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United States Patent	12390894
Kind Code	B2
Date of Patent	August 19, 2025
Inventor(s)	Bowler; Patrick

Piston seal assembly guards and inserts for seal groove

Abstract

A method of repairing a piston seal assembly comprises removing worn material from a piston seal groove to generate a worked seal groove, applying a groove buildup member to the worked seal groove, and disposing a seal member proximate the groove buildup member.

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Appl. No.: **18/589234**

Filed: **February 27, 2024**

Prior Publication Data

Document Identifier	Publication Date
US 20240198462 A1	Jun. 20, 2024

Related U.S. Application Data

division parent-doc US 17893983 20220823 US 11945063 child-doc US 18589234
division parent-doc US 16883442 20200526 US 11453090 20220927 child-doc US 17893983

Publication Classification

Int. Cl.: **B23P6/00** (20060101); **F01D25/18** (20060101)

U.S. Cl.:

CPC **B23P6/007** (20130101); **F01D25/183** (20130101);

Field of Classification Search

CPC: Y10T (29/49233); Y10T (29/49238); Y10T (29/4925); Y10T (29/49318); Y10T (29/49732); Y10T (29/49734); Y10T (29/49735); Y10T (29/49737); Y10T (29/49739); Y10T (29/49741); Y10T (29/49742)

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS (1) This application is a divisional of, and claims priority to, U.S. application Ser. No. 17/893,983, filed Aug. 23, 2022, and entitled “PISTON SEAL ASSEMBLY GUARDS AND INSERTS FOR SEAL GROOVE,” (hereinafter the '983 application). The '983 application is a divisional of, and claims priority to, U.S. application Ser. No. 16/883,442, filed May 26, 2020, and entitled “PISTON SEAL ASSEMBLY GUARDS AND INSERTS FOR SEAL GROOVE,” (hereinafter the '442 application), issued as U.S. Pat. No. 11,453,090 B2 on Sep. 27, 2022. The '983 application and the '442 applications are hereby incorporated in their entirety by reference herein for all purposes.

FIELD
(1) The disclosure relates generally to vehicles and machinery and, more specifically, to bearing carries and systems for turbine engines.
BACKGROUND
(2) Gas turbine engines are known to include piston seal assemblies between various components, for example, to inhibit pressure loss between compartments or provide fluid sealing between compartments. In operation, piston seal assemblies may tend to degrade over time. For example, operational conditions of the gas turbine engine may tend to induce fretting at the loaded face of a seal groove. In this regard, piston seal assembly performance may tend to be reduced over time in response to fretting and/or other wear of the piston seal assembly features.
SUMMARY
(3) In various embodiments, a method of repairing a piston seal assembly is disclosed comprising removing worn material from a piston seal groove to generate a worked seal groove, applying a groove buildup member to the worked seal groove, and disposing a seal member proximate the groove buildup member.
(4) In various embodiments, the method includes securing the groove buildup member to the worked seal groove. In various embodiments, the method includes disposing the seal member within the groove buildup member. In various embodiments, the groove buildup member is a guard type member. In various embodiments, the groove buildup member is an insert type member. In various embodiments, the groove buildup member is a sectioned insert type member. In various embodiments, the groove buildup member comprises circumferentially segmented sections. In various embodiments, the groove buildup member is circumferentially continuous.

