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(54) **FAN TRACK LINER ASSEMBLY**

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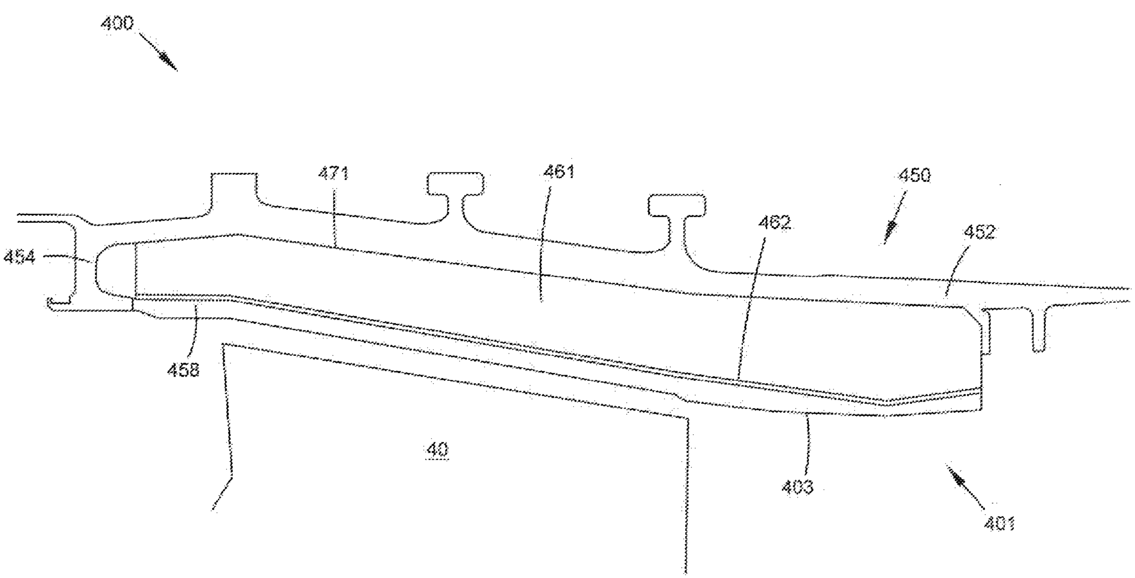
(57) **ABSTRACT**

A fan track liner assembly for a gas turbine engine. The assembly may comprise an annular attrition liner, outer member, containment core, and containment liner. The containment core may be embedded between the attrition liner and the outer member. The containment liner may be bonded to a radially outer surface of the outer member. The fan track liner assembly is disposed between a plurality of rotatable fan blades and an engine casing that encases the fan blades. The containment core and/or containment liner may comprise aerogel.



