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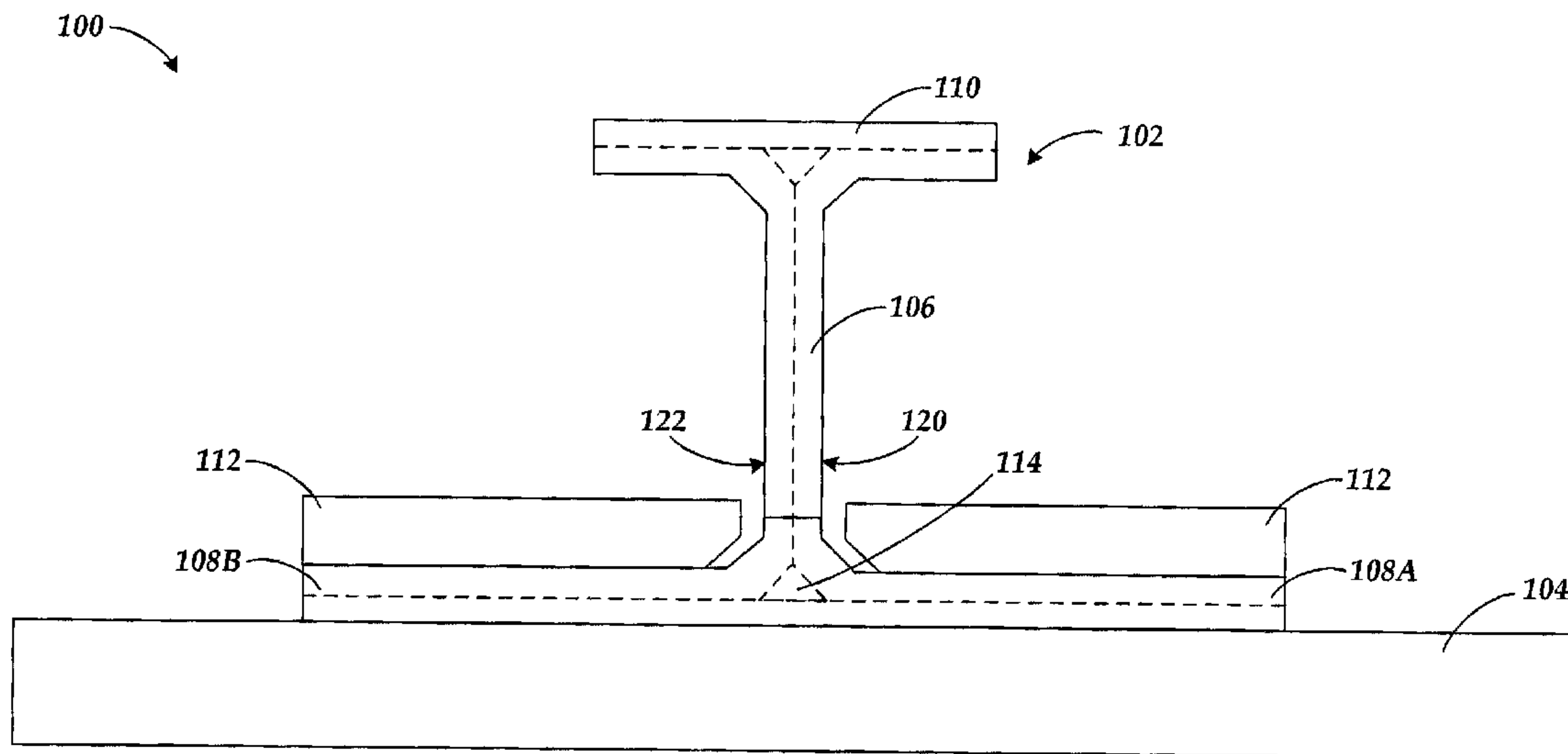
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(54) Title: DISBOND RESISTANT COMPOSITE STIFFENER RUNOUT



(57) Abrégé/Abstract:

The disclosure herein provides for disbond resistant stringer runouts. Various aspects may be used independently or in combination to mitigate disbonding associated with the stiffener runout under operational loads. Aspects include a stiffener runout having rounded base flange corners. A recessed notch may be incorporated within the base flange to provide a flange termination point that is forward of the web termination point, allowing the web to terminate prior to the base flange. The web may be trimmed from a full height to a reduced height at the web termination point. The base flange may be co-bonded to the underlying composite structure via a scarf joint. Perimeter clamp radius fillers may be used to concentrate a clamping force around the perimeter of the base flange.

Abstract

The disclosure herein provides for disbond resistant stringer runouts. Various aspects may be used independently or in combination to mitigate disbonding associated with the stiffener runout under operational loads. Aspects include a stiffener runout having rounded base flange corners. A recessed notch may be incorporated within the base flange to provide a flange termination point that is forward of the web termination point, allowing the web to terminate prior to the base flange. The web may be trimmed from a full height to a reduced height at the web termination point. The base flange may be co-bonded to the underlying composite structure via a scarf joint. Perimeter clamp radius fillers may be used to concentrate a clamping force around the perimeter of the base flange.

DISBOND RESISTANT COMPOSITE STIFFENER RUNOUT

Background

Stringers are structural components that are often used to stiffen panels and other structures. With composite panels, composite stringers may be co-bonded, or secondarily bonded, onto the panel to prevent the panel from buckling or otherwise failing when subjected to compressive loads. The combined panel and stringers may then be secured to a substructure.

While stiffeners provide adequate reinforcement of the corresponding composite panel with respect to compressive loads, the stiffener runouts, or areas at which the stringers terminate, may experience disbonding between the stringers and the panel under certain conditions. The sudden discontinuity of the load path, combined with a low composite interlaminar toughness, may result in a structural component that may delaminate or disbond at operational loads.

Traditionally, the disbond potential that exists at the stiffener runout locations of a composite structure has been accommodated via various techniques. For example, the architecture of a composite panel may be designed to move the stiffener terminations to an edge of the panel. However, doing so may negatively affect the cost and weight of the corresponding panel. According to an alternative traditional solution, the disbond may be allowed to occur at operational loads and fasteners used to arrest the disbond. With this solution, extensive certification testing is required and any amount of disbond, even though non-critical, may be disconcerting to a customer.

Another conventional method for controlling disbond at stiffener runout locations includes the use of flat metallic radius fillers secured to the stiffeners at the termination ends. However, these conventional radius fillers are not efficient at arresting the disbond under the flange, and provide no arrest capabilities under a web of a stringer. Relatively large mechanically attached metallic fittings may also be used to transfer loads from stringers into the attached composite structure. A disadvantage of these types of fittings is that the fittings increase the weight of the corresponding structure and may be expensive to install, while not completely suppressing the disbond at operational loads.

It is with respect to these considerations and others that the disclosure made herein is presented.

Summary

It should be appreciated that this Summary is provided to introduce a selection
5 of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to be used to limit the scope of the claimed subject matter.

Apparatus and methods described herein provide for disbond resistant stiffener runouts. According to one aspect, a stiffener runout may include a web and a base
10 flange. The web may be configured in a vertical orientation having a front surface, a rear surface, a bottom edge, and web termination point that is positioned at an outermost location of the web. The base flange may include two flanges extending horizontally from the front and rear surfaces of the web, respectively. The base flange may include a flange termination point that is positioned at an outermost
15 location of the base flange, which is forward of the web termination point.

According to another aspect, a method of controlling bondline separation between a composite stiffener and a composite structure may be provided. The method may include providing a composite stiffener having a web and a base flange. The web may terminate at a web termination point, while the base flange terminates at
20 a flange termination point that is forward of the web termination point. The base flange may include rounded corners. The web may be trimmed from a full height prior to the web termination point to a reduced height at the web termination point. A recessed notch may be provided within the base flange at the flange termination point, with the web termination point being positioned at the center of the recessed notch.
25 The base flange may be bonded to the composite structure.