(5) In various embodiments, a gas turbine engine is disclosed comprising a compressor section configured to compress a gas, a combustor section aft of the compressor section and configured to combust the gas, and a piston seal assembly comprising, a worked seal groove, a groove buildup member secured to the worked seal groove, and a seal member disposed proximate the groove buildup member.
(6) In various embodiments, the seal member is disposed within the groove buildup member. In various embodiments, the groove buildup member is a guard type member. In various embodiments, the groove buildup member is an insert type member. In various embodiments, the groove buildup member is a sectioned insert type member. In various embodiments, the groove buildup member comprises circumferentially segmented sections. In various embodiments, the groove buildup member is circumferentially continuous.
(7) In various embodiments, and article of manufacture is disclosed comprising a groove buildup member configured to be secured to a worked seal groove of a piston seal assembly, wherein the groove buildup member comprises one of a guard type member, an insert type member, or a sectioned insert type member each respectively configured to engage with a surface of the worked seal groove.
(8) In various embodiments, the guard type member is further configured to interface with a reduced wall of the piston seal assembly and comprises an inner guard and an outer guard each joined at a distal end by an orthogonal web, wherein the inner guard is relatively longer than the outer guard. In various embodiments, the insert type member is configured to be disposed within the worked seal groove and comprises a forward wall, an aft wall, and a base web joining the forward wall and the aft wall and mutually orthogonal thereto. In various embodiments, the sectioned insert type member is relatively L-shaped and defined by a leg member and an orthogonal foot member extending at a distal end of the leg member. In various embodiments, the groove buildup member comprises circumferentially segmented sections.
(9) The foregoing features and elements may be combined in various combinations without exclusivity, unless expressly indicated herein otherwise. These features and elements as well as the operation of the disclosed embodiments will become more apparent in light of the following description and accompanying drawings.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) The subject matter of the present disclosure is particularly pointed out and distinctly claimed in the concluding portion of the specification. A more complete understanding of the present disclosures, however, may best be obtained by referring to the detailed description and claims when considered in connection with the drawing figures, wherein like numerals denote like elements.
(2) FIG. **1** illustrates an exemplary gas turbine engine, in accordance with various embodiments;
(3) FIG. **2**A illustrates a piston seal assembly in a gas turbine engine, in accordance with various embodiments;
(4) FIG. **2**B illustrates a worn seal groove of a piston seal assembly, in accordance with various embodiments;
(5) FIG. **3**A illustrates a machining step of a repair method for a piston seal assembly, in accordance with various embodiments;
(6) FIG. **3**B illustrates the outcome of a machining step of a repair method for a piston seal assembly;
(7) FIG. **4**A illustrates groove buildup members of a piston seal assembly, in accordance with various embodiments;
(8) FIG. **4**B illustrates a reworked piston seal assembly including a first groove buildup member, in

accordance with various embodiments;
(9) FIG. **4**C illustrates a reworked piston seal assembly including a second groove buildup member, in accordance with various embodiments;
(10) FIG. **4**D illustrates a reworked piston seal assembly including a third groove buildup member, in accordance with various embodiments;
(11) FIG. **4**E illustrates a reworked piston seal assembly including a third groove buildup member, in accordance with various embodiments;
(12) FIG. **4**F a groove buildup member, in accordance with various embodiments; and
(13) FIG. **4**G a groove buildup member, in accordance with various embodiments.

DETAILED DESCRIPTION

(14) The detailed description of exemplary embodiments herein makes reference to the accompanying drawings, which show exemplary embodiments by way of illustration and their best mode. While these exemplary embodiments are described in sufficient detail to enable those skilled in the art to practice the disclosures, it should be understood that other embodiments may be realized and that logical, chemical, and mechanical changes may be made without departing from the spirit and scope of the disclosures. Thus, the detailed description herein is presented for purposes of illustration only and not of limitation. For example, the steps recited in any of the method or process descriptions may be executed in any order and are not necessarily limited to the order presented. Furthermore, any reference to singular includes plural embodiments, and any reference to more than one component or step may include a singular embodiment or step. Also, any reference to attached, fixed, connected or the like may include permanent, removable, temporary, partial, full and/or any other possible attachment option. Additionally, any reference to without contact (or similar phrases) may also include reduced contact or minimal contact.
(15) In various embodiments and with reference to FIG. **1**, a gas turbine engine **20** is provided. Gas turbine engine **20** may be a two-spool turbofan that generally incorporates a fan section **22**, a compressor section **24**, a combustor section **26** and a turbine section **28**. In operation, fan section **22** can drive air along a bypass flow-path B while compressor section **24** can drive air for compression and communication into combustor section **26** then expansion through turbine section **28**. Although depicted as a turbofan gas turbine engine **20** herein, it should be understood that the concepts described herein are not limited to use with turbofans as the teachings may be applied to other types of turbine engines including turbojet engines, a low-bypass turbofans, a high bypass turbofans, or any other gas turbine known to those skilled in the art.
(16) Gas turbine engine **20** may generally comprise a low speed spool **30** and a high-speed spool **32** mounted for rotation about an engine central longitudinal axis A-A′ relative to an engine static structure **36** via one or more bearing systems **38** (shown as bearing system **38-1** and bearing system **38-2**). It should be understood that various bearing systems **38** at various locations may alternatively or additionally be provided, including for example, bearing system **38**, bearing system **38-1**, and bearing system **38-2**.
(17) Low speed spool **30** may generally comprise an inner shaft **40** that interconnects a fan **42**, a low pressure (or first) compressor section **44** (also referred to a low pressure compressor) and a low pressure (or first) turbine section **46**. Inner shaft **40** may be connected to fan **42** through a geared architecture **48** that can drive fan **42** at a lower speed than low speed spool **30**. Geared architecture **48** may comprise a gear assembly **60** enclosed within a gear housing **62**. Gear assembly **60** couples inner shaft **40** to a rotating fan structure. High speed spool **32** may comprise an outer shaft **50** that interconnects a high pressure compressor (“HPC”) **52** (e.g., a second compressor section) and high pressure (or second) turbine section **54**. A combustor **56** may be located between HPC **52** and high pressure turbine **54**. A mid-turbine frame **57** of engine static structure **36** may be located generally between high pressure turbine **54** and low pressure turbine **46**. Mid-turbine frame **57** may support one or more bearing systems **38** in turbine section **28**. Inner shaft **40** and outer shaft **50** may be concentric and rotate via bearing systems **38** about the engine central longitudinal axis A-A′, which

