the radius filler kit is transferred to the stringer.

In some illustrative examples, method **1200** seals a vacuum bag material to a stiffener forming tool holding the stringer (operation **1218**). In some illustrative examples, method **1200**

then applies a vacuum to the stringer and radius filler kit below the vacuum bag material (operation **1220**). In some illustrative examples, the vacuum applies a compaction force to the radius filler kit. In some illustrative examples, by applying a vacuum to the stringer and the radius filler kit, the radius filler kit is transferred from the vacuum bag material to the stringer.

In some illustrative examples, method **1200** co-cures the radius filler kit and the stringer to form a portion of an aircraft (operation **1222**). The radius filler kit and the stringer may comprise any desirable portion of an aircraft that has a composite stiffener.

Turning now to **Figure 13**, an illustration of a flowchart of a method for forming a radius filler kit is depicted in accordance with an illustrative embodiment. Method **1300** may be implemented using radius filler forming tool **112** of **Figure 1**. Method **1300** may be implemented using radius filler forming tool **200** of **Figure 2**. Method **1300** may be implemented using radius filler forming tool **500** of **Figure 5**. Method **1300** may result in radius filler kit **600** of **Figure 6**.

Method **1300** positions a plurality of segments of radius filler onto a radius filler forming tool (operation **1302**). Method **1300** applies a ply over the plurality of segments of radius filler (operation **1304**). Method **1300** applies a compression force to the plurality of segments of radius filler and the ply to form a radius filler kit (operation **1306**). Afterwards, the method terminates.

In some illustrative examples, positioning the plurality of segments of radius filler comprises forming joints using the plurality of segments of radius filler (operation **1308**). In some illustrative examples, positioning the plurality of segments of radius filler comprises forming a plurality of butt joints. In some illustrative examples, by forming joints, the plurality of segments of radius filler is formed into a smaller quantity of sections of radius filler, each section having a greater length than the provided length of the plurality of segments of radius filler. In one illustrative example, the plurality of segments of radius filler may have a manufactured length in the range of four feet to six feet. In this illustrative example, the plurality of segments of radius filler is joined to form at least one section of radius filler that is greater than the manufactured length of the plurality of segments of radius filler. For example, the at least one section of radius filler may be 10 feet long, 20 feet long, 25 feet long, or any other desirable length.

In some illustrative examples of method **1100**, the plurality of segments of radius filler is joined to form more than one section of radius filler. In some illustrative examples, the resulting sections of radius filler are each greater than the manufactured length of the plurality of segments of radius filler. In some illustrative examples, the resulting sections of radius filler are all the same length.

In some illustrative examples, positioning the plurality of segments of radius filler comprises placing the plurality of segments of radius filler into two grooves in the radius filler forming tool, wherein the two grooves are separated by a distance (operation **1310**).

In some illustrative examples, placing the plurality of segments of radius filler into the two grooves forms a first section of radius filler and a second section of radius filler (operation **1312**). In some illustrative examples, method **1300** also coils the radius filler kit and a carrier material into a roll, wherein the first section of radius filler and a second section of radius filler are separated by the distance (operation **1314**).

In some illustrative examples, method **1300** shapes the plurality of segments of radius filler using a number of grooves of the radius filler forming tool (operation **1316**). The number of grooves of the radius filler forming tool may impart any desirable shape to plurality of segments of radius filler. In some illustrative examples, the number of grooves are configured to shape the plurality of segments of radius filler to a domed cross-sectional shape. In some illustrative examples, the number of grooves are configured to shape the plurality of segments of radius filler to a triangular cross-sectional shape.

After forming the radius filler kit, the radius filler kit will be transported for application to a stringer. In some illustrative examples, the radius filler kit will be stored prior to application to a stringer. In some illustrative examples, the radius filler kit is at least one of transported or stored on the radius filler forming tool.

In other illustrative examples, method **1300** removes the radius filler kit from the radius filler forming tool using a carrier material (operation **1318**). In some illustrative examples, method **1300** coils the radius filler kit and the carrier material into a roll (operation **1320**).

In some illustrative examples, the carrier material is a component of a radius filler placement system. In these illustrative examples, coiling the radius filler kit and the carrier material into a roll comprises rolling the radius filler kit and the carrier material around a manifold of a radius filler placement system (operation **1322**).

In some illustrative examples, method **1300** applies the radius filler kit to a stringer (operation **1324**). In some illustrative examples, method **1300** also co-cures the radius filler kit and the stringer (operation **1326**).

The flowcharts and block diagrams in the different depicted embodiments illustrate the architecture, functionality, and operation of some possible implementations of apparatus and methods in an illustrative embodiment. In this regard, each block in the flowcharts or block diagrams may represent a module, a segment, a function, and/or a portion of an operation or step.

In some alternative implementations of an illustrative embodiment, the function or functions noted in the blocks may occur out of the order noted in the figures. For example, in some cases, two blocks shown in succession may be executed substantially concurrently, or the blocks may sometimes be performed in the reverse order, depending upon the functionality involved. Also, other blocks may be added, in addition to the illustrated blocks, in a flowchart or block diagram.

In some illustrative examples, not all blocks of method **1100**, method **1200**, or method **1300** are performed. For example, each of operations **1116–1124** in **Figure 11B** may be optional operations of method **1100**. Additionally, operations **1106** and **1114** may be optional operations of method **1100**. As another example, each of operations **1206–1220** may be optional operations of method **1200**. More specifically, operations **1206** and operation **1212** may be alternative operations. As yet another example, each of operations **1308–1322** may be optional.

Illustrative embodiments of the present disclosure may be described in the context of aircraft manufacturing and service method **1400** as shown in **Figure 14** and aircraft **1500** as shown in **Figure 15**. Turning first to **Figure 14**, an illustration of an aircraft manufacturing and service method is depicted in accordance with an illustrative embodiment. During pre-production, aircraft manufacturing and service method **1400** may include specification and design **1402** of aircraft **1500** in **Figure 15** and material procurement **1404**.

During production, component and subassembly manufacturing **1406** and system integration **1408** of aircraft **1500** takes place. Thereafter, aircraft **1500** may go through certification and delivery **1410** in order to be placed in service **1412**. While in service **1412** by a customer, aircraft **1500** is scheduled for routine maintenance and service **1414**, which may include modification, reconfiguration, refurbishment, and other maintenance or service.

Each of the processes of aircraft manufacturing and service method **1400** may be performed or carried out by a system integrator, a third party, and/or an operator. In these examples, the operator may be a customer. For the purposes of this description, a system integrator may include, without limitation, any number of aircraft manufacturers or major-system subcontractors; a third party may include, without limitation, any number of vendors, subcontractors, or suppliers; and an operator may be an airline, a leasing company, a military entity, a service organization, and so on.

With reference now to **Figure 15**, an illustration of an aircraft is depicted in which an illustrative embodiment may be implemented. In this example, aircraft **1500** is produced by aircraft manufacturing and service method **1400** in **Figure 14** and may include airframe **1502** with a plurality of systems **1504** and interior **1506**. Examples of systems **1504** include one or more of propulsion system **1508**, electrical system **1510**, hydraulic system **1512**, and environmental system **1514**. Any number of other systems may be included. Although an aerospace example is shown, different illustrative embodiments may be applied to other industries, such as the automotive industry.

Apparatuses and methods embodied herein may be employed during at least one of the stages of aircraft manufacturing and service method **1400**. One or more illustrative embodiments may be used during component and subassembly manufacturing **1406**, system integration **1408,** or maintenance and surface **1414** of **Figure 14**. For example, radius filler kit **100** of **Figure 1** may be used to fill radiuses of composite layups during component and subassembly manufacturing **1406**. As another example, radius filler kit **100** of **Figure 1** may be used to fill radiuses of composite layups of replacement parts during maintenance and surface **1414** of **Figure 14**. Additionally, radius filler placement system **154** of **Figure 1** may be used to place composite material, such as radius fillers, during one of component and subassembly manufacturing **1406** or maintenance and surface **1414** of **Figure 14**.

Apparatuses and methods embodied herein may be employed in manufacturing at least one component of aircraft **1500**. For example, radius filler kit **100** of **Figure 1** may be used to manufacture at least one of airframe **1502** or interior **1506**. Further, radius filler placement system **154** of **Figure 1** may be used to place composite material, such as radius fillers or other desirable composite material, to manufacture at least one of airframe **1502** or interior **1506**.

The illustrative examples provide methods and apparatuses to form and apply radius filler kits. By applying radius filler kits, stringer assembly work is developed into a feeder line activity. The application of radius filler kits enables new forming methods for at least one of lower cost or higher rate fabrication.

The illustrative examples provide methods and apparatuses for alternatives to applying radius filler portions individually to a composite layup. The illustrative examples provide methods and apparatuses for applying multiple radius filler portions in a single application step.

The illustrative examples provide an off-line tool, the radius filler forming tool, which controls parallel spacing of the radius filler. In some illustrative examples, the radius filler forming tool shapes the radius filler (noodle). The illustrative examples offer the opportunity to pre-form the noodles to an approximate shape, assemble with an inner mold line fabric ply, transport to assembly, and then aid in installation into the assembly.

The illustrative examples reduce at least one of the quantity of compaction steps, radii buckling, or installation steps. For example, by compacting the ply onto the plurality of segments of radius filler on the radius filler forming tool, a quantity of compaction steps may be reduced. As another example, by pre-shaping the plurality of segments of radius filler, wrinkling or radii buckling may be reduced. The illustrative examples may result in reduced wrinkling due to a pre-formed noodle.

The illustrative examples provide the ability to pre-shape the noodles to a general shape and to kit the radius filler (noodles) with the IML (inner mold line) ply. In some illustrative examples, the radius filler kits are rolled into a spiral for storage. In some illustrative examples, latex material of a radius filler placement system enables rolling the radius filler kits into a spiral for storage. In some illustrative examples, by placing the radius filler (noodles) on the IML ply furnish, an indexing ability is provided relative to a bladder.

The illustrative examples provide a forming plate, the radius filler forming tool, to shape the radius filler (noodle). The illustrative examples allow for cold consolidation of the radius filler (noodle) to a prepreg ply. The illustrative examples provide a radius filler forming tool that pre-aligns the noodles to a desired parallel off-set. The illustrative examples provide a ready vacuum bag layer. The illustrative examples provide a radius filler placement system that has the ability to roll into a spiral for storage or carry, and will also work as an index feature.

One key process parameter to establish is the compaction force between plies and carrier material for adherence. The compaction force enables roll up and transfer, but is below a higher compaction force between prepreg and sub-assembly during final transfer.