According to yet another aspect, a stiffener runout assembly may include a stiffener runout, a composite structure bonded to the stiffener runout, a pair of perimeter clamp radius fillers, and a number of fasteners. The stiffener runout may include a web trimmed from a full height to a reduced height at the web termination
30 point at an outermost location of the web. The stiffener runout may also include the

base flange that extends horizontally in opposite directions from the web and includes a flange termination point at an outermost location of the base flange. The flange termination point may be positioned forward of the web termination point, with the web termination point positioned within a recessed notch of the base flange.

5 The composite structure may be bonded to the base flange of the stiffener runout at a scarf joint. The pair of perimeter clamp radius fillers may be positioned on a top surface of the base flange on opposing sides of the web. Each perimeter clamp radius filler may include a bottom surface that is configured to contact the top surface of the base flange around the perimeter of the top surface to create a contact
10 area between the perimeter clamp radius filler and the perimeter of the top surface. The contact area may define a relief cavity between the perimeter clamp radius filler and the top surface of the base flange. The fasteners may secure the perimeter clamp radius fillers to the top surface of the base flange, extending through a top surface of the perimeter clamp radius fillers, through the relief cavities, through the base flange,
15 and through the composite structure.

 According to yet another aspect, a stiffener runout is provided, the stiffener runout comprising: a web configured in a substantially vertical orientation and including a front surface, a rear surface, a bottom edge, and a web termination point positioned at an outermost location of the web; a base flange comprising: a first
20 flange portion adjacent to the bottom edge of the web and extending substantially horizontally from the front surface of the web, a second flange portion adjacent to the bottom edge of the web and extending substantially horizontally from the rear surface of the web, and a flange termination point positioned at an outermost location of the base flange, wherein the flange termination point is positioned forward of the web
25 termination point; and a perimeter clamp radius filler configured to contact a top surface of the first flange portion around a portion of a perimeter of the top surface to create a contact area between the perimeter clamp radius filler and the portion of the perimeter of the top surface, wherein the contact area defines a relief cavity between the perimeter clamp radius filler and the top surface.

According to yet another aspect, a stiffener runout is provided, the stiffener runout comprising: a web configured in a substantially vertical orientation and including a front surface, a rear surface, a bottom edge, and a web termination point positioned at an outermost location of the web, wherein a height of the web decreases
5 from a full height at a location prior to the web termination point to a reduced height at the web termination point; and a base flange comprising: a first flange portion adjacent to the bottom edge of the web and extending substantially horizontally from the front surface of the web, a second flange portion adjacent to the bottom edge of the web and extending substantially horizontally from the rear surface of the web, a
10 flange termination point positioned at an outermost location of the base flange and forward of the web termination point, wherein a forward edge of the web from the location prior to the web termination point to the web termination point is substantially curved, and a recess notch at the flange termination point at a central location aligned with the web such that the web termination point is positioned
15 substantially at a center of the recess notch.

According to yet another aspect, a stiffener runout assembly is provided, the stiffener runout assembly comprising: a stiffener runout comprising: a web trimmed from a full height at a location prior to a web termination point to a reduced height at the web termination point at an outermost location of the web; and a base flange
20 extending horizontally in opposite directions from the web and including a flange termination point positioned at an outermost location of the base flange, wherein the flange termination point is positioned forward of the web termination point, and wherein the web termination point is positioned within a recessed notch of the base flange; a composite structure bonded to the base flange of the stiffener runout at a
25 scarf joint; a pair of perimeter clamp radius fillers positioned on a top surface of the base flange on opposing sides of the web, each perimeter clamp radius filler comprising a bottom surface configured to contact the top surface of the base flange

around a portion of a perimeter of the top surface to create a contact area between the perimeter clamp radius filler and the portion of the perimeter of the top surface, wherein the contact area defines a relief cavity between the perimeter clamp radius filler and the top surface; and a plurality of fasteners securing the pair of perimeter
5 clamp radius fillers to the top surface of the base flange such that each fastener extends through a top surface of one of the pair of perimeter clamp radius fillers, through the relief cavity, through the base flange, and through the composite structure.

According to yet another aspect, a method of controlling bondline separation
10 between a composite stiffener and a composite structure is provided, the method comprising: providing a composite stiffener comprising a web and a base flange, wherein the web terminates at a web termination point, wherein the base flange terminates at a flange termination point forward of the web termination point, and wherein the base flange comprises rounded corners; trimming the web from a full
15 height at a location prior to the web termination point to a reduced height at the web termination point; providing a recessed notch within the base flange at the flange termination point such that the web termination point is positioned substantially at a center of the recessed notch; bonding a bottom surface of the base flange to a top surface of the composite structure; providing at least one perimeter clamp radius filler
20 comprising a bottom surface configured to contact a top surface of the base flange around a portion of a perimeter of the top surface of the base flange to create a contact area between the perimeter clamp radius filler and the portion of the perimeter of the top surface of the base flange, wherein the contact area defines a relief cavity between the perimeter clamp radius filler and the top surface of the base flange; and securing
25 the at least one perimeter clamp radius filler to the top surface of the base flange using a plurality of fasteners extending through a top surface of the perimeter clamp radius filler, through the relief cavity, through the base flange, and through the composite structure.

According to yet another aspect, a method of controlling bondline separation between a composite stiffener and a composite structure is provided, the method comprising: providing a composite stiffener comprising a web and a base flange, wherein the web terminates at a web termination point, wherein the base flange terminates at a flange termination point forward of the web termination point, and
5 wherein the base flange comprises rounded corners; trimming the web from a full height at a location prior to the web termination point to a reduced height at the web termination point; providing a recessed notch within the base flange at the flange termination point such that the web termination point is positioned substantially at a
10 center of the recessed notch, wherein the recessed notch comprises an arcuate edge such that the web termination point is located on the arcuate edge; and bonding a bottom surface of the base flange to a top surface of the composite structure.

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

Brief Description Of The Drawings

FIGURE 1 is a front view of a stiffener runout assembly illustrating aspects of a stiffener runout for controlling disbond according to various embodiments presented
20 herein;

FIGURE 2 is a top view of a stiffener runout illustrating aspects of the stiffener runout for controlling disbond according to various embodiments presented herein;

FIGURE 3 is a side view of a stiffener runout assembly illustrating aspects of a stiffener runout for controlling disbond according to various embodiments presented
25 herein;

FIGURE 4 is a side view of a stiffener runout assembly illustrating aspects of a stiffener runout and scarf joint for controlling disbond according to various embodiments presented herein;

FIGURE 5 is a side view of a stiffener runout assembly illustrating aspects of a stiffener runout and alternative scarf joint for controlling disbond according to various embodiments presented herein; and

FIGURE 6 is a flow diagram showing a method of controlling bondline separation between a composite stiffener and a composite structure according to various embodiments presented herein.

10 Detailed Description

The following detailed description is directed to controlling bondline separation between a composite stiffener and a composite structure. As discussed above, delamination or disbond may occur between stringers and co-bonded composite structures at stringer runout locations when subjected to operational loads. As composite materials are increasingly used in the construction of vehicles such as aircraft, controlling delamination and disbonding at the stringer runout locations is a primary concern. Solutions to the stringer disbonding issue should contemplate weight factors, as well as cost and complexity of manufacturing, particularly within the aircraft industry.

Utilizing the concepts and technologies described herein, stringer runouts may incorporate various stringer runout aspects, alone or in combination, to prevent disbonding between composite stringers and co-bonded composite structures while minimizing weight and manufacturing complexity and cost. The various embodiments described below will be described within the context of a composite aircraft stringer co-bonded with composite aircraft skin. It should be appreciated that the various embodiments are not limited to these specific components, or to used within aircraft. Rather, the concepts described below may equally apply to any implementation in which a stringer or similar stiffening component is bonded to a composite structure.

In the following detailed description, references are made to the accompanying drawings that form a part hereof, and which are shown by way of illustration, specific embodiments, or examples. Referring now to the drawings, in which like numerals represent like elements through the several figures, a disbond resistant stiffener runout and assembly, as well as methods for controlling disbond between a composite stiffener and a composite structure, will be described.

