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## Restraining plug


### Abstract

A method for assembling a plug assembly for plugging one or more ports of a gas turbine engine including that a connector body and a cover operably connected to the connector body are inserted into a sheath through-passage of a sheath. The connector body including a rotatable joint operably connecting the cover to the connector body. The method also includes that a biasing mechanism configured to apply a force to the cover is installed, the cover is rotated relative to the connector body via the rotatable joint, a top housing is slid over the biasing mechanism such that the biasing mechanism abuts a bottom end of the top housing or is located in a cavity defined within the top housing, and the top housing is secured together with the sheath.



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## Background/Summary

BACKGROUND

(1) The subject matter disclosed herein relates generally to gas turbine engines and, more particularly, to a plug for plugging an inspection port in a gas turbine engine.

(2) Gas turbine engines typically operate at high rotational speeds and high temperatures for increased performance and efficiency. In many cases, performance of an engine may be tied to proper operation and function of engine components. During operation, components may be damaged, fail or otherwise require maintenance. In addition, control of an engine may be based on the operation of components within an engine. Safety inspections and routine maintenance are often required to ensure safe operation and prevent engine failure. Many gas turbine engines include inspection ports to allow for inspection and/or maintenance of an engine. Conventional methods of sealing these ports can be expensive and in some cases, may lead to foreign object damage (FOD) due to improper installation during manufacture or maintenance. Moreover, some gas turbine engines may have dozens of ports. In addition, correct operation and installation of port components may be required for safe and efficient operation of an engine. There is a need in the art for port components for gas turbine engines.

BRIEF DESCRIPTION

(3) According to one embodiment, a method for assembling a plug assembly for plugging one or more ports of a gas turbine engine is provided. The method includes that a connector body and a

cover operably connected to the connector body are inserted into a sheath through-passage of a sheath. The connector body including a rotatable joint operably connecting the cover to the connector body. The method also includes that a biasing mechanism configured to apply a force to the cover is installed, the cover is rotated relative to the connector body via the rotatable joint, a top housing is slid over the biasing mechanism such that the biasing mechanism abuts a bottom end of the top housing or is located in a cavity defined within the top housing, and the top housing is secured together with the sheath.
(4) In addition to one or more of the features described above, or as an alternative, further embodiments may include that a slider seal housing is secured onto a radially outward surface of an inner casing of the gas turbine engine and a slider seal is inserted into the slider seal housing, the slider seal housing including a slider seal seat configured to fit the slider seal therein. The method may further include that a slider seal cover is secured to the slider seal housing. The slider seal cover being configured to secure the slider seal in the slider seal housing.
(5) In addition to one or more of the features described above, or as an alternative, further embodiments may include that the inner casing further includes an inner port. The slider seal housing further includes a slider seal housing through-passage aligned with the inner port. The slider seal further includes a seal through-passage aligned with the inner port. The slider seal cover further includes a cover through-passage aligned with the inner port. The method further includes that the cover is inserted through the cover through-passage, the seal through-passage, the slider seal housing through-passage, and the inner port of the inner casing.
(6) In addition to one or more of the features described above, or as an alternative, further embodiments may include that the cover is rotated to be about parallel with a radially inward surface of the inner casing.
(7) In addition to one or more of the features described above, or as an alternative, further embodiments may include that the cover further includes a first cover and a second cover.
(8) In addition to one or more of the features described above, or as an alternative, further embodiments may include that the second cover overlaps the first cover by a selected portion after the cover is rotated to be about parallel with a radially inward surface of the inner casing.
(9) In addition to one or more of the features described above, or as an alternative, further embodiments may include that the cover is rotated to be about parallel with the connector body prior to inserting the connector body and the cover operably connected to the connector body into the sheath through-passage of the sheath.
(10) In addition to one or more of the features described above, or as an alternative, further embodiments may include that the cover is rotated to be about parallel with the slider seal after inserting the connector body and the cover operably connected to the connector body into the sheath through-passage of the sheath.
(11) In addition to one or more of the features described above, or as an alternative, further embodiments may include that the cover is operably connected to the connector body.
(12) In addition to one or more of the features described above, or as an alternative, further embodiments may include that the cover further includes a first cover and a second cover. The connector body further includes a first connector body and a second connector body. The rotatable joint further includes a first rotatable joint and a second rotatable joint.
(13) In addition to one or more of the features described above, or as an alternative, further embodiments may include that inserting the connector body and the cover operably connected to the connector body into the sheath through-passage of the sheath further includes that the first connector body and the first cover operably connected to the first connector body are inserted into the sheath through-passage of the sheath and the second connector body and the second cover operably connected to the second connector body are inserted into the sheath through-passage of the sheath.
(14) In addition to one or more of the features described above, or as an alternative, further

