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(54) **INJECTION APPARATUS**

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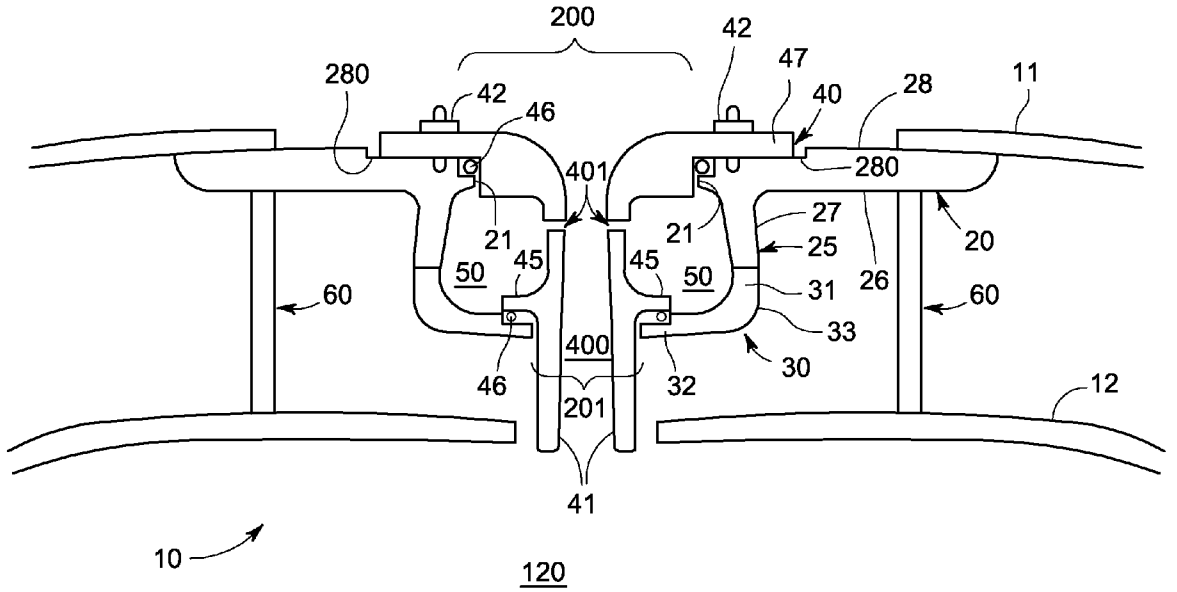
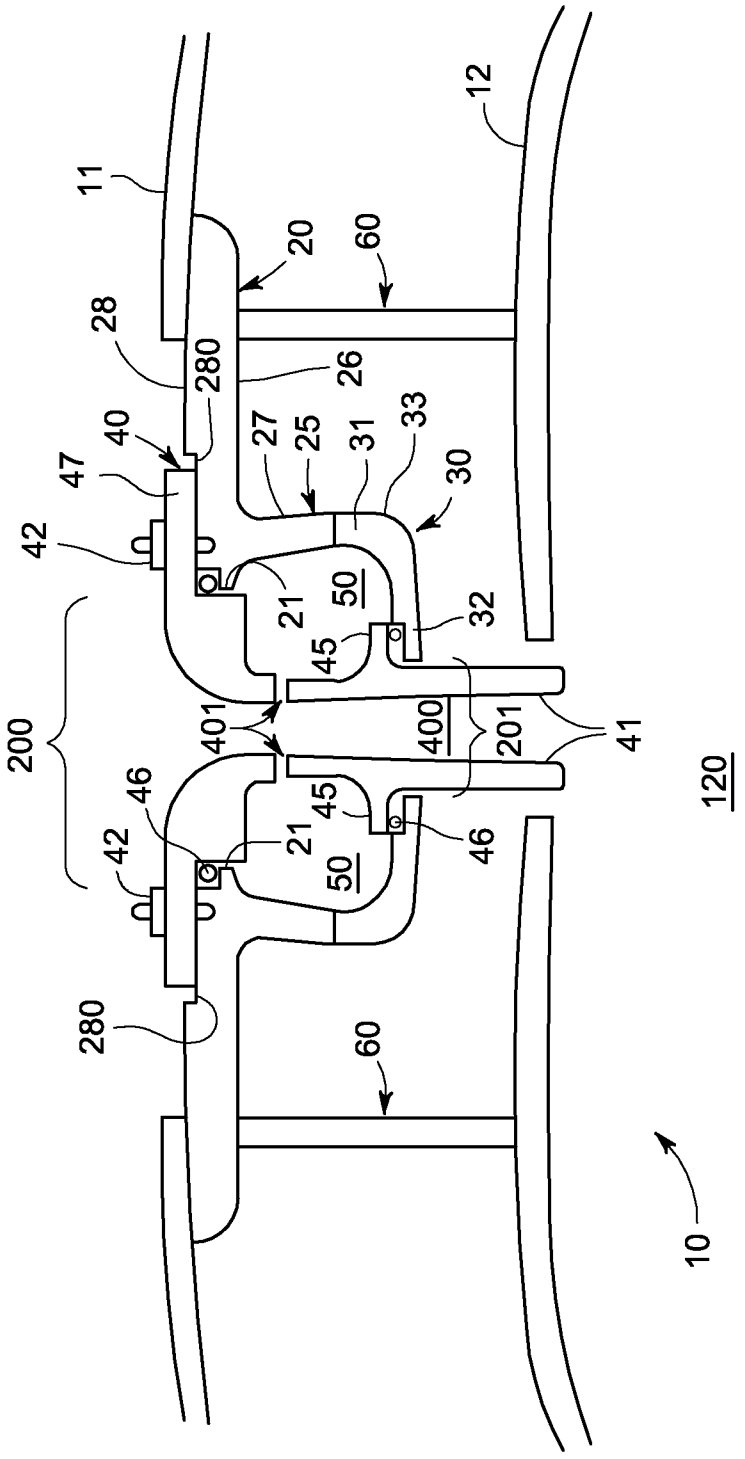
(57) **ABSTRACT**