FIGURE 1 shows a front view of a stiffener runout assembly 100. According to this illustrative embodiment, the stiffener runout assembly 100 includes a stiffener runout 102 co-bonded onto a composite structure 104. The composite structure 104 may be any composite panel, sheet, or other component for which stiffening would be desirable, such as an aircraft skin. The stiffener runout 102 includes a web 106, a base flange 108 that includes a first flange portion 108A and a second flange portion 108B, and a cap 110. A noodle 114 is bonded within the region created between the web 106 and the first and second flange portions 108A and 108B.

As shown in FIGURE 1, the web may extend vertically in relation to the composite structure 104. The base flange 108 may be positioned at a bottom edge of the web 106, with the first flange portion 108A extending substantially horizontally from a front surface 120 of the web 106 and the second flange portion 108B extending substantially horizontally from a rear surface 122 of the web 106. The base flange 108 is bonded to the composite structure 104. According to various embodiments, the stiffener runout assembly 100 may include perimeter clamp radius fillers 112 positioned on the first flange portions 108A and 108B to assist with preventing disbond at the forward edges of the stiffener runout 102. The various features of the perimeter clamp radius fillers 112 will be described in greater detail below with respect to FIGURES 2 and 3. It should be appreciated that the stiffener runout 102 may include additional features and/or varying proportions or configurations as compared to the stiffener runout 102 shown in the figures without departing from the scope of this disclosure. The various figures may not be drawn to scale and are shown for illustrated purposes only.

FIGURES 2 and 3 show top and side views, respectively, of a stiffener runout 102 according to one embodiment. As described above, the stiffener runout 102 may

include a web 106 and a base flange 108. There are multiple features of the stiffener runout 102 that independently and collectively mitigate or eliminate any disbond between the stiffener runout 102 and the composite structure 104. One such feature includes the rounded corners 202 of the base flange 108. Conventional stiffeners
5 include base flanges that have squared off corners. The square corners are easier to manufacture. Historically, delamination tends to occur at the corners of the base flange first, particularly when a partial shear loading exists. However, by trimming or otherwise creating the rounded corners 202 as shown in FIGURE 2, the loads through the corners of the base flange 108 are more easily distributed, reducing the potential
10 for delamination at those locations.

Another feature disclosed herein to control disbonding includes the recessed notch 204 in base flange 108. According to various embodiments, the base flange 108 terminates at a flange termination point 206. The flange termination point 206 may be the most forward location of the stiffener runout 102. Similarly, the web 106
15 terminates at a web termination point 208. Conventional stiffeners include webs and base flanges that terminate at identical locations. The forward edge of a stringer runout is typically stiffer under the web 106 and noodle 114 as compared to the base flange 108. This stiffer central location of the typical stringer forward edge allows for disbonds to occur at this location before occurring at other locations of the base flange
20 108.

However, as shown clearly in FIGURE 2, the stiffener runout 102 of the various embodiments disclosed herein includes a flange termination point 206 that is forward of the web termination point 208. The web termination point 208 is located within a recessed notch 204, which may be on a semicircular or arcuate edge of the
25 base flange 108 aft of the flange termination point 206. In doing so, any curvature between the termination end of the stiffener runout 102 and the composite structure 104 may be matched, which mitigates the disbonding under the web 106 and noodle 114.

Similarly, as seen in FIGURE 3, the web 106 may be trimmed from a full
30 height 304 to a reduced height 306 at the web termination point 208. According to one embodiment, the reduced height 306 may be substantially flush with a top surface

of the base flange 108. By tapering or reducing the height of the web 106, the loads within the stringer 102 are reduced at the flange termination point 206, which reduces the potential for disbond. Additionally, reducing the height of the web 106 reduces the stiffness of the stiffener runout 102 along the central axis of the stiffener, which
5 similar to the benefits described above with respect to the recessed notch 204, mitigates the disbonding under the web 106 and noodle 114. According to one embodiment, the leading edge 302 of the web 106 is tapered according to a curved configuration as shown in FIGURE 3.

An additional feature used to control disbonding includes the use of the
10 perimeter clamp radius fillers 112, as shown in FIGURES 2 and 3. As discussed above, traditional radius fillers are flat metallic components that may be secured to a base flange in order to provide pressure to the flange and corresponding bond between the flange and the underlying composite structure in an effort to mitigate disbonding. However, traditional radius fillers do not efficiently handle panel deformation. For
15 example, when a composite structure 104 or panel deforms under load such that the panel under a portion of the traditional radius filler flexes downward, the traditional radius filler will tend to lift off of the surface, either over the portion of the panel that is deflecting downward, or as that portion of the radius filler deflects downward with the panel, an opposing edge of the traditional radius filler may lift off of the surface.

20 The perimeter clamp radius fillers 112 described herein alleviate these deficiencies of traditional radius fillers by concentrating the clamping force around the perimeter of the base flange 108 where the disbonding is most likely to occur. Moreover, a relief cavity 212 within a central portion of the perimeter clamp radius filler 112 accommodates any deformation of the composite structure 104 and the
25 corresponding base flange 108. The perimeter clamp radius fillers 112 may be metallic, or any other suitable material.

According to one embodiment, each perimeter clamp radius filler 112 includes a bottom surface that projects downward from a portion of the perimeter of the radius filler to create a contact area 210 between the perimeter clamp radius filler 112 and a
30 corresponding portion of the top surface around a perimeter of the base flange 108. The contact area 210 defines the boundaries of the relief cavity 212. Pressure is

applied to the base flange 108 by the perimeter clamp radius filler 112 within the contact area 210 to prevent disbonding at the edges of the stiffener runout 102. Because pressure applied to the perimeter clamp radius filler 112 is distributed and concentrated around the perimeter of the base flange 108 while allowing for deformation within the relief cavity 212, the perimeter clamp radius fillers 112 provide a significant advantage over the less effective conventional radius fillers.

According to various embodiments, the contact area 210 may be substantially C-shaped with an opening 216 that provides access to the relief cavity 212 from one edge of the base flange 108. The opening 216 may be positioned along the edge of the base flange 108 opposite the web 106 as shown in FIGURES 2 and 3 since that portion of the edge opposite the web 106 is not highly susceptible to disbonding. The opening 216 may alternatively be positioned at the most rearward edge or any other edge of the base flange 108, and may be configured according to any size and shape. According to one embodiment, the relief cavity 212 may be filled with a compliant filler, such as a sealant or other material appropriate to the particular application, that allows for deformation without applying pressure to the base flange 108. The opening 216 may provide a passage for excess compliant filler to escape from the relief cavity 212 during installation.

Fasteners 214 may be threaded or otherwise placed through corresponding apertures in the perimeter clamp radius filler 112, base flange 108, and composite structure 104. Torque applied to the fasteners 214 transfers force from the perimeter clamp radius filler 112 to the perimeter of the base flange 108 via the contact area 210 to prevent disbonding. Although two fasteners 214 are shown for each perimeter clamp radius filler 112, any number of fasteners 214 may be used without departing from the scope of this disclosure.

FIGURES 4 and 5 illustrate two alternative embodiments in which a type of scarf joint 402 is created between the stiffener runout 102 and the composite structure 104. For the purposes of this disclosure, the term “scarf joint” will be used to refer to a coupling between two or more components in which two of the components are manufactured or modified to have an angled surface that is engaged with a complementary angled surface of the other component. FIGURE 4 shows a first

embodiment in which the composite structure 104 has a uniform thickness, but is bonded to a fiberglass wedge 404. The fiberglass wedge 404 is hatched in the FIGURE 4 to highlight the wedge for clarity purposes only. The fiberglass wedge 404 provides an angled wedge surface 406 that is co-cured into an angled flange surface 408 of the base flange 108. The angled flange surface 408 may be created by reducing the plies of the composite material according to the desired angle and joint length. The fiberglass wedge 404 is highly compliant and is configured to shear load into the composite structure 104 over a longer length, thereby reducing the local moments that may cause disbonding. Although the fiberglass wedge 404 is described herein as being fiberglass, it should be appreciated that any suitable material that is more compliant (having less stiffness) than the material of the stiffener runout 102 and composite structure 104 may be used to create the wedge.