embodiments may include that the plug assembly is secured to the gas turbine engine.
(15) In addition to one or more of the features described above, or as an alternative, further embodiments may include that the plug assembly is secured to an outer casing of the gas turbine engine.
(16) In addition to one or more of the features described above, or as an alternative, further embodiments may include that securing the plug assembly to the gas turbine engine further includes that a housing through-passage within the top housing is aligned with a threaded hole in the sheath, a fastening mechanism is inserted through the housing through-passage, and the fastening mechanism are rotated such that a threaded portion of the fastening mechanism interlocks with the threaded hole to secure the plug assembly to the gas turbine engine.
(17) In addition to one or more of the features described above, or as an alternative, further embodiments may include that the connector body further includes a lower end, the rotatable joint being located at the lower end, an upper end located opposite the lower end, and a connector body flange located between the lower end and the upper end. The connector body flange dividing the connector body into a lower portion located at or proximate the lower end and an upper portion located at or proximate the upper end.
(18) In addition to one or more of the features described above, or as an alternative, further embodiments may include that installing the biasing mechanism further includes that the biasing mechanism is slide onto the upper portion of the connector body.
(19) In addition to one or more of the features described above, or as an alternative, further embodiments may include that the biasing mechanism is a spring.
(20) According to another embodiment, a plug assembly for plugging one or more ports of a gas turbine engine is provided. The plug assembly includes a sheath including an inner end, an outer end located opposite the inner end, and a sheath through-passage extending from the outer end to the inner end. The plug assembly includes a connector body passing through the sheath through-passage. The connector body including a rotatable joint. The plug assembly includes a cover operably connected to the connector body via the rotatable joint, a biasing mechanism configured to apply a force to the connector body, and a top housing including a bottom end and a connector passageway extending from the bottom end a top end of the top housing. The biasing mechanism abuts the bottom end or is located in the cavity at the bottom end. The connector body passes through the connector passageway.
(21) In addition to one or more of the features described above, or as an alternative, further embodiments may include that the connector body further includes a lower end. The rotatable joint being located at the lower end. The connector body further includes an upper end located opposite the lower end and a connector body flange located between the lower end and the upper end. The connector body flange dividing the connector body into a lower portion located at or proximate the lower end and an upper portion located at or proximate the upper end.
(22) In addition to one or more of the features described above, or as an alternative, further embodiments may include that the biasing mechanism is located on the upper portion of the connector body.

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## Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) The following descriptions should not be considered limiting in any way. With reference to the accompanying drawings, like elements are numbered alike:
(2) FIG. **1** is a partial cross-sectional illustration of a gas turbine engine, in accordance with an embodiment of the disclosure;
(3) FIG. **2** is a side view graphical representation of a plug assembly located within a gas turbine

engine, in accordance with an embodiment of the disclosure;
(4) FIG. **3** is an axial view graphical representation of a plug assembly located within a gas turbine engine, in accordance with an embodiment of the disclosure:
(5) FIG. **4** is a cross-sectional view of a plug assembly, in accordance with an embodiment of the disclosure:
(6) FIG. **5** is a perspective view of a plug assembly, in accordance with an embodiment of the disclosure;
(7) FIG. **6** is a perspective view of a plug assembly, in accordance with an embodiment of the disclosure;
(8) FIG. **7** is a side view of a cover, in accordance with an embodiment of the disclosure:
(9) FIG. **8** is a perspective cut-away view of a plug assembly, in accordance with an embodiment of the disclosure:
(10) FIG. **9** is a perspective cut-away view of a plug assembly, in accordance with an embodiment of the disclosure:
(11) FIGS. **10**A, **10**B, and **10**C is a flow chart illustrating a method of assembling the plug assembly for plugging one or more ports of a gas turbine engine, in accordance with an embodiment of the disclosure.
DETAILED DESCRIPTION
(12) A detailed description of one or more embodiments of the disclosed apparatus and method are presented herein by way of exemplification and not limitation with reference to the Figures.
(13) FIG. **1** schematically illustrates a gas turbine engine **20**. The gas turbine engine **20** is disclosed herein as a two-spool turbofan that generally incorporates a fan section **22**, a compressor section **24**, a combustor section **26**, and a turbine section **28**. The fan section **22** drives air along a bypass flow path B in a bypass duct, while the compressor section **24** drives air along a core flow path C for compression and communication into the combustor section **26** then expansion through the turbine section **28**. Although depicted as a two-spool turbofan gas turbine engine in the disclosed non-limiting embodiment, it should be understood that the concepts described herein are not limited to use with two-spool turbofans as the teachings may be applied to other types of turbine engines including three-spool architectures.
(14) The exemplary engine **20** generally includes a low speed spool **30** and a high speed spool **32** mounted for rotation about an engine central longitudinal axis A relative to an engine static structure **36** via several bearing systems **38**. It should be understood that various bearing systems **38** at various locations may alternatively or additionally be provided, and the location of bearing systems **38** may be varied as appropriate to the application.
(15) The low speed spool **30** generally includes an inner shaft **40** that interconnects a fan **42**, a low pressure compressor **44** and a low pressure turbine **46**. The inner shaft **40** is connected to the fan **42** through a speed change mechanism, which in exemplary gas turbine engine **20** is illustrated as a geared architecture **48** to drive the fan **42** at a lower speed than the low speed spool **30**. The high speed spool **32** includes an outer shaft **50** that interconnects a high pressure compressor **52** and high pressure turbine **54**. A combustor **56** is arranged in exemplary gas turbine **20** between the high pressure compressor **52** and the high pressure turbine **54**. An engine static structure **36** is arranged generally between the high pressure turbine **54** and the low pressure turbine **46**. The engine static structure **36** further supports bearing systems **38** in the turbine section **28**. The inner shaft **40** and the outer shaft **50** are concentric and rotate via bearing systems **38** about the engine central longitudinal axis A which is collinear with their longitudinal axes.
(16) The core airflow is compressed by the low pressure compressor **44** then the high pressure compressor **52**, mixed and burned with fuel in the combustor **56**, then expanded over the high pressure turbine **54** and low pressure turbine **46**. In some embodiments, stator vanes **45** in the low pressure compressor **44** and stator vanes **55** in the high pressure compressor **52** may be adjustable during operation of the gas turbine engine **20** to support various operating conditions. In other

