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Disrupting flow vortices to attenuate resonant tones within a gas turbine engine

Abstract

An assembly is provided for a gas turbine engine. This assembly includes a rotating structure of the gas turbine engine, a stationary structure of the gas turbine engine and a volume formed by and extending between the rotating structure and the stationary structure. The rotating structure is rotatable about an axis. The rotating structure includes a seal land and a fluid nozzle. The stationary structure includes a seal element. The seal element is arranged with the seal land to form a seal assembly that seals an annular gap between the stationary structure and the rotating structure. The volume is adjacent the seal element and the seal land. The fluid nozzle is configured to direct a fluid jet out from the rotating structure and into the volume.

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Background/Summary

TECHNICAL FIELD

(1) This disclosure relates generally to a gas turbine engine and, more particularly, to attenuating noise within the gas turbine engine.

BACKGROUND INFORMATION

(2) A gas turbine engine includes various sources for engine noise. Various techniques and methodologies are known in the art for reducing engine noise. While these known noise reduction techniques and methodologies have various benefits, there is still room in the art for improvement.

SUMMARY

(3) According to an aspect of the present disclosure, an assembly is provided for a gas turbine engine. This assembly includes a rotating structure of the gas turbine engine, a stationary structure of the gas turbine engine and a volume formed by and extending between the rotating structure and the stationary structure. The rotating structure is rotatable about an axis. The rotating structure includes a seal land and a fluid nozzle. The stationary structure includes a seal element. The seal element is arranged with the seal land to form a seal assembly that seals an annular gap between the stationary structure and the rotating structure. The volume is adjacent the seal element and the seal land. The fluid nozzle is configured to direct a fluid jet out from the rotating structure and into the volume.

(4) According to another aspect of the present disclosure, another assembly is provided for a gas turbine engine. This assembly includes a rotating structure of the gas turbine engine, a stationary structure of the gas turbine engine, a volume and a fluid nozzle. The rotating structure is rotatable about an axis. The rotating structure includes a seal land. The stationary structure includes a seal element. The seal element is arranged with the seal land to form a seal assembly that seals an annular gap between the stationary structure and the rotating structure. The volume is formed by and extends between the rotating structure and the stationary structure. The volume is adjacent the seal element and the seal land. The fluid nozzle includes a nozzle passage and a nozzle orifice. The fluid nozzle is configured to direct a fluid out of the nozzle passage, through the nozzle orifice, and into the volume as a diffuse flow of the fluid.

(5) According to still another aspect of the present disclosure, another assembly is provided for a gas turbine engine. This assembly includes a rotating structure of the gas turbine engine, a stationary structure of the gas turbine engine, a volume and a fluid nozzle. The rotating structure is rotatable about an axis. The rotating structure includes a seal land. The stationary structure includes a seal element. The seal element is arranged with the seal land to form a seal assembly that seals an annular gap between the stationary structure and the rotating structure. The volume is formed by and extends between the rotating structure and the stationary structure. The volume is adjacent the seal element and the seal land. The fluid nozzle includes a nozzle passage and a nozzle orifice. The fluid nozzle is configured to direct a fluid out of the nozzle passage, through the nozzle orifice, and into the volume as a turbulent flow of the fluid.

(6) The nozzle passage may follow a curved trajectory to the nozzle orifice.

(7) The rotating structure may include the fluid nozzle.

(8) The stationary structure may include the fluid nozzle.

(9) A width of the nozzle passage may expand as the nozzle passage extends longitudinally towards the nozzle orifice.

(10) The nozzle orifice may have a non-circular cross-sectional geometry.

(11) The fluid nozzle may be configured to direct the fluid jet into the volume to disrupt flow vortices within the volume.

(12) The fluid nozzle may include a nozzle passage and a nozzle orifice fluidly coupling the nozzle passage to the volume. The nozzle passage may taper as the nozzle passage extends longitudinally away from the nozzle orifice.

(13) The fluid nozzle may include a diffuser section configured to diffuse the fluid jet directed into the volume.

(14) The fluid nozzle may include a nozzle passage and a nozzle orifice fluidly coupling the nozzle passage to the volume. The nozzle passage may extend longitudinally along a centerline to the nozzle orifice. At least a portion of the centerline that extends longitudinally to the nozzle orifice may be curved.