In one illustrative example, the same material is used as a carrier, a roller, a backing paper, and a compaction bag. More specifically, the vacuum bag material of the radius filler placement system may be used as a carrier, a roller, a backing paper, and a compaction bag for a radius filler kit. The vacuum bag of the radius filler placement system may lift the radius filler kit from the radius filler forming tool, acting as a carrier. The vacuum bag of the radius filler placement system may then roll along with the radius filler kit, to act as a roller. The vacuum bag of the radius filler placement system may then be unrolled to position the radius filler kit relative to a stringer, acting as a backing paper. The vacuum bag of the radius filler system may then apply a vacuum to the radius filler kit, acting as a compaction bag.

The illustrative examples may transfer and kit entire subassemblies. In some illustrative examples, the subassembly is an inner mold line ply and radii fillers kit. In another illustrative example, radii fillers may be transferred and kitted.

The illustrative examples may transfer a radius filler kit in a roll form. In some illustrative examples, the radius filler kit includes a ply and a plurality of sections of radius filler.

Throughout this specification the word "comprise", or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated element, integer or step, or group of elements, integers or steps, but not the exclusion of any other element, integer or step, or group of elements, integers or steps.

The present apparatus and method is also referred to in the following clauses which are not to be confused with the claims.

A1. A method comprising:

positioning (1102) a plurality of segments of radius filler (132) onto a radius filler forming tool (112); and

applying (1104) the plurality of segments of radius filler (132) to a stringer (124) in a single placement step.

A2. There is also provided, the method of paragraph A1 further comprising:

co-curing (1115) the plurality of segments of radius filler (132) and the stringer (124) to form a portion of an aircraft (1500).

A3. There is also provided, the method of paragraph A1, wherein applying (1114) the plurality of segments of radius filler (132) comprises bending the radius filler forming tool (112) to press the plurality of segments of radius filler (132) against the stringer (124) and remove the plurality of segments of radius filler (132) from the radius filler forming tool (112).

A4. There is also provided, the method of paragraph A1 further comprising:

lifting (1116) the plurality of segments of radius filler (132) from the radius filler forming tool (112) using a carrier material (150), wherein applying the plurality of segments of radius filler (132) is performed using the carrier material (150).

A5. There is also provided, the method of paragraph A4, wherein the carrier material (150) is a vacuum bag material (152), the method further comprising:

sealing (1118) the vacuum bag material (152) to a stiffener forming tool (180) holding the stringer (124); and

applying (1120) a vacuum to the plurality of segments of radius filler (132) and the stringer (124) to apply compression force to the plurality of segments of radius filler (132).

A6. There is also provided, the method of paragraph A5, wherein the vacuum bag material (152) is a component of a radius filler placement system (154), the method further comprising:

rolling (1122) the plurality of segments of radius filler (132) and the carrier material (150) around a roller manifold (156) of a radius filler placement system (154).

A7. There is also provided, the method of paragraph A6, wherein applying (1124) the plurality of segments of radius filler (132) to the stringer (124) comprises unrolling the plurality of segments of radius filler (132) from the roller manifold (156).

A8. There is also provided, the method of paragraph A1, wherein positioning (1106) the plurality of segments of radius filler (132) comprises forming joints (136) using the plurality of segments of radius filler (132).

A9. There is also provided, the method of paragraph A1, wherein positioning (1108) the plurality of segments of radius filler (132) comprises placing the plurality of segments of radius filler (132) into two grooves (114) in the radius filler forming tool (112), wherein the two grooves (114) are separated by a distance (110).

A10. There is also provided, the method of paragraph A8, wherein applying (1110) the plurality of segments of radius filler (132) to the stringer (124) comprises applying the plurality of segments of radius filler (132) to a first gap (186) and a second gap (188) of the stringer (124), wherein the first gap (186) and the second gap (188) are separated by the distance (110).

A11. There is also provided, the method of paragraph A9, wherein applying (1112) the plurality of segments of radius filler (132) to the first gap (186) and the second gap (188) comprises the plurality of segments of radius filler (132) to the first gap (186) and the second gap (188) simultaneously.

According to a further aspect of the present apparatus or method, there is provided:

B1. A method comprising:
positioning (1202) a radius filler kit (100) relative to a stringer (124); and
applying (1204) the radius filler kit (100) to the stringer (124) in a single placement step.

B2. There is also provided, the method of paragraph B1 further comprising:
co-curing (1222) the radius filler kit (100) and the stringer (124) to form a portion of an aircraft (1500).

B3. There is also provided, the method of paragraph B1 further comprising:
applying (1216) a compression force (134) to the radius filler kit (100).

B4. There is also provided, the method of paragraph B1 further comprising:

sealing (1218) a vacuum bag material (152) to a stiffener forming tool (180) holding the stringer (124); and

applying (1220) a vacuum to the stringer (124) and radius filler kit (100) below the vacuum bag material (152).

B5. There is also provided, the method of paragraph B1, wherein applying (1206) the radius filler kit (100) to the stringer (124) comprises unrolling the radius filler kit (100) to contact the stringer (124).

B6. There is also provided, the method of paragraph B1, wherein applying (1208) the radius filler kit (100) to the stringer (124) comprises placing a first section of radius filler (104) of the radius filler kit (100) into a first gap (186) of the stringer (124) and a second section of radius filler (106) of the radius filler kit (100) into a second gap (188) of the stringer (124).

B7. There is also provided, the method of paragraph B6, wherein applying (1210) the radius filler kit (100) to the stringer (124) places the first section of radius filler (104) and the second section of radius filler (106) simultaneously.

B8. There is also provided, the method of paragraph B1, wherein applying (1212) the radius filler kit (100) to the stringer (124) comprises bending a radius filler forming tool (112) to press a plurality of segments of radius filler (132) of the radius filler kit (100) against the stringer (124) and remove the plurality of segments of radius filler (132) from the radius filler forming tool (112).

B9. There is also provided, the method of paragraph B1, wherein applying (1214) the radius filler kit (100) comprises simultaneously applying a first section of radius filler (104), a second section of radius filler (106), and a ply (108) to a stringer (124).

According to a further aspect of the present apparatus or method, there is provided:

C1. A method comprising:

positioning (1302) a plurality of segments of radius filler (132) onto a radius filler forming tool (112);

applying (1304) a ply (108) over the plurality of segments of radius filler (132); and

applying (1306) a compression force (134) to the plurality of segments of radius filler (132) and the ply (108) to form a radius filler kit (100).

C2. There is also provided, the method of paragraph C1 further comprising:

removing (1318) the radius filler kit (100) from the radius filler forming tool (112) using a carrier material (150).

C3. There is also provided, the method of paragraph C2 further comprising:

coiling (1320) the radius filler kit (100) and the carrier material (150) into a roll (153).

C4. There is also provided, the method of paragraph C3, wherein coiling (1322) the radius filler kit (100) and the carrier material (150) into a roll (153) comprises rolling the radius filler kit (100) and the carrier material (150) around a manifold (156) of a radius filler placement system (154).

C5. There is also provided, the method of paragraph C1 further comprising:

shaping (1316) the plurality of segments of radius filler (132) using a number of grooves (114) of the radius filler forming tool (112).

C6. There is also provided, the method of paragraph C1, wherein positioning (1308) the plurality of segments of radius filler (132) comprises forming joints (136) using the plurality of segments of radius filler (132).

C7. There is also provided, the method of paragraph C1, wherein positioning (1310) the plurality of segments of radius filler (132) comprises placing the plurality of segments of radius

filler (132) into two grooves (114) in the radius filler forming tool (112), wherein the two grooves (114) are separated by a distance (110).

C8. There is also provided, the method of paragraph C7, wherein placing (1312) the plurality of segments of radius filler (132) into the two grooves (114) forms a first section of radius filler (104) and a second section of radius filler (106).

C9. There is also provided, the method of paragraph C8 further comprising:

coiling (1314) the radius filler kit (100) and a carrier material (150) into a roll (153), wherein the first section of radius filler (104) and a second section of radius filler (106) are separated by the distance (110).

C10. There is also provided, the method of paragraph C1 further comprising:

applying (1324) the radius filler kit (100) to a stringer (124); and

co-curing (1326) the radius filler kit (100) and the stringer (124).

According to a further aspect of the present apparatus or method, there is provided:

D1

sheet (166) and the second latex sheet (168) each have a respec. An apparatus comprising:

a roller manifold (156) having a vacuum opening (158); and

a vacuum bag material (152) connected to the roller manifold (156), the vacuum bag material (152) having an opening (160) interfacing with the vacuum opening (158).

D2. There is also provided, the apparatus of paragraph D1, wherein the vacuum bag material (152) is a first latex sheet (166).

D3. There is also provided, the apparatus of paragraph D2 further comprising:

a second latex sheet (168) bonded to the first latex sheet (166).

D4. There is also provided, the apparatus of paragraph D3 further comprising:

a breather (172) positioned between the first latex sheet (166) and the second latex sheet (168), wherein the breather (172) is in vacuum communication with the vacuum opening (158).

D5. There is also provided, the apparatus of paragraph 33, wherein the first latex tive mesh surface.

D6. There is also provided, the apparatus of paragraph D1, wherein the roller manifold (156) has a machined surface (174), wherein the vacuum bag material (152) is connected to the machined surface (174).

D7. There is also provided, the apparatus of paragraph D6, wherein the vacuum opening (158) is positioned within the machined surface (174).

D8. There is also provided, the apparatus of paragraph D1, wherein vacuum bag material (152) has integrated heating elements (179).

D9. There is also provided, the apparatus of paragraph D1, wherein the roller manifold (156) has a heating element (171).

D10. There is also provided, the apparatus of paragraph D1 wherein the vacuum bag material (152) is configured to lift a composite material.

According to a further aspect of the present apparatus or method, there is provided:

E1. A radius filler forming tool (112) comprising:
a number of grooves (114) in a surface (116); and
vacuum channels (118) in the surface (116) surrounding the number of grooves (114).

E2. The radius filler forming tool (112) of paragraph E1, wherein each of the number of grooves (114) has a length equivalent to a length of a stringer (124).

E3. The radius filler forming tool (112) of paragraph E2, wherein the stringer (124) is a portion of an aircraft (1500).

E4. The radius filler forming tool (112) of paragraph E1 further comprising:
a flexible material (148).

E5. The radius filler forming tool (112) of paragraph E4, wherein the flexible material (148) is flexible about a line perpendicular to the number of grooves (114) in the surface (116).

E6. The radius filler forming tool (112) of paragraph E1, wherein the number of grooves (114) are configured to shape a plurality of segments of radius filler (132) to a domed cross-sectional shape.