An injection apparatus is provided and includes an annular base defining an injection hole location and having a protrusion about the injection hole location and a tubular body formed to define an injection hole, the tubular body to be sealably fastened to the annular base and the protrusion at the injection hole location such that the tubular body and the protrusion cooperatively define a plenum such that the plenum is communicative with the injection hole.

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INJECTION APPARATUS

BACKGROUND OF THE INVENTION

[0001] The subject matter disclosed herein relates to an injection apparatus and, more particularly, to an injection apparatus for attachment to an outer vessel disposed about an inner vessel formed to define a main flowpath.

[0002] A typical turbomachine, such as a gas turbine engine, includes a compressor, a combustor and a turbine. The compressor compresses inlet gas to produce compressed gas, which is transmitted to the combustor. Within the combustor, the compressed gas is mixed with fuel and combusted to produce high temperature fluids. These high temperature fluids are then directed to the turbine for power and/or electricity generation. In some cases, a transition piece may be disposed between the combustor and the turbine such that the high temperature fluids flow through the transition piece prior to entering the turbine.

[0003] As a result of the process described above, pollutants, such as oxides of nitrogen (NOx) may be produced and emitted to the atmosphere. Recently, efforts have been undertaken to reduce pollutant production and emission. Such efforts include the development of axially staged fuel injection systems, such as late lean injection (LLI) systems. In LLI systems, a quantity of fuel and air are injected into the main flowpath through the combustor or the transition piece downstream of the main combustion zone.

[0004] A problem with such systems, however, is that axially staged or LLI injectors must be integrally mounted to the transition piece, which is a complicated process that may lead to further assembly issues with the transition piece impingement sleeve.

BRIEF DESCRIPTION OF THE INVENTION

[0005] According to one aspect of the invention, an injection apparatus is provided and includes an annular base defining an injection hole location and having a protrusion about the injection hole location and a tubular body formed to define an injection hole, the tubular body to be sealably fastened to the annular base and the protrusion at the injection hole location such that the tubular body and the protrusion cooperatively define a plenum, which is communicative with the injection hole.