(15) The fluid nozzle may include a nozzle passage and a nozzle orifice fluidly coupling the nozzle passage to the volume. The nozzle orifice may have an elongated cross-sectional geometry.
(16) The fluid nozzle may include a nozzle passage and a nozzle orifice fluidly coupling the nozzle passage to the volume. The nozzle orifice may have a polygonal cross-sectional geometry.
(17) The fluid nozzle may include a nozzle passage and a nozzle orifice fluidly coupling the nozzle passage to the volume. The nozzle orifice may have an irregular cross-sectional geometry.
(18) The fluid nozzle may be configured to direct the fluid jet in a direction towards the seal assembly.
(19) The fluid nozzle may be configured to direct the fluid jet in a direction away from the seal assembly.
(20) The assembly may also include a lubricant source fluidly coupled to the fluid nozzle. The fluid jet may be configured as or otherwise include a lubricant jet.
(21) The assembly may also include an air source fluidly coupled to the fluid nozzle. The fluid jet may be configured as or otherwise include an air jet.
(22) The volume may be configured as or otherwise include an air passage extending to the seal assembly.
(23) The volume may be configured as or otherwise include an air cavity.
(24) The assembly may also include a bearing rotatably coupling the rotating structure to the stationary structure. The volume may be configured as or otherwise include a bearing compartment in which the bearing is disposed.
(25) The present disclosure may include any one or more of the individual features disclosed above and/or below alone or in any combination thereof.
(26) The foregoing features and the operation of the invention will become more apparent in light of the following description and the accompanying drawings.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) FIG. **1** is a partial schematic illustration of an assembly for a gas turbine engine.
(2) FIGS. **2-4** are schematic illustrations of a portion of the engine assembly with various fluid nozzle arrangements.
(3) FIGS. **5-10** are illustrations of various nozzle orifice geometries for the fluid nozzles.
(4) FIG. **11** is a side sectional schematic illustration of an aircraft propulsion system which may include the engine system of FIG. **1**.
DETAILED DESCRIPTION
(5) FIG. **1** illustrate an assembly **20** of a gas turbine engine. Briefly, the gas turbine engine may be configured as part of a propulsion system for an aircraft. This aircraft may be an airplane, a helicopter, a drone (e.g., an unmanned aerial vehicle (UAV)) or any other manned or unmanned aerial vehicle or system. The gas turbine engine may also or alternatively be configured as part of an electrical power system for the aircraft. The engine assembly **20** of FIG. **1** includes a rotating structure **22** of the gas turbine engine, a stationary structure **24** of the gas turbine engine and at least one bearing **26** rotatably supporting the rotating structure **22** relative to the stationary structure **24**. This engine assembly **20** also includes a fluid system **28**.
(6) The rotating structure **22** is rotatable about a rotational axis **30**, which rotational axis **30** may also be a centerline axis of the rotating structure **22** and the stationary structure **24**. The rotating structure **22** of FIG. **1** includes an engine shaft **32** and a seal land **34**. The engine shaft **32** extends axially along the axis **30**. The seal land **34** is connected to and rotatable with the engine shaft **32**. The seal land **34** of FIG. **1**, for example, is directly mounted (e.g., mechanically fastened, bonded or otherwise attached) to the engine shaft **32**. The seal land **34**, however, may alternatively be