is collinear with their longitudinal axes. As used herein, a “high pressure” compressor or turbine experiences a higher pressure than a corresponding “low pressure” compressor or turbine.

(18) The core airflow C may be compressed by low pressure compressor **44** then HPC **52**, mixed and burned with fuel in combustor **56**, then expanded over high pressure turbine **54** and low pressure turbine **46**. Mid-turbine frame **57** includes airfoils **59** which are in the core airflow path. Low pressure turbine **46**, and high pressure turbine **54** rotationally drive the respective low speed spool **30** and high speed spool **32** in response to the expansion.

(19) Gas turbine engine **20** may be, for example, a high-bypass geared aircraft engine. In various embodiments, the bypass ratio of gas turbine engine **20** may be greater than about six (6). In various embodiments, the bypass ratio of gas turbine engine **20** may be greater than ten (10). In various embodiments, geared architecture **48** may be an epicyclic gear train, such as a star gear system (sun gear in meshing engagement with a plurality of star gears supported by a carrier and in meshing engagement with a ring gear) or other gear system. Geared architecture **48** may have a gear reduction ratio of greater than about 2.3 and low pressure turbine **46** may have a pressure ratio that is greater than about 5. In various embodiments, the bypass ratio of gas turbine engine **20** is greater than about ten (10:1). In various embodiments, the diameter of fan **42** may be significantly larger than that of the low pressure compressor **44**, and the low pressure turbine **46** may have a pressure ratio that is greater than about (5:1). Low pressure turbine **46** pressure ratio may be measured prior to inlet of low pressure turbine **46** as related to the pressure at the outlet of low pressure turbine **46** prior to an exhaust nozzle. It should be understood, however, that the above parameters are exemplary of various embodiments of a suitable geared architecture engine and that the present disclosure contemplates other gas turbine engines including direct drive turbofans.

(20) In various embodiments, the next generation of turbofan engines may be designed for higher efficiency which is associated with higher pressure ratios and higher temperatures in the HPC **52**. These higher operating temperatures and pressure ratios may create operating environments that may cause thermal loads that are higher than the thermal loads encountered in conventional turbofan engines, which may shorten the operational life of current components.

(21) In various embodiments, HPC **52** may comprise alternating rows of rotating rotors and stationary stators. Stators may have a cantilevered configuration or a shrouded configuration. More specifically, a stator may comprise a stator vane, a casing support and a hub support. In this regard, a stator vane may be supported along an outer diameter by a casing support and along an inner diameter by a hub support. In contrast, a cantilevered stator may comprise a stator vane that is only retained and/or supported at the casing (e.g., along an outer diameter).

(22) In various embodiments, rotors may be configured to compress and spin a fluid flow. Stators may be configured to receive and straighten the fluid flow. In operation, the fluid flow discharged from the trailing edge of stators may be straightened (e.g., the flow may be directed in a substantially parallel path to the centerline of the engine and/or HPC) to increase and/or improve the efficiency of the engine and, more specifically, to achieve maximum and/or near maximum compression and efficiency when the straightened air is compressed and spun by rotor **64**.

