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Crall

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(54) **COMPOSITE FAN INLET BLADE CONTAINMENT**

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(57) **ABSTRACT**

A ribbed composite shell includes an annular grid of relatively thick crack arresting ribs embedded in a relatively thin annular shell and relatively thin panels in thin annular shell between arresting ribs wherein each of panels are completely surrounded by a set of relatively thick adjoining ones of ribs. A shell forward flange may extend radially inwardly from thin annular shell. Arresting ribs may include radially stacked layers of strips between radially stacked annular layers of shell. Annular grid may include a rectangular grid pattern, a diamond grid pattern, or a hexagonal grid pattern. A nacelle inlet may have the ribbed composite shell within one or both of radially spaced apart composite inner and
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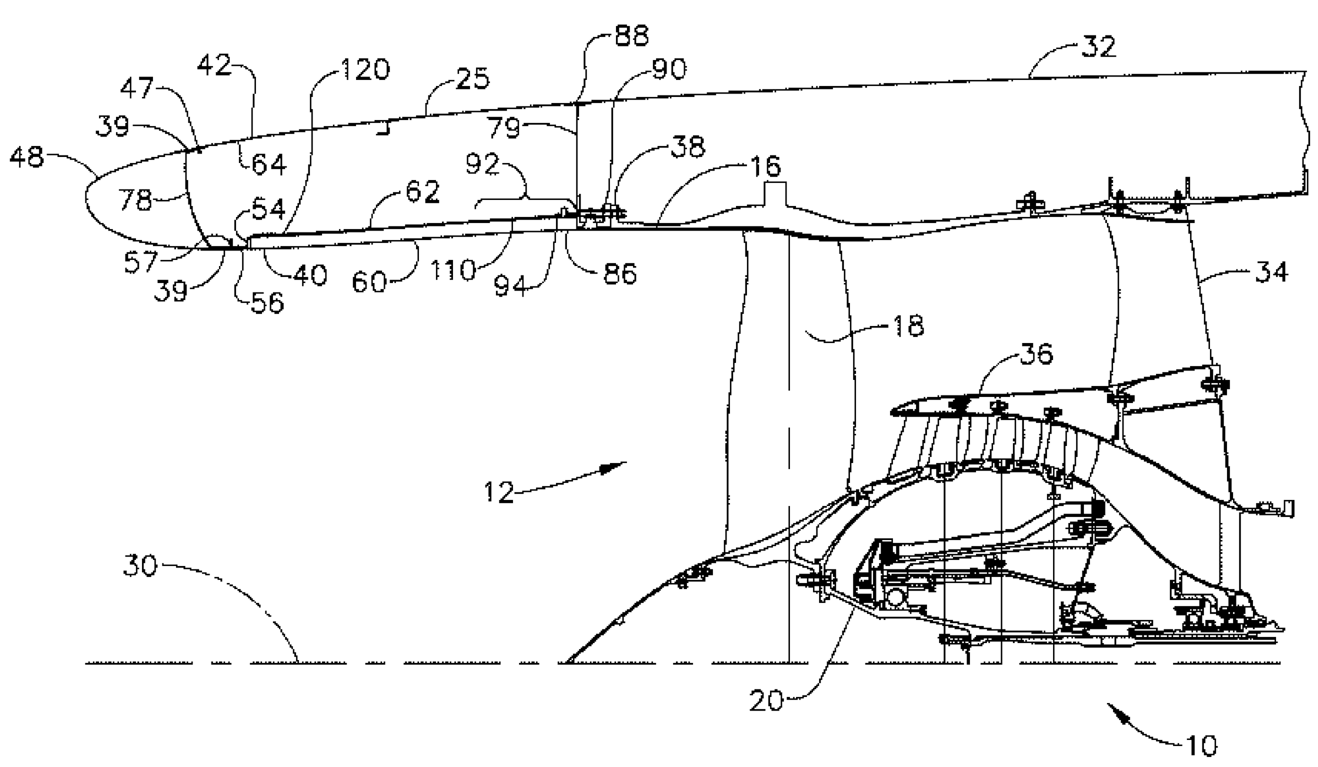

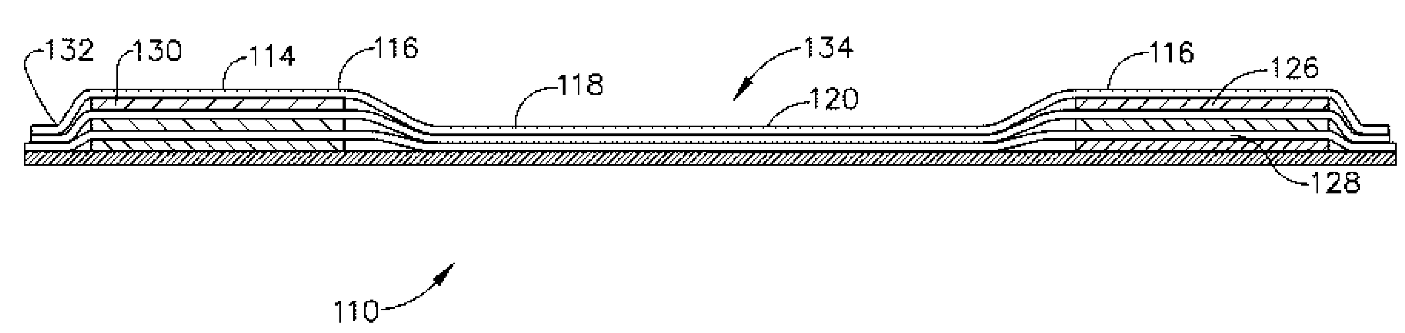

outer skins of an inner barrel. Nacelle inlet may be part of attached to a fan casing and axially disposed forward of fan blades circumscribed by the casing. The inlet may be on an engine nacelle.