indirectly mounted to the engine shaft **32** through one or more other intermediate components which are also connected to and rotatable with the engine shaft **32**. Still alternatively, the seal land **34** may be formed integral with the engine shaft **32**. Referring again to FIG. **1**, the seal land **34** extends circumferentially around and axially along the engine shaft **32**, thereby circumscribing the engine shaft **32**.
(7) The seal land **34** includes a seal land surface **36**. The seal land surface **36** may be configured as a cylindrical surface. The seal land surface **36** of FIG. **1**, for example, extends axially along and circumferentially around the axis **30**. This seal land surface **36** has a circular cross-sectional geometry when viewed in a reference plane perpendicular to the axis **30**. The seal land surface **36** of FIG. **1** is further configured as an outer surface of the seal land **34**. The seal land **34** of FIG. **1**, for example, projects radially outward (e.g., in a direction away from the axis **30**) to the seal land surface **36**. This seal land surface **36** may be formed by/carried on a seal runner **38** (e.g., a flange) of the seal land **34**. The seal runner **38** of FIG. **1** is cantilevered from a base **40** of the seal land **34**. More particularly, the seal runner **38** projects axially out from the seal land base **40** to an unsupported axial distal end **42** of the seal runner **38**. The seal runner **38** extends radially between and to an inner side surface **44** of the seal runner **38** and the seal land surface **36**. The seal land **34** of the present disclosure, however, is not limited to such an exemplary arrangement.
(8) The stationary structure **24** is configured to form one or more enclosed or open volumes (e.g., cavities, passages, etc.) with the rotating structure **22**, which volumes are located internally within the gas turbine engine. The stationary structure **24** of FIG. **1**, for example, is disposed radially outboard of the rotating structure **22**. The stationary structure **24** extends axially along the rotating structure **22**, thereby axially overlapping at least a portion or an entirety of the rotating structure **22**. The stationary structure **24** extends circumferentially around (e.g., circumscribes) the rotating structure **22**. With this arrangement, a bearing compartment **46** (or another air cavity) and an air passage **48** are collectively formed by and extend between at least (or only) the stationary structure **24** and the rotating structure **22** of FIG. **1**.
(9) The stationary structure **24** includes an annular seal element **50**; e.g., a carbon seal element. This seal element **50** includes a seal element surface **52**. The seal element surface **52** may be configured as a cylindrical surface. The seal element surface **52** of FIG. **1**, for example, extends axially along and circumferentially around the axis **30**. This seal element surface **52** has a circular cross-sectional geometry when viewed in a reference plane perpendicular to the axis **30**. The seal element surface **52** of FIG. **1** is further configured as an inner surface of the seal element **50**. The seal element **50** of FIG. **1**, for example, projects radially inward (e.g., in a direction towards the axis **30**) to the seal element surface **52**.
(10) The seal element **50** and its seal element surface **52** are aligned with and configured to sealingly engage the seal land **34** and its seal land surface **36**. The seal element surface **52** of FIG. **1**, for example, is disposed radially outboard of the seal land surface **36**. This seal element surface **52** axially overlaps and circumscribes the seal land surface **36**. The seal element **50** and its seal element surface **52** are adjacent and radially contact the seal land **34** and its seal land surface **36**. With this arrangement, at least (or only) the seal element **50** and the seal land **34** collectively form a seal assembly **54**. The seal assembly **54** of FIG. **1** is disposed axially between the bearing compartment **46** from the air passage **48**. The seal assembly **54** is configured to seal an annular gap radially between the stationary structure **24** and the rotating structure **22**. The seal assembly **54** may thereby substantially fluidly decouple the bearing compartment **46** from the air passage **48**.
(11) The seal element **50** is moveably mounted with another stationary component **55** (e.g., a frame, a strut, etc.) of the stationary structure **24**. In particular, while the seal element **50** is restrained from rotating circumferentially about the axis **30** (e.g., rotationally stationary), the seal element **50** may be operable to shift radially and/or axially relative to the stationary component **55** to accommodate thermally induced and/or vibrationally induced movement (e.g., shifting) between the rotating structure **22** and the stationary structure **24**. The seal element **50** may further be

operable to shift to maintain contact with the seal land **34** as material of the seal element **50** is worn away during gas turbine engine operation. Various mounting techniques are known in the art for mounting a seal element with a stationary structure, and the present disclosure is not limited to any particular ones thereof.

(12) The seal assembly **54** is described above as a radial seal assembly between the rotating structure **22** and the stationary structure **24**. The present disclosure, however, is not limited to such an exemplary arrangement. The seal assembly **54**, for example, may alternatively be configured as an axial seal assembly which seals an axial gap between the rotating structure **22** and the stationary structure **24**. Moreover, while the seal assembly **54** is described above as a contact seal assembly where the seal land **34** contacts and rubs against the seal element **50**, the present disclosure is not limited thereto. The seal assembly **54**, for example, may alternatively be configured as a non-contact seal assembly such as, but not limited to, a hydrostatic seal assembly or a hydrodynamic seal assembly, where the seal element **50** may be sealingly engaged with, but not contact, the seal land **34**.

(13) Referring again to FIG. **1**, the bearing **26** is arranged (e.g., housed) within the bearing compartment **46**. This bearing **26** rotatably couples the rotating structure **22** to the stationary structure **24**. Examples of the bearing **26** include, but are not limited to, a rolling element bearing and a journal bearing.

(14) During operation of the engine assembly **20**, the rotating structure **22** rotates about the axis **30** and relative to the stationary structure **24**. While the seal assembly **54** substantially seals the gap between the stationary structure **24** and the rotating structure **22**, some gas (e.g., compressed air) may leak across the seal assembly **54** between the air passage **48** and the bearing compartment **46**. Some compressed air flowing in the air passage **48**, for example, may leak across the seal assembly **54** (e.g., radially between the seal land surface **36** and the seal element surface **52**) and flow into the bearing compartment **46**. If unmitigated, this leakage air may swirl within the bearing compartment **46** and generate (e.g., strong) resonant tones; e.g., whistling noise. In addition, pressure waves may also be directed upstream into the air passage **48** and generate additional resonant tones. The fluid system **28** of the present disclosure is configured to disrupt the leakage air within the bearing compartment **46** and/or the pressure waves within the air passage **48** to at least partially attenuate the resonant tones.