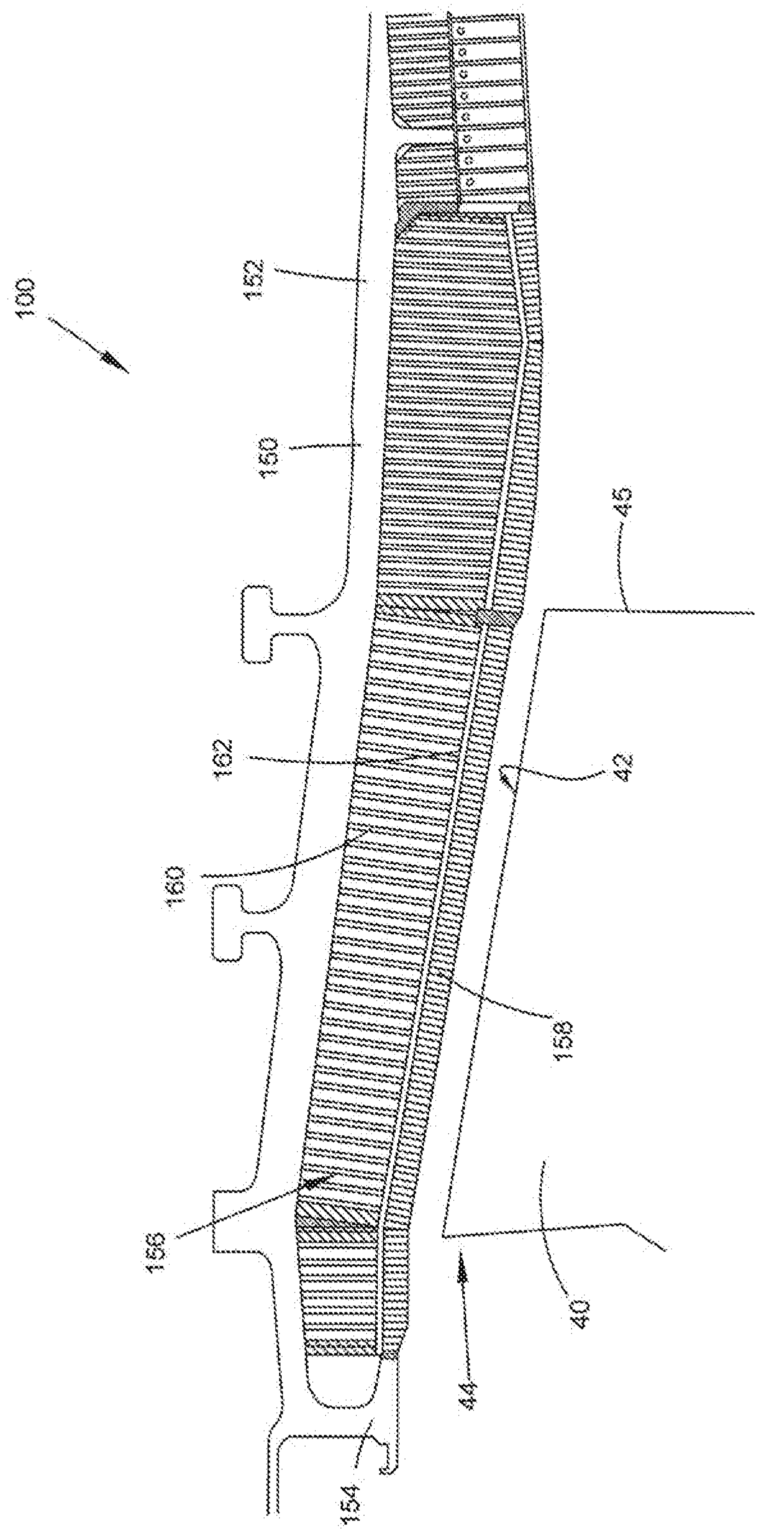


FIG. 1

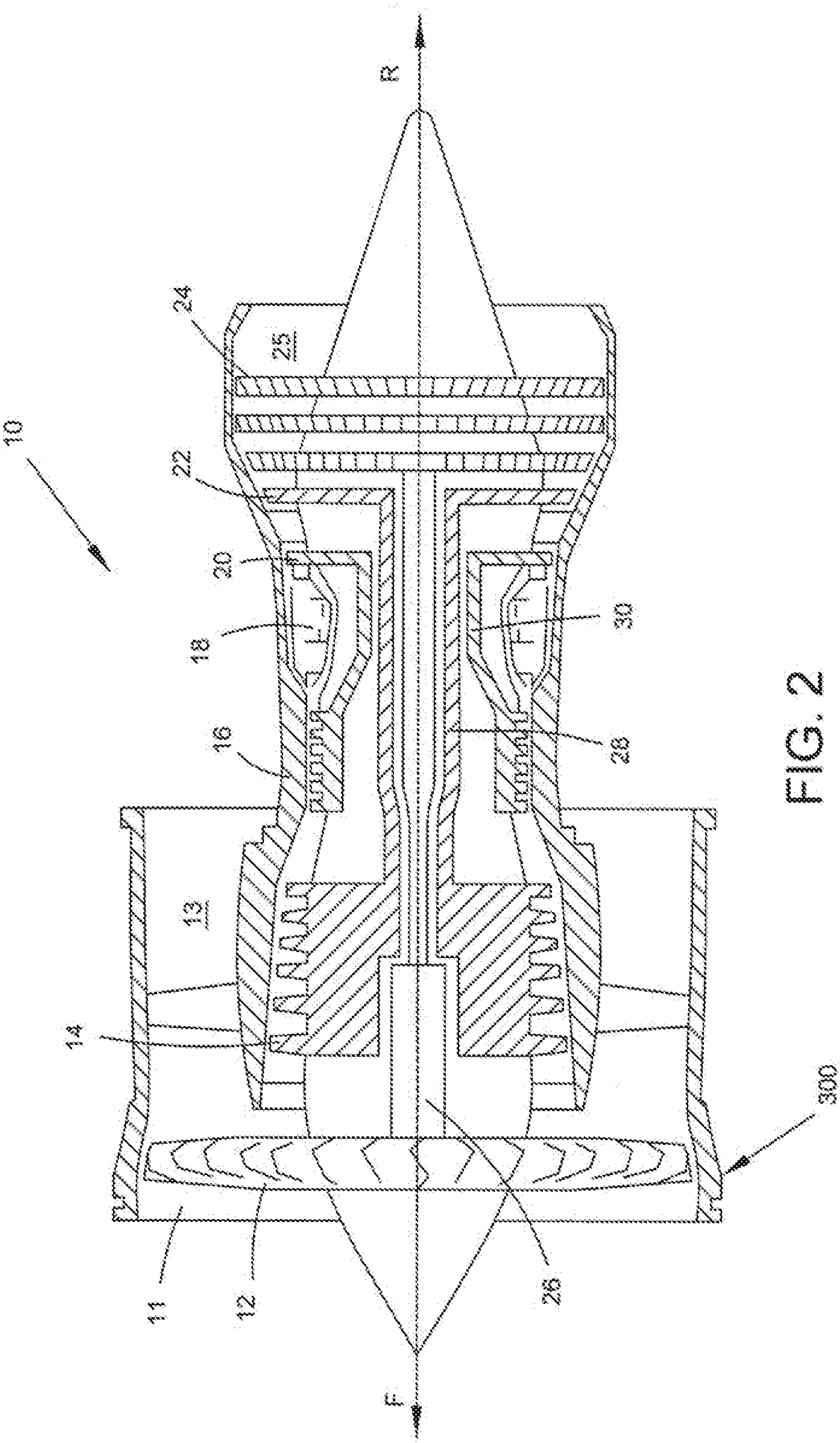


FIG. 2

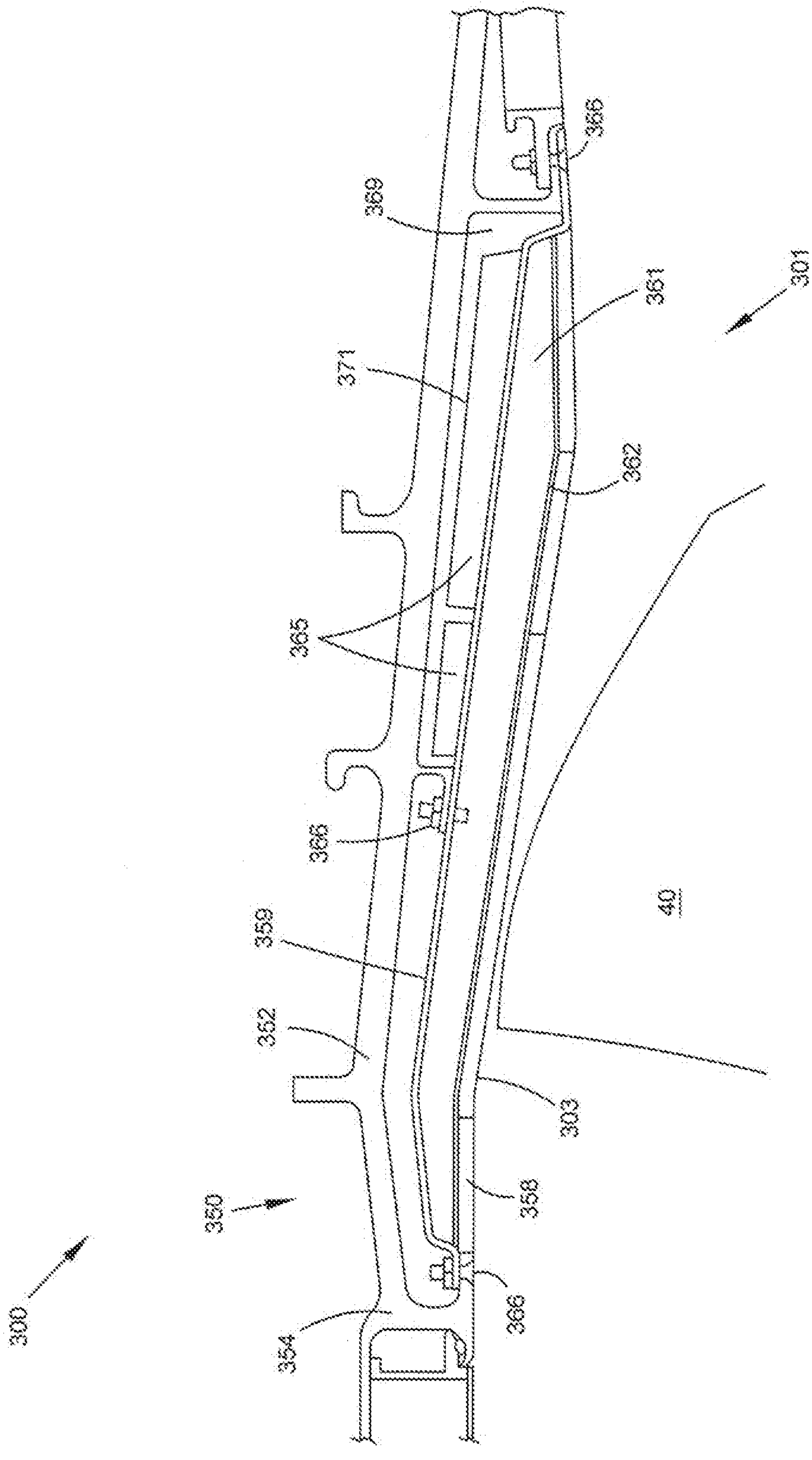


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FIG.3

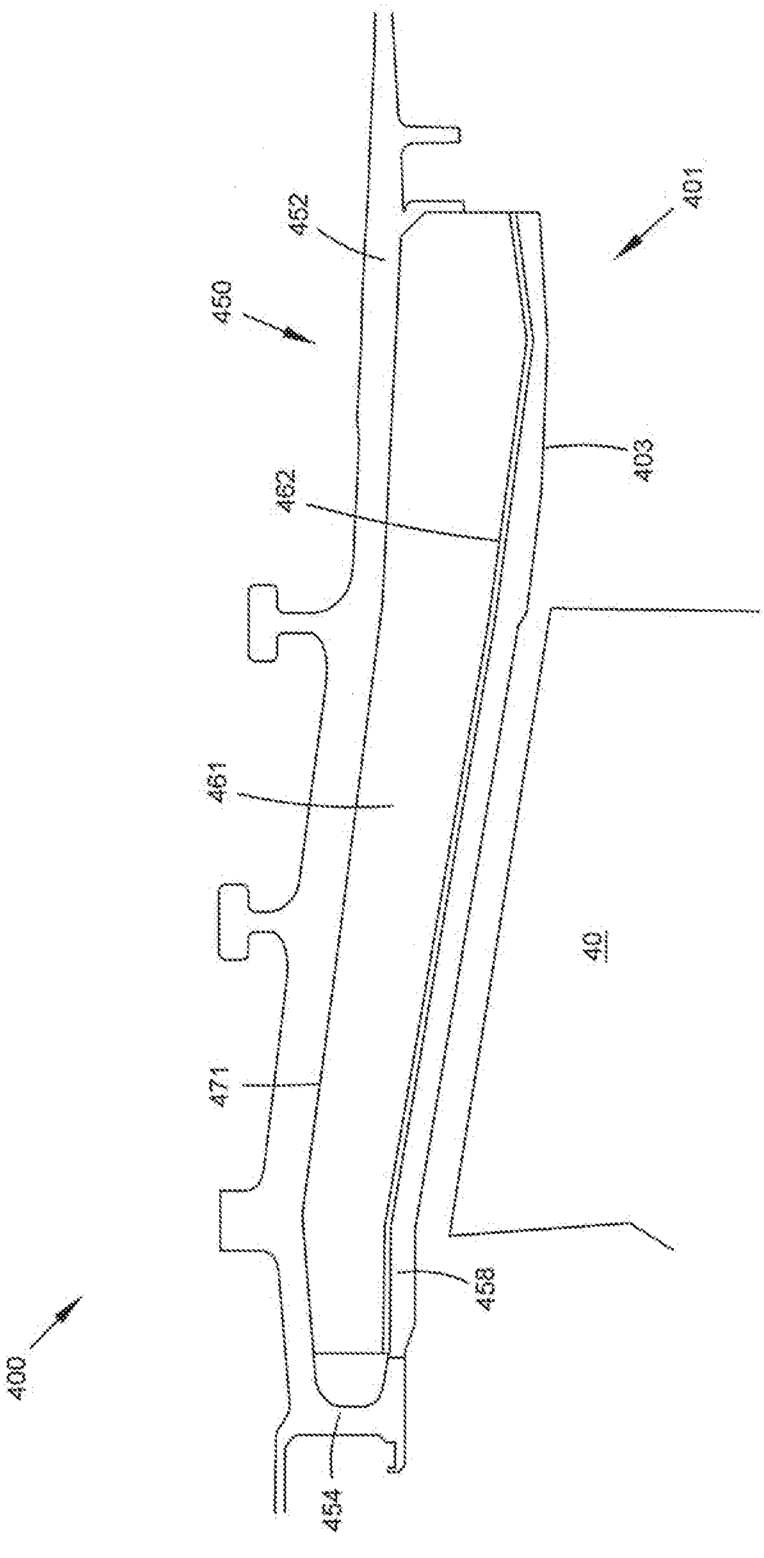

FIG. 4

FAN TRACK LINER ASSEMBLY

FIELD OF THE DISCLOSURE

[0001] The present disclosure relates generally to a fan containment system for a gas turbine engine, and more specifically to a fan track liner having a containment core or containment liner comprising aerogel.

BACKGROUND

[0002] Turbofan gas turbine engines (which may be referred to simply as 'turbofans') are typically employed to power aircraft. Turbofans are particularly useful on commercial aircraft where fuel consumption is a primary concern. Typically a turbofan gas turbine engine will comprise an axial fan driven by an engine core. The engine core is generally made up of one or more turbines that drive respective compressors' via coaxial shafts. The fan is usually driven directly off an additional lower pressure turbine in the engine core.

[0003] The fan comprises an array of radially extending fan blades mounted on a rotor and will usually provide, in current high bypass gas turbine engines, around seventy-five percent of the overall thrust generated by the gas turbine engine. The remaining portion of air from the fan is ingested by the engine core and is further compressed, combusted, accelerated and exhausted through a nozzle. The engine core exhaust mixes with the remaining portion of relatively high-volume, low-velocity air bypassing the engine core through a bypass duct.