FIGURE 5 shows the second embodiment in which the scarf joint 402 is created by reducing the plies of the composite material according to the desired angle of the angled flange surface 408 and length of the scarf joint 402. Similarly, the corresponding angled structure surface 502 may be created by increasing plies of the composite material according to the desired angle of the angled structure surface 502 and length of the scarf joint 402. The result is a non-uniform thickness of the base flange 108 that complements a non-uniform thickness of the composite structure 104 within the scarf joint 402. According to an example embodiment, the run to rise ratio associated with the angled structure surface 502 and angled flange surface 408 of the scarf joint 402 is approximately 20:1. According to various embodiments, the ratio may be between 20:1-30:1. Similar to the effect of a scarf joint 402 created with the fiberglass wedge 404 discussed above with respect to FIGURE 4, the effect of the scarf joint 402 created by altering the plies of the base flange 108 and composite structure 104 as shown in FIGURE 5 is to shear the loads from the stiffener into the composite structure 104 over a relatively long distance. Doing so minimizes the detrimental local moments by reducing the offset in the load line that may initiate disbonding.

Turning now to FIGURE 6, an illustrative routine 600 for controlling bondline separation between a stiffener runout 102 and a composite structure 104 will now be described in detail. It should be appreciated that more or fewer operations may be

performed than shown in the FIGURE 6 and described herein. Moreover, these operations may also be performed in a different order than those described herein. The routine 600 begins at operation 602, where the stiffener runout 102 having a web 106 and a base flange 108 of composite materials is created. It should be appreciated
5 that other features of a stiffener that are not germane to this disclosure may additionally be created during this or any other operation of the routine 600. For example, creation of the stiffener may commonly include bonding the cap 110 to the top edge of the web 106, as well as bonding the noodle 114 in the appropriate position between the bottom edge of the web 106 and the first and second flange portions
10 108A and 108B.

From operation 602, the routine 600 continues to operation 604, where the rounded corners 202 of the base flange 108 are created. This operation may be performed by trimming conventional square corners after curing of the base flange 108, or may be a part of the composite molding process. At operation 606, the
15 recessed notch 204 is created in the base flange 108. The recessed notch 204 may be created via trimming material from the base flange 108 or may be created during the material composite molding process. The size and depth of the recessed notch 204 may depend on the particular implementation and the desired distance between the flange termination point 206 and the web termination point 208. The routine 600
20 continues from operation 606 to operation 608, where the height of the web 106 is trimmed from the full height 304 to the reduced height 306 at the web termination point 208. The leading edge 302 of the web 106 may be trimmed according to a curved configuration or linearly tapered to the reduced height 306.

From operation 608, the routine 600 continues to operation 610, where the
25 scarf joint 402 is created between the stiffener runout 102 and the composite structure 104. As discussed above with respect to FIGURE 4, a first method for creating the scarf joint 402 involves utilizing a fiberglass wedge 404 bonded to a top surface of the composite structure 104, providing an angled wedge surface 406 that is co-cured into an angled flange surface 408 of the base flange 108. The angled flange surface 408 of
30 the base flange 108 may be created by dropping plies to create the desired 20:1-30:1 or other ratio at the scarf joint 402. Also as discussed above with respect to FIGURE 5, a second method for creating the scarf joint 402 includes dropping plies in the base

flange 108 to create the angled flange surface 408 and increasing plies in the composite structure 104 to create the angled structure surface 502. The angled flange surface 408 and the angled structure surface 502 are then co-cured to create the scarf joint 402.

5 The routine 600 continues from operation 610 to operation 612, where the perimeter clamp radius fillers 112 are secured to the base flange 108 with fasteners 214. Torque is applied to the fasteners 214 to concentrate a clamping force within the contact area 210 against the perimeter of the base flange 108 to mitigate disbonding in these areas. At operation 614, the relief cavity 212 is filled with a compliant sealant
10 or other material and the routine 600 ends.

 During use, loads from the stiffener runout 102 may be sheared into the composite structure 104 at the scarf joint 402 over a relatively long distance to reduce the offset in the load line that could initiate a disbond between the stiffener runout 102 and the composite structure 104. These loads may include a first loading condition in
15 which static loads are experienced, such as during a steady straight and level aircraft flight operation. The loads may shift to a second loading condition in which dynamic loads are experienced, such as during a climb, turn, or velocity change. During this load shift, the scarf joint 402 and other features of the stiffener runout 102 described above serve to distribute the loads to the composite structure 104 in a manner that
20 prevents or delays the disbonding that may be present with conventional stringer runouts.

 According to an aspect of the present disclosure there is provided a stiffener runout assembly, comprising a stiffener runout, comprising a web trimmed from a full height at a location prior to a web termination point to a reduced height at the web
25 termination point at an outermost location of the web, a base flange extending horizontally in opposite directions from the web and including a flange termination point positioned at an outermost location of the base flange, wherein the flange termination point is positioned forward of the web termination point, and wherein the web termination point is positioned within a recessed notch of the base flange; a
30 composite structure bonded to the base flange of the stiffener runout at a scarf joint; a pair of perimeter clamp radius fillers positioned on a top surface of the base flange on

opposing sides of the web, each perimeter clamp radius filler comprising a bottom surface configured to contact the top surface of the base flange around a portion of a perimeter of the top surface to create a contact area between the perimeter clamp radius filler and the portion of the perimeter of the top surface, wherein the contact area defines a relief cavity between the perimeter clamp radius filler and the top surface; and a plurality of fasteners securing the pair of perimeter clamp radius fillers to the top surface of the base flange such that each fastener extends through a top surface of one of the pair of perimeter clamp radius fillers, through the relief cavity, through the base flange, and through the composite structure.

10 According to a further aspect of the present invention there is provided a stiffener runout assembly further comprising a fiberglass wedge positioned between the base flange and the composite structure, wherein the base flange comprises a non-uniform thickness corresponding to a configuration of the fiberglass wedge to create the scarf joint.

15 According to an aspect of the present disclosure there is provided a stiffener runout, comprising a web configured in a substantially vertical orientation and including a front surface, a rear surface, a bottom edge, and a web termination point positioned at an outermost location of the web; and a base flange, comprising a first flange portion adjacent to the bottom edge of the web and extending substantially horizontally from the front surface of the web, and a second flange portion adjacent to the bottom edge of the web and extending substantially horizontally from the rear surface of the web, wherein the base flange includes a flange termination point positioned at an outermost location of the base flange, wherein the flange termination point is positioned forward of the web termination point.

25 According to a further aspect of the present invention there is provided a stiffener runout further comprising a structure bonded to a bottom surface of the base flange according to a scarf joint. According to an aspect of the present disclosure there is provided a scarf joint comprising a fiberglass wedge bonded to a top surface of the structure, wherein the structure comprises a substantially uniform thickness, and wherein the base flange comprises a non-uniform thickness corresponding to a configuration of the fiberglass wedge. According to an aspect of the present disclosure there is provided a stiffener runout wherein the structure comprises a non-uniform

thickness, and wherein the base flange comprises a non-uniform thickness corresponding to the non-uniform thickness of the structure.

It should be clear from discussion above that the concepts described herein may be used independently or in combination to mitigate disbonding at the stiffener runout 102 under operational loads. The subject matter described above is provided by way of illustration only and should not be construed as limiting. Various modifications and changes may be made to the subject matter described herein without following the example embodiments and applications illustrated and described, and without departing from the true spirit and scope of the present disclosure, which is set forth in the following claims.