(15) The fluid system **28** of FIG. **1** includes a fluid circuit **56**, a fluid source **58** and one or more fluid nozzles **60**A-E (generally referred to as “**60**”). The fluid circuit **56** may include a system of circuit passages between the fluid source **58** to the fluid nozzles **60**. This fluid circuit **56** and its circuit passages fluidly couple an outlet (or outlets) from the fluid source **58** to inlets into the fluid nozzles **60** (e.g., in parallel).

(16) The fluid source **58** is configured to provide a fluid (e.g., a gas and/or a liquid) to the fluid circuit **56**. The fluid source **58**, for example, may be a lubricant source and the fluid may be lubricant; e.g., engine oil. This lubricant source may include a lubricant reservoir **62** (e.g., a lubricant tank) and/or a lubricant flow regulator **64** (e.g., a pump and/or a valve (or system of valves)). The lubricant reservoir **62** is configured to contain a quantity of the lubricant before, during and/or after gas turbine engine operation. The lubricant flow regulator **64** is configured to direct a flow of the lubricant to the fluid nozzles **60** through the fluid circuit **56**. In another example, the fluid source **58** may be an air source and the fluid may be air; e.g., compressed air. This air source may be configured as a bleed orifice fluidly coupled with a flowpath within the gas turbine engine; e.g., a core flowpath. The bleed orifice is configured to bleed the air from the flowpath, and direct the bleed air into the fluid circuit **56** for delivery to the fluid nozzles **60**. This bleed orifice may bleed the air from a portion of the flowpath extending through a compressor section of the gas turbine engine, or a portion of the flowpath downstream of the compressor section. The present disclosure, however, is not limited to such exemplary fluid sources nor to such exemplary fluids.

(17) Each of the fluid nozzles **60** is configured to direct a jet of the fluid into a respective one of the internal volumes **46**, **48**. While the fluid jet may (or may not) provide a secondary cooling effect to one or more engine components, the fluid jet is (e.g., primarily) directed into the respective internal volume **46**, **48** to disrupt flow vortices within the respective internal volume **46**, **48** and attenuate associated resonant tones. For example, rather than directing a high velocity jet through the respective internal volume **46**, **48** to impingement cool a component surface, the fluid jet may be a relatively low velocity jet that penetrates (e.g., partially) into the respective internal volume **46**, **48**. The fluid jet may also be a relatively diffuse and/or turbulent flow of the fluid to expand coverage and/or enhance disruption of the flow vortices. More particularly, the fluid jet is directed into the respective internal volume **46**, **48** to change a frequency and/or a strength of the flow vortices to generate lower level, wide ranging broadband frequencies rather than the (e.g., strong) resonant tones which would otherwise be generated by the flow vortices.
(18) One or more of the fluid nozzles (e.g., **60**A-C) may each be mounted to, included as part of and/or otherwise configured with the rotating structure **22**. The fluid nozzle **60**A, for example, is radially below and axially aligned with the seal runner **38**. This fluid nozzle **60**A is configured to direct its fluid jet into the bearing compartment **46** in a direction generally (e.g., radially) towards the seal assembly **54** and its seal runner **38**. The fluid nozzle **60**B may also be located radially inboard of the seal runner **38**. This fluid nozzle **60**B, however, is configured to direct its fluid jet into the bearing compartment **46** in a direction (e.g., axially) away from the seal assembly **54** and its seal runner **38**. The fluid nozzle **60**B, for example, may direct its fluid jet into (or towards) a region of the bearing compartment **46** axially between the axial distal end **42** of the seal runner **38** and the stationary structure **24**. The fluid nozzle **60**C, on the other hand, may be generally radially aligned with (or outboard of) the seal runner **38**. This fluid nozzle **60**C is configured to direct its fluid jet into the air passage **48** in a direction (e.g., axially) towards the seal assembly **54** and its seal element **50**. The present disclosure, however, is not limited to the foregoing exemplary fluid nozzle locations nor to the foregoing exemplary fluid jet trajectories.
(19) One or more of the fluid nozzles (e.g., **60**D and **60**E) may each be mounted to, included as part of and/or otherwise configured with the stationary structure **24**. The fluid nozzle **60**D, for example, is radially outboard of the seal runner **38**. This fluid nozzle **60**D is configured to direct its fluid jet into the bearing compartment **46** in a direction generally (e.g., radially and/or axially) towards the seal assembly **54** and its seal runner **38**. The fluid nozzle **60**E, on the other hand, may be generally radially aligned with (or inboard of) the seal runner **38**. This fluid nozzle **60**E is configured to direct its fluid jet into the bearing compartment **46** in a direction (e.g., axially) towards the seal assembly **54** and its seal runner **38**. The fluid nozzle **60**E, for example, may direct its fluid jet into (or towards) a region of the bearing compartment **46** axially between the axial distal end **42** of the seal runner **38** and the stationary structure **24**. The present disclosure, however, is not limited to the foregoing exemplary fluid nozzle locations nor to the foregoing exemplary fluid jet trajectories.
(20) Referring to FIGS. **2-4**, each fluid nozzle **60** may include a nozzle passage **66** and a nozzle orifice **68**. The nozzle passage **66** extends longitudinally along a longitudinal centerline **70** of the respective fluid nozzle **60** in the respective structure **22**, **24** (or another component connected to the respective structure) to the nozzle orifice **68**. This nozzle orifice **68** is disposed in a surface **72** of the respective structure **22**, **24** (or the other component connected to the respective structure), which structure surface **72** forms a (e.g., axial and/or radial) peripheral boundary of the respective internal volume **46**, **48** into which the fluid jet is directed. The nozzle passage **66** is fluidly coupled with the fluid circuit **56**. The fluid nozzle **60** is configured to direct the fluid received from the fluid circuit **56** out of the nozzle passage **66**, through the nozzle orifice **68**, and into the respective internal volume **46**, **48** as the fluid jet.
(21) In some embodiments, referring to FIG. **2**, the nozzle passage **66** and the nozzle centerline **70** of one or more of the fluid nozzles **60** may each follow a straight, linear trajectory (e.g., from the fluid circuit **56**) to the nozzle orifice **68**. The nozzle passage **66** may also be configured with a