[0004] To satisfy regulatory requirements, such engines are required to demonstrate that if part or all of a fan blade were to become detached from the remainder of the fan (known as a Fan Blade Off Event, or FBOE), that the detached parts are suitably captured within the engine containment system.

[0005] The fan is radially surrounded by a fan casing. It is known to provide the fan casing with a fan track liner and a containment system designed to contain any released blades or associated debris. Often, the fan track liner can form part of the fan containment system. The challenge to designing an effective fan track liner—and fan containment system in general—is to provide a system that is strong enough to absorb and spread the energy of a FBOE while minimizing the weight penalty incurred by the system.

[0006] A conventional fan containment system or arrangement **100** is illustrated in FIG. **1** and surrounds a fan comprising an array of radially extending fan blades **40**. Each fan blade **40** has a leading edge **44**, a trailing edge **45** and fan blade tip **42**. The fan containment arrangement **100** comprises a fan case **150**. The fan case **150** has a generally frustoconical or cylindrical annular casing element **152** and a hook **154**. The hook **154** is positioned axially forward of an array of radially extending fan blades **40**. A fan track liner **156** is typically directly bonded to the fan case **150** using adhesive. The fan track liner **156** is provided as a structural filler to bridge a deliberate gap provided between the fan case **150** and the fan blade tip **42**.

[0007] The fan track liner **156** has, in circumferential layers, an attrition liner **158** (also referred to as an abradable liner or an abradable layer), a septum **162**, and an intermediate layer that in this embodiment is a honeycomb layer **160**. The septum layer **162** acts as a bonding, separation, and load spreading layer between the attrition liner **158** and the honeycomb layer **160**. The honeycomb layer **160** may be an aluminium honeycomb. The tips **42** of the fan blades **40** are intended to pass as close as possible to the attrition liner **158** when rotating. The attrition liner **158** is therefore designed to be abraded away by the fan blade tips **42** during abnormal operational movements of the fan blade **40** and to just touch during the extreme of normal operation to ensure the gap between the rotating fan blade tips **42** and the fan track liner **156** is as small as possible without wearing a trench in the attrition liner **158**. During normal operations of the gas turbine engine, ordinary and expected movements of the fan blade **40** rotational envelope cause abrasion of the attrition liner **158**. This allows the best possible seal between the fan blades **40** and the fan track liner **156** and so improves the effectiveness of the fan in driving air through the engine.