According to a further aspect of the present apparatus or method, there is provided:

F1. An apparatus comprising:
a radius filler kit (100) on a carrier material (150), the radius filler kit (100) comprising a plurality of segments of radius filler (132); and
the carrier material (150).

F2. There is also provided, the apparatus of paragraph F1, wherein the plurality of segments of radius filler (132) comprises a first section of radius filler (104) and a second section of radius filler (106) separated from each other by a distance (110).

F3. There is also provided, the apparatus of paragraph F2, wherein the distance (110) is the same as a distance (110) between a first gap (186) and a second gap (188) of a stringer (124) of a portion of an aircraft (1500).

F4. There is also provided, the apparatus of paragraph F2, wherein the first section of radius filler (104) and the second section of radius filler (106) each comprise at least one joint.

F5. There is also provided, the apparatus of paragraph F2, wherein the first section of radius filler (104) and the second section of radius filler (106) have the same length.

F6. There is also provided, the apparatus of paragraph F1, wherein the plurality of segments of radius filler (132) has a domed cross-sectional shape.

F7. There is also provided, the apparatus of paragraph F1, wherein the radius filler kit (100) and the carrier material (150) are coiled into a roll (153).

F8. There is also provided, the apparatus of paragraph F1, wherein the radius filler kit (100) further comprises a ply (108) contacting the plurality of segments of radius filler (132).

The description of the different illustrative embodiments has been presented for purposes of illustration and description, and is not intended to be exhaustive or limited to the embodiments in the form disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art. Further, different illustrative embodiments may provide different features as compared to other illustrative embodiments. The embodiment or embodiments selected are chosen and described in order to best explain the principles of the embodiments, the practical application, and to enable others of ordinary skill in the art to understand the disclosure for various embodiments with various modifications as are suited to the particular use contemplated.

CLAIMS:

What is claimed is:

1. A composite forming method comprising:
positioning a plurality of segments of radius filler onto a radius filler forming tool;
applying a ply over the plurality of segments of radius filler;
applying a compression force to the plurality of segments of radius filler and the ply; and
applying the plurality of segments of radius filler to a stringer in a single placement step.

2. The method of claim 1 further comprising:
co-curing the plurality of segments of radius filler and the stringer to form a portion of an aircraft.

3. The method of claim 1 or 2, wherein applying the plurality of segments of radius filler comprises bending the radius filler forming tool to press the plurality of segments of radius filler against the stringer and remove the plurality of segments of radius filler from the radius filler forming tool.

4. The method of any one of claims 1 to 3 further comprising:
lifting the plurality of segments of radius filler from the radius filler forming tool using a carrier material, wherein applying the plurality of segments of radius filler is performed using the carrier material.

5. The method of claim 4, wherein the carrier material is a vacuum bag material, the method further comprising:
sealing the vacuum bag material to a stiffener forming tool holding the stringer; and
applying a vacuum to the plurality of segments of radius filler and the stringer to apply compression force to the plurality of segments of radius filler.

6. The method of claim 5, wherein the vacuum bag material is a component of a radius filler placement system, the method further comprising:

rolling the plurality of segments of radius filler and the carrier material around a roller manifold of a radius filler placement system.

7. The method of claim 6, wherein applying the plurality of segments of radius filler to the stringer comprises unrolling the plurality of segments of radius filler from the roller manifold.

8. The method of any of the preceding claims, wherein positioning the plurality of segments of radius filler comprises forming joints using the plurality of segments of radius filler; wherein applying the plurality of segments of radius filler to the stringer comprises applying the plurality of segments of radius filler to a first gap and a second gap of the stringer, wherein the first gap and the second gap are separated by a distance.

9. The method of claim 8, wherein applying the plurality of segments of radius filler to the first gap and the second gap comprises applying the plurality of segments of radius filler to the first gap and the second gap simultaneously.

10. The method of any one of the preceding claims, wherein positioning the plurality of segments of radius filler comprises placing the plurality of segments of radius filler into two grooves in the radius filler forming tool, wherein the two grooves are separated by a distance.

11. A radius filler forming tool for use in the method of any one of claims 1 to 10, the radius filler forming tool comprising:

a number of grooves in a surface; and

vacuum channels in the surface surrounding the number of grooves.

12. The radius filler forming tool of claim 11, wherein each of the number of grooves has a length equivalent to a length of the stringer.

13. The radius filler forming tool of claim 12, wherein the stringer is a portion of an aircraft.

14. The radius filler forming tool of any one of claims 11 to 13 further comprising:

a flexible material;

wherein the flexible material is flexible about a line perpendicular to the number of grooves in the surface.

15. The radius filler forming tool of any one of claims 11 to 14, wherein the number of grooves are configured to shape a plurality of segments of radius filler to a domed cross-sectional shape.

16. A method comprising:

applying a ply over a plurality of segments of radius filler;

applying a compression force to the plurality of segments of radius filler and the ply to form a radius filler kit;

positioning the radius filler kit relative to a stringer, the radius filler kit including the plurality of segments of radius filler; and

applying the radius filler kit to the stringer in a single placement step to apply the plurality of segments of radius filler to the stringer.

17. A method comprising:

positioning a plurality of segments of radius filler onto a radius filler forming tool;

applying a ply over the plurality of segments of radius filler;

applying a compression force to the plurality of segments of radius filler and the ply to form a radius filler kit;

positioning the radius filler kit relative to a stringer; and

applying the radius filler kit to the stringer in a single placement step to apply the plurality of segments of radius filler to the stringer.

18. An apparatus for use in the method of any one of claims 1 to 10 and 16 to 17 comprising:

a roller manifold having a vacuum opening; and

a vacuum bag material connected to the roller manifold, the vacuum bag material having an opening interfacing with the vacuum opening.

19. The apparatus of claim 18, wherein the vacuum bag material is a first latex sheet.

20. The apparatus of claim 19 further comprising: a second latex sheet bonded to the first latex sheet.

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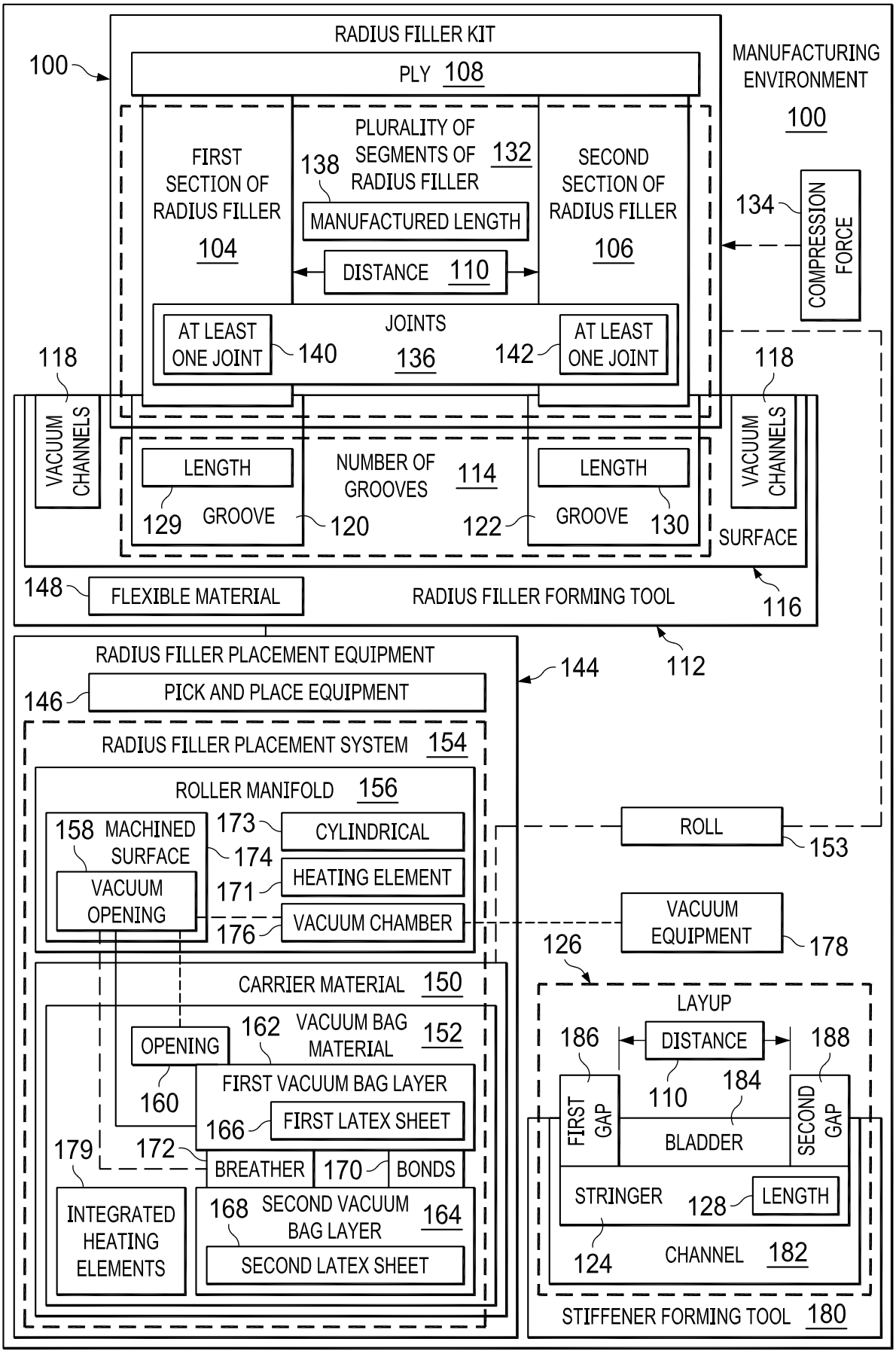
FIG. 1