uniform size **74** (e.g., a cross-sectional area, a lateral width, a diameter, etc.) longitudinally along at least a portion or an entirety of the nozzle centerline **70** to the nozzle orifice **68**.

(22) In some embodiments, referring to FIG. **3**, the nozzle passage **66** of one or more of the fluid nozzles **60** may each include a diffuser. The nozzle passage **66** of FIG. **3**, for example, includes a meter section **76** and a diffuser section **78**. The meter section **76** extends longitudinally along the nozzle centerline **70** (e.g., from the fluid circuit **56**) to the diffuser section **78**. This meter section **76** may be configured with a uniform size **74**A longitudinally along its length to the diffuser section **78**. The diffuser section **78** extends longitudinally along the nozzle centerline **70** from the meter section **76** to the nozzle orifice **68**. This diffuser section **78** is configured with a size **74**B that changes (e.g., continuously or incrementally increases) longitudinally along its length from the meter section **76** to the nozzle orifice **68**. With this arrangement, the nozzle passage **66** and its diffuser section **78** of FIG. **3** laterally tapers as the nozzle passage **66** extends longitudinally along its nozzle centerline **70** away from the nozzle orifice **68**/to the meter section **76**. This diffuser section **78** is configured to diffuse the fluid being directed into the respective internal volume **46**, **48** so as to provide a diffused fluid jet; e.g., a jet of fluid that spreads/fans outward relative to the nozzle centerline **70**. This diffusing the fluid jet increases a coverage area of the fluid jet as well as reduces the velocity and/or penetration of the fluid jet into the respective internal volume **46**, **48**. With the arrangement of FIG. **3**, the nozzle centerline **70** may also follow a non-straight (e.g., a bent, compound, etc.) trajectory to the nozzle orifice **68**.

(23) In some embodiments, referring to FIG. **4**, the nozzle passage **66** and the nozzle centerline **70** of one or more of the fluid nozzles **60** may each follow a non-straight trajectory (e.g., from the fluid circuit **56**) to the nozzle orifice **68**. The nozzle passage **66** and the nozzle centerline **70** of FIG. **4**, for example, follows a curved trajectory (e.g., an arcuate trajectory, a splined trajectory, etc.) from or about the fluid circuit **56** to or about the nozzle orifice **68**. With this arrangement, the fluid jet may be swirled into the respective internal volume **46**, **48**; e.g., the fluid jet may be a turbulent flow (e.g., a pulsing flow) of the fluid. This turbulent flow may facilitate wider ranging frequency modifications to the flow vortices within the respective internal volume **46**, **48**. In some embodiments, the nozzle passage **66** may also be configured with a uniform size **74** longitudinally along at least a portion or an entirety of the nozzle centerline **70** to the nozzle orifice **68**. In other embodiments (see dashed line), the nozzle passage **66** may be configured with a size **74** that changes (e.g., continuously or incrementally increases) longitudinally along its length to the nozzle orifice **68**. The nozzle passage **66** of FIG. **4**, for example, may be configured with a diffuser similar to that described above with respect to FIG. **3**.