What is claimed is:

1. A stiffener runout comprising:
 - a web configured in a substantially vertical orientation and including a front surface, a rear surface, a bottom edge, and a web termination point positioned at an outermost location of the web;
 - a base flange comprising:
 - a first flange portion adjacent to the bottom edge of the web and extending substantially horizontally from the front surface of the web,
 - a second flange portion adjacent to the bottom edge of the web and extending substantially horizontally from the rear surface of the web, and
 - a flange termination point positioned at an outermost location of the base flange, wherein the flange termination point is positioned forward of the web termination point; and
 - a perimeter clamp radius filler configured to contact a top surface of the first flange portion around a portion of a perimeter of the top surface to create a contact area between the perimeter clamp radius filler and the portion of the perimeter of the top surface, wherein the contact area defines a relief cavity between the perimeter clamp radius filler and the top surface.
2. The stiffener runout of claim 1, wherein the base flange comprises a recessed notch at the flange termination point at a central location aligned with the web such that the web termination point is positioned substantially at a center of the recessed notch.
3. The stiffener runout of claim 2, wherein the recessed notch comprises an arcuate edge such that the web termination point is located on the arcuate edge.
4. The stiffener runout of claim 2 or 3, wherein the base flange comprises a plurality of rounded corners at the flange termination point.
5. The stiffener runout of any one of claims 1 to 4, further comprising a compliant filler disposed within the relief cavity.

6. The stiffener runout of any one of claims 1 to 5, wherein the contact area is substantially C-shaped such that an opening to the relief cavity is positioned along an edge of the perimeter clamp radius filler.
7. The stiffener runout of claim 6, wherein the opening to the relief cavity is positioned along the edge of the perimeter clamp radius filler opposite an edge of the perimeter clamp radius filler adjacent to the web.
8. The stiffener runout of any one of claims 1 to 7, further comprising a plurality of fasteners extending through a top surface of the perimeter clamp radius filler, through the relief cavity, through the first flange portion, and through a structure to which the stiffener runout is attached via the plurality of fasteners.
9. The stiffener runout of any one of claims 1 to 8, wherein a height of the web decreases from a full height at a location prior to the web termination point to a reduced height at the web termination point.
10. The stiffener runout of claim 9, wherein a forward edge of the web from the location prior to the web termination point to the web termination point is substantially curved.
11. The stiffener runout of any one of claims 1 to 10, further comprising a structure bonded to a bottom surface of the base flange with a scarf joint.
12. The stiffener runout of claim 11, wherein the structure comprises a substantially uniform thickness.
13. The stiffener runout of claim 11 or 12, wherein the scarf joint comprises a fiberglass wedge bonded to a top surface of the structure, and wherein the base flange comprises a non-uniform thickness corresponding to a configuration of the fiberglass wedge.

14. The stiffener runout of claim 11, wherein the structure comprises a non-uniform thickness, and wherein the base flange comprises a non-uniform thickness corresponding to the non-uniform thickness of the structure.

15. A stiffener runout comprising:

a web configured in a substantially vertical orientation and including a front surface, a rear surface, a bottom edge, and a web termination point positioned at an outermost location of the web, wherein a height of the web decreases from a full height at a location prior to the web termination point to a reduced height at the web termination point; and

a base flange comprising:

a first flange portion adjacent to the bottom edge of the web and extending substantially horizontally from the front surface of the web,

a second flange portion adjacent to the bottom edge of the web and extending substantially horizontally from the rear surface of the web,

a flange termination point positioned at an outermost location of the base flange and forward of the web termination point, wherein a forward edge of the web from the location prior to the web termination point to the web termination point is substantially curved, and

a recess notch at the flange termination point at a central location aligned with the web such that the web termination point is positioned substantially at a center of the recess notch.

16. The stiffener runout of claim 15, further comprising a structure bonded to a bottom surface of the base flange with a scarf joint.

17. The stiffener runout of claim 16, wherein the structure comprises a substantially uniform thickness.

18. The stiffener runout of claim 16 or 17, wherein the scarf joint comprises a fiberglass wedge bonded to a top surface of the structure, and wherein the base flange comprises a non-uniform thickness corresponding to a configuration of the fiberglass wedge.

19. The stiffener runout of claim 16, wherein the structure comprises a non-uniform thickness, and wherein the base flange comprises a non-uniform thickness corresponding to the non-uniform thickness of the structure.
20. The stiffener runout of claim 19, wherein:
each of the base flange and the composite structure is formed of multiple plies of composite material;
the non-uniform thickness of the base flange is formed by reducing a number of plies of composite material in the base flange; and
the non-uniform thickness of the composite structure is formed by increasing a number of plies of composite material in the composite structure.
21. The stiffener runout of claim 19, wherein:
the base flange has an angled surface formed by the non-uniform thickness of the base flange;
the scarf joint has a scarf joint length; and
a run-to-rise ratio of the angled surface along the scarf joint length is between 20:1 and 30:1.
22. The stiffener runout of any one of claims 15 to 21, wherein the recessed notch comprises an arcuate edge such that the web termination point is located on the arcuate edge.
23. A stiffener runout assembly comprising:
a stiffener runout comprising:
a web trimmed from a full height at a location prior to a web termination point to a reduced height at the web termination point at an outermost location of the web; and
a base flange extending horizontally in opposite directions from the web and including a flange termination point positioned at an outermost location of the base flange, wherein the flange termination point is positioned forward of the web termination point, and wherein the web termination point is positioned within a recessed notch of the base flange;

a composite structure bonded to the base flange of the stiffener runout at a scarf joint;

a pair of perimeter clamp radius fillers positioned on a top surface of the base flange on opposing sides of the web, each perimeter clamp radius filler comprising a bottom surface configured to contact the top surface of the base flange around a portion of a perimeter of the top surface to create a contact area between the perimeter clamp radius filler and the portion of the perimeter of the top surface, wherein the contact area defines a relief cavity between the perimeter clamp radius filler and the top surface; and

a plurality of fasteners securing the pair of perimeter clamp radius fillers to the top surface of the base flange such that each fastener extends through a top surface of one of the pair of perimeter clamp radius fillers, through the relief cavity, through the base flange, and through the composite structure.

24. The stiffener runout assembly of claim 23, further comprising a fiberglass wedge positioned between the base flange and the composite structure, wherein the base flange comprises a non-uniform thickness corresponding to a configuration of the fiberglass wedge to create the scarf joint.

25. A method of controlling bondline separation between a composite stiffener and a composite structure, the method comprising:

providing a composite stiffener comprising a web and a base flange, wherein the web terminates at a web termination point, wherein the base flange terminates at a flange termination point forward of the web termination point, and wherein the base flange comprises rounded corners;

trimming the web from a full height at a location prior to the web termination point to a reduced height at the web termination point;

providing a recessed notch within the base flange at the flange termination point such that the web termination point is positioned substantially at a center of the recessed notch;

bonding a bottom surface of the base flange to a top surface of the composite structure;

providing at least one perimeter clamp radius filler comprising a bottom surface configured to contact a top surface of the base flange around a portion of a perimeter of the top surface of the base flange to create a contact area between the perimeter clamp radius filler and the portion of the perimeter of the top surface of the base flange, wherein the contact area defines a relief cavity between the perimeter clamp radius filler and the top surface of the base flange; and

securing the at least one perimeter clamp radius filler to the top surface of the base flange using a plurality of fasteners extending through a top surface of the perimeter clamp radius filler, through the relief cavity, through the base flange, and through the composite structure.

26. The method of claim 25, further comprising providing a fiberglass wedge, wherein bonding the bottom surface of the base flange to the top surface of the composite structure comprises bonding a bottom surface of the fiberglass wedge to the top surface of the composite structure and bonding a top surface of the fiberglass wedge to the bottom surface of the base flange, and wherein the base flange comprises a non-uniform thickness corresponding to a configuration of the fiberglass wedge.

27. The method of claim 26, wherein the composite structure comprises a non-uniform thickness, and wherein the non-uniform thickness of the base flange corresponds to the non-uniform thickness of the composite structure such that bonding the bottom surface of the base flange to the top surface of the composite structure creates a scarf joint between the composite stiffener and the composite structure.