embodiments, the stator vanes **45**, **55** may be held in a fixed position. The turbines **46**, **54** rotationally drive the respective low speed spool **30** and high speed spool **32** in response to the expansion. It will be appreciated that each of the positions of the fan section **22**, compressor section **24**, combustor section **26**, turbine section **28**, and fan drive gear system **48** may be varied. For example, gear system **48** may be located aft of combustor section **26** or even aft of turbine section **28**, and fan section **22** may be positioned forward or aft of the location of gear system **48**.

(17) The engine **20** in one example is a high-bypass geared aircraft engine. In a further example, the engine **20** bypass ratio is greater than about six (6), with an example embodiment being greater than about ten (10), the geared architecture **48** is an epicyclic gear train, such as a planetary gear system or other gear system, with a gear reduction ratio of greater than about 2.3 and the low pressure turbine **46** has a pressure ratio that is greater than about five. In one disclosed embodiment, the engine **20** bypass ratio is greater than about ten (10:1), the fan diameter is significantly larger than that of the low pressure compressor **44**, and the low pressure turbine **46** has a pressure ratio that is greater than about five 5:1. Low pressure turbine **46** pressure ratio is pressure measured prior to inlet of low pressure turbine **46** as related to the pressure at the outlet of the low pressure turbine **46** prior to an exhaust nozzle. The geared architecture **48** may be an epicycle gear train, such as a planetary gear system or other gear system, with a gear reduction ratio of greater than about 2.3:1. It should be understood, however, that the above parameters are only exemplary of one embodiment of a geared architecture engine and that the present disclosure is applicable to other gas turbine engines including direct drive turbofans.

(18) A significant amount of thrust is provided by the bypass flow B due to the high bypass ratio. The fan section **22** of the engine **20** is designed for a particular flight condition—typically cruise at about 0.8 Mach and about 35,000 feet (10,688 meters). The flight condition of 0.8 Mach and 35,000 ft (10,688 meters), with the engine at its best fuel consumption—also known as “bucket cruise Thrust Specific Fuel Consumption (‘TSFC’)”—is the industry standard parameter of lbm of fuel being burned divided by lbf of thrust the engine produces at that minimum point. “Low fan pressure ratio” is the pressure ratio across the fan blade alone, without a Fan Exit Guide Vane (“FEGV”) system. The low fan pressure ratio as disclosed herein according to one non-limiting embodiment is less than about 1.45. “Low corrected fan tip speed” is the actual fan tip speed in ft/sec divided by an industry standard temperature correction of [(Tram° R)/(518.7° R)]0.5. The “Low corrected fan tip speed” as disclosed herein according to one non-limiting embodiment is less than about 1150 ft/second (350.5 m/sec).

(19) Referring now to FIGS. **2** and **3**, with continued reference to FIG. **1**, a graphical representation of a plug assembly **100** (see also FIGS. **3-10**) located within a gas turbine engine **20** is illustrated, in accordance with an embodiment of the present disclosure.