[0008] The purpose of the hook **154** is to ensure that, in the event that a fan blade **40** detaches from the rotor of the fan **12**, the fan blade **40** will not be ejected through the front, or intake, of the gas turbine engine. During such a fan-blade-off event, the fan blade **40** travels tangentially to the curve of rotation defined by the attached fan blades. Impact with the containment system (including the fan track liner **156**) of the fan case **150** prevents the fan blade **40** from travelling any further outside of the curve of rotation defined by the attached fan blades. The fan blade **40** will also move forwards in an axial direction, and the leading edge **44** of the fan blade **40** collides with the hook **154**. Thus the fan blade **40** is held by the hook **154** and further axially forward movement is prevented. A trailing blade (not shown) then forces the held released blade rearwards where the released blade is contained. Thus the fan blade **40** is unable to cause damage to structures outside of the gas turbine engine casings.

[0009] Improvements are desired to the conventional fan track liner described with reference to FIG. **1** that would allow equal or improved fan blade containment capability while incurring a decreased weight penalty.

SUMMARY

[0010] The present application discloses one or more of the features recited in the appended claims and/or the following features that, alone or in any combination, may comprise patentable subject matter.

[0011] According to an aspect of the present invention, a fan track liner assembly for a gas turbine engine comprises an annular attrition liner forming a radially inner member of the assembly; a composite septum bonded to a radially outer surface of the attrition liner; and a containment core bonded to a radially outer surface of the septum, the containment core comprising aerogel.

[0012] In some embodiments the containment core comprises aerogel encased in a sheath. In some embodiments the sheath comprises composite. In some embodiments the radially outer surface of the containment core is adapted to be bonded to a fan casing in the gas turbine engine. In some embodiments the containment core comprises a plurality of arcuate segments that collectively form an annulus. In some embodiments the containment core is axially segmented. In some embodiments the containment core comprises aerogel produced from one of a silica, alumina, chromia, carbon, organic, metal oxide, or metal-based gel.

[0013] According to another aspect of the present disclosure, a fan track liner assembly for a gas turbine engine comprises an annular attrition liner forming a radially inner member of the assembly; an annular outer member positioned radially outward from the annular attrition liner; a containment core embedded between the attrition liner and the outer member; and an outer containment liner bonded to a radially outer surface of the outer member, the outer containment liner comprising aerogel.

[0014] In some embodiments the containment core comprises aerogel. In some embodiments the assembly is adapted to be carried by a fan casing in the gas turbine engine with the outer containment liner being positioned between the outer member and the fan casing. In some embodiments the assembly is coupled to a fan casing with fasteners.

[0015] In some embodiments the containment core comprises a metal honeycomb. In some embodiments the metal is aluminum. In some embodiments the outer containment liner is axially segmented. In some embodiments the outer containment liner comprises a plurality of arcuate segments that collectively form an annulus. In some embodiments the outer containment liner wherein comprises aerogel produced from one of a silica, alumina, chromia, or carbon, gel.

[0016] According to yet another aspect of the present disclosure, a method of making a fan containment system comprises assembling a fan track liner assembly comprising an attrition liner, a septum, a containment core, and an outer member. The step of assembling comprises bonding the septum to a radially outer surface of the attrition liner; bonding the containment core to a radially outer surface of the attrition liner; and coupling the outer member to the attrition liner such that the containment core is encased between the outer member and the attrition liner; bonding a containment liner comprising aerogel to a radially outer surface of the outer member; and coupling the fan track liner assembly to an engine casing such that the fan track liner assembly is disposed radially outward from a plurality of rotatable fan blades.

[0017] In some embodiments the coupling is accomplished with fasteners. In some embodiments the containment liner is encased in a composite sheath prior to bonding to the outer member. In some embodiments the containment core comprises aerogel.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] The following will be apparent from elements of the figures, that are provided for illustrative purposes and are not necessarily to scale.

[0019] FIG. **1** is a partial view of a cross-section through a typical fan case arrangement.

[0020] FIG. **2** is a cross-section through the rotational axis of a gas turbine engine.

[0021] FIG. **3** is a partial view of a cross-section through a fan containment system in accordance with some embodiments of the present disclosure.

[0022] FIG. **4** is a partial view of a cross-section through a fan containment system in accordance with some embodiments of the present disclosure.

[0023] While the present disclosure is susceptible to various modifications and alternative forms, specific embodiments have been shown by way of example in the drawings and will be described in detail herein. It should be understood, however, that the present disclosure is not intended to be limited to the particular forms disclosed. Rather, the present disclosure is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the disclosure as defined by the appended claims.

DETAILED DESCRIPTION

[0024] For the purposes of promoting an understanding of the principles of the disclosure, reference will now be made to a number of illustrative embodiments illustrated in the drawings and specific language will be used to describe the same.

[0025] With reference to FIG. **2** a bypass gas turbine engine is indicated at **10**. The engine **10** comprises, in axial flow series, an air intake duct **11**, fan **12**, a bypass duct **13**, an intermediate pressure compressor **14**, a high pressure compressor **16**, a combustor **18**, a high pressure turbine **20**, an intermediate pressure turbine **22**, a low pressure turbine **24** and an exhaust nozzle **25**. The fan **12**, compressors **14**, **16** and turbines **20**, **22**, **24** all rotate about the major axis of the gas turbine engine **10** and so define the axial direction of the gas turbine engine.