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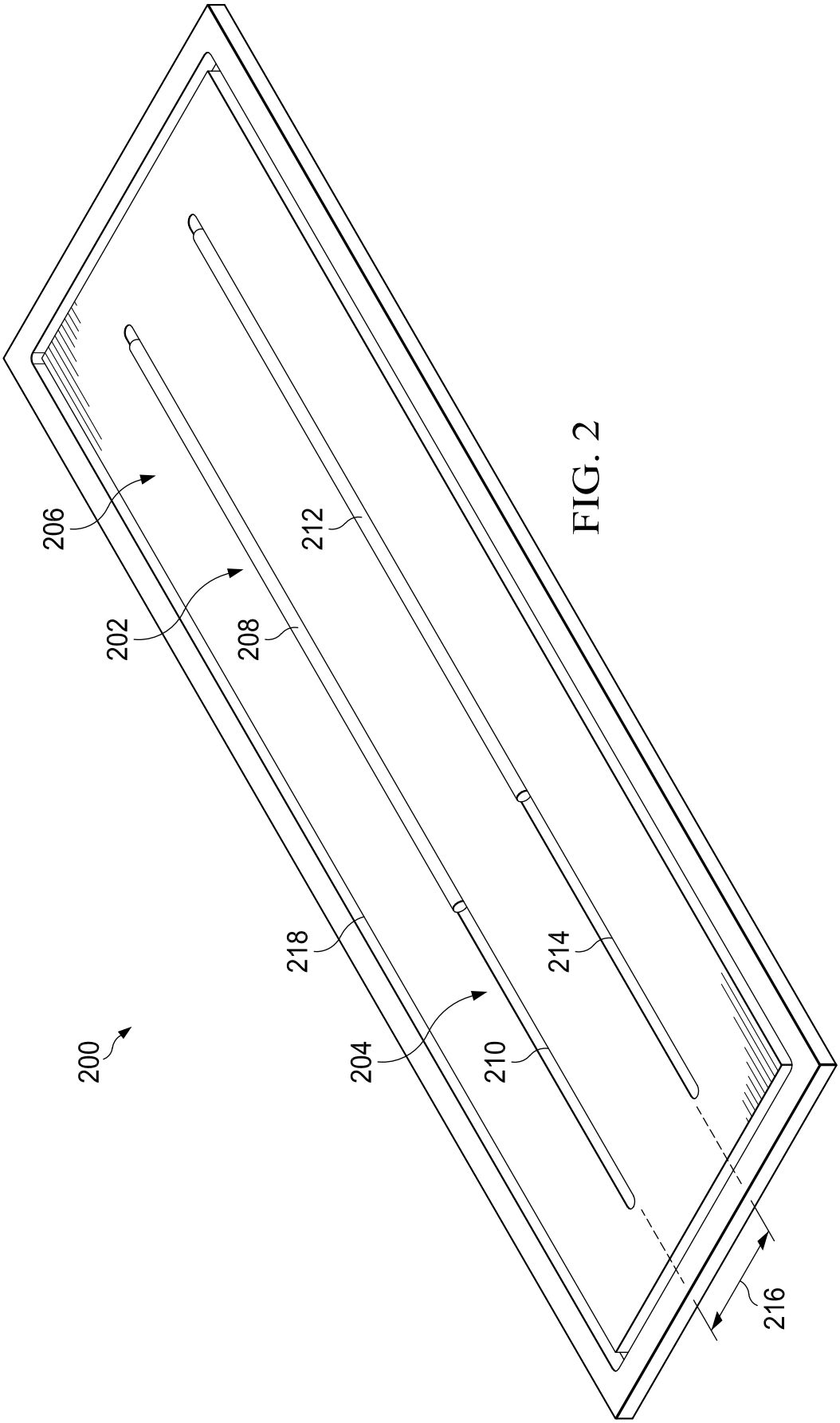

FIG. 2

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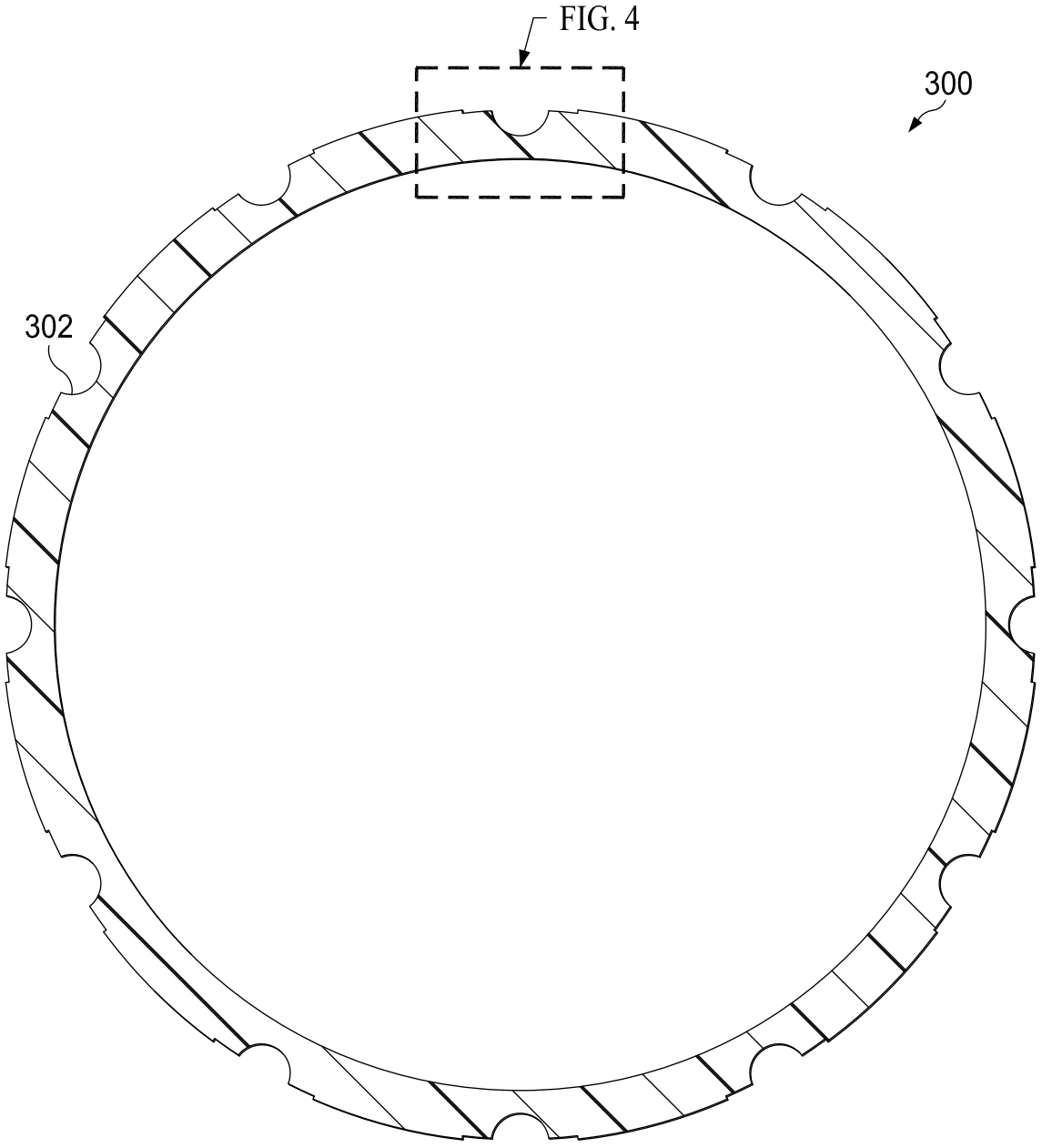

