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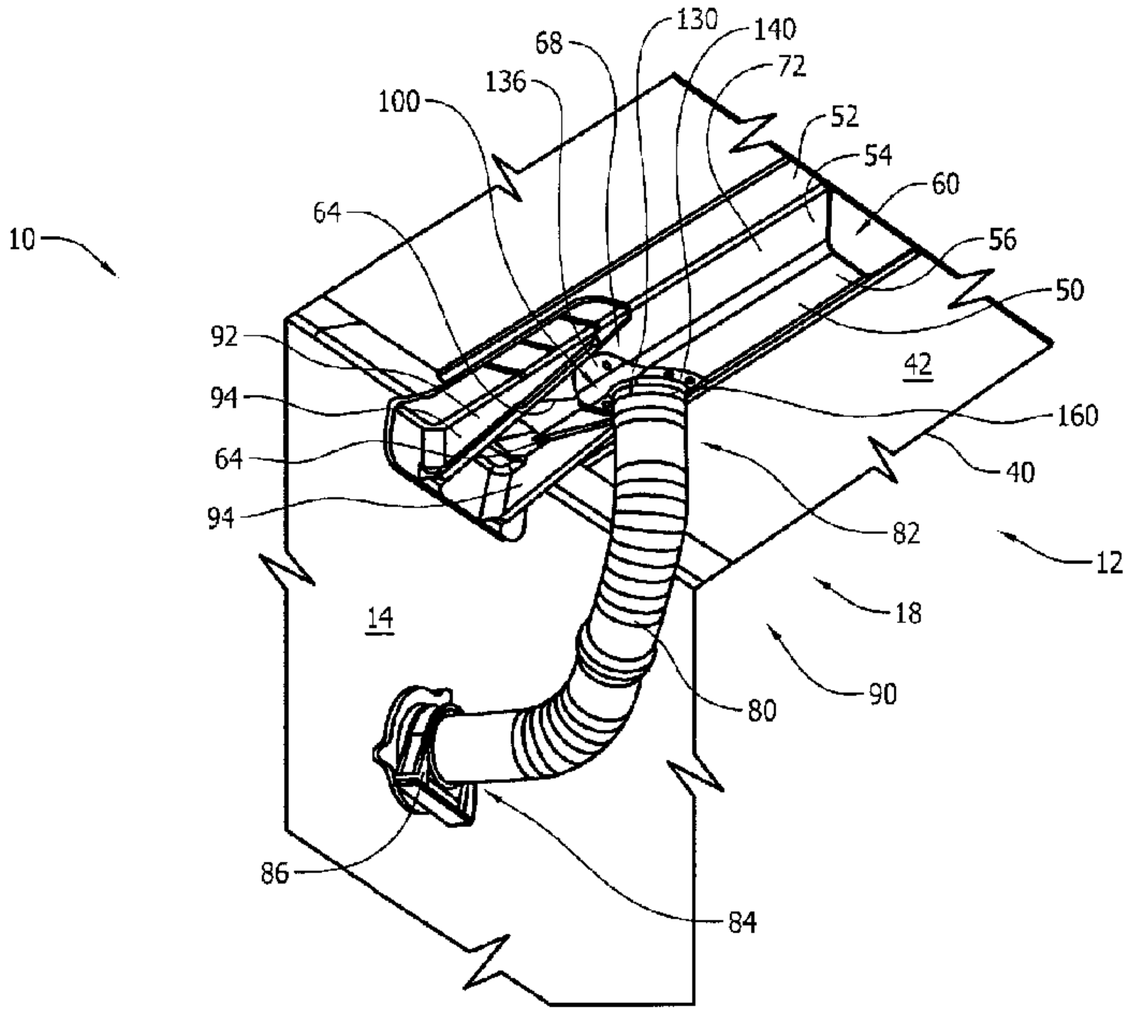

(57) Abrégé/Abstract:
A closeout fitting for a hat stringer includes a cover that has a fitting surface. The fitting surface is substantially complementary to at least a portion of an outer surface of the hat stringer. The cover is configured to couple against the hat stringer outer surface. The cover also includes a first portion configured to extend across a gap defined in a cap portion of the hat stringer. The closeout fitting also includes an insert. The insert includes a first outer perimeter surface that is substantially complementary to at least a portion of an interior surface of a channel defined by the hat stringer. The insert is configured to couple against the channel interior surface proximate the hat stringer closeout portion. The insert and the cover are formed with a suitable stiffness to limit a deformation of the hat stringer proximate the closeout portion.

HAT STRINGER CLOSEOUT FITTING AND METHOD OF MAKING SAME

ABSTRACT OF THE DISCLOSURE

A closeout fitting for a hat stringer includes a cover that has a fitting surface. The fitting surface is substantially complementary to at least a portion of an outer surface of the hat stringer. The cover is configured to couple against the hat stringer outer surface. The cover also includes a first portion configured to extend across a gap defined in a cap portion of the hat stringer. The closeout fitting also includes an insert. The insert includes a first outer perimeter surface that is substantially complementary to at least a portion of an interior surface of a channel defined by the hat stringer. The insert is configured to couple against the channel interior surface proximate the hat stringer closeout portion. The insert and the cover are formed with a suitable stiffness to limit a deformation of the hat stringer proximate the closeout portion.

HAT STRINGER CLOSEOUT FITTING AND METHOD OF MAKING SAME

BACKGROUND

The field of the disclosure relates generally to hat stringer fittings, and, more particularly, to a closeout fitting for a hat stringer that includes a trimmed end.

At least some known structures, such as aircraft, include structural components that are stiffened with hat stringers. At least some such hat stringers are trimmed proximate an end of the hat stringer, sometimes referred to as a "run-out" trim. For example, a run-out trim may be necessary to accommodate a structural joint fitting with another structural component. However, such a run-out trim may decrease a capability of at least some known hat stringers to carry certain loads to which the hat stringer may be subjected, such as, but not limited to, torsional loads on the hat stringer and shear loads in a cap of the hat stringer. As a result, adverse effects, such as, but not limited to, excessive hat stringer web bending and excessive localized loads on the hat stringer noodle, such as bending, torsion, shear, axial, vertical, and/or transverse localized noodle loads, may cause a crack or delamination near the run-out trim location.

Moreover, at least some known structural components include hat stringers that additionally or alternatively provide a vent path for a fluid, such as but not limited to an aircraft fuel and/or fuel vapor, associated with the structural component. To accommodate a vent system connection, an additional hole must be drilled through at least some such hat stringers at a location away from the run-out trim. However, such an additional hole may decrease a structural integrity of at least some known hat stringers. In addition, for at least some known hat stringers, a number of tasks must be performed to seal the vent path proximate a run-out trim as part of a larger process of coupling the structural component, for example an aircraft wing, to another structural component, for example an aircraft fuselage. Thus a time and a cost of the larger process is increased.

SUMMARY

In one embodiment, there is provided a closeout fitting for a hat stringer. The closeout fitting includes a cover including a fitting surface. The fitting surface is substantially complementary to at least a portion of an outer surface of the hat stringer. The cover is configured to couple against the hat stringer outer surface. The cover also has a first portion configured to extend across a gap defined in a cap portion of the hat stringer when the cover is coupled against a closeout portion of the hat stringer. The cover further includes an insert including an outer perimeter surface and a wall that is sealingly enclosed by the outer perimeter surface. At least a first portion of the outer perimeter surface is substantially complementary to at least a portion of an interior surface of a channel defined by the hat stringer, the insert is configured to couple to the cover and to couple against the channel interior surface proximate the hat stringer closeout portion such that the wall is disposed across the channel and such that a deformation of the hat stringer proximate the closeout portion is limited. The insert is configured to substantially block flow communication through the channel.

At least a second portion of the outer perimeter surface may be substantially complementary to at least a portion of the cover fitting surface.

The cover may further include a plurality of first cover openings defined in and extending through the cover, and the insert may further include a plurality of first insert openings defined in and extending through the outer perimeter surface, each first cover opening may be configured to align with a corresponding first insert opening and a corresponding one of a plurality of first closeout openings defined in the hat stringer closeout portion when the cover is positioned for coupling to the hat stringer closeout portion.

The cover may further include a plurality of third cover openings defined in and extending through the cover. Each the third cover opening may be configured to be positioned proximate the gap when the cover is positioned for coupling to the hat stringer closeout portion. Each the third cover opening may also be configured to align with a corresponding one of a plurality of third insert openings defined in the insert when the cover and the insert are positioned for coupling to the hat stringer closeout portion.