29 Claims, 4 Drawing Sheets

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F01D 21/04	(2006.01)
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F04D 29/52	(2006.01)
F01D 25/24	(2006.01)
F04D 29/32	(2006.01)

(52) **U.S. Cl.**
CPC ***F01D 25/24*** (2013.01); ***F04D 29/023*** (2013.01); ***F04D 29/325*** (2013.01); *F01D 11/127* (2013.01); *F05D 2250/12* (2013.01); *F05D 2250/13* (2013.01); *F05D 2250/132* (2013.01); *F05D 2250/18* (2013.01); *F05D 2300/603* (2013.01); *Y02T 50/672* (2013.01)

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CPC F04D 29/325; F04D 29/522; F04D 29/644; B64C 33/02; B64C 2033/0206; F01D 21/045; F01D 25/24; F01D 25/243; F01D 11/125; F01D 11/127; F05D 2250/12; F05D 2250/13; F05D 2250/132; F05D 2250/18; F05D 2300/603; F05D 2260/96; Y02T 50/672
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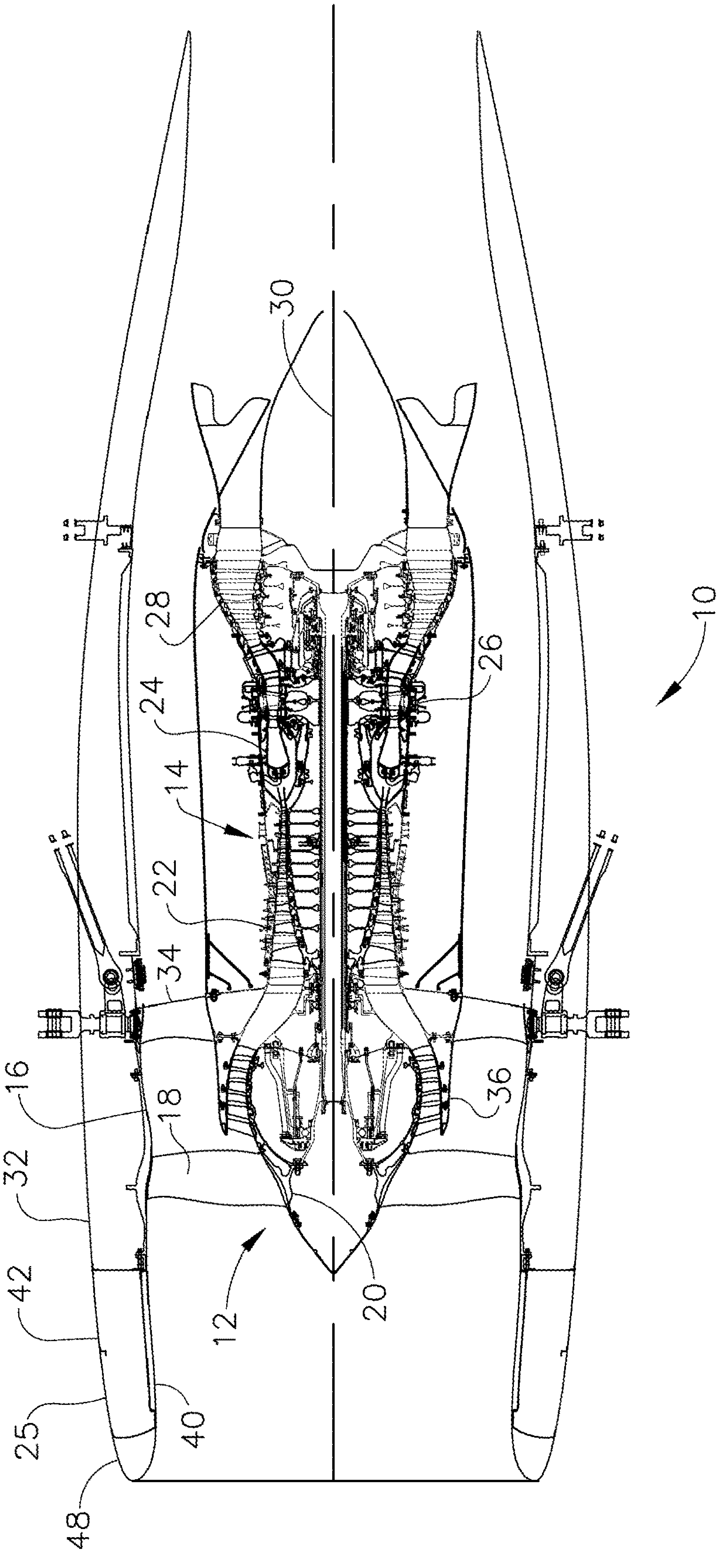

FIG. 1

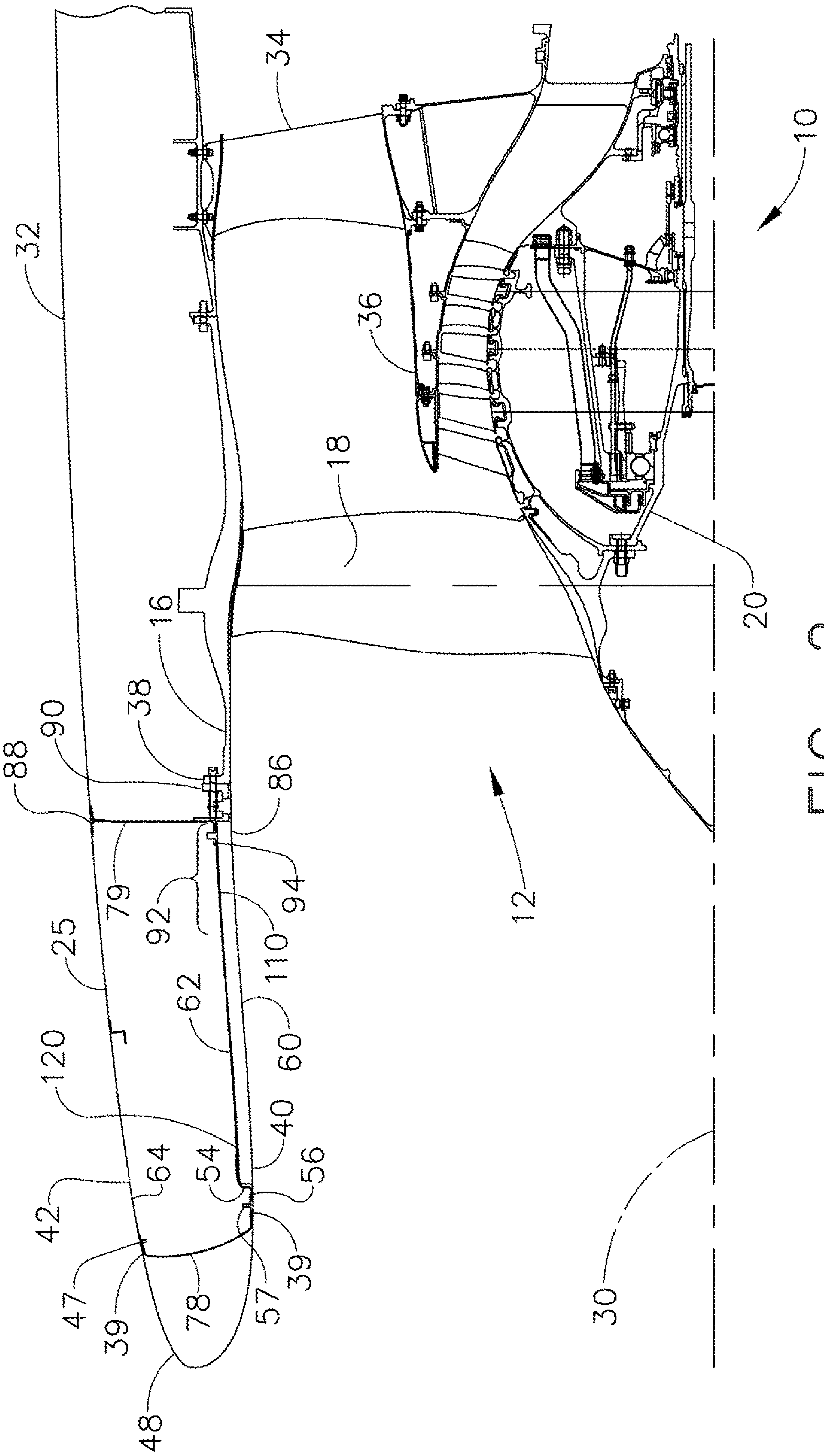
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FIG. 2