FIG. 3

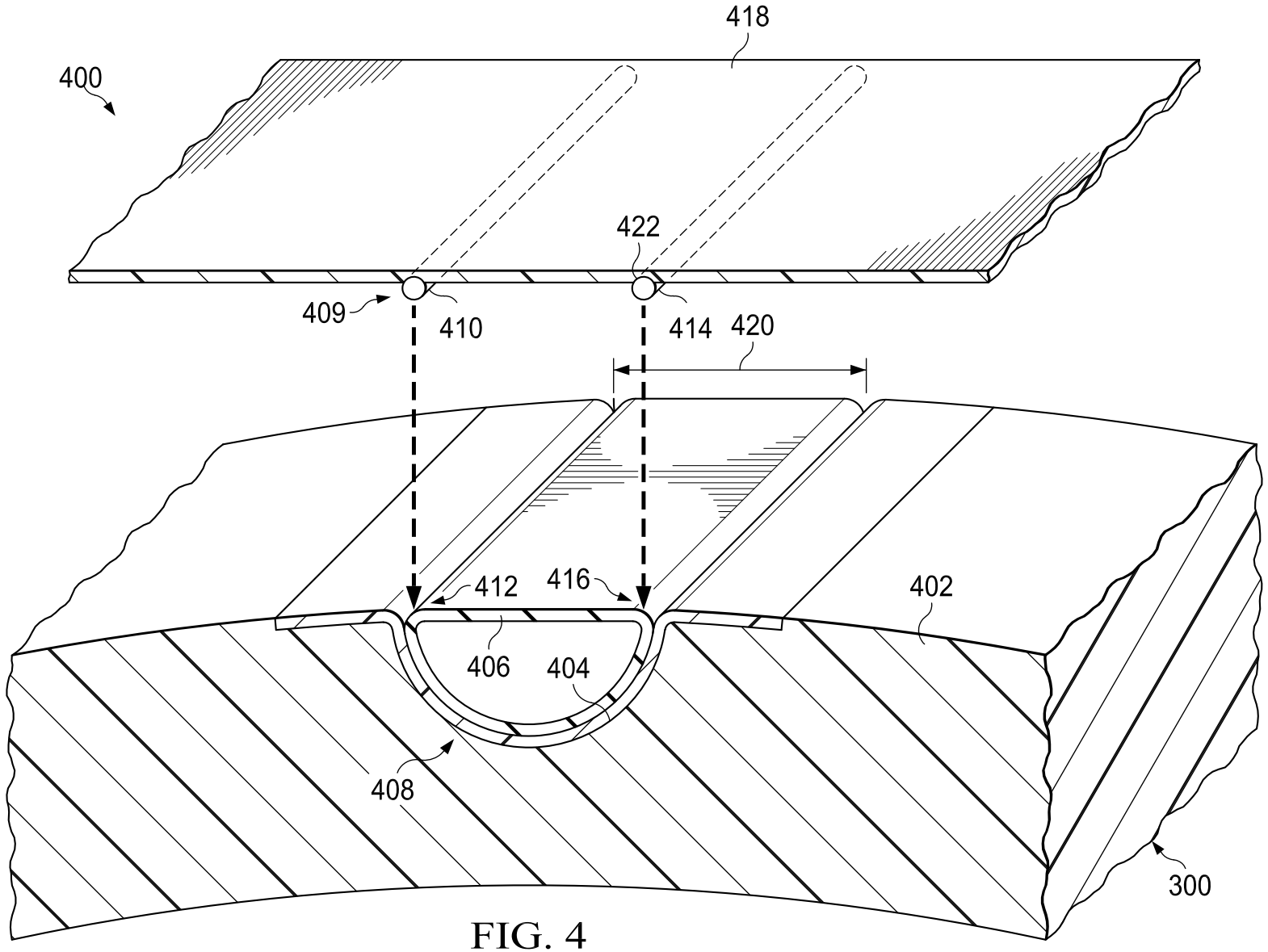

FIG. 4

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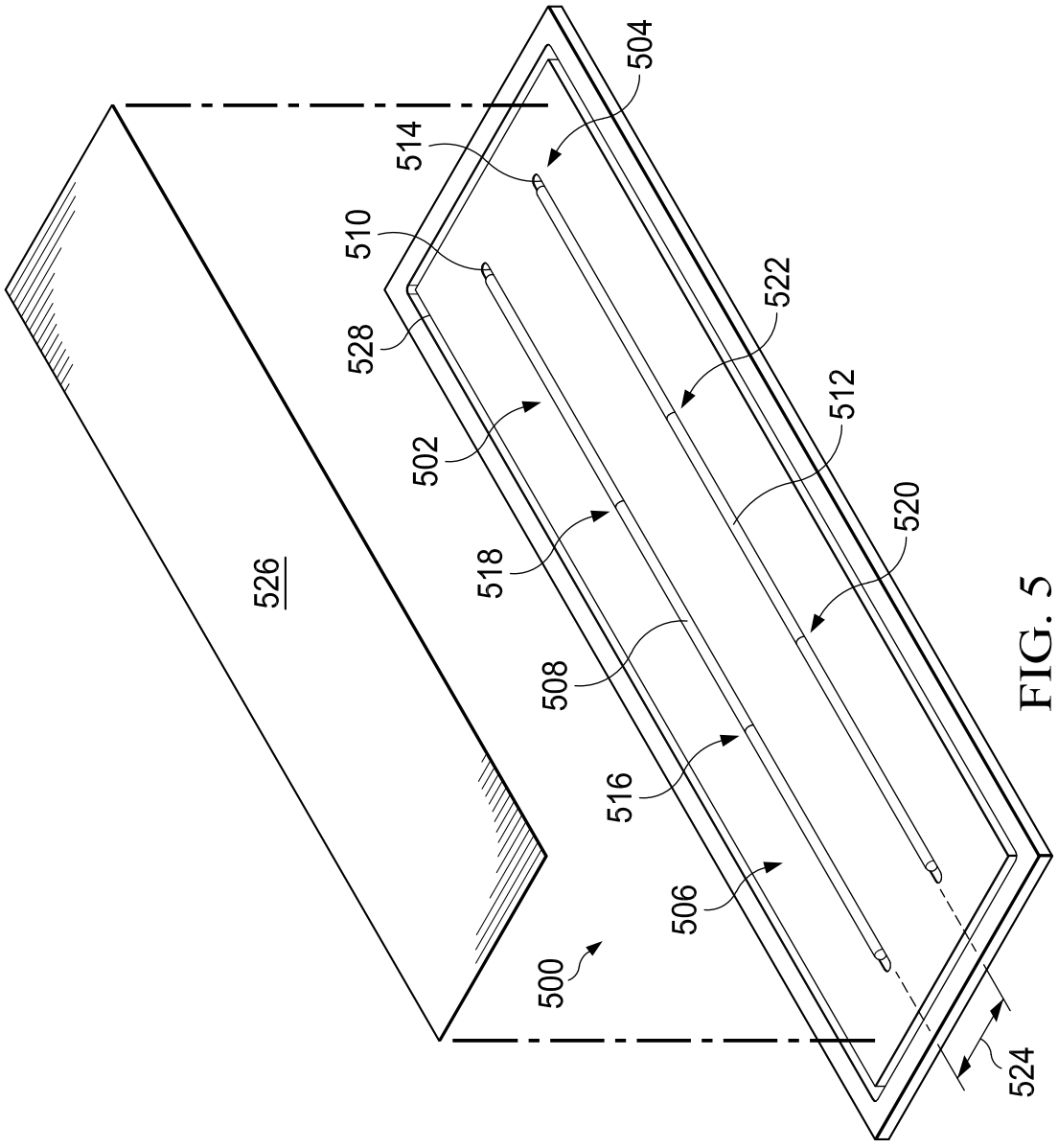