The cover may further include a vent connector. The vent connector defines an orifice that extends through the cover such that the vent connector may be configured to be in flow communication with the channel via the gap when the cover is positioned for coupling to the hat stringer closeout portion.

In another embodiment, there is provided an aircraft. The aircraft includes a wing, and a hat stringer coupled to an interior surface of a panel of the wing. The hat stringer defines a channel and comprises a cap portion. A gap is defined in the cap portion proximate a closeout portion of the hat stringer. The aircraft further includes a closeout fitting including a cover coupled against an outer surface of the hat stringer. A fitting surface of the cover is substantially complementary to at least a portion of the hat stringer outer surface. A first portion of the cover extends across the gap. The closeout fitting further includes an insert including an outer perimeter surface and a wall that is sealingly enclosed by the outer perimeter surface. At least a first portion of the outer perimeter surface of the insert is substantially complementary to at least a portion of the channel interior surface. The insert is coupled to the cover and coupled against the channel interior surface proximate the closeout portion such that the wall is disposed across the channel and such that a deformation of the hat stringer proximate the closeout portion is limited. The insert is configured to substantially block flow communication through the channel.

At least a second portion of the outer perimeter surface may be substantially complementary to at least a portion of the cover fitting surface.

The cover may further include a plurality of first cover openings defined in and extending through the cover, and the insert may further include a plurality of first insert openings defined in and extending through the outer perimeter surface. Each first cover opening may be aligned with a corresponding first insert opening and a corresponding one of a plurality of first closeout openings defined in the hat stringer closeout portion.

The cover may further include a plurality of third cover openings defined in and extending through the cover. Each third cover opening may be positioned proximate the gap, and each third cover opening may be aligned with a corresponding one of a plurality of third insert openings defined in the insert.

The cover may further include a vent connector, defining an orifice that extends through the cover such that the vent connector may be in flow communication with the channel via the gap.

The aircraft may include at least one vent coupled in flow communication with the channel, and at least one fuel tank in flow communication with the vent connector, such that a fluid flow path is defined from the at least one fuel tank, through the vent connector, through the gap, and through the channel, to the at least one vent.

The aircraft may include a fuselage comprising a vent port, and the at least one fuel tank may be disposed in an interior of the fuselage. The at least one fuel tank is in flow communication with the vent port, and a vent tube. A first end of the vent tube may be coupled in flow communication with the vent connector and a second end of the vent tube may be coupled in flow communication with the vent port, such that the fluid flow path is defined from the at least one fuel tank, through the vent port, through the vent tube, through the vent connector, through the gap, and through the channel, to the at least one vent.

In another embodiment, there is provided a method of making a closeout fitting for a hat stringer of a vehicle. The method involves forming a fitting surface of a cover to be substantially complementary to at least a portion of an outer surface of the hat stringer, such that the cover is configured to couple against the hat stringer outer surface, and configuring a first portion of the cover to extend across a gap defined in a cap portion of the hat stringer when the cover is coupled against a closeout portion of the hat stringer. The method further involves forming an insert that includes an outer perimeter surface and a wall that is sealingly enclosed by the outer perimeter surface. At least a first portion of the outer perimeter surface is substantially complementary to at least a portion of an interior surface of a channel defined by the hat stringer, such that the insert is configured to couple to the cover and to couple against the channel interior surface proximate the hat stringer closeout portion such that the wall is disposed across the channel and such that a deformation of the hat stringer proximate the closeout portion is limited. Forming the insert further involves configuring the insert to substantially block flow communication through the channel.

The method may involve forming at least a second portion of the outer perimeter surface of the insert to be substantially complementary to at least a portion of the cover fitting surface.

The method may involve forming a plurality of first cover openings in the cover and a plurality of first insert openings in the outer perimeter surface. Each first cover opening may extend through the cover and each first insert opening may extend through the outer perimeter surface. Each first cover opening may be configured to align with a corresponding first insert opening and a corresponding one of a plurality of first closeout openings defined in the hat stringer closeout portion when the cover is positioned for coupling to the hat stringer closeout portion.

The method may involve forming a plurality of third cover openings in the cover. Each third cover opening may extend through the cover, and may be configured to be positioned proximate the gap when the cover is positioned for coupling to the hat stringer closeout portion, and each third cover opening may be configured to align with a corresponding one of a plurality of third insert openings defined in the insert when the cover and the insert are positioned for coupling to the hat stringer closeout portion.

The method may involve forming a vent connector of the cover. The vent connector may define an orifice that extends through the cover such that the vent connector may be configured to be in flow communication with the channel via the gap when the cover is positioned for coupling to the hat stringer closeout portion.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic diagram of an exemplary aircraft on which embodiments of a hat stringer closeout fitting may be used;

FIG. **2** is a schematic perspective view of an exemplary embodiment of a hat stringer that may be used on the exemplary aircraft shown in FIG. **1**:

FIG. **3** is a schematic cross-sectional view of the exemplary hat stringer shown in FIG. **2**;

FIG. **4** is a schematic exploded perspective view of an exemplary embodiment of a hat stringer closeout fitting that may be used with the hat stringer shown in FIG. **2** and the aircraft shown in FIG. **1**;

FIG. **5** is a schematic perspective view of the exemplary hat stringer closeout fitting shown in FIG. **4** coupled to the hat stringer shown in FIG. **2**;

FIG. **6** is a schematic perspective view of a portion of a side-of-body joint of the exemplary aircraft shown in FIG. **1**, with the exemplary hat stringer shown in FIG. **2** coupled to a wing of the exemplary aircraft and the exemplary hat stringer closeout fitting shown in FIG. **4** coupled to the exemplary hat stringer; and

FIG. **7** is a flowchart of an embodiment of a method of making a closeout fitting for a hat stringer, such as the exemplary hat stringer closeout fitting shown in FIG. **4**.

DETAILED DESCRIPTION

Embodiments of the system and method described herein provide a closeout fitting for a hat stringer closeout portion, such as a closeout portion defined by a run-out trim. The closeout fitting improves a capability of the hat stringer at the trimmed location to carry loads to which the hat stringer is subjected. In certain embodiments, the closeout fitting

additionally includes a vent connector configured to couple a channel defined by the hat stringer in flow communication with a vent system.

Referring more particularly to the drawings, implementations of the disclosure may be described in the context of a structure such as an exemplary aircraft **10** shown schematically in FIG. **1**. Various components of aircraft **10**, such as, but not limited to, wings **12** and fuselage **14**, are formed from structural components that include at least one hat stringer **50**. It should be understood, however, that the disclosure applies equally to other vehicles, including but not limited to automobiles, heavy work vehicles, aquatic vessels, and other vehicles.

In the illustrated embodiment, for example, at least one hat stringer **50** is disposed along an interior of each wing **12**. Each hat stringer **50** extends from a first end **51** to a second end **53**. In the illustrated embodiment, each first end **51** is located near a tip **16** of wing **12**, and each second end **53** is located near a root **18** of wing **12**. In alternative embodiments, at least one of first end **51** and second end **53** are located at a different location along wing **12** for at least one of the at least one hat stringers **50**.

Also in the illustrated embodiment, at least one fuel tank **30** is disposed in an interior of each wing **12**. Additionally or alternatively, at least one fuel tank **30** is disposed in an interior of fuselage **14**. Each fuel tank **30** is in flow communication with at least one vent **32** of aircraft **10**. The at least one vent **32** facilitates reducing a pressure difference between an interior of each fuel tank **30** and an atmospheric pressure.

FIG. **2** is a schematic perspective view of an exemplary embodiment of hat stringer **50**, and FIG. **3** is a schematic cross-sectional view of exemplary hat stringer **50** taken along line **3-3** shown in FIG. **2**. With reference to FIGS. **2** and **3**, hat stringer **50** includes a pair of opposing flange portions **52**, a pair of opposing web portions **54**, and a cap portion **56** that extends between web portions **54**. Each web portion **54** extends between one of the pair of flange portions **52** and an edge of cap portion **56**. In an embodiment, hat stringer **50** is formed from a carbon fiber reinforced polymer material. In alternative embodiments, hat stringer **50** is formed from any other suitable material that enables hat stringer **50** to function as described herein.

In the illustrated embodiment, hat stringer **50** is coupled to a surface **42** of a panel **40**. For example, panel **40** is a skin panel of wing **12** (shown in FIG. **1**), and surface **42** is an

interior surface of the skin panel. More specifically, each flange portion **52** of hat stringer **50** is coupled to surface **42** in any suitable fashion, such as but not limited to by an adhesive or co-bonding, that enables hat stringer **50** to function as described herein. A noodle **58** also is coupled in any suitable fashion between surface **42** and hat stringer **50** at each location where one of the flange portions **52** transitions into one of the web portions **54**. In alternative embodiments, noodles **58** are not present.