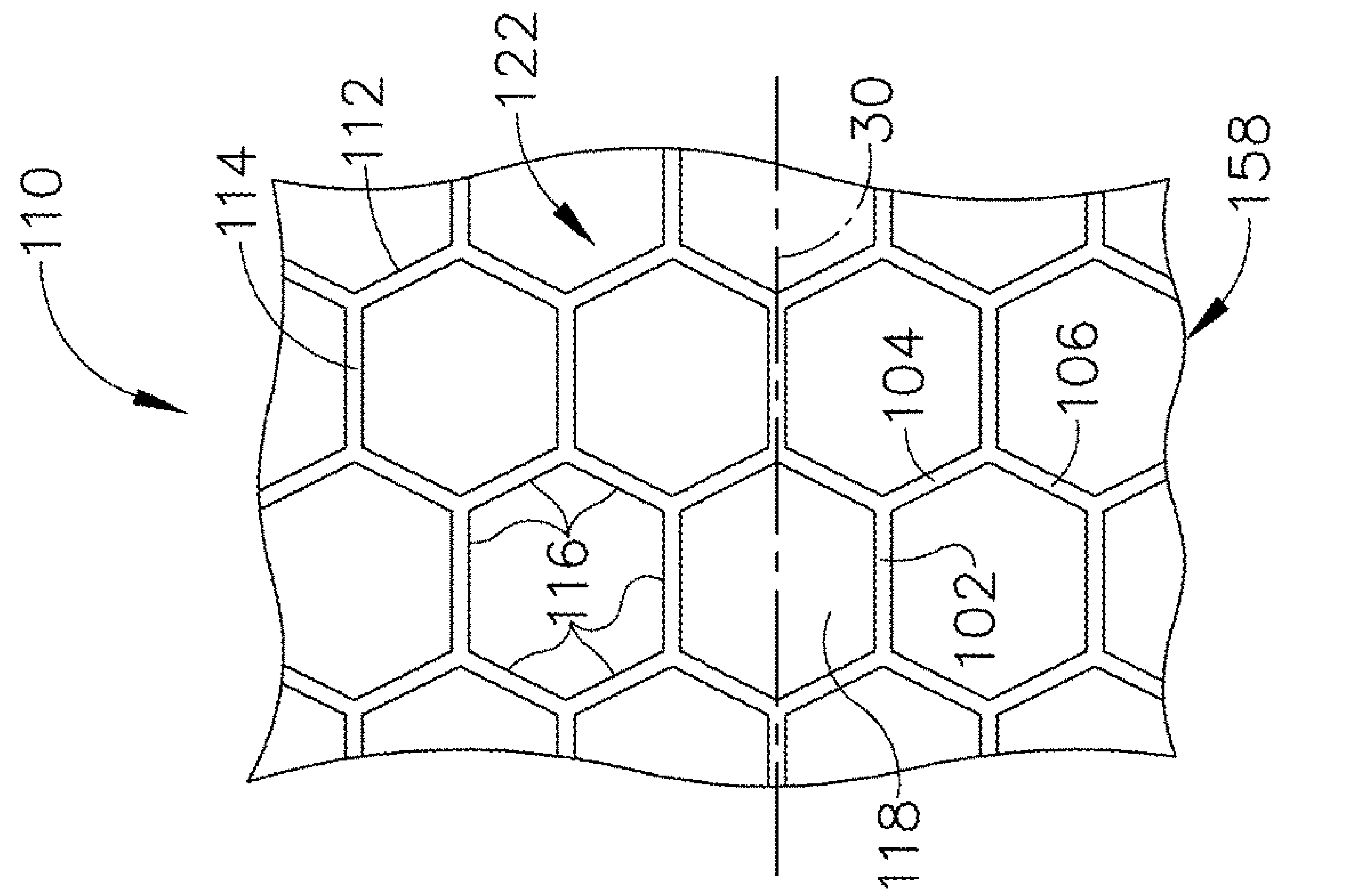

FIG. 5

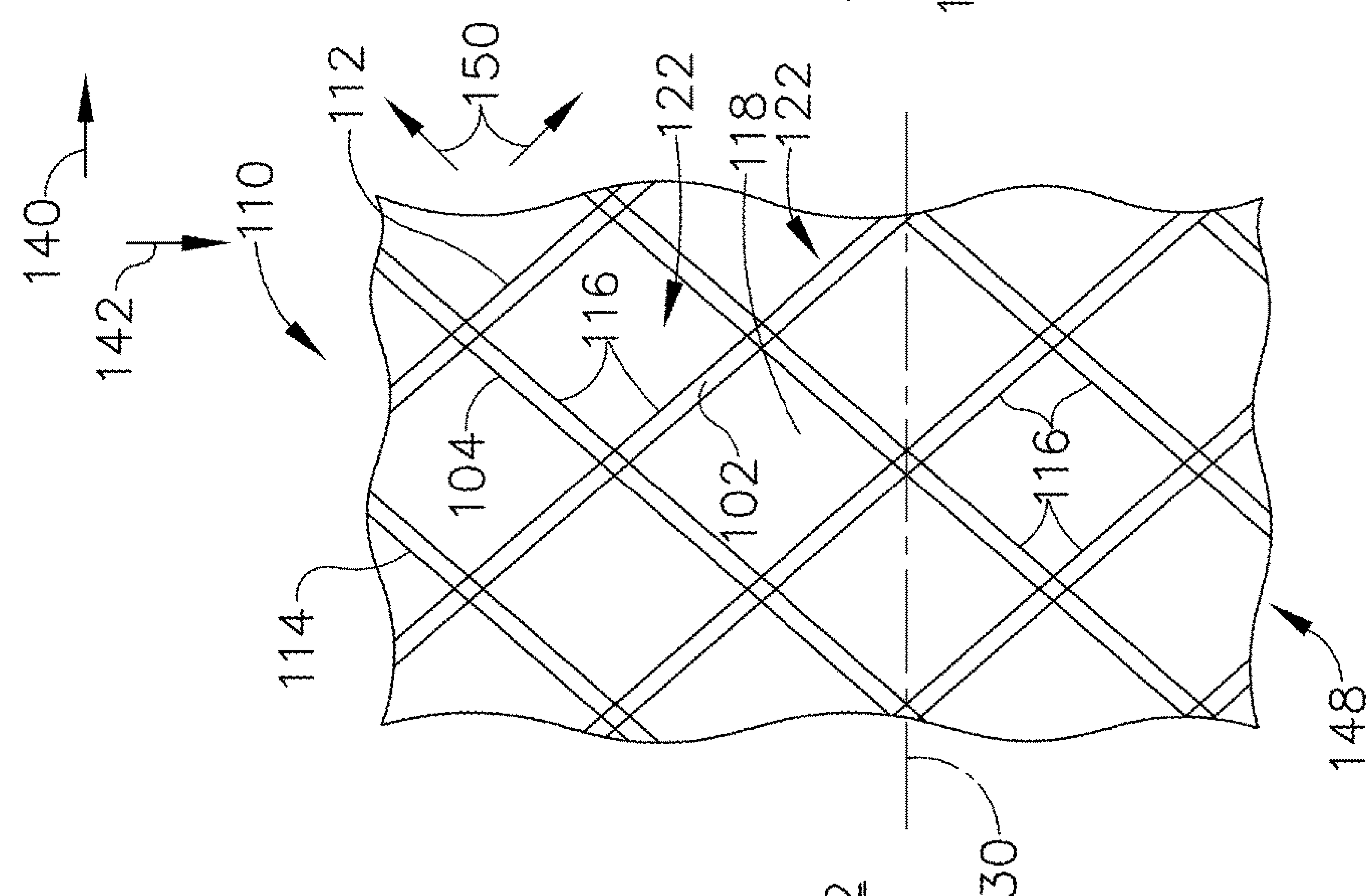

FIG. 4

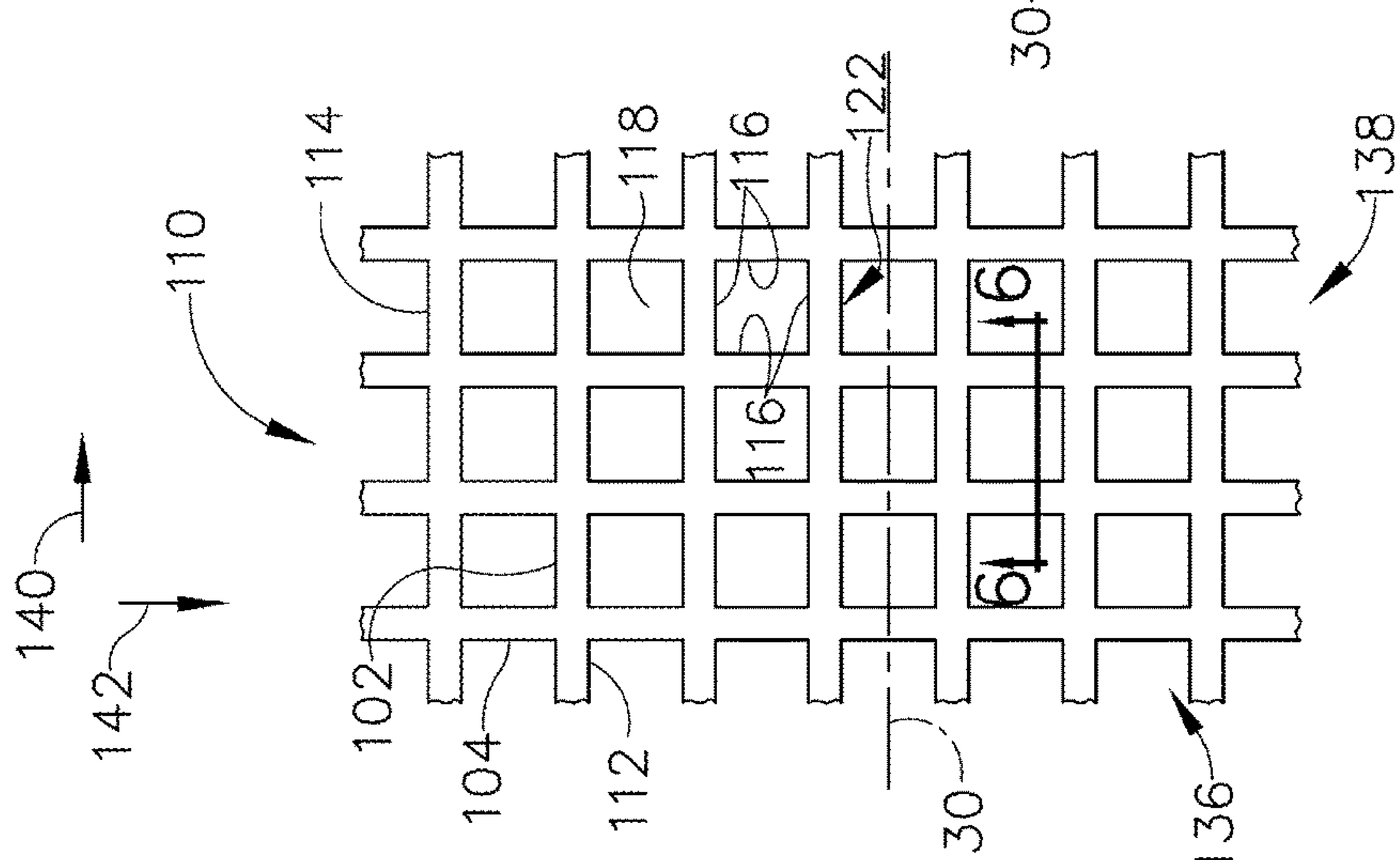

FIG. 3

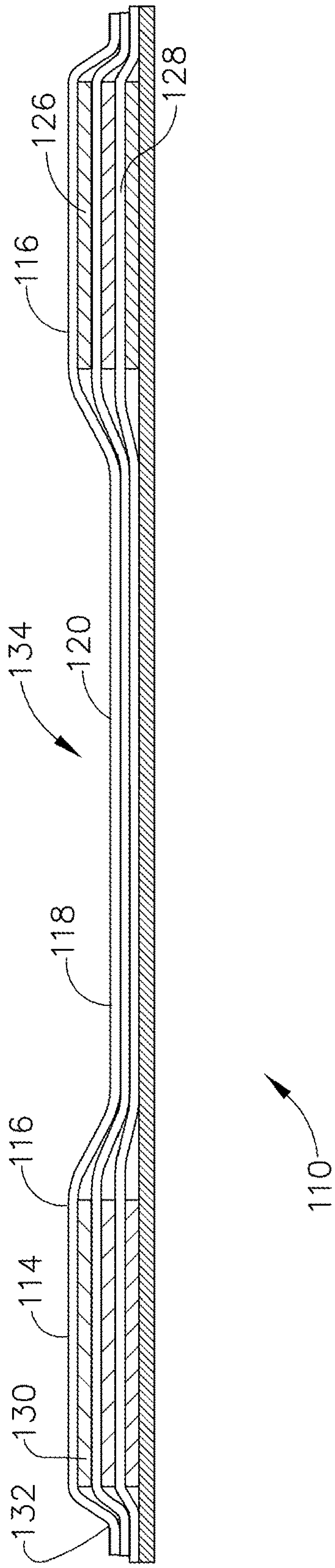

FIG. 6

COMPOSITE FAN INLET BLADE CONTAINMENT

BACKGROUND

Technical Field

Embodiments of the present invention relate generally to gas turbine engine fan inlets and, more particularly, to fan blade containment in the inlets for containing blade fragments ejected from damaged fan blades.

Aircraft gas turbine engines operate in various conditions and foreign objects may be ingested into the engine. During operation of the engine and, in particular, during movement of an aircraft powered by the engine, the fan blades may be impacted and damaged by foreign objects such as, for example, birds or debris picked up on a runway. Impacts on the blades may damage the blades and result in blade fragments or entire blades being dislodged and flying radially outward at relatively high velocity.

To limit or minimize consequential damage, some known engines include a metallic casing shell to facilitate increasing a radial and an axial stiffness of the engine, and to facilitate reducing stresses near the engine casing penetration. However, casing shells are typically fabricated from a metallic material which results in an increased weight of the engine and, therefore, the airframe. To overcome the increased weight, composite fan casings for a gas turbine engine have been developed.

Some containment structures have been effective in engines to provide the necessary containment of blade fragments. Large engines with high-bypass ratios have revealed blade failure modes in which fan blade fragments have been found to be thrown radially outward and axially forward of the fan casing striking an inlet area of a nacelle surrounding the engine. The blade fragments may have sufficiently high velocities resulting in high energy impacts on the inlet causing damage to the inlet which may be made at least in part of composite materials.