28. A method of controlling bondline separation between a composite stiffener and a composite structure, the method comprising:

providing a composite stiffener comprising a web and a base flange, wherein the web terminates at a web termination point, wherein the base flange terminates at a flange termination point forward of the web termination point, and wherein the base flange comprises rounded corners;

trimming the web from a full height at a location prior to the web termination point to a reduced height at the web termination point;

providing a recessed notch within the base flange at the flange termination point such that the web termination point is positioned substantially at a center of the recessed notch, wherein the recessed notch comprises an arcuate edge such that the web termination point is located on the arcuate edge; and

bonding a bottom surface of the base flange to a top surface of the composite structure.

29. The method of claim 28, further comprising:

providing at least one perimeter clamp radius filler comprising a bottom surface configured to contact a top surface of the base flange around a portion of a perimeter of the top surface of the base flange to create a contact area between the perimeter clamp radius filler and the portion of the perimeter of the top surface of the base flange, wherein the contact area defines a relief cavity between the perimeter clamp radius filler and the top surface of the base flange; and

securing the at least one perimeter clamp radius filler to the top surface of the base flange using a plurality of fasteners extending through a top surface of the perimeter clamp radius filler, through the relief cavity, through the base flange, and through the composite structure.

30. The method of claim 29, further comprising forming the contact surface of the at least one perimeter clamp radius filler with a C-shape such that an opening to the relief cavity is positioned along an edge of the perimeter clamp radius filler.

31. The method of claim 29 or 30, further comprising filling the relief cavity of the at least one perimeter clamp radius filler with a compliant filler material.

32. The method of any one of claims 28 to 31, further comprising providing a fiberglass wedge, wherein bonding the bottom surface of the base flange to the top surface of the composite structure comprises bonding a bottom surface of the fiberglass wedge to the top surface of the composite structure and bonding a top surface of the fiberglass wedge to the bottom surface of the base flange, and wherein

the base flange comprises a non-uniform thickness corresponding to a configuration of the fiberglass wedge.

33. The method of claim 32, in which the base flange is formed of multiple plies of composite material, and wherein the method further comprises forming the non-uniform thickness of the base flange by reducing a number of plies of composite material in the base flange.

34. The method of claim 32, wherein each of the base flange and the composite structure is formed of multiple plies of composite material, and wherein the method further comprises forming the non-uniform thickness of the base flange by reducing a number of plies of composite material in the base flange, and forming the non-uniform thickness of the composite structure by increasing a number of plies of composite material in the composite structure.

35. The method of claim 32, wherein the composite structure comprises a non-uniform thickness, and wherein the non-uniform thickness of the base flange corresponds to the non-uniform thickness of the composite structure such that bonding the bottom surface of the base flange to the top surface of the composite structure creates a scarf joint between the composite stiffener and the composite structure.

36. The method of any one of claims 28 to 35, wherein trimming the web from the full height to the reduced height comprises forming a leading edge of the web with a curved configuration.