FIG. 5

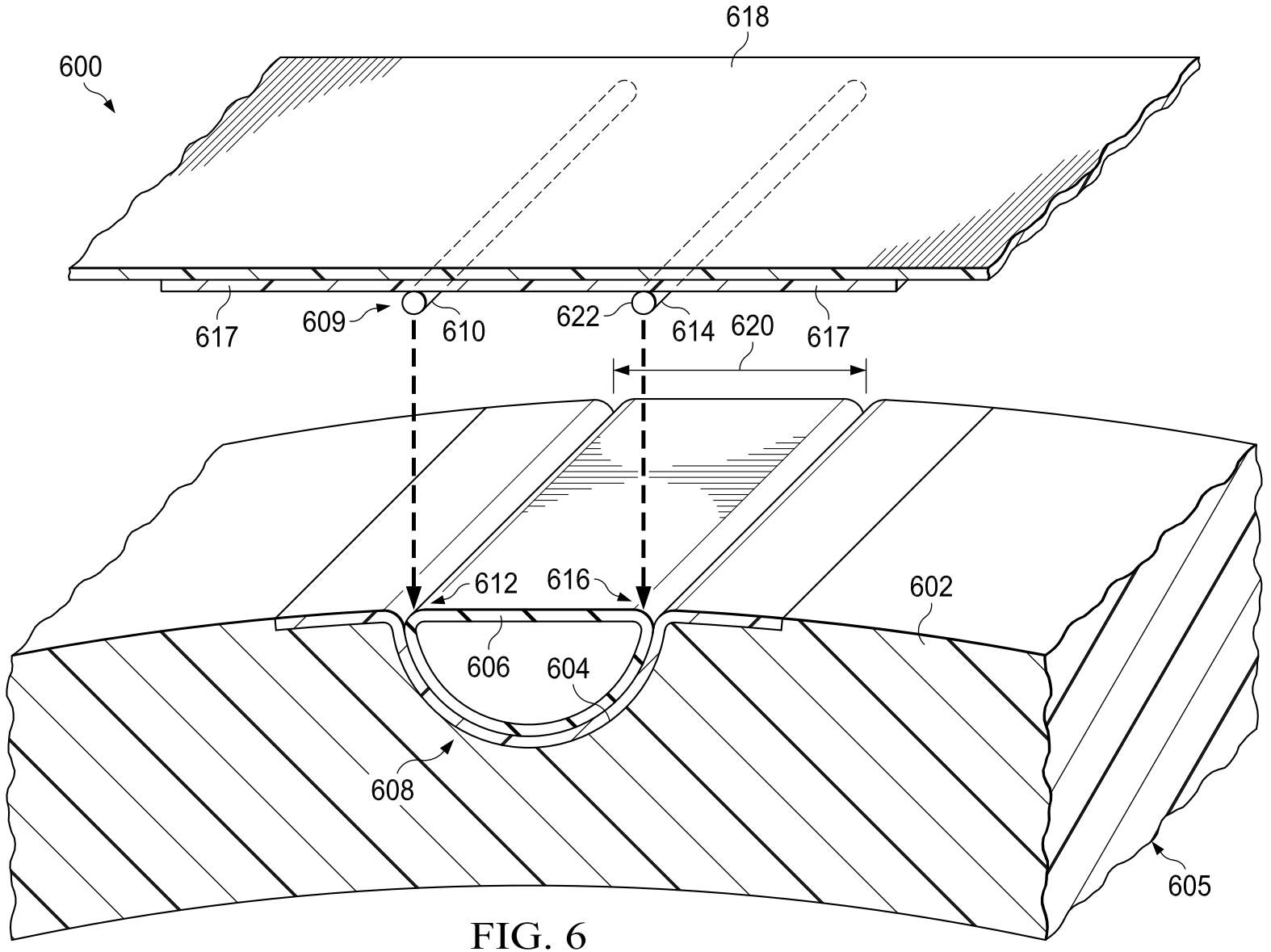

FIG. 6

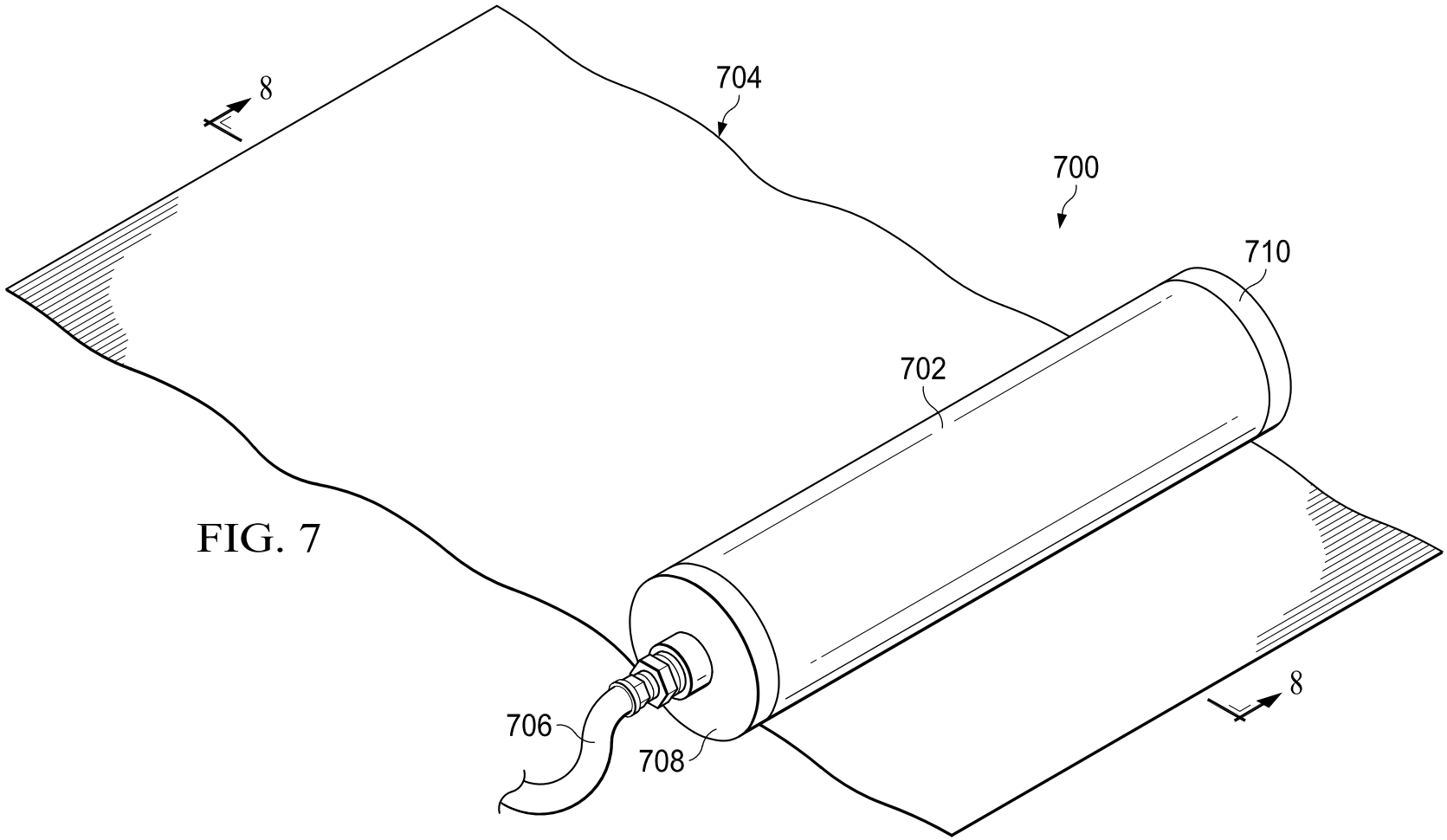

FIG. 7

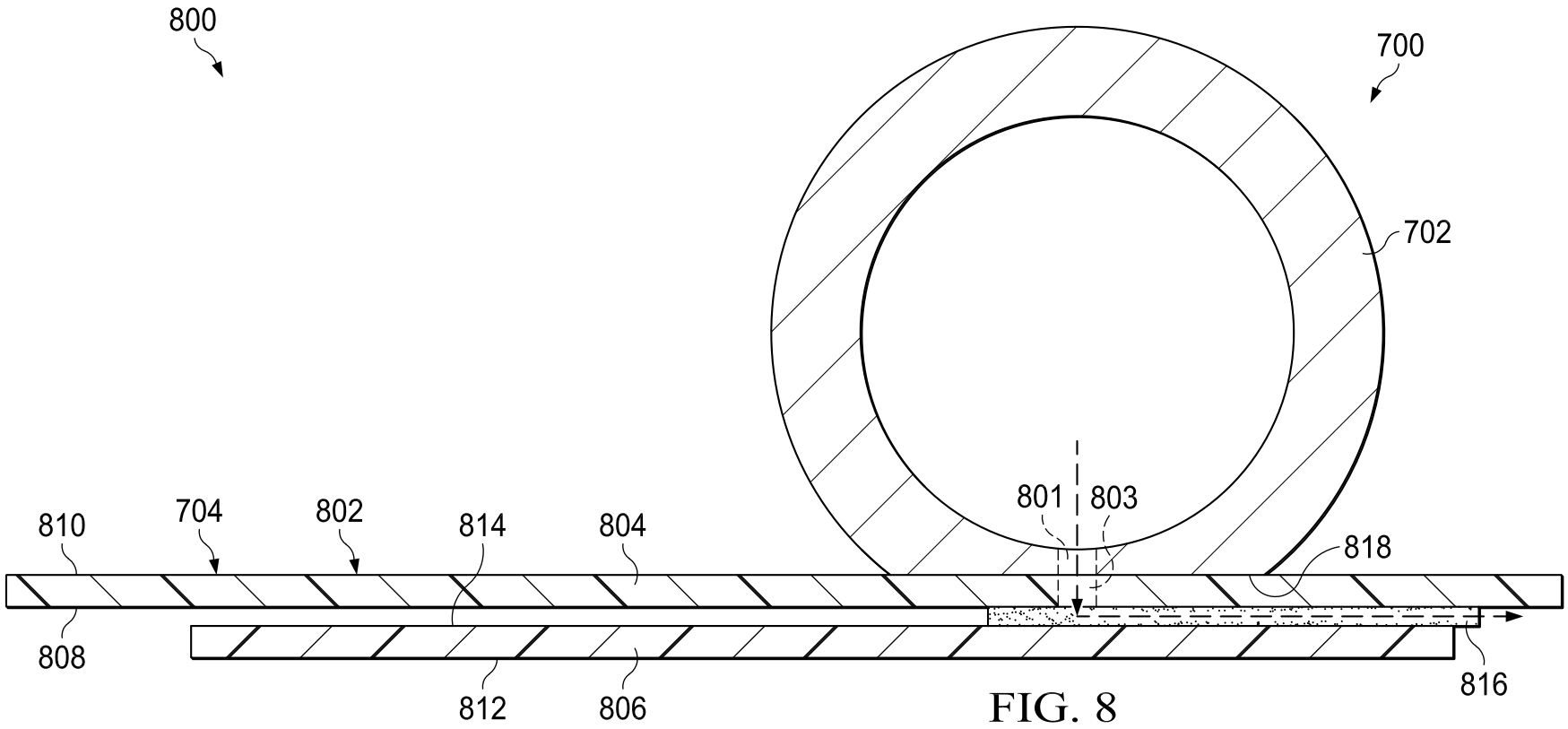

FIG. 8

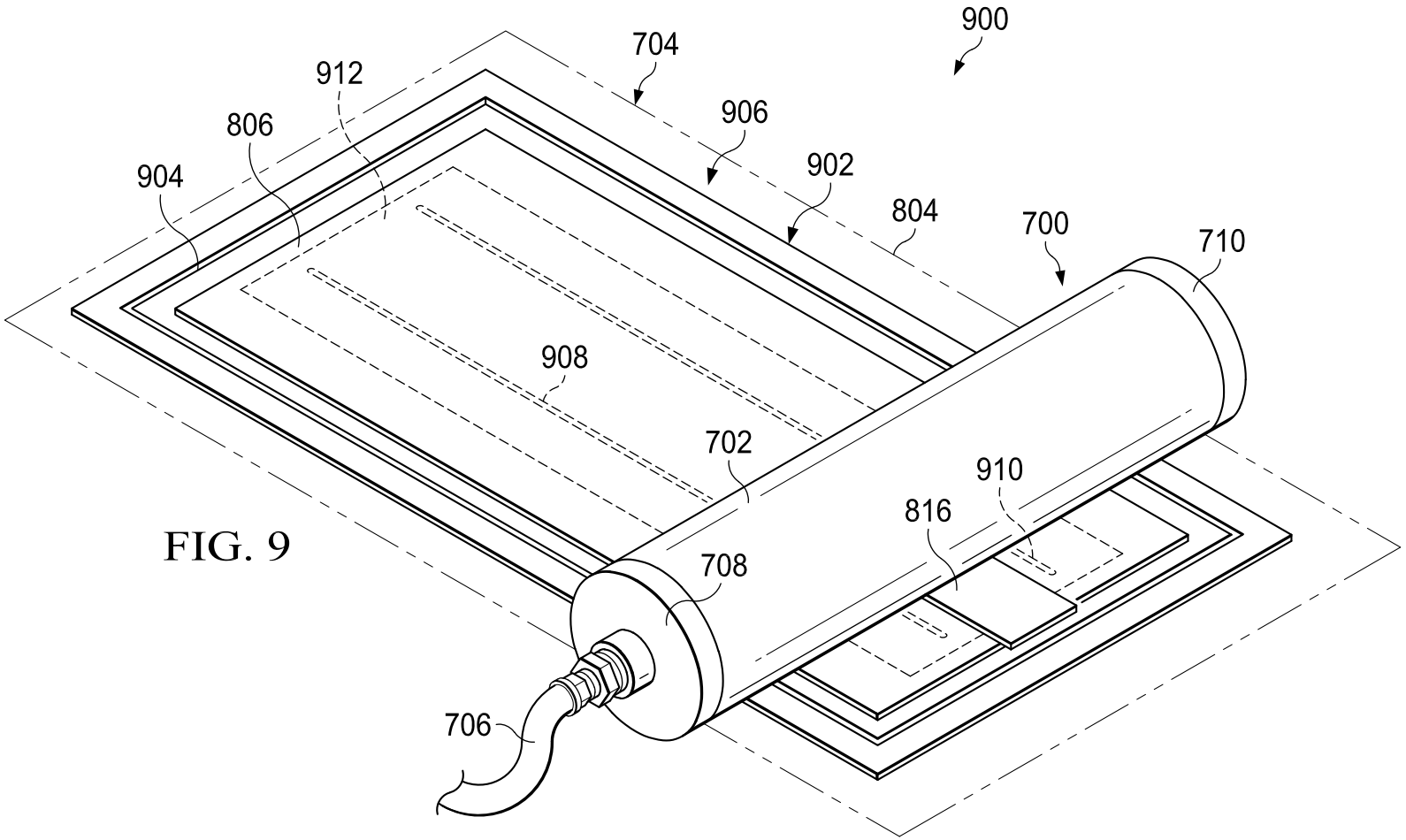

FIG. 9

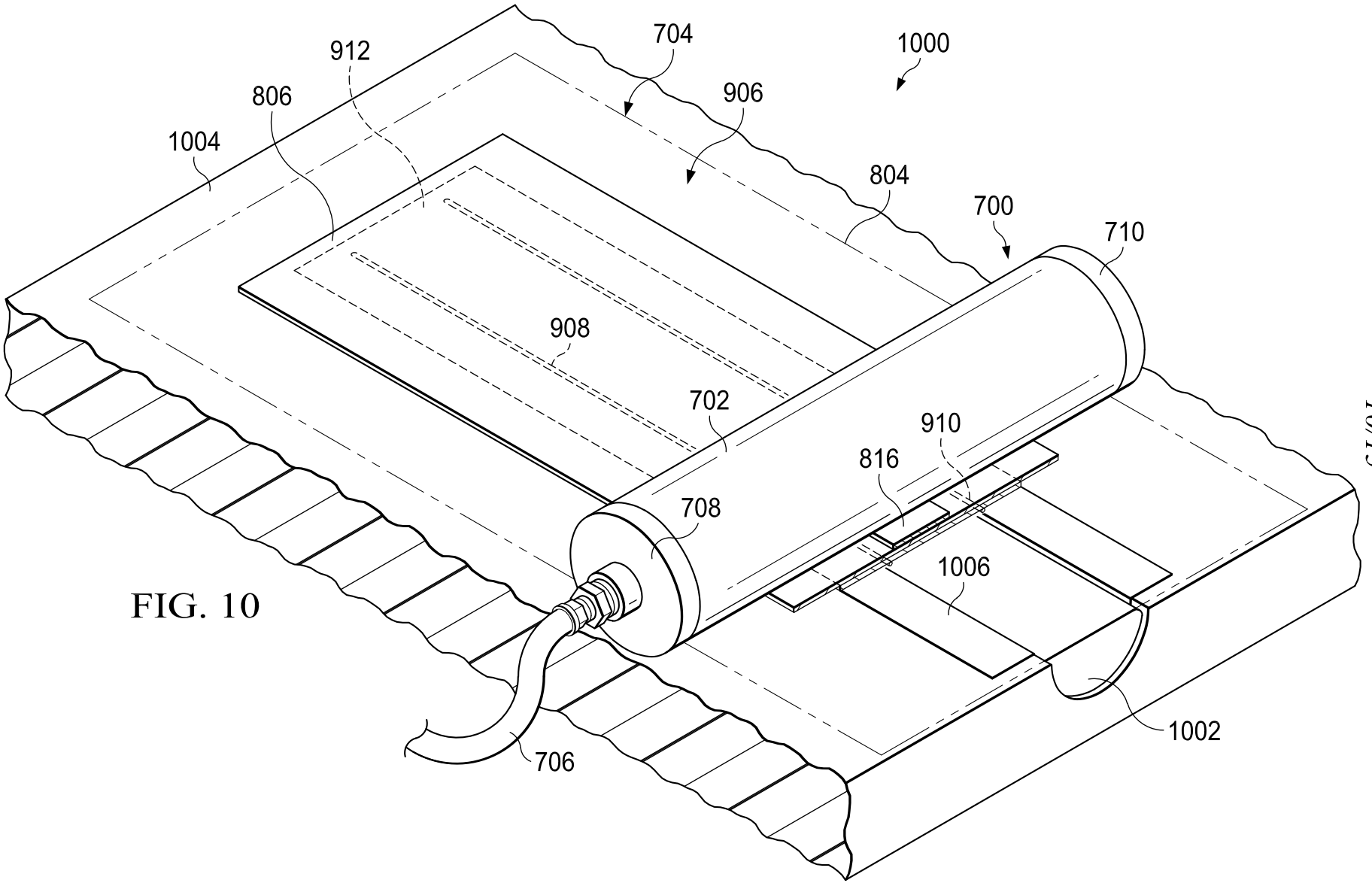
912