Web portions **54**, cap portion **56**, panel **40**, and, if present, noodles **58** cooperate to define a channel **60** having an interior surface **70**. In the illustrated embodiment, channel interior surface **70** has a generally trapezoidal cross-section. In alternative embodiments, channel interior surface **70** has a cross-section that is other than generally trapezoidal. In addition, web portions **54** and cap portion **56** cooperate to define an outer surface **72** of hat stringer **50**.

In certain embodiments, channel **60** is configured to be in flow communication with a venting system. For example, channel **60** is configured to be in flow communication with at least one fuel tank **30** and at least one vent **32** of aircraft **10** (shown in FIG. **1**) to facilitate reducing a pressure difference between an interior of the at least one fuel tank **30** and an atmospheric pressure. In alternative embodiments, channel **60** is not configured to be in flow communication with a venting system.

With reference to FIG. **2**, in the illustrated embodiment, a run-out trim **62** of hat stringer **50** is defined proximate to one of first end **51** and second end **53** of hat stringer **50**. More specifically, run-out trim **62** is defined by a region in which material has been trimmed from hat stringer **50** along an edge **64** of each web portion **54** and along an edge **66** of cap portion **56**. In certain embodiments, a shape and location of edges **64** and **66** is predetermined to accommodate a structural fitting of panel **40** with another structural component. For example, panel **40** is a skin panel of wing **12** (shown in FIG. **1**), and end **44** is proximate root **18** (shown in FIG. **1**) and configured to be coupled to fuselage **14** via a structural joint, such as joint **90** (shown in FIG. **6**).

A gap **69** is defined in hat stringer cap portion **56** between opposing web portion edges **64** and between opposing portions of cap edge **66**. A closeout portion **68** of hat stringer **50** is defined proximate gap **69**. A first end **61** of channel **60** is defined adjacent closeout portion **68**.

A plurality of first closeout openings **76** are defined in, and extend through, opposing web portions **54** of hat stringer closeout portion **68**. In alternative embodiments, plurality of first closeout openings **76** additionally or alternatively are defined in, and extend through, cap portion **56** of closeout portion **68**. In other alternative embodiments, plurality of first closeout openings **76** are not defined in any of web portions **54** and cap portion **56**. Also in the illustrated embodiment, a plurality of second closeout openings **78** are defined in, and extend through, opposing web portions **54** and cap portion **56** of closeout portion **68**. In alternative embodiments, plurality of second closeout openings **78** are not defined in at least one of web portions **54** and cap portion **56**. Plurality of first closeout openings **76** and plurality of second closeout openings **78** are configured for coupling closeout portion **68** to a closeout fitting **100** (shown in FIGS. **4** and **5**), as will be described herein.

FIG. **4** is a schematic exploded perspective view of an exemplary embodiment of closeout fitting **100**. FIG. **5** is a schematic perspective view of exemplary closeout fitting **100** coupled to hat stringer closeout portion **68**. With reference to FIGS. **4** and **5**, closeout fitting **100** includes an insert **102** and a cover **130**. Insert **102** and cover **130** are configured to couple to closeout portion **68** such that insert **102** and cover **130** provide a structural path for reacting loads to which hat stringer **50** is subjected. In certain embodiments, insert **102** and cover **130** are formed with a suitable stiffness to limit a deformation of hat stringer **50** proximate closeout portion **68** when closeout fitting **100** is coupled to closeout portion **68**. For example, insert **102** and cover **130** are formed with a suitable stiffness to limit a torsional and/or bending deformation in web portions **54** proximate closeout portion **68**. For another example, insert **102** and cover **130** are formed with a suitable stiffness to limit a deformation from shear loads in hat stringer cap portion **56** proximate cap portion edge **66**. In an embodiment, insert **102** and cover **130** are formed from a metallic material. In alternative embodiments, insert **102** and cover **130** are formed from any suitable material that enables closeout fitting **100** to function as described herein.

Cover **130** defines a fitting surface **134** that is substantially complementary to at least a portion of hat stringer outer surface **72**, such that cover **130** is configured to couple against outer surface **72**. In the illustrated embodiment, cover **130** includes a pair of opposing sides **136** that are each substantially complementary to an outer surface of at least a portion of a respective hat stringer web portion **54**, and a cap **140** that is substantially complementary to an

outer surface of hat stringer cap portion **56**. Cover **130** includes at least a first portion **132** configured to extend across gap **69** when cover **130** is coupled against hat stringer outer surface **72** at closeout portion **68**.

In the illustrated embodiment, a plurality of first cover openings **144** are defined in, and extend through, cover **130**. Each first cover opening **144** is configured to align with a corresponding first closeout opening **76** (shown in FIG. **2**) when cover **130** is positioned for coupling to closeout portion **68**. In the illustrated embodiment, first cover openings are defined in each opposing cover side **136**. In alternative embodiments, plurality of first cover openings **144** additionally or alternatively are defined in, and extend through, cover cap **140**. In other alternative embodiments, first cover openings **144** are not defined in cover **130**.

Also in the illustrated embodiment, a plurality of second cover openings **154** are defined in, and extend through, cover **130**. Each second cover opening **154** is configured to align with a corresponding second closeout opening **78** (shown in FIG. **2**) when cover **130** is positioned for coupling to closeout portion **68**. In the illustrated embodiment, second cover openings **154** are defined in each opposing cover side **136** and cover cap **140**. In alternative embodiments, second cover openings **154** are not defined in at least one of opposing cover sides **136** and cover cap **140**. When closeout fitting **100** is assembled, a suitable second fastener **168** is disposed in each corresponding aligned second closeout opening **78** and second cover opening **154** to couple cover **130** to closeout portion **68**. In alternative embodiments, second cover openings **154** are not defined in cover **130**, and insert **102** and cover **130** are coupled to closeout portion **68** in another suitable fashion, such as but not limited to by at least one first fastener **170** (as will be described herein) or by an adhesive.

Further in the illustrated embodiment, a plurality of third cover openings **148** are defined in, and extend through, cover cap **140**. Each third cover opening **148** is configured to be positioned proximate gap **69** (shown in FIG. **2**) when cover **130** is positioned for coupling to closeout portion **68**. Moreover, each third cover opening **148** is configured to align with a corresponding third insert opening **116** in insert **102**, as will be described herein, when cover **130** and insert **102** are positioned for coupling to closeout portion **68**. In alternative embodiments, third cover openings **148** are additionally or alternatively are defined in, and extend through, opposing cover sides **136**. In other alternative embodiments, third cover openings **148** are not defined in any of opposing cover sides **136** and cover cap **140**.

In certain embodiments, cover **130** includes a vent connector **160**. In the illustrated embodiment, vent connector **160** extends from cover cap **140**. Vent connector **160** defines an orifice **162** that extends through cover cap **140** such that vent connector **160** is configured to be in flow communication with channel **60** via gap **69** when cover **130** is positioned for coupling to closeout portion **68**. A rim **164** of vent connector **160** is configured for coupling to a vent tube **80** (shown in FIG. **6**) in any suitable fashion, such as but not limited to by a threaded connection. In certain embodiments, vent tube **80** is in flow communication with at least one of plurality of fuel tanks **30** of aircraft **10**, such that channel **60** provides a conduit between the at least one fuel tank **30** and at least one vent **32** of aircraft **10**. In alternative embodiments, cover **130** does not include vent connector **160**, and closeout fitting **100** is not configured to couple channel **60** to a vent system.

Insert **102** is configured to be positioned at channel first end **61** when closeout fitting **100** is positioned for coupling to closeout portion **68**. Insert **102** defines a first outer perimeter surface **103** that is substantially complementary to at least a portion of channel interior surface **70** (shown in FIG. **3**), such that insert **102** is configured to couple against channel interior surface **70** proximate closeout portion **68**. Moreover, in certain embodiments, insert **102** defines a second outer perimeter surface **105** that is substantially complementary to at least a portion of fitting surface **134** of cover **130**.

For example, in the illustrated embodiment, insert **102** includes a pair of opposing sides **106**, a cap end **110**, and a panel end **112** opposite cap end **110**. First outer perimeter surface **103** is defined by opposing insert sides **106** that are each substantially complementary to an inner surface of a respective hat stringer web portion **54**, and insert panel end **112** that is substantially complementary to a portion of panel surface **42** that extends between web portions **54**. Insert panel end **112** also is substantially complementary to a surface of noodles **58**, if present. Also in the illustrated embodiment, second outer perimeter surface **105** is defined by insert cap end **110**. Insert cap end **110** is configured to be positioned proximate gap **69** when insert **102** is positioned for coupling to closeout portion **68**, and insert cap end **110** is substantially complementary to fitting surface **134** of first portion **132** of cover **130**.