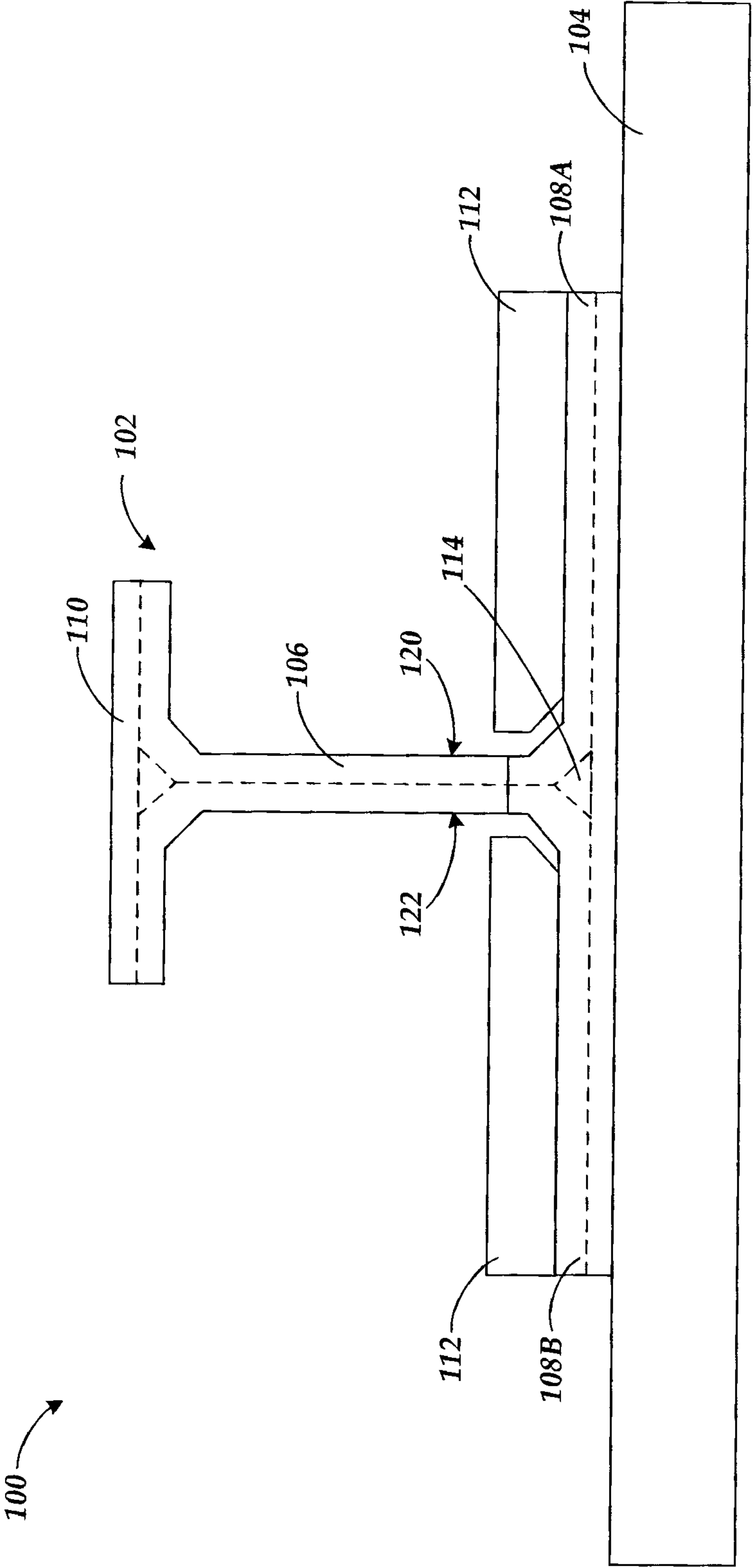


FIG. 1

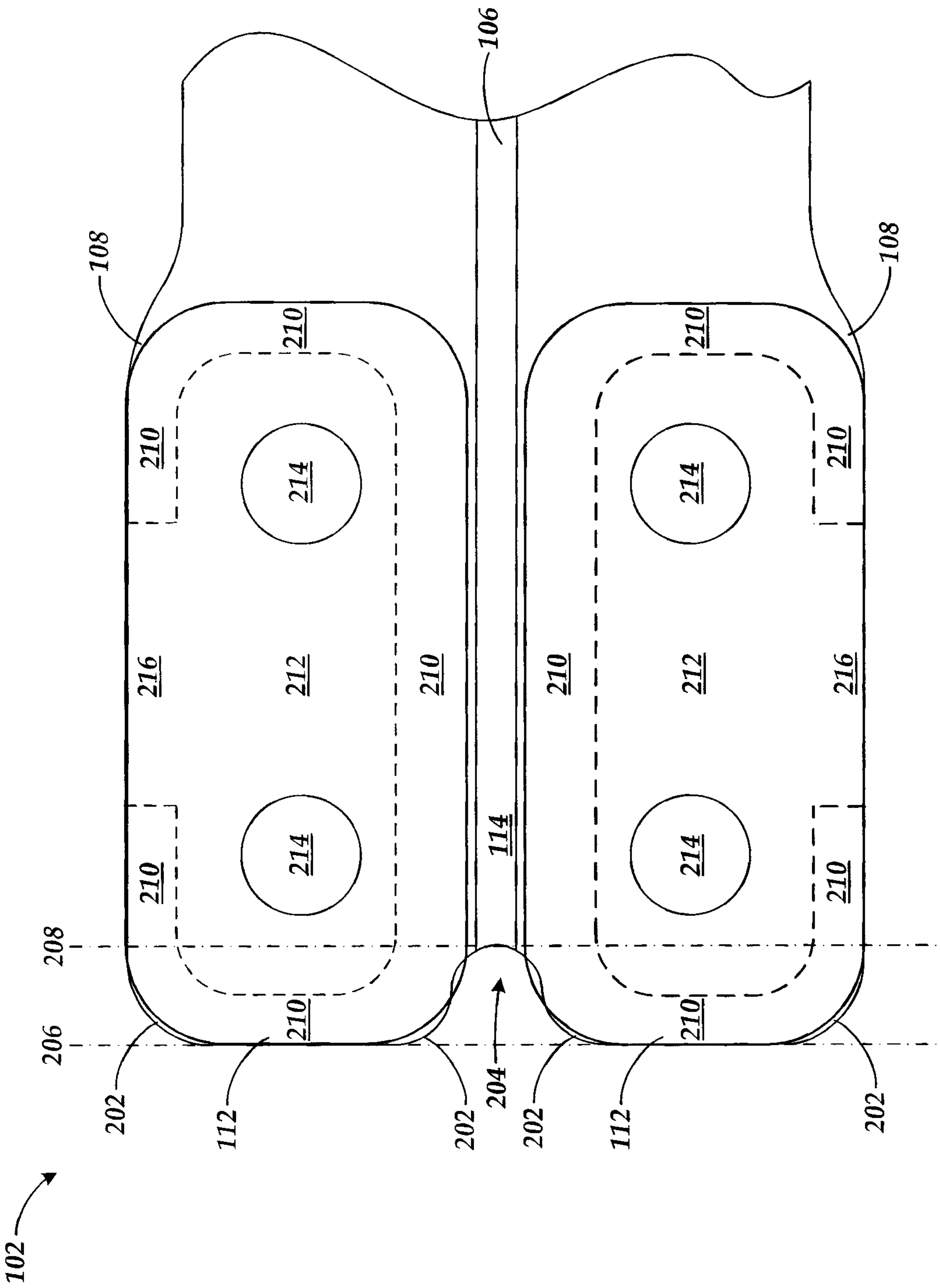


FIG. 2

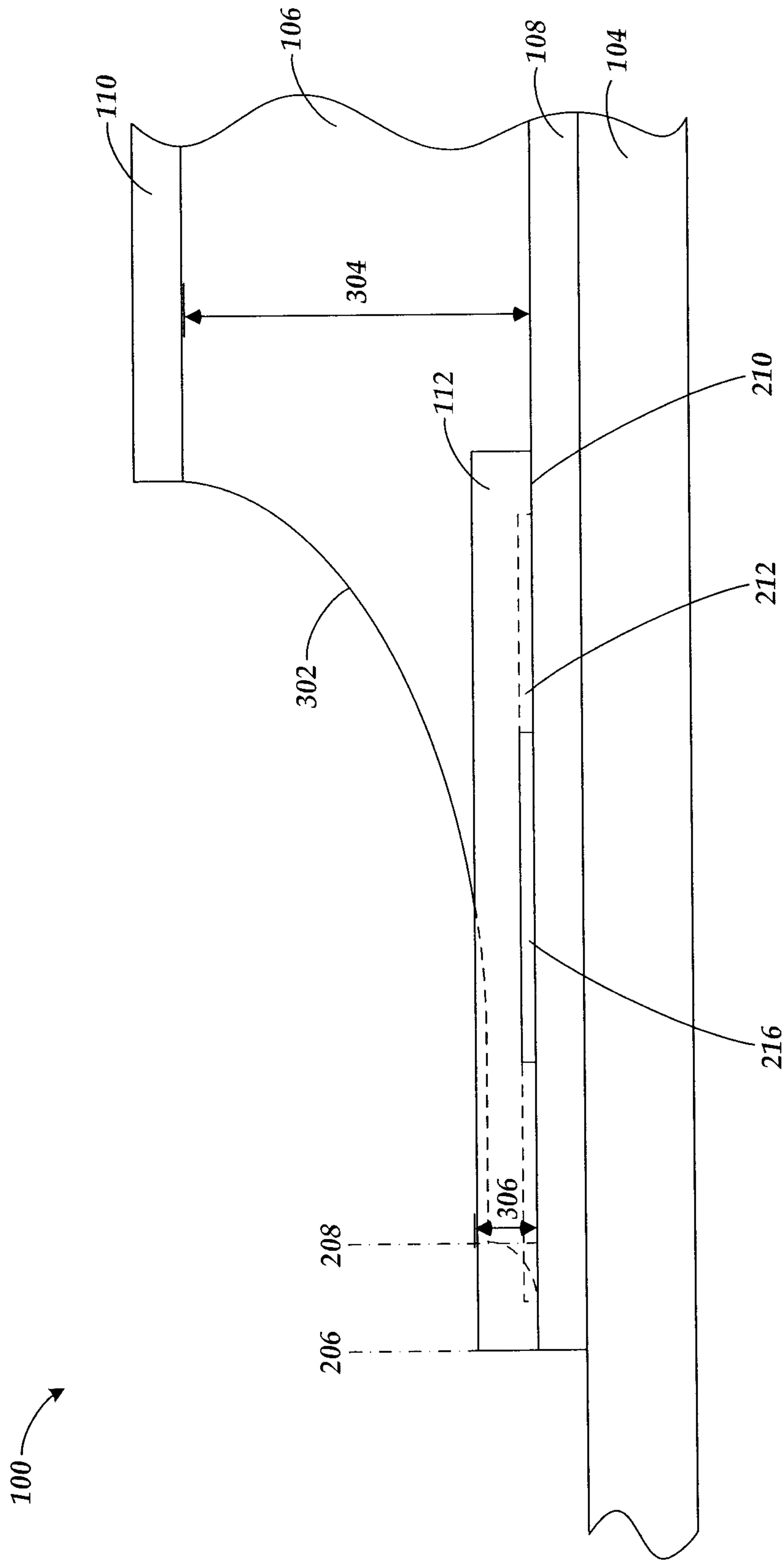


FIG. 3

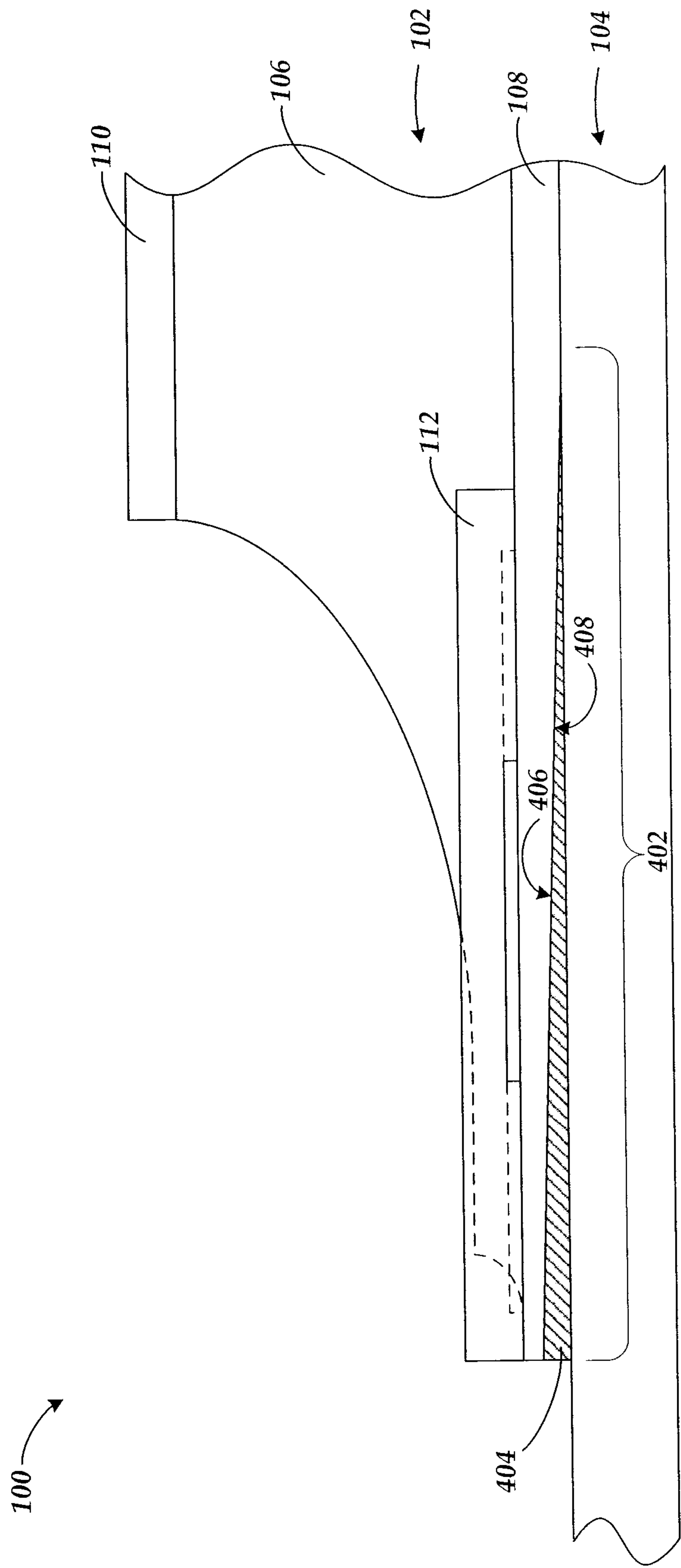