(24) Referring to FIGS. **5-10**, each nozzle orifice **68** has a cross-sectional geometry (“orifice geometry”) when viewed in a reference plane perpendicular to its nozzle centerline **70**. Referring to FIG. **5**, the orifice geometry for one or more of the fluid nozzles **60** may have a circular shape. Referring to FIGS. **6**, **7** and **9**, the orifice geometry for one or more of the fluid nozzles **60** may have an elongated shape; e.g., an oval shape (see FIG. **6**), a rectangular shape (see FIG. **7**), a triangular shape (see FIG. **9**), etc. Referring to FIGS. **7-9**, the orifice geometry for one or more of the fluid nozzles **60** may have a polygonal shape; e.g., a rectangular shape (see FIG. **7**), a star shape (see FIG. **8**), a triangular shape (see FIG. **9**), etc. Referring to FIGS. **5-8**, the orifice geometry for one or more of the fluid nozzles **60** may have a regular shape. Herein, the term “regular” may describe an axisymmetric shape and/or a shape where all interior angles and sides respectively measure the same. Referring to FIGS. **9** and **10**, the orifice geometry for one or more of the fluid nozzles **60** may have an irregular shape. Herein, the term “irregular” may describe a non-axisymmetric shape and/or a shape which includes interior angles and sides with different respective measurements. In generally, provide the nozzle orifice **68** with a non-circular orifice geometry may help to facilitate enhanced diffusion and/or perturbation of the fluid jet, particularly where the orifice geometry includes one or more interior corners (e.g., see FIGS. **7-10**). The present disclosure, however, is not limited to the foregoing exemplary orifice geometries.

(25) FIG. **11** is a side sectional schematic illustration of an aircraft propulsion system which may include the gas turbine engine and its engine assembly **20** (see FIG. **1**). The gas turbine engine of FIG. **11** is configured as a turbofan gas turbine engine **80** ("turbofan engine"). This turbofan engine **80** extends axially along an axial centerline (e.g., the axis **30**) from an upstream end **82** of the turbofan engine **80** to a downstream end **84** of the turbofan engine **80**. The turbofan engine **80** includes a fan section **86**, a compressor section **88**, a combustor section **90** and a turbine section **92**. The turbine section **92** of FIG. **11** includes a high pressure turbine (HPT) section **92**A and a power turbine (PT) section **92**B.
(26) The engine sections **86**, **88**, **90**, **92**A and **92**B are arranged within an engine housing **94**. This engine housing **94** includes an inner case **96** (e.g., a core case) and an outer case **98** (e.g., a fan case). The inner case **96** may house one or more of the engine sections **88**, **90**, **92**A and **92**B; e.g., a core of the turbofan engine **80**. The outer case **98** may house at least the fan section **86**. The engine housing **94** may also include (or support) the stationary structure **24** (see FIG. **1**) within the inner case **96**.
(27) Each of the engine sections **86**, **88**, **92**A and **92**B includes a respective bladed rotor **100-103**. Each of these bladed engine rotors **100-103** includes a plurality of rotor blades arranged circumferentially around and connected to one or more respective rotor disks. The rotor blades, for example, may be formed integral with or mechanically fastened, welded, brazed and/or otherwise attached to the respective rotor disk(s).
(28) The fan rotor **100** is connected to and driven by the PT rotor **103** through a power turbine (PT) shaft **106**. At least (or only) the fan rotor **100**, the PT rotor **103** and the PT shaft **106** may collectively form a power turbine (PT) rotating assembly **108**; e.g., a spool. The compressor rotor **101** is connected to and driven by the HPT rotor **102** through a high speed shaft **110**. At least (or only) the compressor rotor **101**, the HPT rotor **102** and the high speed shaft **110** may collectively form a high speed rotating assembly **112**; e.g., a spool. At least one of these rotating assemblies **108**, **112** may include or may otherwise be rotatable with the rotating structure **22** (see FIG. **1**).
(29) During operation of the turbofan engine **80**, air enters the turbofan engine **80** through an airflow inlet **114** into the turbofan engine **80**. This air is directed through the fan section **86** and into a core flowpath **116** and a bypass flowpath **118**. The core flowpath **116** extends sequentially through the engine sections **88**, **90**, **92**A and **92**B; e.g., the engine core. The air within the core flowpath **116** may be referred to as "core air". The bypass flowpath **118** extends through a bypass duct which bypasses (e.g., is radially outboard of and extends along) the engine core. The air within the bypass flowpath **118** may be referred to as "bypass air".
(30) The core air is compressed by the compressor rotor **101** and directed into a combustion chamber **120** of a combustor **122** in the combustor section **90**. Fuel is injected into the combustion chamber **120** and mixed with the compressed core air to provide a fuel-air mixture. This fuel-air mixture is ignited and combustion products thereof flow through and sequentially cause the HPT rotor **102** and the PT rotor **103** to rotate. The rotation of the HPT rotor **102** drives rotation of the compressor rotor **101** and, thus, compression of the air received into the core flowpath **116**. The rotation of the PT rotor **103** drives rotation of the fan rotor **100**, which propels the bypass air through and out of the bypass flowpath **118**. The propulsion of the bypass air may account for a majority of thrust generated by the turbofan engine **80**, e.g., more than seventy-five percent (75%) of engine thrust. The turbofan engine **80** of the present disclosure, however, is not limited to the foregoing exemplary thrust ratio.
(31) The engine assembly **20** may be included in various gas turbine engines other than the one described above. The engine assembly **20**, for example, may be included in a geared gas turbine engine where a geartrain connects one or more shafts to one or more rotors in a fan section, a compressor section and/or any other engine section. Alternatively, the engine assembly **20** may be included in a gas turbine engine configured without a geartrain; e.g., a direct-drive gas turbine engine. The engine assembly **20** may be included in a gas turbine engine configured with a single