[0026] Air is drawn through the air intake duct **11** by the fan **12** where it is accelerated. A significant portion of the airflow is discharged through the bypass duct **13** generating a corresponding portion of the engine thrust. The remainder is drawn through the intermediate pressure compressor **14** into what is termed the core of the engine **10** where the air is compressed. A further stage of compression takes place in the high pressure compressor **16** before the air is mixed with fuel and burned in the combustor **18**. The resulting hot working fluid is discharged through the high pressure turbine **20**, the intermediate pressure turbine **22** and the low pressure turbine **24** in series where work is extracted from the working fluid. The work extracted drives the intake fan **12**, the intermediate pressure compressor **14** and the high pressure compressor **16** via shafts **26**, **28**, **30**. The working fluid, that has reduced in pressure and temperature, is then expelled through the exhaust nozzle **25** generating the remainder of the engine thrust.

[0027] The intake fan **12** comprises an array of radially extending fan blades **40** that are mounted to the shaft **26**. The shaft **26** may be considered a hub at the position where the fan blades **40** are mounted. FIG. **2** shows that the fan **12** is surrounded by a fan containment system **300** that also forms one wall or a part of the bypass duct **13**.

[0028] In the present application a forward direction (indicated by arrow F in FIG. **2**) and a rearward direction (indicated by arrow R in FIG. **2**) are defined in terms of axial airflow through the engine **10**.

[0029] Fan track liners in a gas turbine engine have several functions. A fan track liner defines the outer annulus line of the fan flowpath. A fan track liner must be tolerant of fan blade impingement or rub; these rubs may be light if caused by routine operational excursions of the fan blades or may be heavy if caused by a more severe event such as a bird strike. The fan track liner must also be able to withstand substantial impacts from ice and other debris. Finally, the fan track liner must work in conjunction with the fan casing to contain a fan blade during a FBOE.

[0030] The fan track liner **156** described above with reference to FIG. **1** is a typical fan track liner used in the art. During a FBOE, the honeycomb layer **160** of fan track liner **156** undergoes plastic deformation to absorb some energy of the detached fan blade. However, the honeycomb layer **160**

may not provide good load spreading to the fan casing **152**, sometimes rendering the fan track liner **156** of FIG. **1** inadequate.

[0031] Fan track liner **156** may also be difficult, time-consuming, and expensive to repair. As blade rubs and debris impacts degrade the attrition liner **158**, this liner must occasionally be replaced. In current versions, replacing the attrition liner typically requires removal of the old liner and bonding a new liner in place with adhesive. This process can be time-consuming and expensive, and can result in long down-times for the affected engine. Bonding of the new liner is typically required to be performed in a controlled environment, requiring removal of the engine and/or aircraft from operation.

[0032] The present disclosure is directed to a fan blade containment assembly and fan track liner that improve fan blade containment capability and/or reduce the weight penalty attributed to fan containment. More specifically, the present disclosure is directed to an embodiment of fan containment assembly comprising a containment core and outer containment liner. One or both of the containment core and outer containment liner may comprise aerogel. The present disclosure is additionally directed to an embodiment of a fan containment assembly comprising a containment core of aerogel bonded to an ending casing. By using aerogel to form one or both of the containment core and the containment liner, the present disclosure provides systems and methods of improving the containment capability of a fan containment assembly with a marginal weight penalty. In some embodiments the weight of the fan containment assembly is decreased by replacing metallic components with aerogel components.

[0033] An aerogel is an ultralight material derived from a gel. The liquid of the gel (typically water) is dried and replaced with gas (typically air). Aerogels tend to have strong structural and insulating properties.

[0034] FIG. **3** is a partial view of a cross-section through a fan containment system **300** in accordance with some embodiments of the present disclosure. Fan containment system **300** comprises fan track liner assembly **301** and fan case **350**.

[0035] The fan case **350** has a generally frustoconical or cylindrical annular casing element **352** and a hook **354**. The hook **354** is positioned axially forward of an array of radially extending fan blades **40**.

[0036] Fan track liner assembly **301** comprises attrition liner **358**, septum **362**, containment core **361**, outer member **359**, and containment liner **365**.

[0037] Attrition liner **358** comprises an annular, abradable material and is designed to be abraded away by the fan blade tips **42** during abnormal operational movements of the fan blade **40**. Attrition liner **358** forms fan flowpath boundary **303** that is the radially outer surface of the fan flowpath. Attrition liner **358** additionally forms the radially inner member of the fan containment system **300**.

[0038] Septum **362** is bonded to a radially outer surface of the attrition liner **358**. Septum **362** acts as a bonding, separation, and load spreading layer between the attrition liner **358** and the containment core **361**. Septum **362** distributes any applied load between the attrition liner **358** and the containment core **361**. In some embodiments septum **362** may comprise composite material, for example ceramic matrix composite. In other embodiments septum **362** may comprise an organic matrix composite, and that organic matrix composite may include carbon fiber or fiberglass.

[0039] A containment core **361** is defined between an outer member **359** and attrition liner **358**. Outer member **359** is an annular member that may comprise metal or composite material. Outer member **359** is coupled to casing element **352** by one or more fasteners **366**, that may be used in conjunction with washers (not shown) to affix outer member **359** to casing element **352**. Outer member **359** is disposed radially inward and offset from casing element **352** such that one or more voids **369** may be defined between the outer member **359** and casing element **352**.