In an alternative embodiment (not shown), first outer perimeter surface **103** also is partially defined by insert cap end **110**. For example, insert cap end **110** is configured to be

positioned proximate hat stringer cap portion **56** when insert **110** is positioned for coupling to closeout portion **68**, and insert cap end **110** is substantially complementary to an inner surface of cap portion **56**.

In certain embodiments, insert **102** is configured to block flow communication through first end **61** of channel **60** when insert **102** is coupled to closeout portion **68** (shown in FIG. **2**). For example, in certain embodiments, insert **102** includes a wall **118** that is sealingly enclosed by first outer perimeter surface **103** and second outer perimeter surface **105**. In the illustrated embodiment, wall **118** extends between opposing insert sides **106** and extends between insert cap end **110** and insert panel end **112**. In alternative embodiments, wall **118** is sealingly enclosed substantially entirely by first outer perimeter surface **103**.

A plurality of first insert openings **114** are defined in, and extend through, first outer perimeter surface **103**. Each first insert opening **114** is configured to align with a corresponding first closeout opening **76** and a corresponding first cover opening **144** when insert **102** and cover **130** are positioned for coupling to closeout portion **68**. In the illustrated embodiment, first insert openings **114** are defined in each opposing insert side **106**. In alternative embodiments, plurality of first insert openings **114** additionally or alternatively are defined in, and extend through, insert cap end **110**. When closeout fitting **100** is assembled, a suitable first fastener **170** is disposed in each corresponding aligned first insert opening **114**, first closeout opening **76**, and first cover opening **144** to couple insert **102** and cover **130** to closeout portion **68**. In alternative embodiments, first insert openings **114** are not defined in first outer perimeter surface **103**, and insert **102** and cover **130** are coupled to closeout portion **68** in another suitable fashion, such as but not limited to by second fasteners **168** and third fasteners **172** (as will be described herein) or by an adhesive.

Also in the illustrated embodiment, a plurality of third insert openings **116** are defined in, and extend through, second outer perimeter surface **105**. Plurality of third insert openings **116** are configured to be positioned proximate gap **69** (shown in FIG. **2**) when insert **102** is positioned for coupling to closeout portion **68**. Moreover, each third insert opening **116** is configured to align with a corresponding third cover opening **148** when cover **130** and insert **102** are positioned for coupling to closeout portion **68**. In the illustrated embodiment, third insert openings **116** are defined in insert cap end **110**. In alternative embodiments, third insert openings **116** additionally or alternatively are defined in, and extend through, opposing insert

sides **106**. When closeout fitting **100** is assembled, a suitable third fastener **172** is disposed in each corresponding aligned third insert opening **116** and third cover opening **148** to couple insert **102** to cover **130**, and thus, indirectly, to closeout portion **68**. In other alternative embodiments, third insert openings **116** are not defined in second outer perimeter surface **105**, and insert **102** is coupled to cover **130** in another suitable fashion, such as but not limited to by first fasteners **170** and/or by an adhesive.

In certain embodiments, aligned first insert openings **114** and first cover openings **144**, as well as aligned third insert openings **116** and third cover openings **148**, are fully accessible externally to closeout fitting **100** to enable installation of corresponding first fasteners **170** and third fasteners **172**. For example, in the illustrated embodiment, each of first outer perimeter surface **103** and second outer perimeter surface **105** extends from a first end **120** to a second end **122**, with second end **122** configured to face channel **60** when closeout fitting **100** is coupled to hat stringer **50**. Wall **118** is positioned proximate second end **122** such that, when cover **130** and insert **102** are positioned for coupling to closeout portion **68** and corresponding first fasteners **170** and third fasteners **172** are inserted, both ends of each first fastener **170** and each third fastener **172** are accessible externally to closeout fitting **100** to facilitate completion of the coupling process. Thus, each of first fasteners **170** and third fasteners **172** can be installed without a need for access to an interior of hat stringer **50**. In alternative embodiments, at least one of aligned first insert openings **114** and first cover openings **144** and aligned third insert openings **116** and third cover openings **148** are not fully accessible externally to closeout fitting **100** to enable installation of corresponding first fasteners **170** and third fasteners **172**, and the corresponding first fasteners **170** and third fasteners **172** are installed by, for example, accessing a second end of the fasteners through orifice **162**.

As described above, insert **102** is configured in certain embodiments to substantially block flow communication through channel first end **61** (shown in FIG. **2**) when closeout fitting **100** is coupled to closeout portion **68**. In particular embodiments, a suitable sealant material is positioned between insert **102** and at least one of closeout portion **68** and cover **130** to improve a sealing effectiveness of insert **102** at channel first end **61**. For example, the sealant material is positioned at an interface between insert **102** and at least one of hat stringer web portion edges **64** and cover first portion **132**. In alternative embodiments, no

sealant material is positioned between insert **102** and either of closeout portion **68** and cover **130**.

FIG. **6** is a schematic perspective view of a portion of a side-of-body joint **90** coupling wing **12** and fuselage **14** of aircraft **10**, with hat stringer **50** coupled to wing **12** and closeout fitting **100** coupled to hat stringer **50**. In the illustrated embodiment, panel **40** is an upper wing skin panel, and surface **42** is an interior surface of panel **40**. Thus, as illustrated in FIG. **6**, hat stringer outer surface **72** extends downward from surface **42**. Joint **90** includes at least one structural fitting **92** that couples hat stringer **50** to fuselage **14**. In the illustrated embodiment, the at least one structural fitting **92** includes a pair of structural fitting web portions **94**, and each structural fitting web portion **94** is coupled to a corresponding hat stringer flange portion **52** and web portion **54** in any suitable fashion, such as but not limited to using suitable fasteners (not shown).

In the illustrated embodiment, hat stringer channel **60** is coupled in flow communication with at least one fuel tank **30** (shown in FIG. **1**) and at least one vent **32** (shown in FIG. **1**) of aircraft **10**. More specifically, a first end **82** of vent tube **80** is coupled in flow communication with closeout fitting vent connector **160**, and a second end **84** of vent tube **80** is coupled in flow communication with a vent port **86** of fuselage **14**. Vent port **86** is in flow communication with at least one fuel tank **30** located in an interior of fuselage **14**. Thus, a fluid flow path is defined from the at least one fuel tank **30**, through vent port **86**, through vent tube **80**, through closeout fitting vent connector **160**, through gap **69** (shown in FIG. **2**), through channel **60** (shown in FIG. **2**), to the at least one vent **32**. Moreover, the flow path is at least partially defined at channel first end **61** by insert **102** (visible in FIG. **5**) of closeout fitting **100**. In an alternative embodiment, closeout fitting **100** does not include vent connector **160**, and hat stringer channel **60** is not coupled in flow communication with any fuel tank **30** and/or any vent **32**.

FIG. **7** is a flowchart of an embodiment of a method **200** of making a closeout fitting, such as closeout fitting **100**, for a hat stringer, such as hat stringer **50**, of a vehicle, such as aircraft **10**. Method **200** includes forming **202** a fitting surface of a cover, such as fitting surface **134** of cover **130**, to be substantially complementary to at least a portion of an outer surface, such as outer surface **72**, of the hat stringer, such that the cover is configured to couple against the hat stringer outer surface. Method **200** also includes configuring **204** a first portion,

such as first portion **132**, of the cover to extend across a gap defined in a cap portion, such as gap **69** defined in cap portion **56**, of the hat stringer when the cover is coupled against a closeout portion, such as closeout portion **68**, of the hat stringer. Method **200** further includes forming **206** a first outer perimeter surface of an insert, such as first perimeter outer surface **103** of insert **102**, to be substantially complementary to at least a portion of an interior surface of a channel defined by the hat stringer, such as interior surface **70** of channel **60**, such that the insert is configured to couple against the channel interior surface proximate the hat stringer closeout portion. The insert and the cover are formed with a suitable stiffness to limit a deformation of the hat stringer proximate the closeout portion when the closeout fitting is coupled to the closeout portion.