FIG. 4

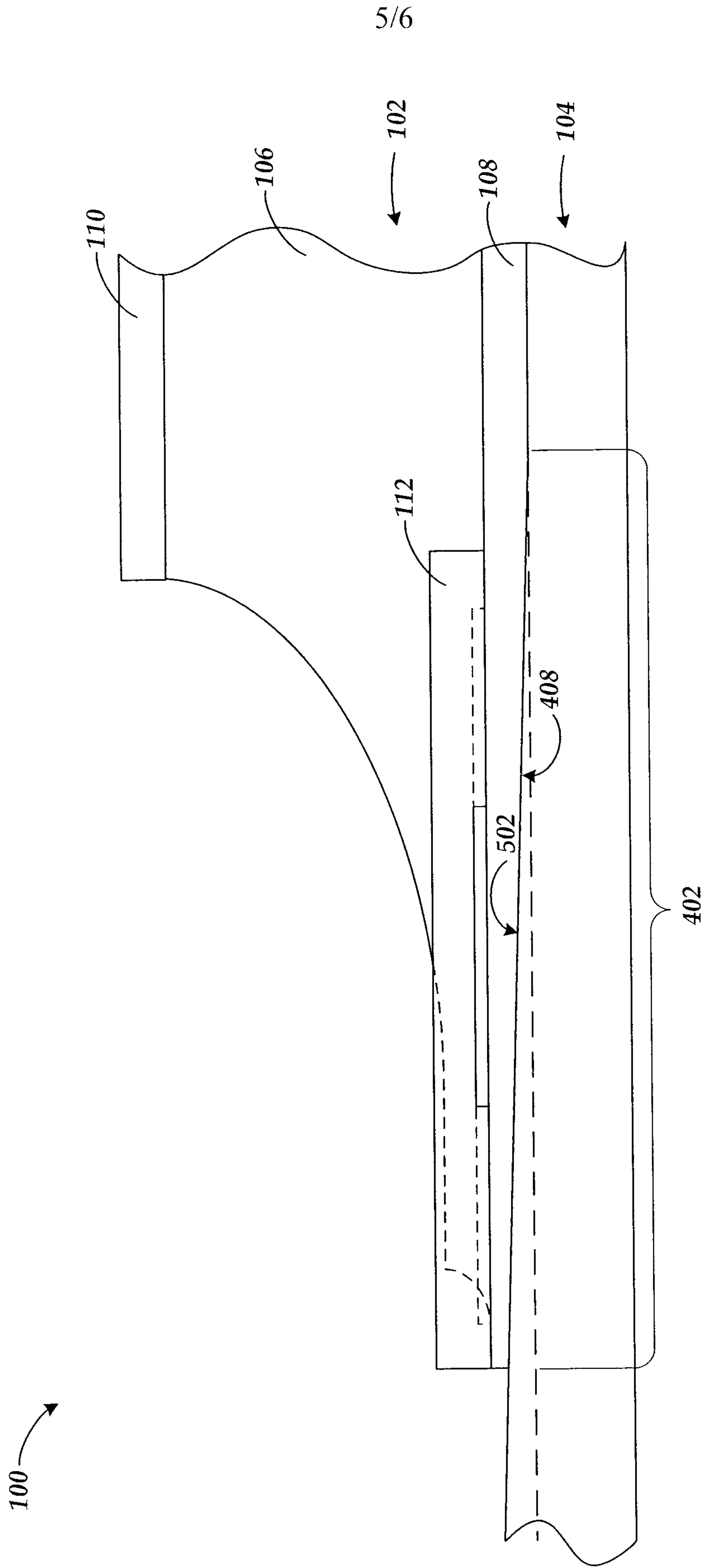
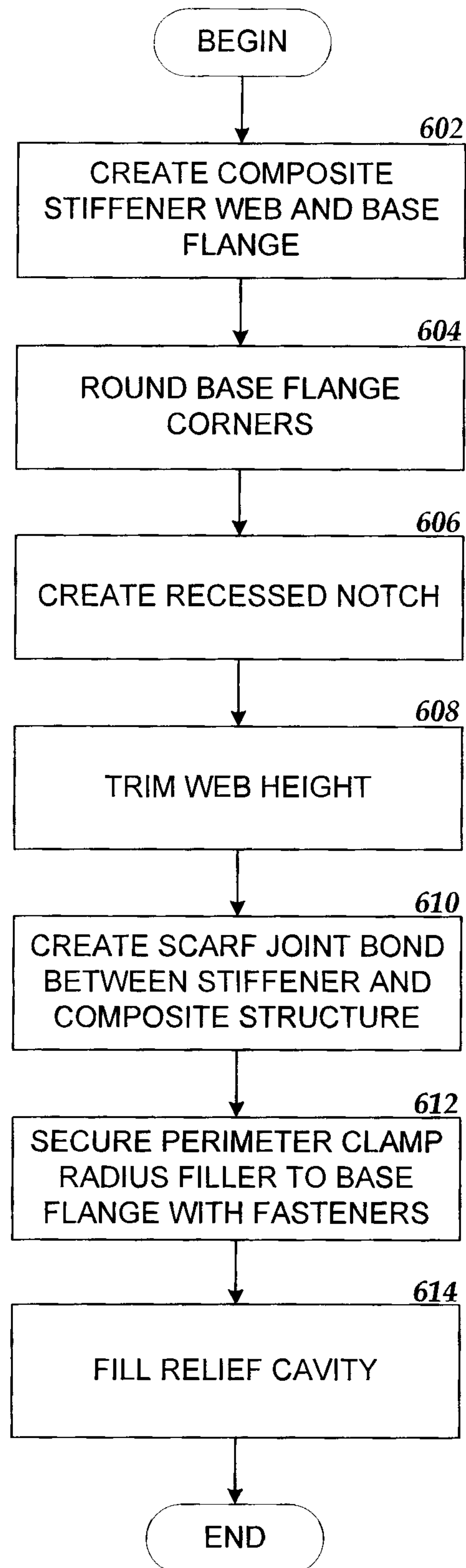


FIG. 5

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**FIG. 6**