(20) The plug assembly **100** may be a borescope plug assembly and inspection port assembly. The plug assembly **100** are shown within an outer port **62** located within an outer casing **60** of the gas turbine engine **20** and an inner port **66** located in an inner casing **64** of the gas turbine engine **20**. The port **62** may be a borescope port or an inspection port. In an embodiment, the outer casing **60** may be a high pressure turbine case. The outer casing **60** may also be a lower pressure turbine case, a diffuser case, a high pressure compressor case, or any other case that requires an in section port in the gas turbine engine **20**.

(21) The plug assembly **100** extend radially inward toward the engine central longitudinal axis A of the gas turbine engine **20**. As illustrated in FIG. **2**, the plug assembly **100** may extend from the inner port **66** to the outer port **62**. The inner casing **64** is located radially inward from the outer casing **60**. The inner casing **64** may be a mid-turbine frame (MTF) vane casing. It is understood that the inner casing **64** is not limited to the MTF vane casing and the embodiment described herein are applicable to the inner casing **64** being any other casing or component located within the gas turbine engine **20** that is radially inward from the outer casing **60**. The inner casing **64** includes a radially inward surface **67** and a radially outward surface **65** located opposite the radially inward

surface **67**. The radially outward surface **65** is located radially outward of the radially inward surface **67**. The inner port **66** extends from the radially inward surface **67** to the radially outward surface **65**.
(22) In an embodiment, the inner port **66** and the outer port **62** may be located in the turbine section **28** of the gas turbine engine **20**. It is understood that the embodiments disclosed herein are not limited to the inner port **66** and the outer port **62** being located in the turbine section **28** of the gas turbine engine **20**, and therefore the inner port **66** and the outer port **62** may be located in other sections of the gas turbine engine. The turbine section **28** is located aft of the combustor section **26**. The turbine section **28** includes a plurality of vanes **68** extending circumferentially around the engine central longitudinal axis A. The inner port **66** and the outer port **62** may be located interposed circumferentially between two adjacent vanes **68**, as illustrated in FIG. **3**.
(23) Removal of at least a portion or an entirety of the plug assembly **100** from the outer port **62** and the inner port **66** may allow inspection into the outer port **62** and inner port **66**. As such, the plug assembly **100** provides access to the gas turbine engine **20** radially inward of the outer port **62** and/or the inner port **66** for mechanical diagnostics or other diagnostic reasons.
(24) Referring now to FIGS. **4** and **5**, with continued reference to FIGS. **1-3**, a cross-sectional view of a plug assembly **100** is illustrated, in accordance with an embodiment of the present disclosure.
(25) The plug assembly **100** may be configured to secure an outer casing **60** in place, a slider seal housing **110** in place, a slider seal **120** in place, a slider seal cover **130** in place, or any other component of the gas turbine engine **20** in place. Further it is understood that while the plug assembly **100** has been described herein as securing the slider seal cover **130** in place, the plug assembly **100** may secure any component of the gas turbine engine **20** in place.
(26) The plug assembly **100** of FIGS. **4** and **5** may include the slider seal housing **110**, the slider seal **120**, the slider seal cover **130**, a sheath **140**, a cover **150**, a connector body **160**, a top housing **180**, one or more fastening mechanism **190**, and a biasing mechanism **192**.
(27) The slider seal housing **110** abuts the radially outward surface **65** of the inner casing **64**. The slider seal housing **110** may be secured to the radially outward surface **65** of the inner casing **64**. The slider seal housing **110** may be secured to the radially outward surface **65** of the inner casing **64** via a weld or any other attachment method know to one of skill in the art. The slider seal housing **110** includes a slider seal seat **112** configured to fit the slider seal **120** therein. The slider seal **120** is configured to fit within the slider seal seat **112**. The slider seal **120** is secured within the slider seal seat **112** by a slider seal cover **130**. The slider seal cover **130** is secured to the slider seal housing **110**. The slider seal cover **130** may be secured to the slider seal housing **110** via a weld or any other attachment method know to one of skill in the art. The slider seal cover **130** is configured to maintain or entrap the slider seal **120** within the slider seal housing **110** such that the slider seal **120** is free to slide between the slider seal cover **120** and slider seal housing **110** and is not fixed in place. The slider seal cover **130** may be configured to allow the slider seal **120** to move freely relative to the slider seal cover **130** and the slider seal housing **110**.
(28) The slider seal housing **110** may be circular in shape with a slider seal housing through-passage **114**. The slider seal **120** may be circular in shape with a seal through-passage **124**. The slider seal cover **130** may be circular in shape with a cover through-passage **134**. The connector body **160** is configured to pass through the sheath **140** with the cover **150** and the cover **150** is configured to cover the inner port **66**. The cover **150** may be configured too completely cover the inner port **66** or partially cover the inner port **66**. The cover **150** may compress against the slider seal **120**. The cover **150** may be configured too partially cover the seal through-passage **124** to plug the inner port **66**.
(29) The sheath **140** includes an inner end **142** and outer end **144** located radially outward from the inner end **142** when the plug assembly **100** is installed in the gas turbine engine **20**. A sheath through-passage **141** extends through the sheath **140** from the inner end **142** to the outer end **144**.
(30) The top housing **180** includes a top end **184** and a bottom end **182** located opposite the top end