In certain embodiments, method **200** includes forming **208** a second outer perimeter surface of the insert, such as second outer perimeter surface **105**, to be substantially complementary to at least a portion of the cover fitting surface. In some embodiments, method **200** also includes forming **210** a plurality of first cover openings, such as first cover openings **144**, in the cover. Each first cover opening extends through the cover, and each first cover opening is configured to align with a corresponding one of a plurality of first closeout openings, such as first closeout openings **76**, defined in the hat stringer closeout portion when the cover is positioned for coupling to the hat stringer closeout portion. Also in some embodiments, method **200** includes forming **212** a plurality of first insert openings, such as first insert openings **114**, in the first outer perimeter surface. Each first insert opening extends through the first outer perimeter surface, and each first insert opening is configured to align with a corresponding one of the plurality of first cover openings and a corresponding one of the plurality of first closeout openings when the insert and the cover are positioned for coupling to the hat stringer closeout portion.

Additionally, in certain embodiments, method **200** includes forming **214** a plurality of third cover openings, such as third cover openings **148**, in the cover. Each third cover opening extends through the cover, and each third cover opening is configured to be positioned proximate the gap when the cover is positioned for coupling to the hat stringer closeout portion. Each third cover opening is configured to align with a corresponding one of a plurality of third insert openings, such as third insert openings **116**, defined in the insert when the cover and the insert are positioned for coupling to the hat stringer closeout portion. In some

embodiments, method **200** includes forming **216** a vent connector, such as vent connector **160**, of the cover. The vent connector defines an orifice, such as orifice **162**, that extends through the cover such that the vent connector is configured to be in flow communication with the channel via the gap when the cover is positioned for coupling to the hat stringer closeout portion.

Each of the processes of method **200** may be performed or carried out by a system integrator, a third party, and/or a customer. For the purposes of this description, a system integrator may include without limitation any number of aircraft manufacturers and major-system subcontractors; a third party may include without limitation any number of venders, subcontractors, and suppliers; and a customer may be an airline, leasing company, military entity, service organization, and so on. Moreover, although an aerospace example is shown, the principles described herein may be applied to other industries, such as the automotive industry.

The embodiments described herein provide a closeout fitting for a hat stringer closeout portion, such as a closeout portion defined by a run-out trim. The embodiments improve a capability of the hat stringer at the trimmed location to carry loads to which the hat stringer is subjected. Certain embodiments additionally provide a vent connector configured to couple a channel defined by the hat stringer in flow communication with a vent system.

The embodiments described herein provide improvements over at least some structures that include hat stringer run-out trims. As compared to at least some known structures, the closeout fitting described herein reduces or eliminates adverse structural effects proximate a hat stringer run-out trim such as, but not limited to, excessive hat stringer web bending and excessive localized loads on the hat stringer noodle, such as bending, torsion, shear, axial, vertical, and/or transverse localized noodle loads. In addition, in certain embodiments, the closeout fitting includes a vent connector that eliminates a need for an additional hole in the hat stringer to couple a channel defined by the hat stringer in flow communication with a vent system. Moreover, the closeout fitting can be coupled to the hat stringer closeout portion, and additionally a simple vent system connection can established, prior to initiation of a larger coupling process involving the associated structure, such as a wing-to-fuselage coupling process. Thus, the embodiments described herein facilitate reducing a number of tasks associated with a critical stage in an overall manufacturing process.

This written description uses examples to disclose various implementations, which include the best mode, to enable any person skilled in the art to practice those implementations, including making and using any devices or systems and performing any incorporated methods. The patentable scope is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal language of the claims.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A closeout fitting for a hat stringer, said closeout fitting comprising:

a cover comprising:

a fitting surface, said fitting surface is substantially complementary to at least a portion of an outer surface of the hat stringer, wherein said cover is configured to couple against said hat stringer outer surface; and

a first portion configured to extend across a gap defined in a cap portion of the hat stringer when said cover is coupled against a closeout portion of the hat stringer; and

an insert comprising an outer perimeter surface and a wall that is sealingly enclosed by said outer perimeter surface, wherein at least a first portion of said outer perimeter surface is substantially complementary to at least a portion of an interior surface of a channel defined by the hat stringer, said insert is configured to couple to said cover and to couple against the channel interior surface proximate the hat stringer closeout portion such that said wall is disposed across the channel and such that a deformation of the hat stringer proximate the closeout portion is limited, and wherein said insert is configured to substantially block flow communication through the channel.

2. The closeout fitting according to claim **1**, wherein at least a second portion of said outer perimeter surface is substantially complementary to at least a portion of said cover fitting surface.

3. The closeout fitting according to claim **1**, wherein said cover further comprises a plurality of first cover openings defined in and extending through said cover, and said insert further comprises a plurality of first insert openings defined in and extending through said outer perimeter surface, each said first cover opening is configured to align with a corresponding said first insert opening and a corresponding one of a plurality of first closeout openings defined in the hat stringer closeout portion when said cover is positioned for coupling to the hat stringer closeout portion.

4. The closeout fitting according to claim **1**, wherein said cover further comprises a plurality of third cover openings defined in and extending through said cover, each said third cover opening is configured to be positioned proximate the gap when said cover is positioned for coupling to the hat stringer closeout portion, each said third cover opening is configured to align with a corresponding one of a plurality of third insert openings defined in said insert when said cover and said insert are positioned for coupling to the hat stringer closeout portion.

5. The closeout fitting according to claim **1**, wherein said cover further comprises a vent connector, said vent connector defines an orifice that extends through said cover such that said vent connector is configured to be in flow communication with the channel via the gap when said cover is positioned for coupling to the hat stringer closeout portion.

6. An aircraft comprising:

a wing;

a hat stringer coupled to an interior surface of a panel of said wing, said hat stringer defines a channel, said hat stringer comprises a cap portion, wherein a gap is defined in said cap portion proximate a closeout portion of said hat stringer; and

a closeout fitting comprising:

a cover coupled against an outer surface of said hat stringer, wherein a fitting surface of said cover is substantially complementary to at least a portion of said hat stringer outer surface, and wherein a first portion of said cover extends across said gap; and

an insert comprising an outer perimeter surface and a wall that is sealingly enclosed by said outer perimeter surface, wherein at least a first portion of said outer perimeter surface of said insert is substantially complementary to at least a portion of said channel interior surface, said insert is coupled to said cover and coupled against said channel interior surface proximate said closeout portion such that said wall is disposed across said channel and such that a deformation of said hat stringer proximate said closeout portion is limited, and wherein said insert is configured to substantially block flow communication through said channel.

7. The aircraft according to claim **6**, wherein at least a second portion of said outer perimeter surface is substantially complementary to at least a portion of said cover fitting surface.

8. The aircraft according to claim **6**, wherein said cover further comprises a plurality of first cover openings defined in and extending through said cover, and said insert further comprises a plurality of first insert openings defined in and extending through said outer perimeter surface, each said first cover opening is aligned with a corresponding said first

insert opening and a corresponding one of a plurality of first closeout openings defined in said hat stringer closeout portion.

9. The aircraft according to claim **6**, wherein said cover further comprises a plurality of third cover openings defined in and extending through said cover, each said third cover opening is positioned proximate said gap, each said third cover opening is aligned with a corresponding one of a plurality of third insert openings defined in said insert.

10. The aircraft according to claim **6**, wherein said cover further comprises a vent connector, said vent connector defines an orifice that extends through said cover such that said vent connector is in flow communication with said channel via said gap.

11. The aircraft according to claim **10**, further comprising:

at least one vent coupled in flow communication with said channel; and

at least one fuel tank in flow communication with said vent connector, such that a fluid flow path is defined from said at least one fuel tank, through said vent connector, through said gap, through said channel, to said at least one vent.

12. The aircraft according to claim **11**, further comprising:

a fuselage comprising a vent port, said at least one fuel tank is disposed in an interior of said fuselage, said at least one fuel tank is in flow communication with said vent port; and

a vent tube, wherein a first end of said vent tube is coupled in flow communication with said vent connector and a second end of said vent tube is coupled in flow communication with said vent port, such that said fluid flow path is defined from said at least one fuel tank, through said vent port, through said vent tube, through said vent connector, through said gap, through said channel, to said at least one vent.

13. A method of making a closeout fitting for a hat stringer of a vehicle, said method comprising:

forming a fitting surface of a cover to be substantially complementary to at least a portion of an outer surface of the hat stringer, such that the cover is configured to couple against the hat stringer outer surface;

configuring a first portion of the cover to extend across a gap defined in a cap portion of the hat stringer when the cover is coupled against a closeout portion of the hat stringer; and

forming an insert that includes an outer perimeter surface and a wall that is sealingly enclosed by the outer perimeter surface, wherein at least a first portion of the outer perimeter surface is substantially complementary to at least a portion of an interior surface of a channel defined by the hat stringer, such that the insert is configured to couple to the cover and to couple against the channel interior surface proximate the hat stringer closeout portion such that the wall is disposed across the channel and such that a deformation of the hat stringer proximate the closeout portion is limited, and wherein forming the insert further comprises configuring the insert to substantially block flow communication through the channel.

