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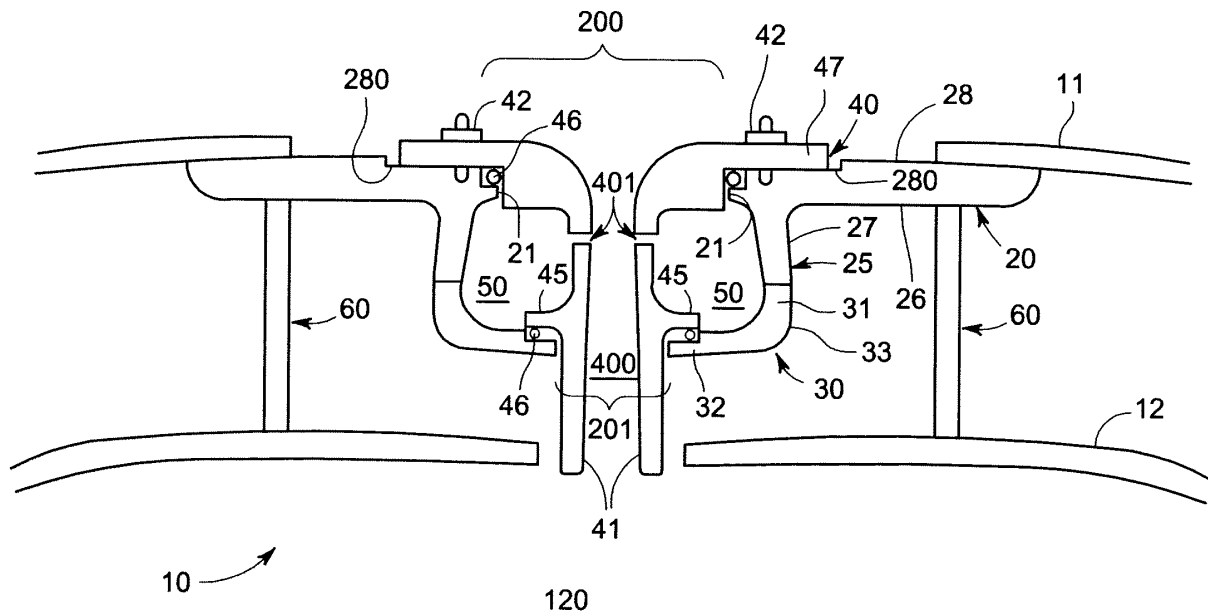
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(54) **injection Apparatus**

(57) An injection apparatus (10) is provided and includes an annular base (20) defining an injection hole location (200) and having a protrusion (25) about the injection hole location (200) and a tubular body (40) formed to define an injection hole (401), the tubular body (40) to

be sealably fastened to the annular base (20) and the protrusion (25) at the injection hole location (200) such that the tubular body (40) and the protrusion (25) cooperatively define a plenum (50) such that the plenum (50) is communicative with the injection hole (401).



## Description

### 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]** Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings in which:

**[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 (NO<sub>x</sub>).

**[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.

## Claims

### 1. An injection apparatus (10), comprising:

an annular base (20) defining an injection hole location (200) and having a protrusion (25) about the injection hole location (200); and a tubular body (40) formed to define an injection hole (400), the tubular body (46) to be sealably fastened to the annular base (20) and the protrusion (25) at the injection hole location (400) such that:

the tubular body (40) and the protrusion (25) cooperatively define a plenum (50), which is communicative with the injection hole (400).

### 2. The injection apparatus according to claim 1, wherein the annular base (20) includes an exterior facing surface (28) having a fastening surface (280) formed thereon at the injection hole location (200).

### 3. The injection apparatus according to claim 1 or 2, further comprising seals (46) disposed between the tubular body (40) and the annular base (20) and between the tubular body (40) and the protrusion (25).

### 4. The injection apparatus of any of claims 1 to 3, further comprising:

a plurality of injection hole locations (200) and a plurality of protrusions (25) about the injection hole locations (200) defined in the annular base (20); and

a plurality of tubular bodies (40) each formed to define an injection hole (400) and each to be sealably fastened to the annular base (20) and the protrusions (25) at each injection hole location (200),

the corresponding one of the tubular bodies (40) being further formed to define additional injection holes (401) for communication between the plenum (50) and the injection hole (400).

### 5. The injection apparatus according to claim 4, wherein the injection hole locations (200) are non-uniformly

separated from one another.

### 6. The injection apparatus according to claim 4, wherein the injection hole locations (200) are clustered.

### 7. The injection apparatus according to any of claims 4 to 6, wherein the additional injection holes (401) for each corresponding tubular body (40) are arrayed about a circumference of the injection hole (200) defined by the corresponding tubular body (40).