**184**. The bottom end **182** of the top housing **180** abuts the outer end **144** of the sheath **140**. The top housing **180** may include a cavity **186** extending from the bottom end **182** of the top housing **180** into the top housing **180** to a base **188**. The cavity **186** is a blind hole as it does not pass completely through the top housing **180**. Alternatively, no cavity **186** may be present in the top housing **180** the biasing mechanism **192** illustrated may abut the bottom end **182** of the top housing **180**. The top housing **180** includes a connector passageway **181** that extends from the top end **184** to bottom end **182** or the base **188** if the cavity **186** is present. The top housing **180** is slid over the upper end **164** of the connector body **160** by sliding the upper end **164** of the connector body **160** through the connector passageway **181**. The upper end **164** of the connector body **160** is slid through the connector passageway **181** and the upper end **164** projects out of the connector passageway **181** past the top end **184** of the top housing **180**, such that a locking pin through-passage **168** is fully accessible by a locking pin **196**.

(31) The cavity **186**, if present, may be configured to align with the sheath through-passage **141**. A portion of the connector body **160** is located within the combined cavity defined by the cavity **186** and the sheath through-passage **141**. Thus, the connector body **160** extends across the cavity **186** and the sheath through-passage **141**.

(32) The connector body **160** includes a lower end **162** and an upper end **164** located opposite the lower end **162**. The connector body **160** includes a rotatable joint **169** at the lower end **162**. The cover **150** is operably connected to the connector body **160** at the rotatable joint **169**. The cover **150** is configured to rotate relative to the connector body **160** at the rotatable joint **169**. The cover **150** may be rotated to be substantially parallel or roughly parallel (i.e., about parallel) with the connector body **160** in order to fit through the sheath through-passage **141** during installation and then the cover **150** may be rotated to be substantially parallel or roughly parallel with the slider seal **120**. The plug assembly **100** is configured to press the cover **150** into the slider seal **120** using a biasing mechanism **192** in order to seal the inner port **66**. The length of the cover **150** is larger than the diameter of the sheath through-passage **141**.

(33) The connector body **160** includes a connector body flange **166** located between the upper end **164** and the lower end **162**. The connector body flange **166** includes an upper surface **165** and a lower surface **167** located opposite the upper surface **165**.

(34) The connector body flange **166** divides or separates the connector body flange **166** into an upper portion **161** and a lower portion **163**. The upper portion **161** is located at or proximate the upper end **164** and the lower portion **163** is located at or proximate the lower end **162**.

(35) If the cavity **186** is present, the biasing mechanism **192** may be interposed between the base **188** of the cavity **186** and the upper surface **165** of the connector body flange **166**. If the cavity **186** is not present, the biasing mechanism **192** may be interposed between the bottom end **182** of the top housing **180** and the upper surface **165** of the connector body flange **166**. In an embodiment, the biasing mechanism **192** may be a spring. The biasing mechanism **192** applies a force against the base **188** or the bottom end **182** and the upper surface **165** and pushes the upper surface **165** and the connector body **160** radially inward towards the inner port **66**, which applies a radially inward force to the cover **150** and the cover **150** then applies a force to the slider seal **120**.

(36) The connector body **160** includes a locking pin through-passage **168** located proximate the upper end **164**. The locking pin through-passage **168** is configured to fit a locking pin **196** therein. The locking pin **196** may be configured to lock the connector body **160** in place relative to the top housing **180**.

(37) The plug assembly **100** further includes one or more fastening mechanisms **190** configured to secure the plug assembly **100** to the outer casing **60**. The one or more fastening mechanisms **190** passes through the top housing **180** to secure the plug assembly **100** to the outer casing **60**. In an embodiment, the fastening mechanism **190** may be a bolt. The fastening mechanism **190** may have a threaded portion **194**. The fastening mechanism **190** passes through a housing through-passage **189** in the top housing **180** to secure within a threaded hole (not shown) located in the sheath **140**.

The threaded portion **194** is configured to interlock with the threaded hole (not shown) when the fastening mechanism **190** is rotated.

(38) Referring now to FIGS. **6** and **7**, with continued reference to FIGS. **1-5**, an alternate embodiment of a separating mechanism for use in the plug assembly **100** is illustrated, in accordance with an embodiment of the present disclosure.