14. The method according to claim **13**, further comprising forming at least a second portion of the outer perimeter surface of the insert to be substantially complementary to at least a portion of the cover fitting surface.

15. The method according to claim **13**, further comprising forming a plurality of first cover openings in the cover and a plurality of first insert openings in the outer perimeter surface, wherein each first cover opening extends through the cover and each first insert opening extends through the outer perimeter surface, each first cover opening is configured to align with a corresponding first insert opening and a corresponding one of a plurality of first closeout openings defined in the hat stringer closeout portion when the cover is positioned for coupling to the hat stringer closeout portion.

16. The method according to claim **13**, further comprising forming a plurality of third cover openings in the cover, wherein each third cover opening extends through the cover, each third cover opening is configured to be positioned proximate the gap when the cover is positioned for coupling to the hat stringer closeout portion, and each third cover opening is configured to align with a corresponding one of a plurality of third insert openings defined in the insert when the cover and the insert are positioned for coupling to the hat stringer closeout portion.

17. The method according to claim **13**, further comprising forming a vent connector of the cover, wherein the vent connector defines an orifice that extends through the cover such that the vent connector is configured to be in flow communication with the channel via the gap when the cover is positioned for coupling to the hat stringer closeout portion.

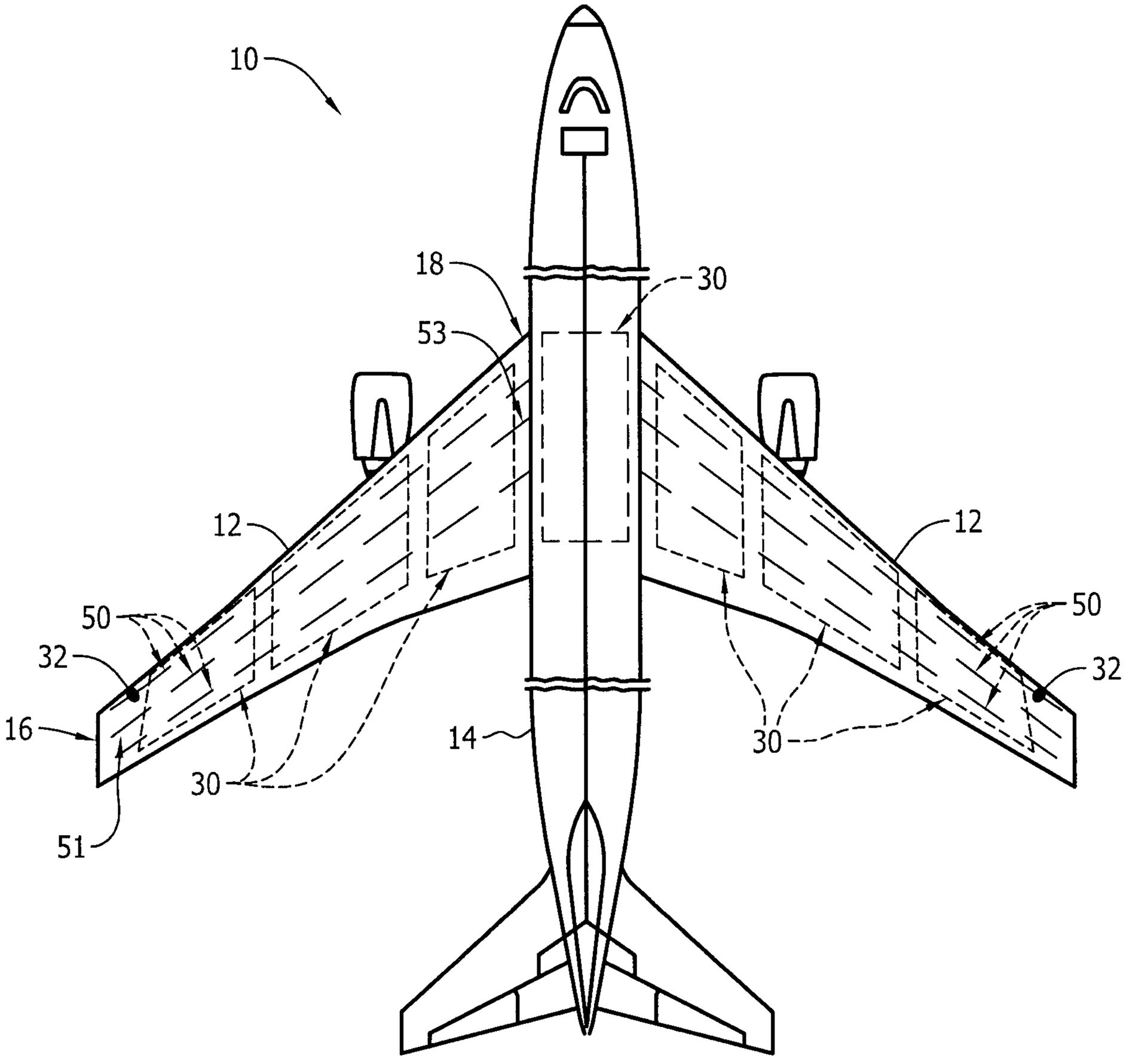

FIG. 1

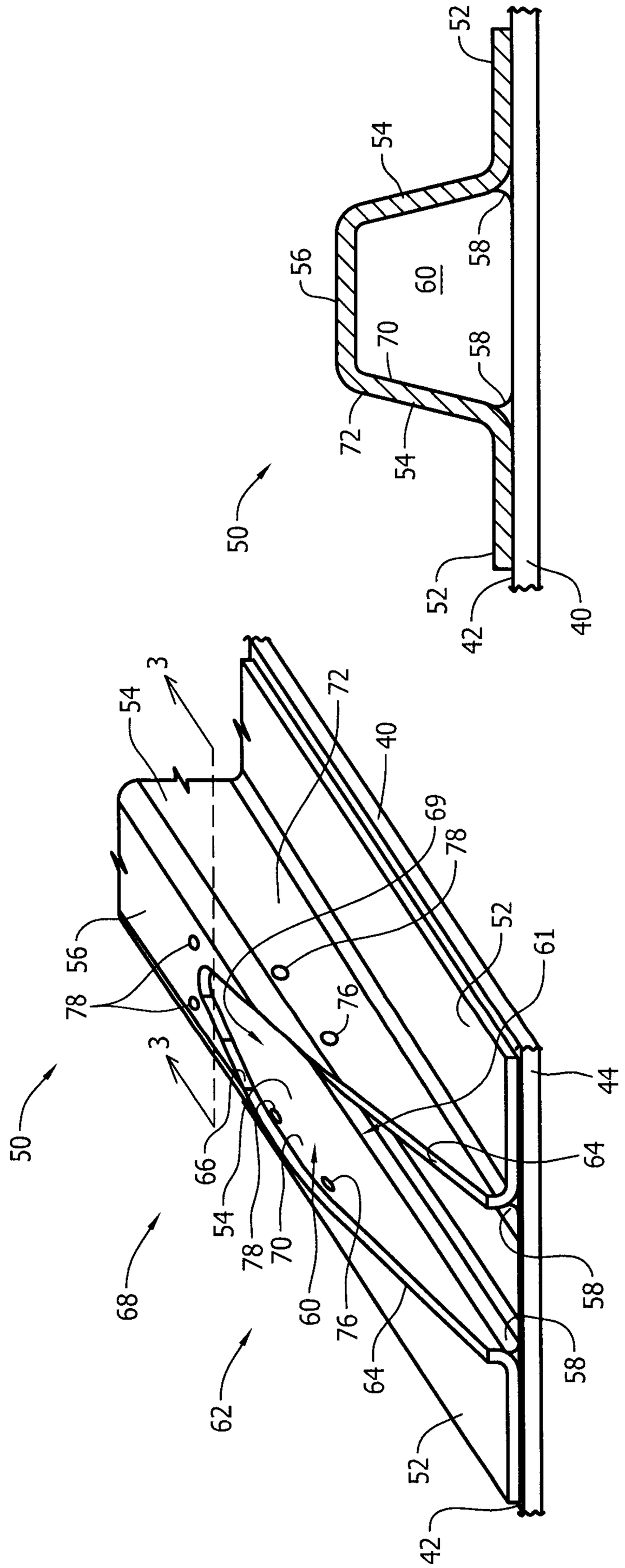
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FIG. 2