[0040] In some embodiments an outer containment liner **365** may be disposed in void **369** between outer member **359** and casing element **352**. Containment liner **365** may be bonded to a radially outer surface of outer member **359**, bonded to a radially inner surface of casing element **352**, or both. In the illustrated embodiment, containment liner **365** is bonded to a radially outer surface of outer member **359**.

[0041] In embodiments where the structure of the outer member **359** and casing element **352** are such that multiple voids **369** are formed, an outer containment liner **365** may be disposed in one or more of the voids **369**. For example, a portion of containment liner **365** may be disposed in a forward void **369** while a portion of containment liner **365** may also be disposed in an aft void **369**.

[0042] In some embodiments the containment liner **365** of the illustrated embodiment may be axially segmented. For example, in the embodiment illustrated in FIG. **3**, the containment liner **365** is formed in two portions, one axially forward of the other. In some embodiments a gap is provided between axially segmented portions, while in other embodiments the axially adjacent portions abut one another.

[0043] Containment core **361** and/or containment liner **365** may comprise aerogel. In some embodiments the aerogel of the containment core **361** and/or containment liner **365** is encased in a respective composite sheath **371**. A composite sheath prevents moisture migration into the aerogel. Moisture migration would undesirably add weight to the fan track liner assembly **301** and potentially degrade performance of the aerogel. In some embodiments the aerogel of the containment core **361** and/or containment liner **365** may be encased in a plastic, metal, or similar sheath.

[0044] Each of outer member **359**, containment core **361**, and containment liner **365** may be axially or circumferentially segmented. An axially segmented component comprises more than one axially adjacent annular containment cores. A circumferentially segmented component comprises a plurality of arcuate segment that collectively form a component annulus. The component may be axially and circumferentially segmented. Alternatively, the component may be integrally formed.

[0045] The aerogel used to form containment core **361** and/or containment liner **365** may be made from silica, alumina, chromia, or carbon gel. The aerogel may be optimized to achieve maximum strength, maximum insulation, or a combination of the two.

[0046] Containment core **361** may comprise a metal honeycomb structure, for example a honeycomb structure made of aluminum or aluminum-based material.

[0047] During a FBOE, the aerogel of the containment core **361** and/or containment liner **365** functions to absorb and spread the energy of a released fan blade. The aerogel absorbs energy through brittle fracture of the material and through frictional forces generated by the entrained gas passing through the voidal structure of the aerogel. The brittle fracture of the aerogel minimizes the secondary damage caused by the FBOE, and the aerogel does not impede the released blade from nesting in the fan track liner assembly **301** to prevent ricochet damage. The aerogel's structure will provide for spreading the fan blade load over a greater area of the fan case **350**, reducing stresses on the fan case **350** and thus allowing for a thinner and/or lighter fan case **350**.

[0048] The fan containment system **300** of FIG. **3** provides numerous advantages. The addition of a containment liner **365** comprising aerogel incurs only a marginal weight penalty that substantially improves the absorption capability of the fan track liner assembly **301**. In embodiments having a containment core **361** comprising aerogel, the replacement of a metallic structure with an aerogel structure results in a weight savings. Aerogel in contact with structural elements such as the fan case **350** may provide vibrational damping.

[0049] The present disclosure of a containment liner and/or a containment core comprising aerogel is amenable to use with a variety of existing fan containment systems. For example, the present disclosure may be combined with existing hard wall (e.g. steel, aluminum, titanium, carbon composite) or soft wall (e.g. woven aramid fiber) systems.

[0050] In another embodiment of the present disclosure, the typical honeycomb layer disclosed with reference to FIG. **1** above is replaced with aerogel. FIG. **4** is a partial view of a cross-section through a fan containment system **400** in accordance with some embodiments of the present disclosure. Fan containment system **400** comprises fan track liner assembly **401** and fan case **450**.

[0051] The fan case **450** has a generally frustoconical or cylindrical annular casing element **452** and a hook **454**. The hook **454** is positioned axially forward of an array of radially extending fan blades **40**.

[0052] Fan track liner assembly **401** comprises attrition liner **458**, septum **462**, and containment core **461**. Attrition liner **458** comprises an abradable material and is designed to be abraded away by the fan blade tips **42** during abnormal operational movements of the fan blade **40**. Attrition liner **458** forms fan flowpath boundary **403** that is the radially outer surface of the fan flowpath. Attrition liner **458** additionally forms the radially inner member of the fan track liner assembly **401**.

[0053] Septum **462** is bonded to a radially outer surface of the attrition liner **458**. Septum **462** acts as a bonding, separation, and load spreading layer between the attrition liner **458** and the containment core **461**. Septum **462** distributes any applied load between the attrition liner **458** and the containment core **461**. In some embodiments septum **462** may comprise composite material, for example ceramic matrix composite. In other embodiments septum **462** may comprise an organic matrix composite, and that organic matrix composite may include carbon fiber or fiberglass.

[0054] Containment core **461** may comprise aerogel. In some embodiments the aerogel of the containment core **461** is encased in a composite sheath **471**. A composite sheath prevents moisture migration into the aerogel. Moisture migration would undesirably add weight to the fan track liner assembly **401** and potentially degrade performance of the aerogel. In some embodiments the aerogel of the containment core **461** may be encased in a plastic, metal, or similar sheath.