These impacts may be sufficient to cause collapse of an acoustic honeycomb liner by compression of the honeycomb cell structure. Blade fragments may then exit tangentially through the inlet and, if the aircraft is in flight, perhaps result in damage to the aircraft. A second blade containment structure may be positioned axially forward of the fan casing within an engine nacelle. The second containment structure may include an inner liner of noise absorbing material, such as honeycomb paneling, and a ring of titanium material having axially oriented stiffeners for controlling bending upon impact by a broken blade or blade fragment. The ring may be formed as a plurality of arcuate segments having edges adapted for joining with adjacent segments to form a complete ring. A flange may be attached to an aft edge of the ring and used to connect the ring to the fan casing. A forward edge of the ring may have an integrally formed flange for attaching the ring to a support member within the nacelle. The position of the second blade containment structure is such that blades or blade fragments ejected forward of a blade rotation path are captured by the ring and honeycomb liner, thus, preventing axial projection of the blade fragments out of the nacelle.

In an embodiment, it may be beneficial to have a lightweight engine and nacelle so blade-out containment systems may incorporate composite materials. If the inlet is made of a composite, damage from a blade-out event can result in fiber breakage and delamination that can further propagate and cause additional secondary failures during the subsequent coast down and windmilling phases of the engine after the event.

It may also be beneficial to have a fan inlet blade-out or fan blade composite containment system operable for limiting or containing the damage caused by blade fragments ejected forward of a fan casing surrounding the fan.

BRIEF DESCRIPTION

A ribbed composite shell **110** includes an annular grid **112** of relatively thick crack arresting ribs **114** embedded in a relatively thin annular shell **120**, relatively thin panels **118** in the thin annular shell **120** between the arresting ribs **114**, and each of the panels **118** completely surrounded by a set **122** of relatively thick adjoining ribs **116** of the relatively thick crack arresting ribs **114**.

A shell forward flange **54** may extend radially inwardly from the thin annular shell **120** an axial flange extension **56** may extend axially from the shell forward flange **54**.

The arresting ribs **114** may include radially stacked layers of strips **126** between radially stacked annular layers **128**.