(39) The plug assembly **100** of FIG. **6** uses a connector body **160** that is composed of a first connector body **160***a* and a second connector body **160***b*. The connector body **160** is divided into the first connector body **160***a* and a second connector body **160***b* along a seam **199** that stretches from the lower end **162** to the upper end **164**. In other words, the first connector body **160***a* extends from the upper end **164** to the lower end **162** and the second connector body **160***b* extends from the upper end **164** to the lower end **162**.

(40) The plug assembly **100** of FIG. **6** uses a cover **150** that is composed of a first cover **150***a* and a second cover **150***b*. The plug assembly **100** of FIG. **6** uses a rotatable joint **169** that is composed of a first rotatable joint **169***a* and a second rotatable joint **169***b*. The first connector body **160***a* includes the first rotatable joint **169***a* located at the lower end **162** and the second connector body **160***b* the second rotatable joint **169***b* located at the lower end **162**. The first cover **150***a* may be operably or rotatably connected to first connector body **160***a* at the first rotatable joint **169***a*. The second cover **150***b* may be operably or rotatably connected to the second connector body **160***b* at the second rotatable joint **169***b*.

(41) The first cover **150***a* may be rotated to be substantially parallel or roughly parallel with the first connector body **160***a* in order to fit through the sheath through-passage **141** during installation and then the first cover **150***a* may be rotated to be substantially parallel or roughly parallel with the slider seal **120**. The plug assembly **100** is configured to press the first cover **150***a* into the slider seal **120** using a biasing mechanism **192** in order to seal the inner port **66**.

(42) The second cover **150***b* may be rotated to be substantially parallel or roughly parallel with the second connector body **160***b* in order to fit through the sheath through-passage **141** during installation and then the second cover **150***b* may be rotated to be substantially parallel or roughly parallel with the slider seal **120**. The plug assembly **100** is configured to press the second cover **150***b* into the slider seal **120** using a biasing mechanism **192** in order to seal the inner port **66**.

(43) As illustrated in FIG. **7**, the second cover **150***b* may overlap the first cover **150***a* by a selected portion **151** in order to achieve a better seal between the first cover **150***a* and the second cover **150***b*, such that air leakage between the first cover **150***a* and the second cover **150***b* is reduced or eliminated. Alternatively, the first cover **150***a* may overlap the second cover **150***b* by a selected portion **151** in order to achieve a better seal between the first cover **150***a* and the second cover **150***b*, such that air leakage between the first cover **150***a* and the second cover **150***b* is reduced or eliminated. Alternatively, the first cover **150***a* may abut the second cover **150***b*.

(44) Referring now to FIGS. **8** and **9**, with continued reference to FIGS. **1-7**, an alternate embodiment of a cover **150** for use in the plug assembly **100** is illustrated, in accordance with an embodiment of the present disclosure. The plug assembly **100** of FIGS. **7** and **8** seals the inner port **66** by compressing the cover **150** into the radially inward surface **67** of the inner casing **64**.

(45) The cover **150** may be rotated to be substantially parallel or roughly parallel with the connector body **160** in order to fit through the sheath through-passage **141**, the cover through-passage **134** of the slider seal cover **130**, the seal through-passage **124** of the slider seal **120**, the slider seal housing through-passage **114** of the slider seal housing **110**, and the inner port **66** during installation, then the cover **150** may be rotated to be substantially parallel or roughly parallel with the radially inward surface **67** of the inner casing **64**. The plug assembly **100** is configured to pull the cover **150** radially outward into the radially inward surface **67** using a tension mechanism (not shown) or a pressure differential between the gas turbine engine **20** radially inward of the inner casing **64** and the gas turbine engine **20** radially outward of the inner casing **64**. The locking pin **196** of a mechanism similar to the locking pin **196** may be used to prevent the cover **150** and the