[0055] Containment core **461** may be bonded to a radially outer surface of septum **462** and may be bonded to fan casing element **452**. In some embodiments a radially outer surface of the containment core **461** is adapted to be bonded to fan casing element **452**.

[0056] Containment core **461** may be axially or circumferentially segmented. An axially segmented containment core **461** comprises more than one axially adjacent annular containment cores. A circumferentially segmented containment core **461** comprises a plurality of arcuate segment that collectively form a containment core annulus. Containment core **461** may be axially and circumferentially segmented. Alternatively, containment core **461** may be integrally formed.

[0057] The aerogel used to form containment core **461** may be made from silica, alumina, chromia, carbon, organic, metal oxide, or metal-based gels. The aerogel may be crosslinked, doped, or re-enforced. The aerogel may be optimized to achieve maximum strength, maximum insulation, or a combination of the two.

[0058] The embodiment of FIG. **4** provides numerous advantages over the prior art described above with reference to FIG. **1**. First and foremost, the fan track liner assembly **401** of FIG. **4** achieves a substantial weight savings over the design in FIG. **1** by replacing honeycomb layer **160**—typically made of aluminum or other metal honeycomb—with a containment core **461** formed from aerogel.

[0059] The present disclosure additionally provides a method of making a fan containment system. The method comprises coupling a fan track liner assembly to a fan casing, such that the fan track liner assembly is disposed radially outward from a fan. The fan track liner assembly may be coupled to the fan casing using fasteners.

[0060] The fan track liner assembly is assembled by bonding a septum to a radially outer surface of an attrition liner, bonding a containment core to a radially outer surface of the septum, and coupling an outer member to the attrition layer such that the containment core is encased between the outer member and the attrition layer. In some embodiments the outer member may be bonded to one or both of the attrition layer and the containment core. In some embodiments the containment core comprises a metallic honeycomb, while in other embodiments the containment core comprises aerogel. A containment liner may be bonded to outer member, such that upon installation of the fan track liner assembly the containment liner is disposed between the outer member and the fan casing. The containment core and/or containment liner may be encased in a sheath prior to or during assembly.

[0061] Although examples are illustrated and described herein, embodiments are nevertheless not limited to the details shown, since various modifications and structural changes may be made therein by those of ordinary skill within the scope and range of equivalents of the claims.

What is claimed is:

1. A fan track liner assembly for a gas turbine engine comprising:

an annular attrition liner forming a radially inner member of said assembly;

a composite septum bonded to a radially outer surface of said attrition liner; and

a containment core bonded to a radially outer surface of said septum, said containment core comprising aerogel.

2. The fan track liner assembly of claim **1** wherein said containment core comprises aerogel encased in a sheath.

3. The fan track liner assembly of claim **2** wherein said sheath comprises composite.

4. The fan track liner assembly of claim **1** wherein the radially outer surface of said containment core is adapted to be bonded to a fan casing in the gas turbine engine.

5. The fan track liner assembly of claim **1** wherein said containment core comprises a plurality of arcuate segments that collectively form an annulus.

6. The fan track liner assembly of claim **1** wherein said containment core is axially segmented.

7. The fan track liner assembly of claim **1** wherein said containment core comprises aerogel produced from one of a silica, alumina, chromia, carbon, organic, metal oxide, or metal-based gel.

8. A fan track liner assembly for a gas turbine engine, said assembly comprising:
- an annular attrition liner forming a radially inner member of said assembly;
- an annular outer member positioned radially outward from said annular attrition liner;
- a containment core embedded between said attrition liner and said outer member; and
- an outer containment liner bonded to a radially outer surface of said outer member, said outer containment liner comprising aerogel.

9. The fan track liner assembly of claim **8** wherein said containment core comprises aerogel.

10. The fan track liner assembly of claim **8** wherein said assembly is adapted to be carried by a fan casing in the gas turbine engine with said outer containment liner being positioned between said outer member and the fan casing.

11. The fan track liner assembly of claim **8** wherein said assembly is coupled to a fan casing with fasteners.

12. The fan track liner assembly of claim **8** wherein said containment core comprises a metal honeycomb.

13. The fan track liner assembly of claim **12** wherein said metal is aluminum.

14. The fan track liner assembly of claim **8** wherein said outer containment liner is axially segmented.

15. The fan track liner assembly of claim **8** wherein said outer containment liner comprises a plurality of arcuate segments that collectively form an annulus.

16. The fan track liner assembly of claim **8** said outer containment liner wherein comprises aerogel produced from one of a silica, alumina, chromia, or carbon gel.

17. A method of making a fan containment system comprising:
- assembling a fan track liner assembly comprising an attrition liner, a septum, a containment core, and an outer member, said step of assembling comprising:
  - bonding said septum to a radially outer surface of said attrition liner;
  - bonding said containment core to a radially outer surface of said attrition liner; and
  - coupling said outer member to said attrition liner such that said containment core is encased between said outer member and said attrition liner;
- bonding a containment liner comprising aerogel to a radially outer surface of said outer member; and
- coupling said fan track liner assembly to an engine casing such that said fan track liner assembly is disposed radially outward from a plurality of rotatable fan blades.

18. The method of claim **17** wherein said coupling is accomplished with fasteners.

19. The method of claim **17** wherein the containment liner is encased in a composite sheath prior to bonding to said outer member.

20. The method of claim **17** wherein said containment core comprises aerogel.

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