spool, with two spools (e.g., see FIG. **11**), or with more than two spools. The gas turbine engine may be configured as a turbofan engine, a turbojet engine, a turboprop engine, a turboshaft engine, a propfan engine, a pusher fan engine or any other type of gas turbine engine. The gas turbine engine may alternatively be configured as an auxiliary power unit (APU). The present disclosure therefore is not limited to any particular types or configurations of gas turbine engines.
(32) While various embodiments of the present disclosure have been described, it will be apparent to those of ordinary skill in the art that many more embodiments and implementations are possible within the scope of the disclosure. For example, the present disclosure as described herein includes several aspects and embodiments that include particular features. Although these features may be described individually, it is within the scope of the present disclosure that some or all of these features may be combined with any one of the aspects and remain within the scope of the disclosure. Accordingly, the present disclosure is not to be restricted except in light of the attached claims and their equivalents.

Claims

1. An assembly for a gas turbine engine, comprising: a rotating structure of the gas turbine engine rotatable about an axis, the rotating structure including a seal land, an engine shaft, and a plurality of fluid nozzles, the plurality of fluid nozzles including a first nozzle and a second nozzle, the seal land connected to and rotatable with the engine shaft; a stationary structure of the gas turbine engine comprising a seal element, the seal element arranged with the seal land to form a seal assembly that seals an annular gap between the stationary structure and the rotating structure; and a volume formed by and extending between the rotating structure and the stationary structure, the volume adjacent the seal element and the seal land; each of the plurality of fluid nozzles configured to direct a respective fluid jet out from the rotating structure and into the volume, wherein each of the plurality of fluid nozzles is mounted to and/or included as part of the rotating structure, and wherein the first nozzle is configured to direct the respective fluid jet into the volume in a radial direction towards the seal assembly, and the second nozzle is configured to direct the respective fluid jet into the volume in an axial direction away from the seal assembly.
2. The assembly of claim 1, wherein each of the plurality of fluid nozzles is configured to direct the respective fluid jet into the volume to disrupt flow vortices within the volume.
3. The assembly of claim 1, wherein at least one fluid nozzle of the plurality of fluid nozzles includes a nozzle passage and a nozzle orifice fluidly coupling the nozzle passage to the volume; and the nozzle passage tapers as the nozzle passage extends longitudinally away from the nozzle orifice.
4. The assembly of claim 1, wherein at least one fluid nozzle of the plurality of fluid nozzles comprises a diffuser section configured to diffuse the fluid jet directed into the volume.
5. The assembly of claim 1, wherein at least one fluid nozzle of the plurality of fluid nozzles includes a nozzle passage and a nozzle orifice fluidly coupling the nozzle passage to the volume; and the nozzle passage extends longitudinally along a centerline to the nozzle orifice, and at least a portion of the centerline that extends longitudinally to the nozzle orifice is curved.
6. The assembly of claim 1, wherein at least one fluid nozzle of the plurality of fluid nozzles includes a nozzle passage and a nozzle orifice fluidly coupling the nozzle passage to the volume; and the nozzle orifice has an elongated cross-sectional geometry.
7. The assembly of claim 1, wherein at least one fluid nozzle of the plurality of fluid nozzles includes a nozzle passage and a nozzle orifice fluidly coupling the nozzle passage to the volume; and the nozzle orifice has a polygonal cross-sectional geometry.
8. The assembly of claim 1, wherein at least one fluid nozzle of the plurality of fluid nozzles includes a nozzle passage and a nozzle orifice fluidly coupling the nozzle passage to the volume; and the nozzle orifice has an irregular cross-sectional geometry.