The annular grid **112** may be circumscribed about an axial centerline axis **30** and each of the panels **118** may be surrounded at least in part by adjoining first and second ribs **102**, **104**. The crack arresting ribs **114** may be arranged in one of the following grid patterns **136**: a rectangular grid pattern **138** wherein the adjoining first ribs **102** running axially **140**and the adjoining second ribs **104** running circumferentially **142** relative to the axial centerline axis **30**; a diamond grid pattern **148** wherein the adjoining first ribs **102** running axially **140** and circumferentially **142** clockwise and the adjoining second ribs **104** running axially **140** and circumferentially **142** counter-clockwise relative to the axial centerline axis **30**; and a hexagonal grid pattern **158** wherein the adjoining first ribs **102** running axially **140**, the adjoining second ribs **104** running axially **140** and circumferentially **142** clockwise, and adjoining third ribs **106** running axially **140** and circumferentially **142** counter-clockwise relative to the axial centerline axis **30**.

The ribbed composite shell **110** may include the annular grid **112** of crack arresting ribs **114** disposed only in an axially extending portion **92** of the ribbed composite shell (**110** and the axially extending portion **92** may be at or near an aft end **94** of the ribbed composite shell **110**.

A nacelle inlet **25** includes a rounded annular nose lip section **48** radially disposed between radially spaced apart annular inner and outer barrels **40**, **42**, the inner barrel **40**includes radially spaced apart composite inner and outer skins **60**, **62**, and at least one of the inner and outer skins **60**, **62** has a ribbed composite shell **110**. The ribbed composite shell **110** includes an annular grid **112** of relatively thick crack arresting ribs **114** embedded in a relatively thin annular shell **120**, relatively thin panels **118** in the thin annular shell **120** between the arresting ribs **114**, and each of the panels **118** completely surrounded by a set **122** of relatively thick adjoining ribs **116** of the relatively thick crack arresting ribs **114**. A honeycomb core **63** may be sandwiched between the inner and outer skins **60**, **62**.