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FIG. 3

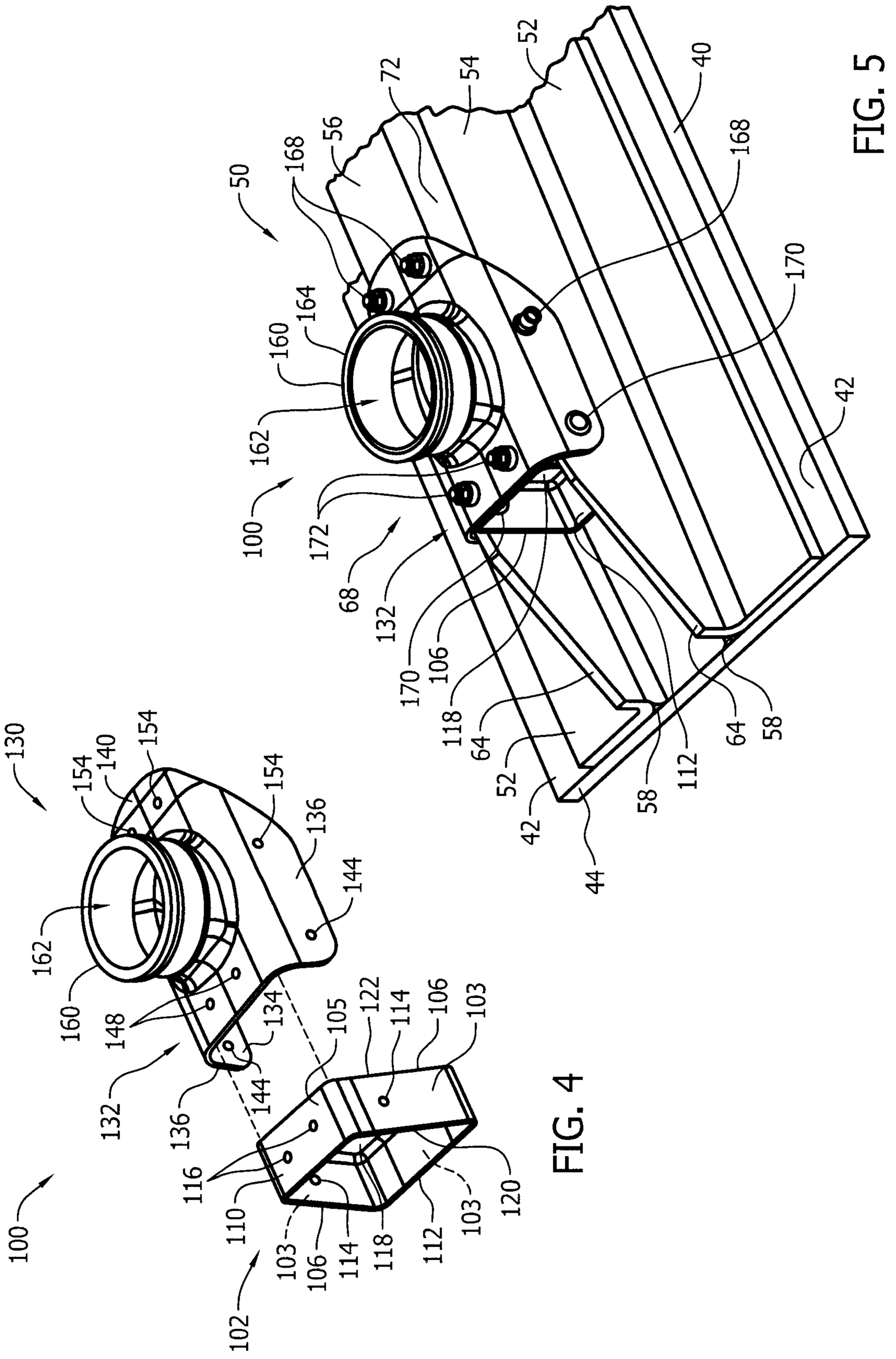
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FIG. 5

FIG. 4

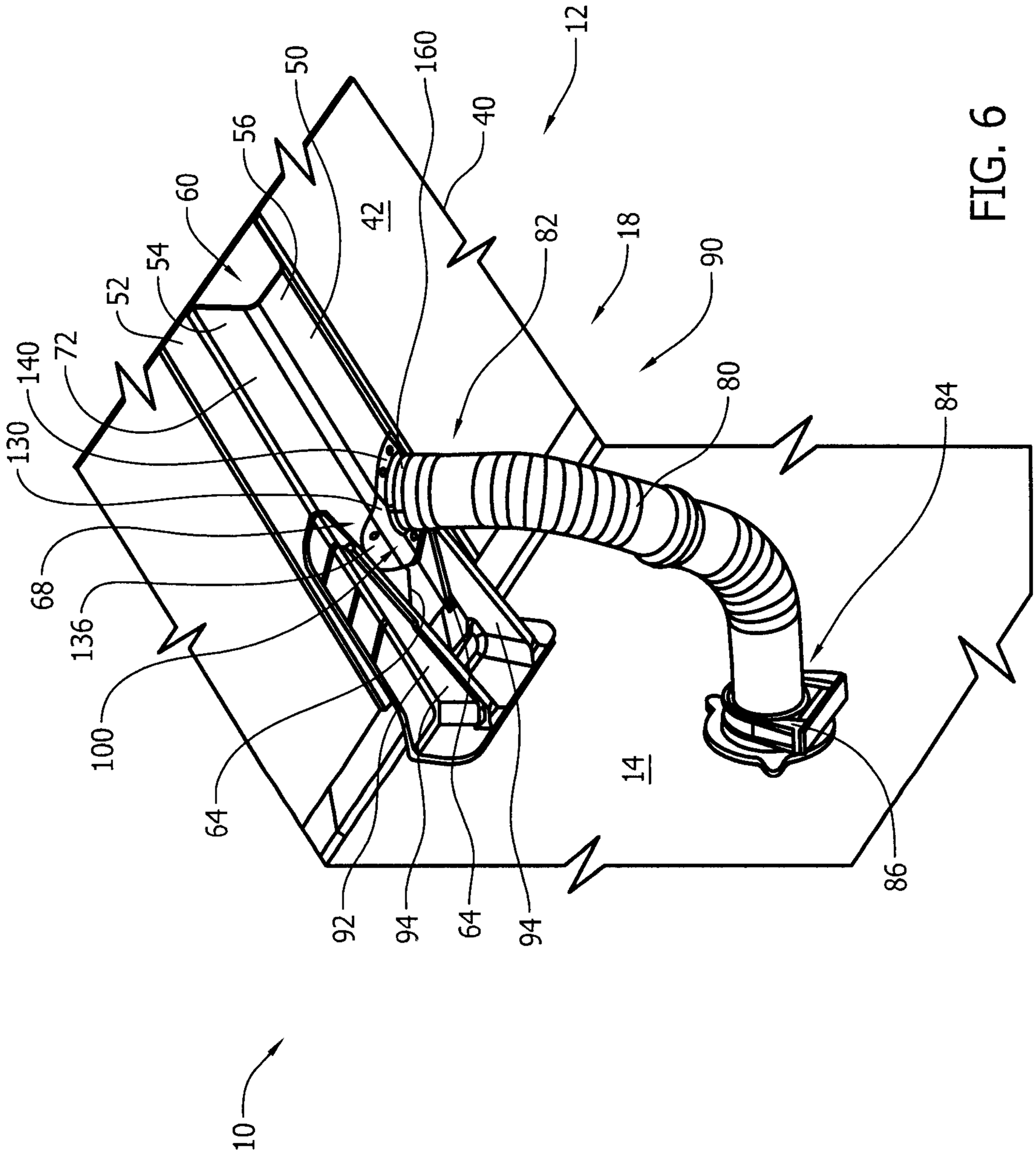
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FIG. 6