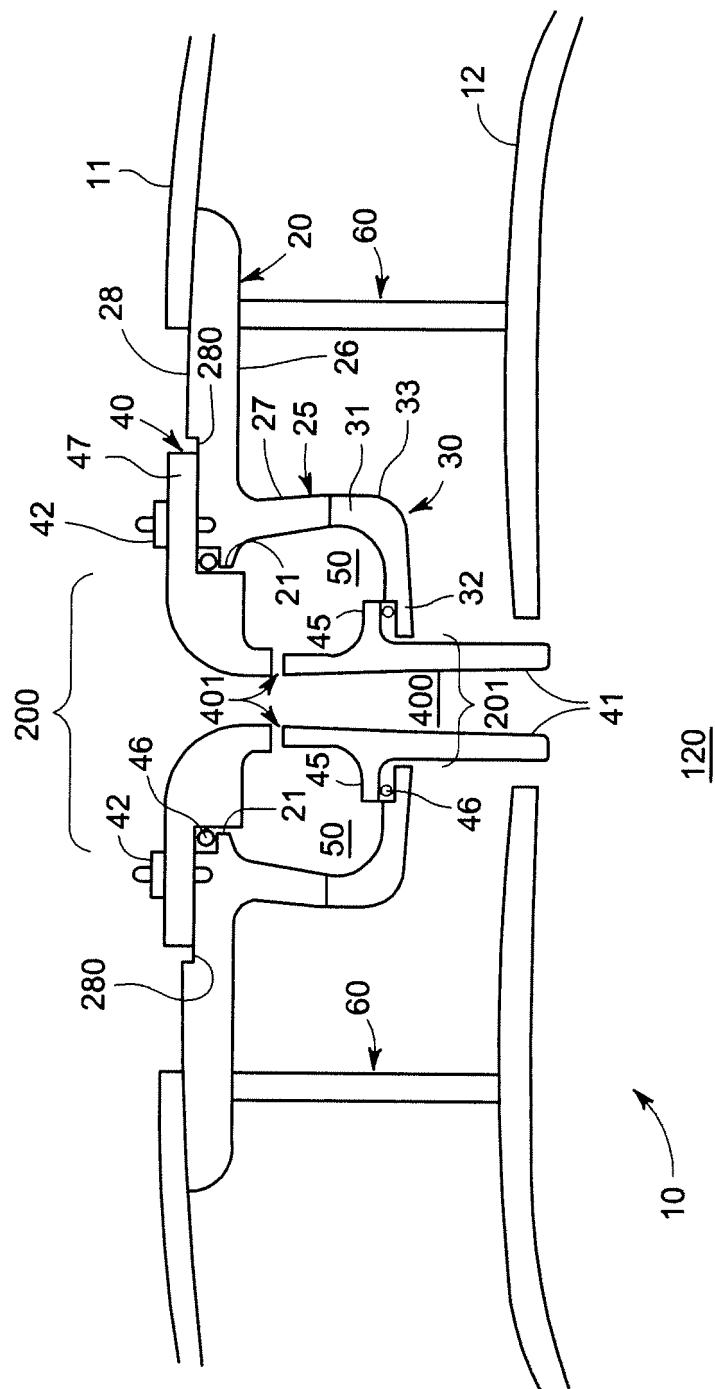
### 8. The injection apparatus of any of claims 1 to 7, for attachment to an outer vessel (11) disposed about an inner vessel (120) formed to define a main flowpath (120), wherein the annular base (20) is to be fastened to the outer vessel (11), and the injection hole (400) permits communication between an exterior of the outer vessel (11) and the main flowpath (120).

### 9. The injection apparatus according to claim 8, wherein the outer vessel (11) comprises an impingement sleeve of a turbomachine transition piece.

### 10. The injection apparatus according to claim 8 or 9, wherein the plenum (50) is supplied with fuel and the exterior of the outer vessel (11) comprises compressed air.

### 11. The injection apparatus according to claim 8, 9 or 10, wherein the annular base (20) is fastened to the outer vessel (11) by one or more of bolting, welding, sealing and butt welding.

### 12. The injection apparatus according to any of claims 8 to 11, further comprising support structures (60) to support the annular base (20) on the inner vessel (12).





## EUROPEAN SEARCH REPORT

Application Number  
EP 12 19 0273

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 7 000 396 B1 (STOREY JAMES M [US] STOREY JAMES MICHAEL [US]) 21 February 2006 (2006-02-21) * column 3, line 50 - line 59 * * figures 3,4 * -----	1-9,11, 12	INV. F23R3/06 F23R3/34
			TECHNICAL FIELDS SEARCHED (IPC)
			F23R
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 14 January 2013	Examiner Christen, Jérôme
<p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ..... &amp; : member of the same patent family, corresponding document</p>			

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EPO FORM 1503 03 82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

EP 12 19 0273

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.  
The members are as contained in the European Patent Office EDP file on  
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14-01-2013

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