An aircraft gas turbine engine assembly includes an aircraft gas turbine engine **10** having a fan assembly **12** with a plurality of radially outwardly extending fan blades **18** rotatable about a longitudinally extending axial centerline axis **30**, the engine **10** mounted within a nacelle **32** connected to a fan casing **16** of the engine **10**, the fan casing **16** circumscribed about the fan blades **18**, and a nacelle inlet **25** including a rounded annular nose lip section **48** radially disposed between radially spaced apart annular inner and outer barrels **40**, **42** axially disposed forward of the fan casing **16** and the fan blades **18**. The inner barrel **40** includes radially spaced apart composite inner and outer skins **60**, **62** and at least one of the inner and outer skins **60**, **62** has a ribbed composite shell **110** including an annular grid **112** of relatively thick crack arresting ribs **114** embedded in a relatively thin annular shell **120**. Relatively thin panels **118** are in the thin annular shell **120** between the arresting ribs **114**, and each of the panels **118** is completely surrounded by a set **122** of relatively thick adjoining ribs **116** of the relatively thick crack arresting ribs **114**.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is schematic illustration of a gas turbine engine including a composite fan inlet including a ribbed composite shell with crack arresting ribs for blade out containment.

FIG. **2** is an enlarged cross-sectional illustration of the composite fan inlet illustrated in FIG. **1**.

FIG. **3** is a schematic illustration of a rectangular grid pattern of the crack arresting ribs in the composite fan inlet illustrated in FIG. **2**.

FIG. **4** is a schematic illustration of a diamond grid pattern of the crack arresting ribs in the composite fan inlet illustrated in FIG. **2**.

FIG. **5** is a schematic illustration of a hexagonal grid pattern of the crack arresting ribs in the composite fan inlet illustrated in FIG. **2**.

FIG. **6** is a schematic cross-sectional illustration of layers and a lay up of the composite plies used to form ribbed composite shell with crack arresting ribs illustrated in FIG. **2**.

DETAILED DESCRIPTION

A composite fan inlet casing for an aircraft gas turbine engine is described below in detail. The composite casing includes an inner composite barrel with crack arresting ribs. The crack arresting ribs allows the composite casing to resist crack propagation under impact loading. The inner barrel of the composite casing is typically made of circumferentially arranged panels so that when the inlet becomes damaged by fan blade fragments, the panels between the ribs can be punched out, but the damage is contained within a few panels. During impact, kinetic energy is dissipated by delamination of braided layers which then capture and contain the impact objects.

Illustrated in FIG. **1** is one exemplary embodiment of an aircraft gas turbine engine **10** including a fan assembly **12** and a core engine **14**. The fan assembly **12** includes a fan casing **16** surrounding an array of fan blades **18** extending radially outwardly from a rotor **20**. The core engine **14** includes a high-pressure compressor **22**, a combustor **24**, a high pressure turbine **26**. A low pressure turbine **28** drives the fan blades **18**.

Referring to FIGS. **1** and **2**, the fan assembly **12** is rotatable about a longitudinally extending axial centerline axis **30**. The engine **10** is mounted within a nacelle **32** that is connected to a fan casing **16** of the engine **10**. The fan casing **16** is circumscribed about the fan blades **18**. The fan casing **16** supports the fan assembly **12** through a plurality of circumferentially spaced struts **34** and through a booster fan assembly **36**. The nacelle **32** includes an annular composite inlet **25** attached to a forward casing flange **38** on the fan casing **16** by a plurality of circumferentially spaced fasteners, such as bolts or the like. The inlet **25** typically includes radially spaced apart annular inner and outer barrels **40**, **42**. A rounded annular nose lip section **48** is radially disposed between the inner and outer barrels **40**, **42**. Air entering the engine **10** passes through the inlet **25**.

The inner barrel **40** includes radially spaced apart composite inner and outer skins **60**, **62**. A honeycomb core **63** may be sandwiched between the inner and outer skins **60**, **62**. The outer barrel **42** may be a single composite skin **64** as illustrated herein. A forward edge **39** of the outer barrel **42** may be connected to the nose lip section **48** by a first plurality of circumferentially spaced fasteners **47**, such as rivets, or the like. Similarly, a forward edge **39** of the inner barrel **40** may be connected to the nose lip section **48** by a second plurality of circumferentially spaced fasteners **57**, such as rivets, bolts, or the like. The fasteners **47**, **57** secure the components of the inlet **25** together and transmit loads between fastened components.

A forward bulkhead **78** extends between radially spaced apart outer and inner annular walls **80**, **82** of the nose lip section **48**. An aft bulkhead **79** connect radially spaced apart inner and outer barrel aft ends **86**, **88** of the inner and outer barrels **40**, **42**. The forward and aft bulkheads **78**, **79** contribute to the rigidity and strength of the inlet **25**. An aft flange **90** on the inner barrel **40** may be used to connect the inlet **25** to the forward casing flange **38** of the fan casing **16**. The composite inner barrel **40** directly supports the outer barrel **42** and nose lip section **48**. The weight of the inlet **25** and external loads borne by the inlet **25** are transferred to the fan casing **16** through the inner barrel **40**. Therefore, the composite inner barrel **40** of a typical nacelle's inlet **25** can substantially contribute to the overall rigidity, strength and stability of the inlet **25** of the nacelle **32**.

A "blade-out event" arises when a fan blade or portion thereof is accidentally released from a rotor of a high-bypass turbofan engine. When suddenly released during flight, a fan blade can impact a surrounding fan case with substantial force, and resulting loads on the fan case can be transferred to surrounding structures, such as to the inlet of a surrounding nacelle **32**. These loads can cause substantial damage to the nacelle inlet, including damage to the adjoining inner barrel **40**. In addition, or alternatively, a released fan blade or portion thereof may directly impact a portion of an adjacent inner barrel **40**, thereby, causing direct damage to the inner barrel **40**. Because the inner barrel **40** directly supports the inlet **25** on the fan casing **16**, including the outer barrel **42** and nose lip section **48**, damage to the inner barrel **40** can compromise the structural integrity and stability of the nacelle **32**, and may negatively affect the fly-home capability of an aircraft.