connector body **160** from falling radially inward into the gas turbine engine **20**.
(46) In an embodiment, the cover **150** of FIG. **8** and FIG. **9**, may be composed of a first cover **150***a* and a second cover **150***b* as described previously in relations to FIG. **6**. In an embodiment, the connector body **160** of FIG. **8** and FIG. **9**, may be composed of a first connector body **160***a* and a second connector body **160***b* as described previously in relations to FIG. **6**. In an embodiment, the rotatable joint **169** of FIG. **8** and FIG. **9**, may be composed of a first rotatable joint **169***a* and a second rotatable joint **169***b* as described previously in relations to FIG. **6**.
(47) Referring now to FIGS. **10**A, **10**B, and **10**C, with continued reference to FIGS. **1-9**, a flow chart of a method **500** of assembling the plug assembly **100** for plugging one or more ports **66**, **62** of a gas turbine engine **20** is illustrated, in accordance with an embodiment of the present disclosure.
(48) It is understood that while the method **500** is being illustrated and described largely with the embodiments of FIGS. **4** and **5**, the method **500** is not limited to the embodiments illustrated in FIGS. **4-5** and may also be applicable to the embodiments illustrated in FIGS. **6-9**.
(49) At block **504**, a connector body **160** and a cover **150** operably connected to the connector body **160** are inserted into a sheath through-passage **141** of a sheath **140**. The connector body **160** including a rotatable joint **169** located operably connecting the cover **150** to the connector body **160**. Prior to block **504**, the method **500** may also include operably connecting the cover **150** to the connector body **160**. Prior to block **504**, the method **500** may additionally include that the cover **150** is rotated to be about parallel with the connector body **160** prior to inserting the connector body **160** and the cover **150** into the sheath through-passage **141** of the sheath **140**. This may be necessary to fit the cover **150** and the connector body **160** through the sheath through-passage **141** of a sheath **140**.
(50) As aforementioned, the cover **150** may further include a first cover **150***a* and a second cover **150***b*. The connector body **160** may further include a first connector body **160***a* and a second connector body **160***b*, and the rotatable joint **129** may further include a first rotatable joint **129***a* and a second rotatable joint **129***b*. If the cover **150** includes a first cover **150***a* and a second cover **150***b* then the method **500** may include that a first connector body **160***a* and the first cover **150***a* operably connected to the first connector body **160***a* is inserted into the sheath through-passage **141** of the sheath **140** and a second connector body **160***b* and the second cover **150***b* operably connected to the second connector body **160***b* is inserted into the sheath through-passage **141** of the sheath **140.** The first cover **150***a* and a second cover **150***b* may be fit together at a seam **99** to create a single cover **150**. The second cover **150***b* may overlap the first cover **150***a* by a selected portion **151** when fit together.
(51) At block **506**, a biasing mechanism **192** configured to apply a force to the cover **150** is installed. The biasing mechanism **192** may apply the force to the cover **150** through the connector body **160**. Block **506** may further include that the biasing mechanism **192** is slid onto the upper portion **161** of the connector body **160**. In an embodiment, the biasing mechanism **192** may be a spring.
(52) At block **508**, the cover **150** is rotated relative to the connector body **160** via the rotatable joint **129**. The cover **150** may be rotated to be about parallel with the slider seal **120**. Block **508** may occur before or after block **510** and/or block **512**.
(53) At block **510**, a top housing **180** is slid over the biasing mechanism **192** such that the biasing mechanism **192** abuts a bottom end **182** of the top housing **180** or is located in a cavity **186** defined within the top housing **180**.
(54) At block **512**, the top housing **180** is secured together with the sheath **140**. The top housing **180** may be secured together with the sheath **140** using one or more fastening mechanism **190**.
(55) The method **500** may also include that a slider seal housing **110** is secured onto a radially outward surface **65** of an inner casing **64** of the gas turbine engine **20** and a slider seal **120** is inserted into the slider seal housing **110**. The slider seal housing **110** including a slider seal seat **112**

configured to fit the slider seal **120** therein. The method **500** may also include that a slider seal cover **130** is secured to the slider seal housing **110**. The slider seal cover **130** being configured to secure the slider seal **120** in the slider seal housing **110** such that the slider seal **120** may be free to move.

(56) The method **500** may further include that the cover **150** is inserted through the cover through-passage **134**, the seal through-passage **124**, the slider seal housing through-passage **114**, and the inner port **66** of the inner casing **64**. The method **500** may also include the cover **150** is rotated to be about parallel with a radially inward surface **67** of the inner casing **64** after the cover **150** passes through the cover through-passage **134**, the seal through-passage **124**, the slider seal housing through-passage **114**, and the inner port **66** of the inner casing **64**. As aforementioned, the cover **150** may further comprises a first cover **150***a* and a second cover **150***b*. The second cover **150***b* may overlap the first cover **150***a* by a selected portion **151** after the cover **150** is rotated to be about parallel with a radially inward surface **67** of the inner casing **64**.

(57) The method **500** may include securing the plug assembly **100** to the gas turbine engine **20**. The plug assembly **100** may be secured to an outer casing **60** of the gas turbine engine **20**. The plug assembly **100** may be secured to an outer casing **60** of the gas turbine engine **20** by securing the sheath **140** to the outer casing **60**. The plug assembly **100** may be secured to the gas turbine engine **20** by aligning a housing through-passage **189** within the top housing **180** with a threaded hole in the sheath **140**, inserting a fastening mechanism **190** through the housing through-passage **189**, and rotating the fastening mechanism **190** such that a threaded portion **194** of the fastening mechanism **190** interlocks with the threaded hole to secure the plug assembly **100** to the gas turbine engine **20**.