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FIG. 10

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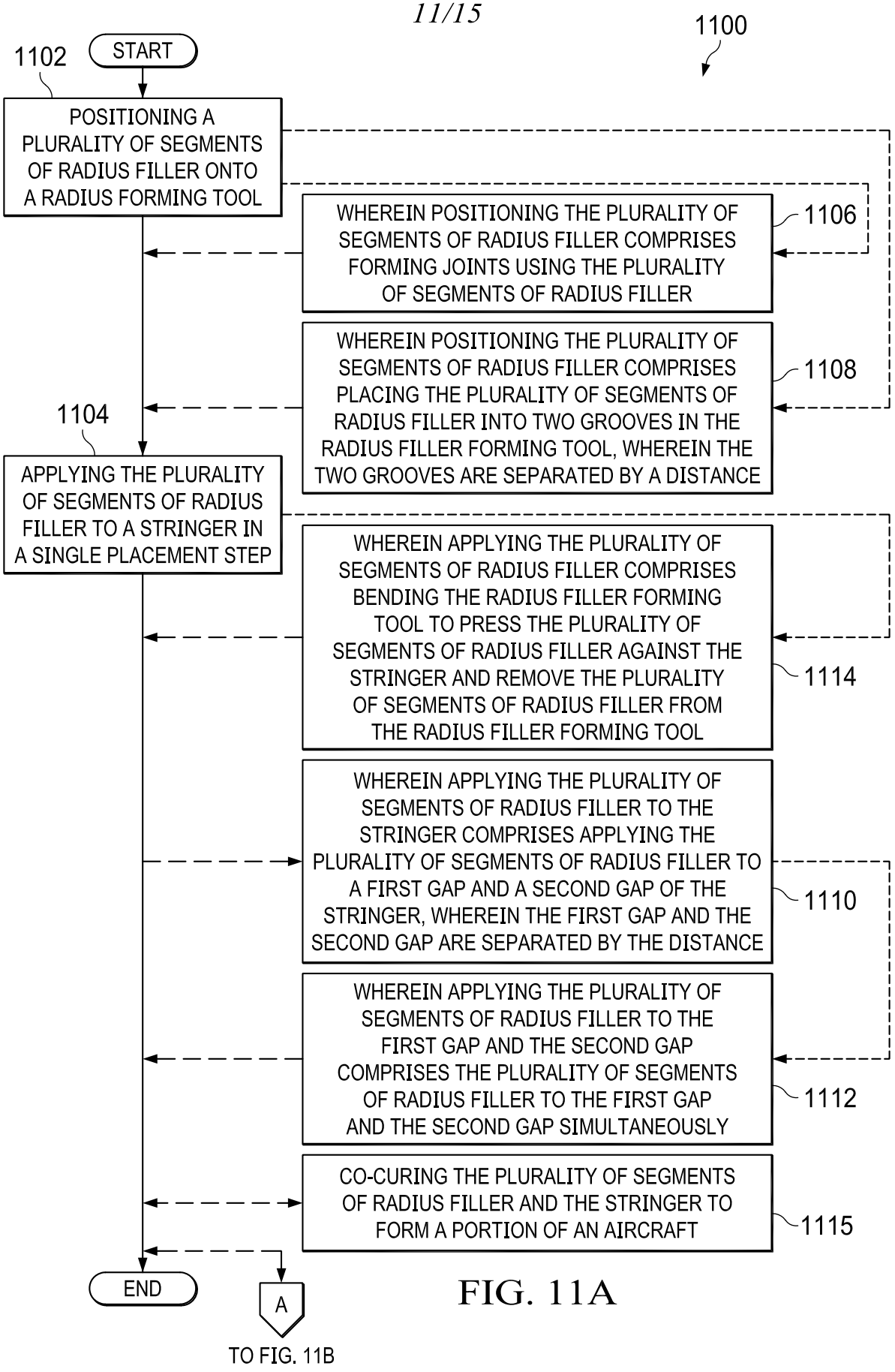

FIG. 11A

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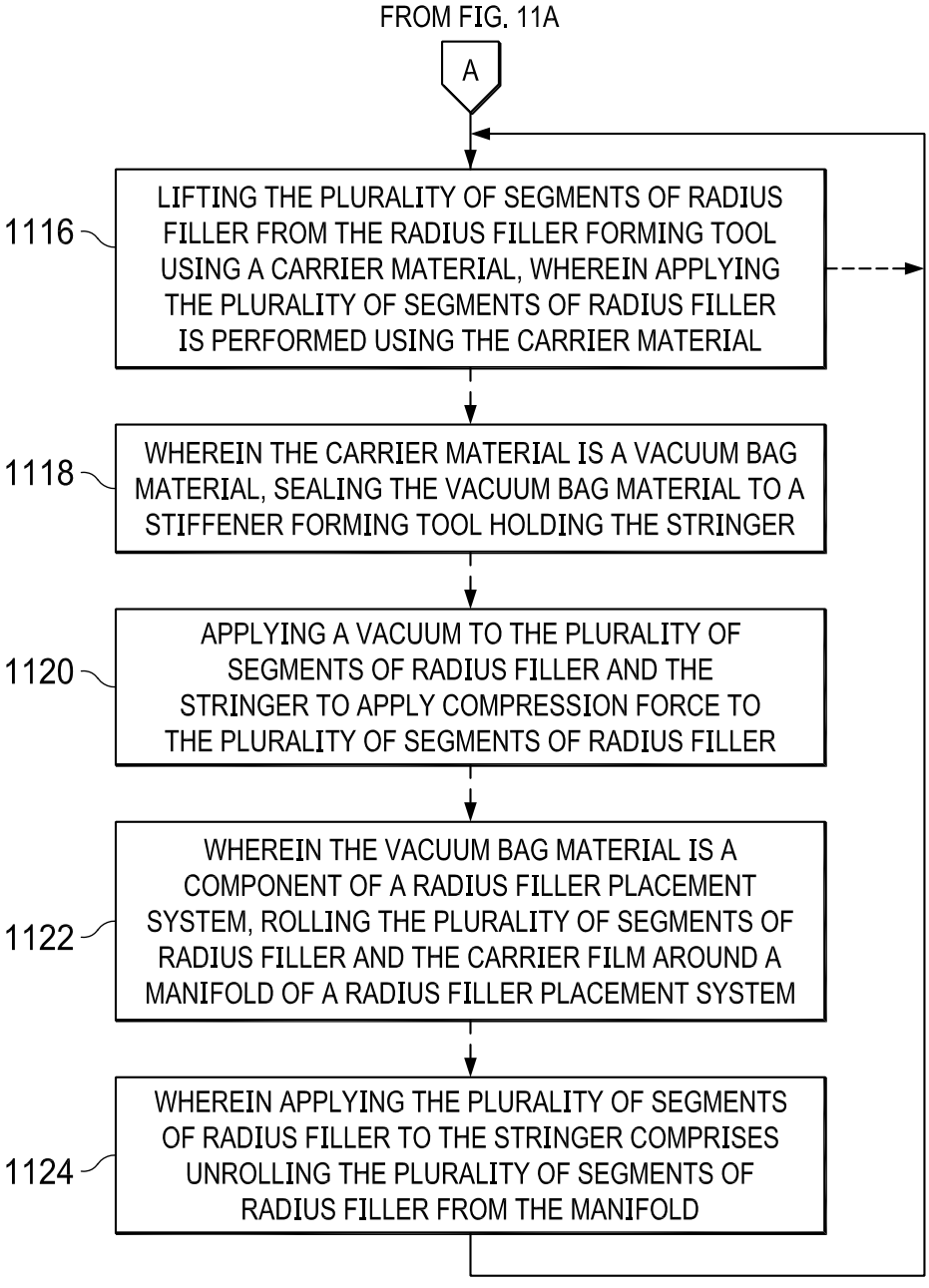