[0006] According to another aspect of the invention, an injection apparatus for attachment to an outer vessel disposed about an inner vessel formed to define a main flowpath is provided. The injection apparatus includes an annular base to be fastened to the outer vessel, the annular base defining an injection hole location and having a protrusion about the injection hole location and a tubular body formed to define an injection hole, the tubular body to be sealably fastened to the annular base and the protrusion at the injection hole location such that the injection hole permits communication between an exterior of the outer vessel and the main flowpath and the tubular body and the protrusion cooperatively define a plenum, which is communicative with the injection hole.

[0007] According to yet another aspect of the invention, an injection apparatus for attachment to an outer vessel disposed about an inner vessel formed to define a main flowpath is provided. The injection apparatus includes an annular base to be fastened to the outer vessel, the annular base defining injection hole locations and having protrusions about the injection hole locations and tubular bodies each formed to define an injection hole and each to be sealably fastened to the annular bases and the protrusions at each injection hole location such that at each injection hole location the corresponding one of the injection holes permits communication between an exterior of the outer vessel and the main flowpath and the corresponding one of the tubular bodies and the corresponding one of the protrusions cooperatively define a plenum. The corresponding one of the tubular bodies is further formed to define additional injection holes for communication between the plenum and the injection hole.

[0008] These and other advantages and features will become more apparent from the following description taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWING

[0009] The subject matter, which is regarded as the invention, is particularly pointed out and distinctly claimed in the claims at the conclusion of the specification. The foregoing and other features, and advantages of the invention are apparent from the following detailed description taken in conjunction with the accompanying drawings in which the sole figure is:

[0010] A schematic side view of an injection apparatus in accordance with embodiments.

[0011] The detailed description explains embodiments of the invention, together with advantages and features, by way of example with reference to the drawings.

DETAILED DESCRIPTION OF THE INVENTION

[0012] With reference to the sole FIGURE, an injection apparatus **10** is provided. The injection apparatus **10** is attachable to an outer vessel **11**, such as an impingement sleeve or a flow sleeve of an exemplary turbomachine transition piece. The outer vessel **11** may be disposed about an inner vessel **12**, which may be the turbomachine transition piece and may be formed to define a main flowpath **120**. During turbomachine operations, high temperature fluids are produced in a combustor and directed toward a turbine by way of the turbomachine transition piece. The flow of the high temperature fluids thus proceeds along the main flowpath **120** of the inner vessel **12**. It is, however, to be understood that the injection apparatus **10** may be attachable to other vessels in the turbomachine and/or other systems. As an alternate example, the injection apparatus **10** may be attachable to a forward end of the impingement sleeve (i.e., proximate to the axial injection flow sleeve), the aft end of the impingement sleeve or to a flow sleeve of the combustor.

[0013] The injection apparatus **10** includes a ring-shaped or annular base **20** and a tubular body **40**. The annular base **20** is configured to be fastened to the outer vessel **11** by one or more of bolting, welding, sealing and butt welding. The annular base **20** has a first surface **21** that is formed to define an injection hole location **200** and a protrusion **25**. The protrusion **25** protrudes from an interior facing surface **26** of the annular base **20** and extends perimetrically about the injection hole location **200** such that the protrusion **25** is axisymmetric about a centerline of the inner vessel **12**. The protrusion **25** includes a first part **27** and a connector **30**. The first part **27** protrudes from the interior facing surface **26** such that the first part **27** is axisymmetric about the centerline of the inner vessel **12**. The connector **30** has a first end **31**, which is configured to be fastened by, for example, welding to a distal end of the protrusion **25** perimetrically about the injection

hole location **200**, and a second end **32**. The first end **31** and the second end **32** supportively meet at bend **33**, which may be angular or curved, such that the second end **32** defines a secondary injection hole location **201**, which may correspond to the injection hole location **200**.