(58) While the above description has described the flow process of FIGS. **10**A, **10**B, and **10**C in a particular order, it should be appreciated that unless otherwise specifically required in the attached claims that the ordering of the steps may be varied.

(59) As used herein radially outward is intended to be in the direction away from the engine central longitudinal axis A and radially outward is intended to be in the direction towards the engine central longitudinal axis A.

(60) The term “about” is intended to include the degree of error associated with measurement of the particular quantity based upon the equipment available at the time of filing the application.

(61) The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the present disclosure. As used herein, the singular forms “a”, “an” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms “comprises” and/or “comprising,” when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, element components, and/or groups thereof.

(62) While the present disclosure has been described with reference to an exemplary embodiment or embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the present disclosure. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the present disclosure without departing from the essential scope thereof. Therefore, it is intended that the present disclosure not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this present disclosure, but that the present disclosure will include all embodiments falling within the scope of the claims.

## Claims

1. A method for assembling a plug assembly for plugging one or more ports of a gas turbine engine, the method comprising: inserting a connector body and a cover operably connected to the connector body into a sheath through-passage of a sheath, the connector body including a rotatable

joint operably connecting the cover to the connector body; installing a biasing mechanism configured to apply a force to the cover; rotating the cover relative to the connector body via the rotatable joint; sliding a top housing over the biasing mechanism such that an upper end of the connector body projects past a top end of the top housing, the biasing mechanism abuts a bottom end of the top housing or is located in a cavity defined within the top housing; and inserting a locking pin into a locking pin through-passage in the upper end of the connector body; and securing the top housing together with the sheath.

2. The method of claim 1, further comprising: securing a slider seal housing onto a radially outward surface of an inner casing of the gas turbine engine; inserting a slider seal into the slider seal housing, the slider seal housing including a slider seal seat configured to fit the slider seal therein; and securing a slider seal cover to the slider seal housing, the slider seal cover being configured to secure the slider seal in the slider seal housing.

3. The method of claim 2, wherein the inner casing further comprises an inner port, wherein the slider seal housing further comprises a slider seal housing through-passage aligned with the inner port, wherein the slider seal further comprises a seal through-passage aligned with the inner port, wherein the slider seal cover further comprises a cover through-passage aligned with the inner port, and wherein the method further comprises: inserting the cover through the cover through-passage, the seal through-passage, the slider seal housing through-passage, and the inner port of the inner casing.

4. The method of claim 3, further comprising: rotating the cover to be about parallel with a radially inward surface of the inner casing.

5. The method of claim 4, wherein the cover further comprises a first cover and a second cover.

6. The method of claim 5, wherein the second cover overlaps the first cover by a selected portion after the cover is rotated to be about parallel with the radially inward surface of the inner casing.

7. The method of claim 2, further comprising: rotating the cover to be about parallel with the slider seal after inserting the connector body and the cover operably connected to the connector body into the sheath through-passage of the sheath.

8. The method of claim 1, further comprising: rotating the cover to be about parallel with the connector body prior to inserting the connector body and the cover operably connected to the connector body into the sheath through-passage of the sheath.

9. The method of claim 1, further comprising: operably connecting the cover to the connector body.

10. The method of claim 1, wherein the cover further comprises a first cover and a second cover, the connector body further comprises a first connector body and a second connector body, and the rotatable joint further comprises a first rotatable joint and a second rotatable joint.

11. The method of claim 10, wherein inserting the connector body and the cover operably connected to the connector body into the sheath through-passage of the sheath further comprises: inserting the first connector body and the first cover operably connected to the first connector body into the sheath through-passage of the sheath; and inserting the second connector body and the second cover operably connected to the second connector body into the sheath through-passage of the sheath.

12. The method of claim 1, further comprising: securing the plug assembly to the gas turbine engine.

13. The method of claim 12, wherein the plug assembly is secured to an outer casing of the gas turbine engine.

14. The method of claim 13, wherein securing the plug assembly to the gas turbine engine further comprises: aligning a housing through-passage within the top housing with a threaded hole in the sheath; inserting a fastening mechanism through the housing through-passage; and rotating the fastening mechanism such that a threaded portion of the fastening mechanism interlocks with the threaded hole to secure the plug assembly to the gas turbine engine.

15. The method of claim 1, wherein the connector body further comprises: a lower end, the

rotatable joint being located at the lower end; the upper end located opposite the lower end; a connector body flange located between the lower end and the upper end, the connector body flange dividing the connector body into: a lower portion located at or proximate the lower end; and an upper portion located at or proximate the upper end.

16. The method of claim 15, wherein installing the biasing mechanism further comprises sliding the biasing mechanism onto the upper portion of the connector body.

17. The method of claim 1, wherein the biasing mechanism is a spring.