FIG. 11B

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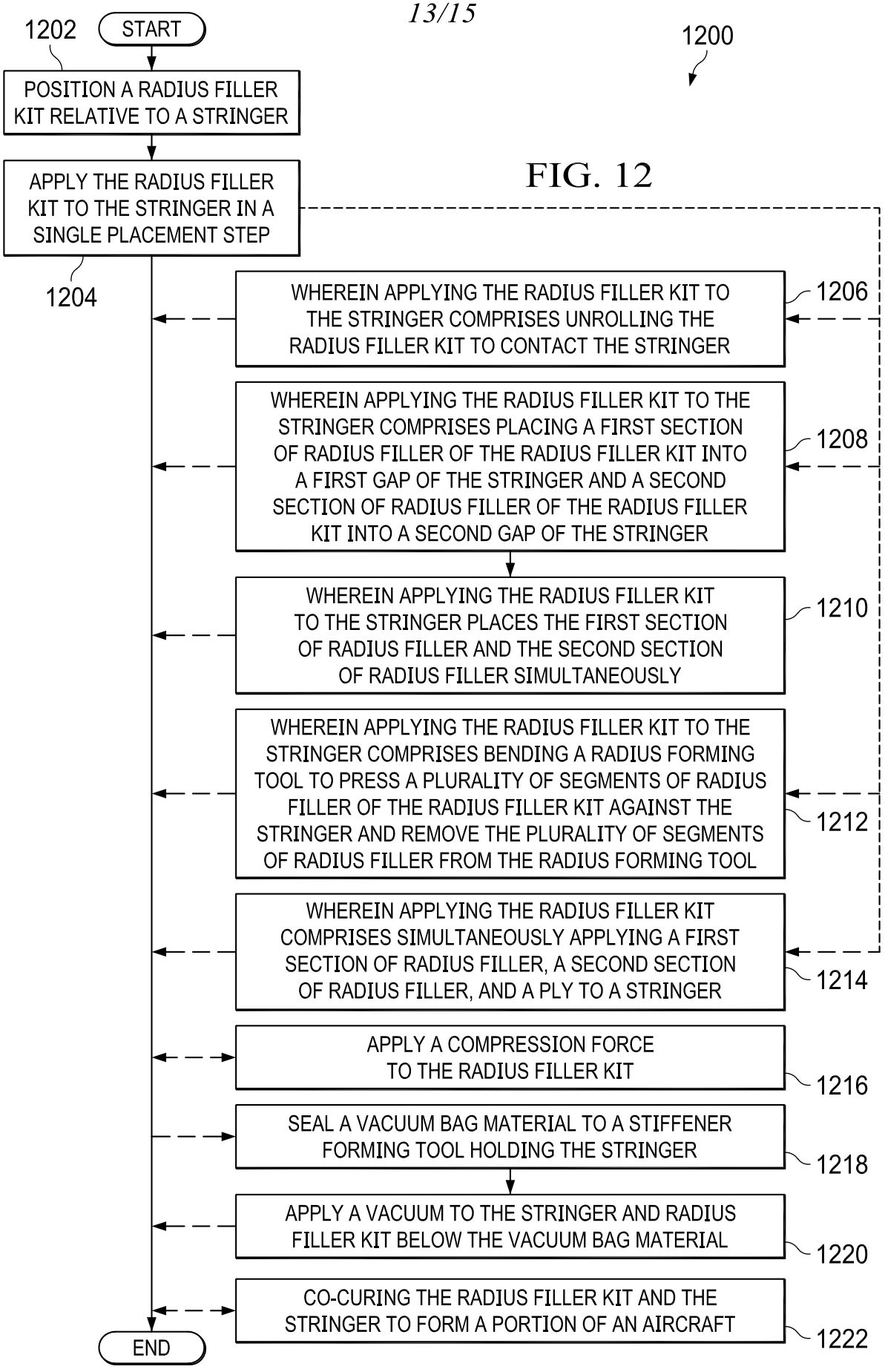

FIG. 12

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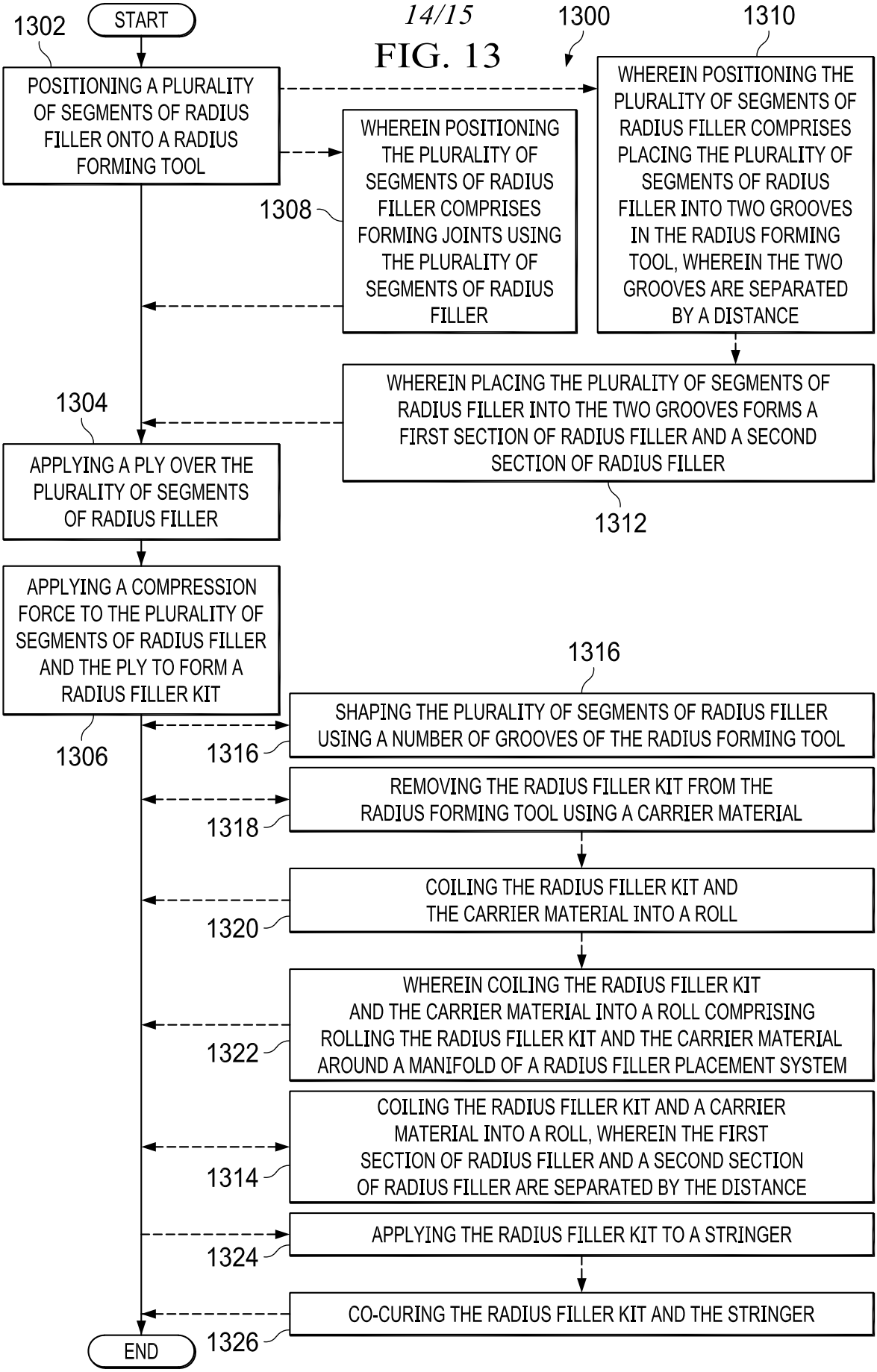
FIG. 13



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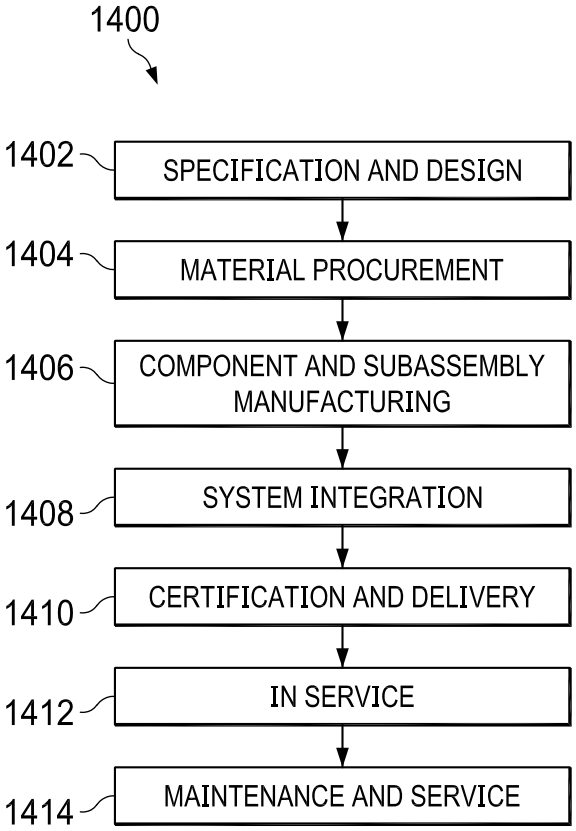

FIG. 14

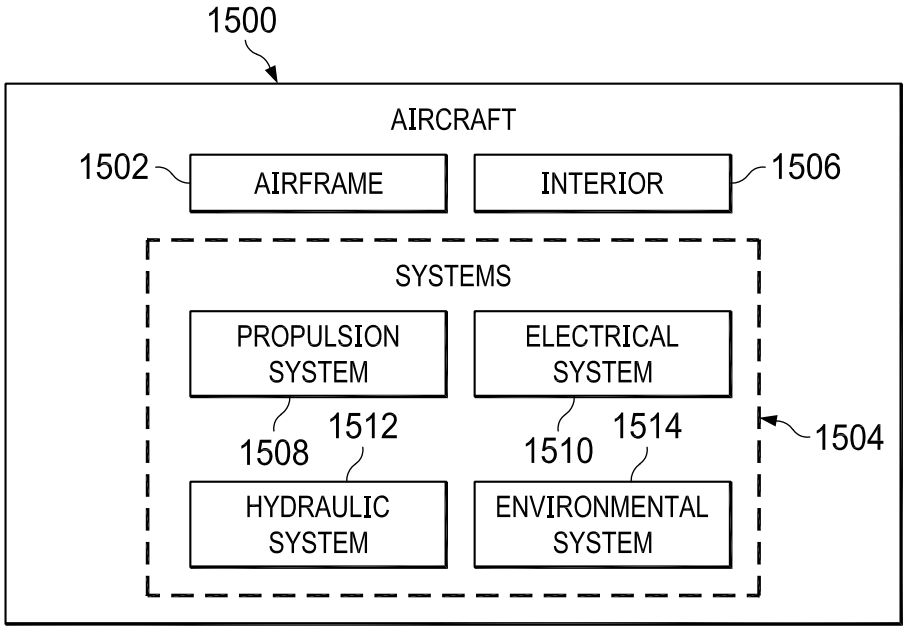

FIG. 15