(23) In various embodiments and with additional reference to FIGS. **2**A and **2**B, gas turbine engine **20** includes one or more piston seal assemblies **200**. Piston seal assembly **200** is illustrated in cross section through the X-Y plane and may comprise a portion of a case **202** such as, for example, a high pressure compressor case, a combustor case, a mid turbine frame, and/or the like. The case **202** may extend axially along the engine **20** axis A-A′. The assembly **200** comprises a forward seal wall **206** and an aft seal wall **208**. The seal walls **206** and **208** extend radially (along the Y-axis) from the case **202**. In various embodiments, each of the seal walls **206**, **208** may be orthogonal to the case **202**. The seal walls **206**, **208** define a seal groove **204** axially therebetween. The seal groove **204** comprises a forward face **212**, an aft face **216**, and a base **214**. A seal member **210** is seated toward the base **214** in the seal groove **204** and retained axially relatively between the forward face **212** and the aft face **216**. In various embodiments and in operation of the gas turbine

engine **20**, the seal member **210** may be loaded relatively toward the forward face **212** as indicated by arrow F. In response, the seal groove may **204** may experience wear, fretting, and/or the like within the groove **204** at the forward face **212** and the base **214**. In various embodiments and in response to seal groove **204** experiencing wear in the forwarded loaded condition, the groove surface may be eroded to generate a forward worn face **212′** and a worn base **214′**. Such wear and/or erosion of the seal groove **204** tends to degrade performance of the piston seal assembly **200**, for example, by allowing gasses to bypass the seal member **210** along the worn surfaces (forward face **212′**, base **214′**).

(24) In various embodiments and with additional reference to FIG. **3**A, a tool **300** is applied to the seal groove **204**. In various embodiments, the tool **300** may be a machining tool applied directly to the worn surfaces (**212′**, **214′**). In various embodiments, the tool **300** may be an ablative tool such as, for example, a laser. Tool **300** operations continue until the entire worn surface of the seal groove **204** is removed (e.g., by machining, ablation, polishing, lapping, etc.) as shown in FIG. **3**B. In various embodiments and with additional reference to FIG. **3**B, the seal groove **204** has been enlarged by the tool **300** operation to generate a worked seal groove **204′**. In like regard, the worked seal groove **204′** may be further defined by a reduced wall **206′** (as illustrated, a reduced forward wall) which is thinned by tool **300** operations. In various embodiments, the worked seal groove **204′** may not provide adequate retention for the seal member **210**.

(25) In various embodiments and with additional reference to FIG. **4**A, one or more groove buildup members **400** such as, for example, a first groove buildup member **402**, a second groove buildup member **404**, and/or a third groove buildup member **406** may be inserted (e.g., along arrows) into the worked seal groove **204′** and/or over the reduced wall **206′**. In various embodiments, the buildup member **400** may be manufactured from the same parent material, a different material, a ceramic material, or a coated material. In various embodiments, a groove buildup member **400** may be formed for an appropriate metal or other material which is similar to the parent material (such as, for example, steel, stainless steel, aluminum alloy, titanium alloy, nickel alloy, and/or the like) and which provides wear characteristics equivalent or superior to the material of the case **202**. The groove buildup member **400** may be secured to the worked seal groove **204′** by any suitable process such as, for example, brazing, press fitting, welding, bonding, crimping, staking, a retention feature (e.g., undercutting) and/or the like.

(26) In various embodiments, the first groove buildup member **402** may be a guard type member configured to interface with the reduced wall **206′**. The guard type member comprises an inner guard **408** and an outer guard **410** joined at a distal end by an orthogonal web **412**. The inner guard **408** is configured to be disposed within the worked seal groove **204′** and may thereby be relatively radially (along the Y-axis) longer than the outer guard **410**. Stated another way, the outer guard **410** may be shorter than the inner guard **408**. As shown in FIG. **4**B, the first groove buildup member **402** may be coupled to the reduced wall **206′** and the seal member **210** may be disposed in the worked seal groove **204′** to complete the rebuild of the piston seal assembly **200**.

(27) In various embodiments, the second groove buildup member **404** may be an insert type member comprising a forward wall **414**, an aft wall **416**, and a mutually orthogonal base web **418** joining the forward wall **414** and the aft wall **416**. The insert type member is configured to be disposed within the worked seal groove **204′**. As shown in FIG. **4**C, the second groove buildup member **404** is inserted into the worked seal groove **204′**. The forward wall **414** and the aft wall **416** are contacted, respectively, with the reduced wall **206′** and the aft seal wall **208**. In like regard, the base web **418** is contacted with the base of the worked seal groove **204**. The seal member **210** is disposed within the second groove buildup member **404** to complete the rebuild of the piston seal assembly **200**.