[0014] In accordance with embodiments, the injection hole location **200** and the secondary injection hole location **201** may be round or, in some cases, substantially circular. Similarly, the protrusion **25**, the connector **30** and the tubular body **40** may also have round or, in some cases, substantially circular cross-sections (i.e., they may be ring-shaped) in correspondence with the shape of the injection hole location **200** and the secondary injection hole location **201**.

[0015] The tubular body **40** has sufficient length to extend across an annulus defined between the outer vessel **11** and the inner vessel **12** and has an interior facing surface **41** that is formed to define a tubular injection hole **400**. The tubular body **40** is sealably fastened to the first surface **21** of the annular base **20** at the injection hole location **200** by way of, for example, bolt **42** that engages with the annular base **20**. The tubular body **40** also has a protrusion **45** that may be sealably fastened to the second end **32** of the connector **30** at the secondary injection hole location **201**. Seals **46**, such as o-rings or c-seals, may be sealably disposed between the tubular body **40** and the first surface **21** and between the protrusion **45** and the second end **32** of the connector **30**. The tubular injection hole **400** permits fluid communication between an exterior of the outer vessel **11** and the main flowpath **120**.

[0016] In accordance with embodiments, at an inlet end of the tubular body **40**, the tubular body **40** may include a flange **47**. The annular base **20** may include an exterior facing surface **28** that faces radially outwardly and away from the main flowpath **120**. This exterior facing surface **28** may have a fastening surface **280** formed thereon at the injection hole location **200** where the exterior facing surface **28** is machined to be flat and/or smooth and therefore configured for mating with the flange **47**. Where bolt **42** is employed to fasten the tubular body **40** to the annular base **20**, the bolt **42** extends through both the flange **47** and the fastening surface **280** of the exterior facing surface **28**.

[0017] The tubular body **40**, the connector **30**, the protrusion **25** and the annular base **20** may cooperatively define a plenum **50**. The tubular body **40** is further formed to define an additional injection hole **401** for permitting fluid communication between an interior of the plenum **50** and the tubular injection hole **400**. The additional injection hole **401** may be defined as a plurality of additional injection holes **401**, which are arrayed about the tubular injection hole **400** of the tubular body **40** at the plenum **50**. Separation between adjacent additional injection holes **401** may be uniform or non-uniform.

[0018] Where the injection apparatus **10** is attachable to an impingement sleeve or another similar feature of a turbomachine, the plenum **50** may be supplied with fuel and the exterior of the outer vessel **11** may include compressed air, such as compressor discharge air that is produced by a compressor of the turbomachine. In these cases, the compressed air flows through the tubular injection hole **400** and entrains a flow of the fuel from the plenum **50** into the tubular injection hole **400**. The fuel is thereby mixed with the compressed air and injected into the main flowpath **120** as a fuel/air mixture. As such, the injection apparatus **10** may be employed as part of an axially staged injection system of a turbomachine or, more particularly, as part of a late lean injection (LLI) system of the turbomachine. In the latter case, the fuel/air mixture may be lean such that combustion of the fuel/air mixture within the main flowpath **120** serves to reduce the production and subsequent emission of pollutants, such as oxides of nitrogen (NOx).

[0019] The annulus defined between the outer vessel **11** and the inner vessel **12** is generally supported by support structures **60**, such as a-spacers arrayed about the inner vessel **12**. In accordance with embodiments, these support structures **60** may be disposed between an exterior facing surface of the inner vessel **12** and the interior facing surface **26** of the annular base **20**.

[0020] In accordance with aspects of the invention, the injection hole location **200** (and the accompanying structures as described above) may be provided as a plurality of injection hole locations **200**. In these cases, the plural injection hole locations **200** may be arrayed about the outer vessel **11** and the inner vessel **12** as non-axisymmetric features. Separation between adjacent injection hole locations **200** may be uniform or non-uniform. In accordance with an exemplary embodiment, four injection hole locations **200** may be clustered about respective lower portions of the outer vessel **11** and the inner vessel **12**.