A blade-out event also causes the rotational balance of an engine's fan blades **18** to be lost. After a damaged engine **10** is typically shut down following a blade-out event, airflow impinging on the unbalanced fan blades **18** can cause the fan blades **18** to rapidly spin or "windmill." Such wind-milling of an unbalanced fan **18** can exert substantial vibrational loads on the engine **10** and fan casing **16**, and at least some of these loads can be transmitted to an attached inlet **25** and inner barrel **40** of the nacelle **32**. In addition, following a blade-out event, aerodynamic forces and a suction created by a windmilling fan blade **18** can exert substantial loads on a damaged inlet **25** of the nacelle **32**. Such loads can cause substantial deformation of a damaged inlet **25** and can result in unwanted aerodynamic drag. Such loads also can cause cracks or breaks in a damaged composite inner barrel **40** to propagate, further compromising the structural integrity and stability of a damaged inlet **25** of a nacelle **32**. This damage may result in fiber breakage and delamination that can further propagate and cause additional secondary failures during the subsequent coast down and windmilling phases after the event. Accordingly, there is a need for a nacelle structure for a turbofan aircraft engine that is capable of maintaining a substantially stable and aerodynamic configuration subsequent to a blade-out event, and which thereby supports an aircraft's fly-home capability following such an incident. In particular, there is a need for a nacelle's inlet structure for a high-bypass turbofan aircraft engine that maintains its structural integrity and a stable aerodynamic configuration even though its composite inner barrel has been substantially damaged due to a blade-out event.

Referring to FIGS. **3** and **6**, ribbed composite shells **110** may be used in the composite inner and outer skins **60**, **62** of the inner barrel **40** and in the outer barrel **42**. Each ribbed composite shell **110** includes an annular grid **112** of relatively thick crack arresting ribs **114** embedded in a relatively thin annular shell **120**. The exemplary embodiment of the ribbed composite shell **110** illustrated herein has the annular grid **112** of crack arresting ribs **114** embedded only in an axially extending portion **92** of the ribbed composite shell **110** as illustrated in FIG. **2**. A more particular embodiment of ribbed composite shell **110** has the annular grid **112** of crack arresting ribs **114** disposed only in an axially extending portion **92** of the ribbed composite shell **110** at or near an aft end **94** of the ribbed composite shell **110** as illustrated in FIG. **2**.

Referring to FIGS. **3-5**, each ribbed composite shell **110** includes relatively thin panels **118** completely surrounded by sets **122** of relatively thick adjoining ribs **116**. The adjoining ribs **116** are angled with respect to each other. Referring to FIG. **2**, the ribbed composite shell **110** includes a shell forward flange **54** extending radially inwardly from the thin annular shell **120**. An axial flange extension **56** extending axially from the shell forward flange **54** is used to attach the ribbed composite shell **110** to the inner barrel **40**.

Referring to FIGS. **3-6**, the ribbed composite shell **110** is designed to contain the damage within the thin shell portions or panels **118** between the ribs **114** of the ribbed composite shells **110**. The ribs **114** radially extend entirely through the ribbed composite shells **110**. The ribs **114** may be formed by inserting thin or narrow strips or narrow composite plies **130** between wide composite plies **132** during the lay up of a prepreg **134** of the ribbed composite shells **110** as illustrated in FIG. **6**. A lay up of the narrow composite plies **130** interspersed between the annular wide composite plies **132** form the ribs **114** and the panels **118** between the ribs **114**. The ribbed composite shell **110** includes radially stacked layers of strips **126** between radially stacked annular layers **128** corresponding to the narrow composite plies **130** interspersed between the annular wide composite plies **132**.

Composite plies used to build the prepreg may be made of a type of fiber textile formed and held together by a matrix. Fiber textiles may include a tape, a cloth, a braid, a Jacquard weave, or a satin. A matrix may include epoxy, Bismolyamid, or PMR15. Fibers may include carbon, kevlar or other aramids, or glass.

The grid **112** of relatively thick crack arresting ribs **114** may have various grid patterns **136**, examples of which are illustrated in FIGS. **3-5**. A rectangular grid pattern **138** illustrated in FIG. **3** includes adjoining first ribs **102** running axially **140** and adjoining second ribs **104** running circumferentially **142** relative to the axial centerline axis **30**. A diamond grid pattern **148** illustrated in FIG. **4** includes adjoining ribs **116** running diagonally **150** relative to the axial centerline axis **30**. Each set **122** of the adjoining ribs **116** in the diamond grid pattern **148** include a first rib **102** running axially and circumferentially clockwise and a second rib **104** running axially and circumferentially counter-clockwise. A hexagonal grid pattern **158** illustrated in FIG. **5** includes ribs **114** arranged in hexagons **160** and include first ribs **102** running axially, second ribs **104** running axially and circumferentially clockwise, and third ribs **106** running axially and circumferentially counter-clockwise. The ribs **114** in all of the patterns circumscribe panels **118** between the ribs **114**.

While there have been described herein what are considered to be preferred and exemplary embodiments of the present invention, other modifications of the embodiments shall be apparent to those skilled in the art from the teachings herein and, it is therefore, desired to be secured in the appended claims all such modifications as fall within the true spirit and scope of the embodiments. Accordingly, what is desired to be secured by Letters Patent of the United States are the embodiments of the present invention as defined and differentiated in the following claims.

What is claimed is:

1. A ribbed composite shell comprising:

an annular grid of relatively thick crack arresting ribs embedded in a relatively thin annular shell, and

relatively thin panels in the thin annular shell between the arresting ribs,

wherein each of the relatively thin panels is completely surrounded by a set of relatively thick adjoining ribs of the relatively thick crack arresting ribs, and wherein the arresting ribs comprise radially stacked layers of strips between radially stacked annular layers corresponding to narrow composite plies interspersed between annular wide composite plies, and wherein the narrow composite plies interspersed between the annular wide composite plies form the arresting ribs and the panels between the arresting ribs.

2. The ribbed composite shell in accordance with claim **1**, further comprising a shell forward flange extending radially inwardly from the thin annular shell.

3. The ribbed composite shell in accordance with claim **2**, further comprising an axial flange extension extending axially from the shell forward flange.

4. The ribbed composite shell in accordance with claim **1**, further comprising a shell forward flange extending radially inwardly from the thin annular shell and an axial flange extension extending axially from the shell forward flange.

5. The ribbed composite shell in accordance with claim **1** further comprising:

the annular grid circumscribed about an axial centerline axis;

each of the panels surrounded at least in part by adjoining first and second ribs;

the crack arresting ribs arranged in a grid pattern chosen from the following grid patterns;

a rectangular grid pattern including the adjoining first ribs running axially and the adjoining second ribs running circumferentially relative to the axial centerline axis;

a diamond grid pattern including the adjoining first ribs running axially and circumferentially clockwise and the adjoining second ribs running axially and circumferentially counter-clockwise relative to the axial centerline axis; and

a hexagonal grid pattern including the adjoining first ribs running axially, the adjoining second ribs running axially and circumferentially clockwise, and adjoining third ribs running axially and circumferentially counter-clockwise relative to the axial centerline axis.