(28) In various embodiments, the third groove buildup member **406** may comprise a sectioned insert type member including a forward section **420** and an aft section **422**. Each section may be relatively L-shaped and defined by a leg member **424** and an orthogonal foot member **426** which

extends at a distal end of the leg member **424**. Each section (**420**, **422**) is configured to be disposed within the worked seal groove **204′** and may be configured to retain the seal member **210** relatively therebetween as shown in FIG. **4**D. In various embodiments as shown in FIG. **4**E, a rework procedure may call for only one section of a sectioned insert type member to be inserted into the worked seal groove **204′**. For example, where the reduced wall **206′** is generated from the forward seal wall **206**, the forward section **420** of the third groove buildup member **406** may be inserted into the worked seal groove **204′**. In various embodiments, the forward section **420** may comprise an elongate foot **426′** configured to extend across the entirety of the base of the worked seal groove **204′**. The seal member **210** is disposed within the respective section (as illustrated, the forward section **420**) of third groove buildup member **406** to complete the rebuild of the piston seal assembly **200**.

(29) In various embodiments and with additional reference to FIGS. **4**F and **4**G groove buildup member **400** is viewed along the Z-axis through the Y-Z plane. In various embodiments, a groove buildup member **400** may be continuous about a center axis C (e.g, axis A-A of engine **20**) or may be formed of a plurality of circumferentially segmented sections **400**S (i.e., arcuate segments) all centered about the center axis C.

(30) Benefits, other advantages, and solutions to problems have been described herein with regard to specific embodiments. Furthermore, the connecting lines shown in the various figures contained herein are intended to represent exemplary functional relationships and/or physical couplings between the various elements. It should be noted that many alternative or additional functional relationships or physical connections may be present in a practical system. However, the benefits, advantages, solutions to problems, and any elements that may cause any benefit, advantage, or solution to occur or become more pronounced are not to be construed as critical, required, or essential features or elements of the disclosures.

(31) The scope of the disclosures is accordingly to be limited by nothing other than the appended claims, in which reference to an element in the singular is not intended to mean “one and only one” unless explicitly so stated, but rather “one or more.” Moreover, where a phrase similar to “at least one of A, B, or C” is used in the claims, it is intended that the phrase be interpreted to mean that A alone may be present in an embodiment, B alone may be present in an embodiment, C alone may be present in an embodiment, or that any combination of the elements A, B and C may be present in a single embodiment; for example, A and B, A and C, B and C, or A and B and C. Different cross-hatching is used throughout the figures to denote different parts but not necessarily to denote the same or different materials.

(32) Systems, methods and apparatus are provided herein. In the detailed description herein, references to “one embodiment”, “an embodiment”, “an example embodiment”, etc., indicate that the embodiment described may include a particular feature, structure, or characteristic, but every embodiment may not necessarily include the particular feature, structure, or characteristic. Moreover, such phrases are not necessarily referring to the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with an embodiment, it is submitted that it is within the knowledge of one skilled in the art to affect such feature, structure, or characteristic in connection with other embodiments whether or not explicitly described. After reading the description, it will be apparent to one skilled in the relevant art(s) how to implement the disclosure in alternative embodiment

(33) Furthermore, no element, component, or method step in the present disclosure is intended to be dedicated to the public regardless of whether the element, component, or method step is explicitly recited in the claims. No claim element is intended to invoke 35 U.S.C. 112(f) unless the element is expressly recited using the phrase “means for.” As used herein, the terms “comprises”, “comprising”, or any other variation thereof, are intended to cover a non-exclusive inclusion, such that a process, method, article, or apparatus that comprises a list of elements does not include only

those elements but may include other elements not expressly listed or inherent to such process, method, article, or apparatus.

Claims

1. An article of manufacture, comprising: a groove buildup member configured to be secured to a worked seal groove of a piston seal assembly, wherein the groove buildup member is a guard type member, wherein the worked seal groove is generated between a forward seal wall and an aft seal wall of the piston seal assembly, wherein the forward seal wall and the aft seal wall extend radially from a case comprising the piston seal assembly, wherein after removing worn material, one of the seal walls comprises a first thickness and the other seal wall comprises a second thickness, wherein the first thickness is smaller relative the second thickness, wherein the guard type member comprises an inner guard and an outer guard joined at a distal end by an orthogonal web, wherein the outer guard is shorter relative the inner guard, wherein the inner guard is disposed within the worked seal groove, wherein the guard type member is configured to interface with the seal wall having the first thickness, wherein the orthogonal web of the guard type member is disposed over the seal wall having the first thickness.

2. The article of manufacture of claim 1, wherein the groove buildup member comprises circumferentially segmented sections.