[0021] While the invention has been described in detail in connection with only a limited number of embodiments, it should be readily understood that the invention is not limited to such disclosed embodiments. Rather, the invention can be modified to incorporate any number of variations, alterations, substitutions or equivalent arrangements not heretofore described, but which are commensurate with the spirit and scope of the invention. Additionally, while various embodiments of the invention have been described, it is to be understood that aspects of the invention may include only some of the described embodiments. Accordingly, the invention is not to be seen as limited by the foregoing description, but is only limited by the scope of the appended claims.

1. An injection apparatus, comprising:

an annular base defining an injection hole location and having a protrusion about the injection hole location; and

a tubular body formed to define an injection hole, the tubular body to be sealably fastened to the annular base and the protrusion at the injection hole location such that:

the tubular body and the protrusion cooperatively define a plenum, which is communicative with the injection hole.

2. The injection apparatus according to claim **1**, wherein the annular base includes an exterior facing surface having a fastening surface formed thereon at the injection hole location.

3. The injection apparatus according to claim **1**, further comprising seals disposed between the tubular body and the annular base and between the tubular body and the protrusion.

4. An injection apparatus for attachment to an outer vessel disposed about an inner vessel formed to define a main flowpath, the injection apparatus comprising:

an annular base to be fastened to the outer vessel, the annular base defining an injection hole location and having a protrusion about the injection hole location; and

a tubular body formed to define an injection hole, the tubular body to be sealably fastened to the annular base and the protrusion at the injection hole location such that:

the injection hole permits communication between an exterior of the outer vessel and the main flowpath and the tubular body and the protrusion cooperatively define a plenum, which is communicative with the injection hole.

5. The injection apparatus according to claim **4**, wherein the outer vessel comprises an impingement sleeve of a turbomachine transition piece.

6. The injection apparatus according to claim **4**, wherein the plenum is supplied with fuel and the exterior of the outer vessel comprises compressed air.

7. The injection apparatus according to claim **4**, wherein the annular base is fastened to the outer vessel by one or more of bolting, welding, sealing and butt welding.

8. The injection apparatus according to claim **4**, wherein the annular base includes an exterior facing surface having a fastening surface formed thereon at the injection hole location.

9. The injection apparatus according to claim **4**, further comprising support structures to support the annular base on the inner vessel.

10. The injection apparatus according to claim **4**, further comprising seals disposed between the tubular body and the annular base and between the tubular body and the protrusion.

11. An injection apparatus for attachment to an outer vessel disposed about an inner vessel formed to define a main flowpath, the injection apparatus comprising:

an annular base to be fastened to the outer vessel, the annular base defining injection hole locations and having protrusions about the injection hole locations; and

tubular bodies each formed to define an injection hole and each to be sealably fastened to the annular base and the protrusions at each injection hole location such that at each injection hole location:

the corresponding one of the injection holes permits communication between an exterior of the outer vessel and the main flowpath and the corresponding one of the tubular bodies and the corresponding one of the protrusions cooperatively define a plenum,

the corresponding one of the tubular bodies being further formed to define additional injection holes for communication between the plenum and the injection hole.

12. The injection apparatus according to claim **11**, wherein the outer vessel comprises an impingement sleeve of a turbomachine transition piece.

13. The injection apparatus according to claim **11**, wherein the plenum is supplied with fuel and the exterior of the outer vessel comprises compressed air.

14. The injection apparatus according to claim **11**, wherein the annular base is fastened to the outer vessel by one or more of bolting, welding, sealing and butt welding.

15. The injection apparatus according to claim **11**, wherein the annular base includes an exterior facing surface having a fastening surface formed thereon at the injection hole location.

16. The injection apparatus according to claim **11**, further comprising support structures to support the annular base on the inner vessel.

17. The injection apparatus according to claim **11**, further comprising seals disposed between the tubular bodies and the annular base and between the tubular bodies and the protrusions.

18. The injection apparatus according to claim **11**, wherein the injection hole locations are non-uniformly separated from one another.

19. The injection apparatus according to claim **11**, wherein the injection hole locations are clustered.

20. The injection apparatus according to claim **11**, wherein the additional injection holes for each corresponding tubular body are arrayed about a circumference of the injection hole defined by the corresponding tubular body.

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