9. The assembly of claim 1, further comprising: a lubricant source fluidly coupled to at least one fluid nozzle of the plurality of fluid nozzles; the fluid jet comprising a lubricant jet.
10. The assembly of claim 1, further comprising: an air source fluidly coupled to at least one fluid nozzle of the plurality of fluid nozzles; the fluid jet comprising an air jet.
11. The assembly of claim 1, wherein the volume comprises an air passage extending to the seal assembly.
12. The assembly of claim 1, wherein the volume comprises an air cavity.
13. The assembly of claim 1, further comprising: a bearing rotatably coupling the rotating structure to the stationary structure; the volume comprising a bearing compartment in which the bearing is disposed.
14. The assembly of claim 1, further comprising a second plurality of fluid nozzles, each of the fluid nozzles of the second plurality of fluid nozzles mounted to and/or included as part of the stationary structure, and each of the fluid nozzles of the second plurality of fluid nozzles configured to direct a respective fluid jet out from the stationary structure and into the volume, wherein the second plurality of fluid nozzles includes a third nozzle and a fourth nozzle, the third nozzle configured to direct the respective fluid jet into the volume radially towards the seal assembly, and the fourth nozzle configured to direct the respective fluid jet into the volume axially towards from the seal assembly.
15. An assembly for a gas turbine engine, comprising: a rotating structure of the gas turbine engine rotatable about an axis, the rotating structure comprising a seal land; a stationary structure of the gas turbine engine comprising a seal element, the seal element arranged with the seal land to form a seal assembly that seals an annular gap between the stationary structure and the rotating structure; a volume formed by and extending between the rotating structure and the stationary structure, the volume adjacent the seal element and the seal land, wherein the volume comprises an air passage extending to the seal assembly; and a plurality of fluid nozzles, the plurality of fluid nozzles including a first nozzle and a second nozzle, each fluid nozzle of the plurality of fluid nozzles including a respective nozzle passage and a respective nozzle orifice, each fluid nozzle of the plurality of fluid nozzles configured to direct a fluid out of the respective nozzle passage, through the respective nozzle orifice, and into the volume as a diffuse flow of the fluid, wherein the first nozzle and the second nozzle are mounted to and/or included as part of the rotating structure, and wherein the first nozzle is configured to direct the respective fluid into the volume in a radial direction towards the seal assembly, and the second nozzle is configured to direct the fluid into the volume in an axial direction away from the seal assembly.
16. The assembly of claim 15, wherein a width of each respective nozzle passage expands as the nozzle passage extends longitudinally towards the respective nozzle orifice.
17. The assembly of claim 15, wherein each respective nozzle orifice has a non-circular cross-sectional geometry.
18. An assembly for a gas turbine engine, comprising: a rotating structure of the gas turbine engine rotatable about an axis, the rotating structure comprising a seal land; a stationary structure of the gas turbine engine comprising a seal element, the seal element arranged with the seal land to form a seal assembly that seals an annular gap between the stationary structure and the rotating structure; a volume formed by and extending between the rotating structure and the stationary structure, the volume adjacent the seal element and the seal land, wherein the volume comprises an air passage extending to the seal assembly; and a plurality of fluid nozzles, the plurality of fluid nozzles including a first nozzle and a second nozzle, each of the first nozzle and the second nozzle including a respective nozzle passage and a respective nozzle orifice, each of the first nozzle and the second nozzle configured to direct a fluid out of the respective nozzle passage, through the respective nozzle orifice, and into the volume as a turbulent flow of the fluid, wherein each of the first nozzle and the second nozzle is configured and rotatable with the rotating structure, and wherein the first nozzle is configured to direct the fluid into the volume in a radial direction

towards the seal assembly, and the second nozzle is configured to direct the fluid into the volume in an axial direction away from the seal assembly.

19. The assembly of claim 18, wherein each respective nozzle passage follows a curved trajectory to each respective nozzle orifice.