6. The ribbed composite shell in accordance with claim **5**, further comprising a shell forward flange extending radially inwardly from the thin annular shell.

7. The ribbed composite shell in accordance with claim **6**, further comprising an axial flange extension extending axially from the shell forward flange.

8. The ribbed composite shell in accordance with claim **5**, further comprising the arresting ribs including radially stacked layers of strips between radially stacked annular layers.

9. The ribbed composite shell in accordance with claim **8**, further comprising a shell forward flange extending radially inwardly from the thin annular shell.

10. The ribbed composite shell in accordance with claim **9**, further comprising an axial flange extension extending axially from the shell forward flange.

11. The ribbed composite shell in accordance with claim **8**, further comprising the annular grid of crack arresting ribs disposed only in an axially extending portion of the ribbed composite shell.

12. The ribbed composite shell in accordance with claim **11** further comprising the axially extending portion at or near an aft end of the ribbed composite shell.

13. A nacelle inlet comprising:
- a rounded annular nose lip section radially disposed between radially spaced apart annular inner and outer barrels,
- the inner barrel including radially spaced apart composite inner and outer skins, at least one of the inner and outer skins having a ribbed composite shell including an annular grid of relatively thick crack arresting ribs embedded in a relatively thin annular shell, wherein the arresting ribs comprise radially stacked layers of strips between radially stacked annular layers corresponding to narrow composite plies interspersed between annular wide composite plies, and wherein the narrow composite plies interspersed between the annular wide composite plies form the arresting ribs and the panels between the arresting ribs, and
- relatively thin panels in the thin annular shell between the arresting ribs, and each of the panels completely surrounded by a set of relatively thick adjoining ribs of the relatively thick crack arresting ribs.

14. The nacelle inlet in accordance with claim **13**, further comprising the outer skin having the ribbed composite shell and a shell forward flange extending radially inwardly from the thin annular shell.

15. The nacelle inlet in accordance with claim **14**, further comprising an axial flange extension extending axially from the shell forward flange.

16. The nacelle inlet in accordance with claim **13**, further comprising the arresting ribs including radially stacked layers of strips between radially stacked annular layers.

17. The nacelle inlet in accordance with claim **16**, further comprising the annular grid of crack arresting ribs disposed only in an axially extending portion at or near an aft end of the ribbed composite shell.

18. The nacelle inlet in accordance with claim **13**, further comprising:
- the annular grid circumscribed about an axial centerline axis;
- each of the panels surrounded at least in part by adjoining first and second ribs;
- the crack arresting ribs arranged in a grid pattern chosen from the following grid patterns;
- a rectangular grid pattern including the adjoining first ribs running axially and the adjoining second ribs running circumferentially relative to the axial centerline axis;
- a diamond grid pattern including the adjoining first ribs running axially and circumferentially clockwise and the adjoining second ribs running axially and circumferentially counter-clockwise relative to the axial centerline axis; and
- a hexagonal grid pattern including the adjoining first ribs running axially, the adjoining second ribs running axially and circumferentially clockwise, and adjoining third ribs running axially and circumferentially counter-clockwise relative to the axial centerline axis.

19. The nacelle inlet in accordance with claim **18**, further comprising the arresting ribs including radially stacked layers of strips between radially stacked annular layers.

20. The nacelle inlet in accordance with claim **19**, further comprising the annular grid of crack arresting ribs disposed only in an axially extending portion at or near an aft end of the ribbed composite shell.

21. The nacelle inlet in accordance with claim **20**, further comprising a honeycomb core) sandwiched between the inner and outer skins.

22. An aircraft gas turbine engine assembly comprising:
- an aircraft gas turbine engine including a fan assembly including a plurality of radially outwardly extending fan blades rotatable about a longitudinally extending axial centerline axis,
- the engine mounted within a nacelle connected to a fan casing of the engine,
- the fan casing circumscribed about the fan blades,
- a nacelle inlet including a rounded annular nose lip section radially disposed between radially spaced apart annular inner and outer barrels axially disposed forward of the fan casing and the fan blades,
- the inner barrel including radially spaced apart composite inner and outer skins,
- at least one of the inner and outer skins having a ribbed composite shell including an annular grid of relatively thick crack arresting ribs embedded in a relatively thin annular shell, wherein the arresting ribs comprise radially stacked layers of strips between radially stacked annular layers corresponding to narrow composite plies interspersed between annular wide composite plies,
- relatively thin panels in the thin annular shell between the arresting ribs, and
- each of the panels completely surrounded by a set of relatively thick adjoining ribs of the relatively thick crack arresting ribs, wherein the narrow composite plies interspersed between the annular wide composite plies form the arresting ribs and the panels between the arresting ribs.

23. The aircraft gas turbine engine assembly in accordance with claim **22**, further comprising the outer skin having the ribbed composite shell and a shell forward flange extending radially inwardly from the thin annular shell.

24. The aircraft gas turbine engine assembly in accordance with claim **22**, further comprising the arresting ribs including radially stacked layers of strips between radially stacked annular layers.

25. The aircraft gas turbine engine assembly in accordance with claim **24**, further comprising the annular grid of crack arresting ribs disposed only in an axially extending portion at or near an aft end of the ribbed composite shell.

26. The aircraft gas turbine engine assembly in accordance with claim **22**, further comprising:

the annular grid circumscribed about an axial centerline axis;

each of the panels surrounded at least in part by adjoining first and second ribs;

the crack arresting ribs arranged in a grid pattern chosen from the following grid patterns;

a rectangular grid pattern including the adjoining first ribs running axially and the adjoining second ribs running circumferentially relative to the axial centerline axis;

a diamond grid pattern including the adjoining first ribs running axially and circumferentially clockwise and the adjoining second ribs running axially and circumferentially counter-clockwise relative to the axial centerline axis ; and

a hexagonal grid pattern including the adjoining first ribs running axially, the adjoining second ribs running axially and circumferentially clockwise, and adjoining third ribs running axially and circumferentially counter-clockwise relative to the axial centerline axis.

27. The aircraft gas turbine engine assembly in accordance with claim **26**, further comprising the arresting ribs including radially stacked layers of strips between radially stacked annular layers.

28. The aircraft gas turbine engine assembly in accordance with claim **27**, further comprising the annular grid of crack arresting ribs disposed only in an axially extending portion at or near an aft end of the ribbed composite shell.

29. The aircraft gas turbine engine assembly in accordance with claim **28**, further comprising a honeycomb core sandwiched between the inner and outer skins.

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