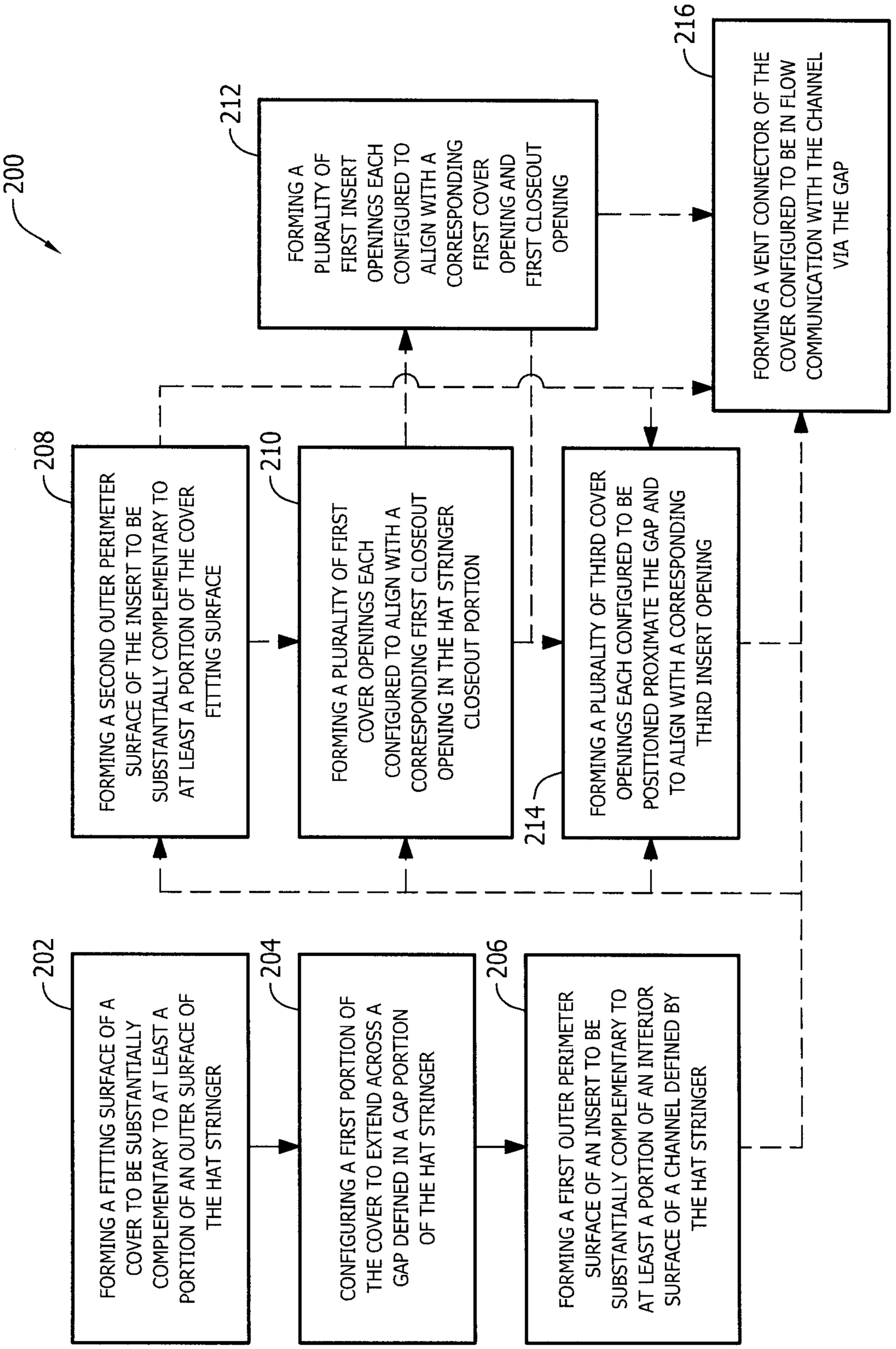
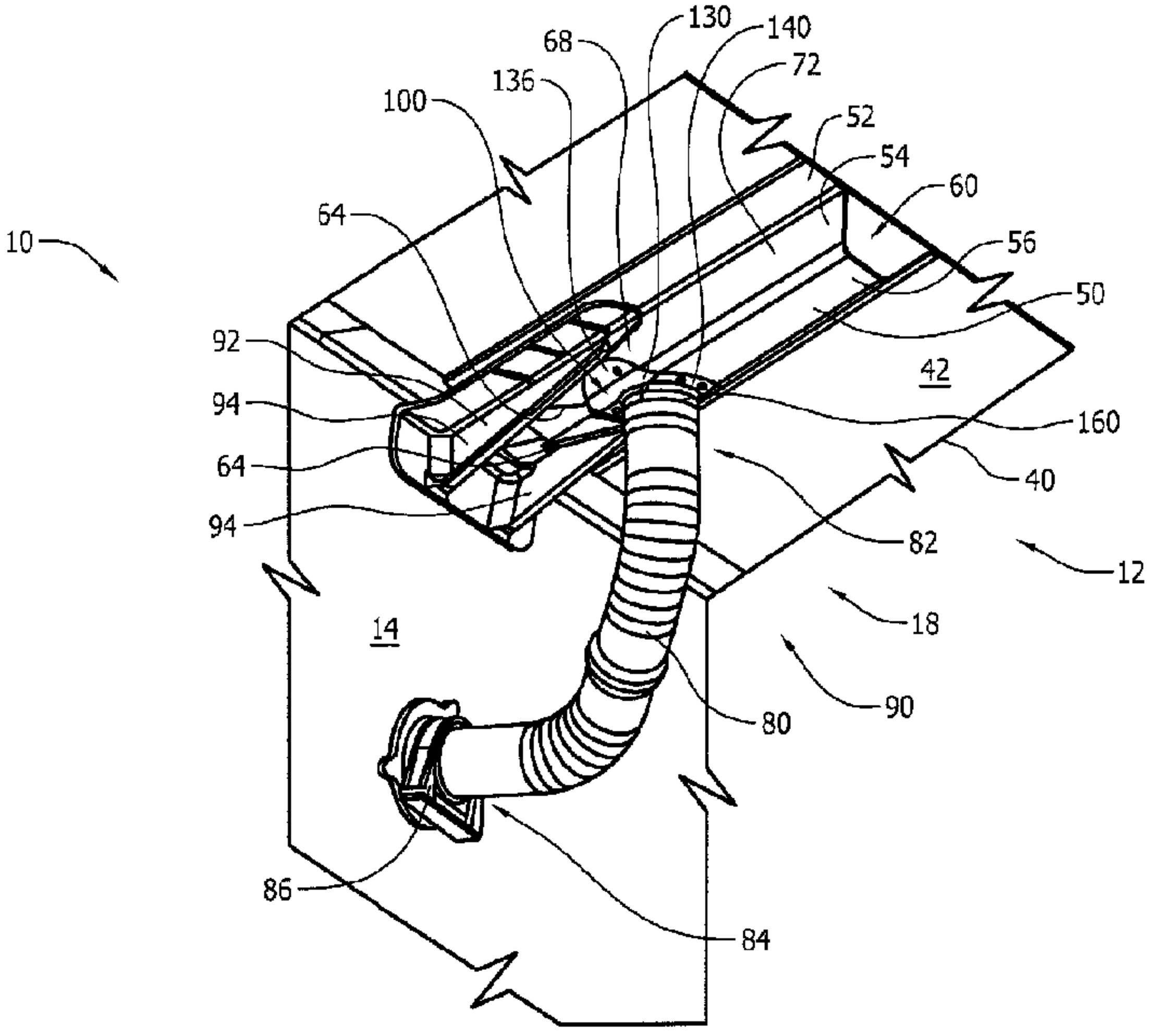

200
202
FORMING A FITTING SURFACE OF A COVER TO BE SUBSTANTIALLY COMPLEMENTARY TO AT LEAST A PORTION OF AN OUTER SURFACE OF THE HAT STRINGER
204
CONFIGURING A FIRST PORTION OF THE COVER TO EXTEND ACROSS A GAP DEFINED IN A CAP PORTION OF THE HAT STRINGER
206
FORMING A FIRST OUTER PERIMETER SURFACE OF AN INSERT TO BE SUBSTANTIALLY COMPLEMENTARY TO AT LEAST A PORTION OF AN INTERIOR SURFACE OF A CHANNEL DEFINED BY THE HAT STRINGER
208
FORMING A SECOND OUTER PERIMETER SURFACE OF THE INSERT TO BE SUBSTANTIALLY COMPLEMENTARY TO AT LEAST A PORTION OF THE COVER FITTING SURFACE
210
FORMING A PLURALITY OF FIRST COVER OPENINGS EACH CONFIGURED TO ALIGN WITH A CORRESPONDING FIRST CLOSEOUT OPENING IN THE HAT STRINGER CLOSEOUT PORTION
212
FORMING A PLURALITY OF FIRST INSERT OPENINGS EACH CONFIGURED TO ALIGN WITH A CORRESPONDING FIRST COVER OPENING AND FIRST CLOSEOUT OPENING
214
FORMING A PLURALITY OF THIRD COVER OPENINGS EACH CONFIGURED TO BE POSITIONED PROXIMATE THE GAP AND TO ALIGN WITH A CORRESPONDING THIRD INSERT OPENING
216
FORMING A VENT CONNECTOR OF THE COVER CONFIGURED TO BE IN FLOW COMMUNICATION WITH THE CHANNEL VIA THE GAP

FIG. 7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