



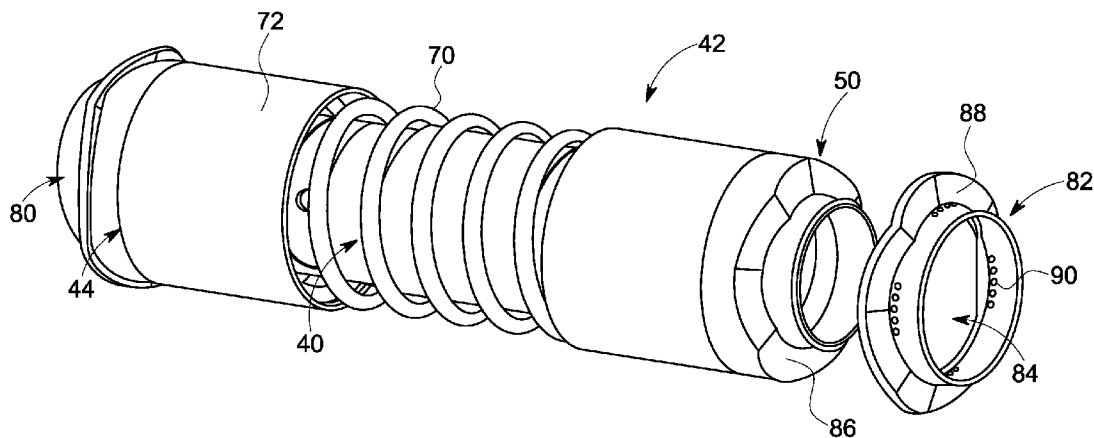
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Cloninger et al.(10) **Pub. No.: US 2014/0137536 A1**(43) **Pub. Date: May 22, 2014**(54) **SUPER TELESCOPING CROSS-FIRE TUBE
AND METHOD OF ASSEMBLING A
COMBUSTOR STRUCTURE****Publication Classification**(51) **Int. Cl.**
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Schenectady, NY (US)(21) Appl. No.: **13/682,965**(22) Filed: **Nov. 21, 2012**(57) **ABSTRACT**

A super-telescoping cross-fire tube includes a cross-fire tube including a first portion and a second portion in mating engagement, the cross-fire tube extending from a first end region to a second end region for fluidly connecting a combustor chamber and an adjacent combustor chamber. Also included is an outer shield spaced radially outwardly and surrounding at least a portion of the cross-fire tube. Further included is a spring extending from proximate the first end region to the second end region and disposed between the cross-fire tube and the outer shield, wherein the cross-fire tube is telescopingly moveable between a first position and a second position.



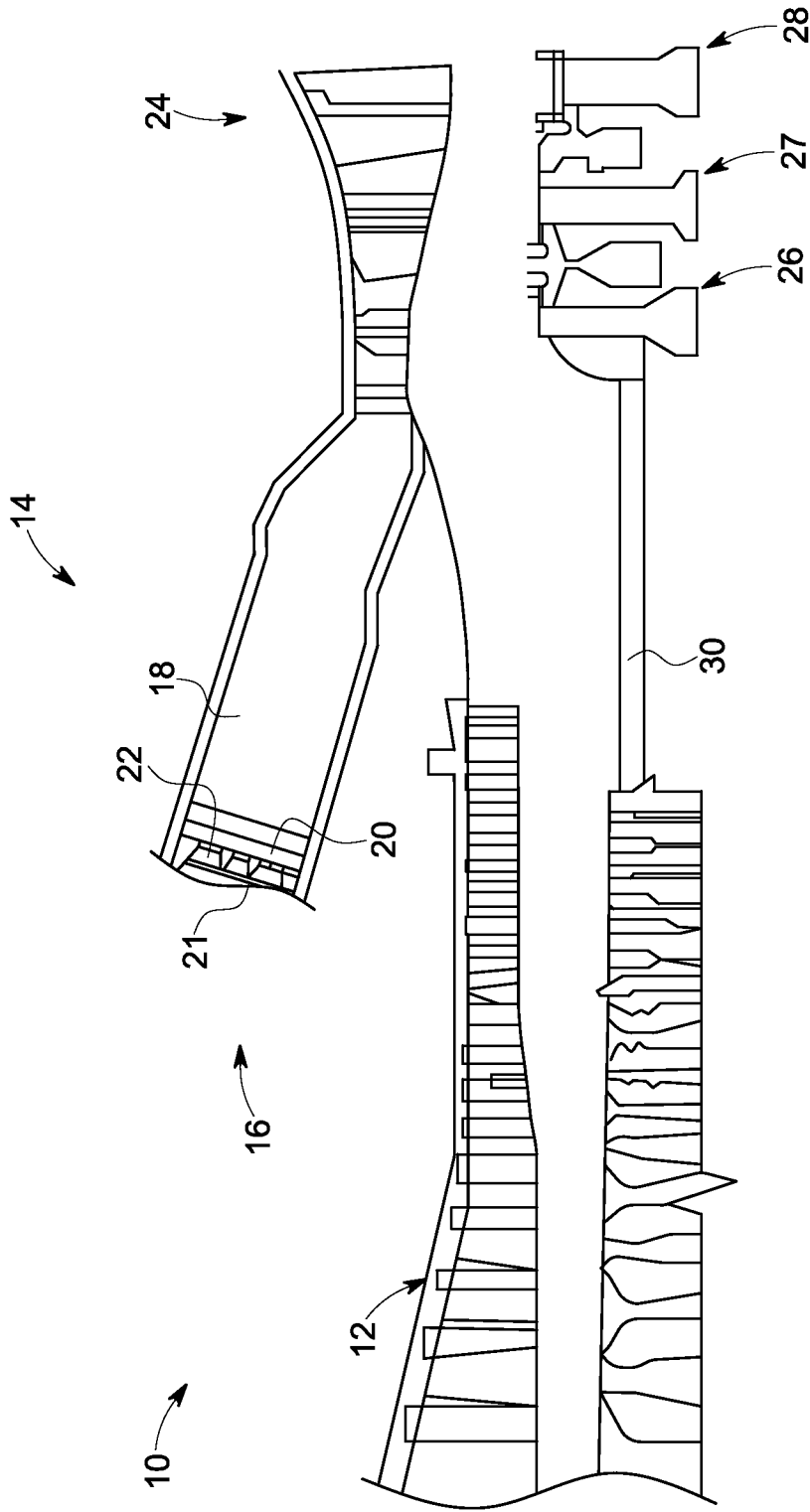
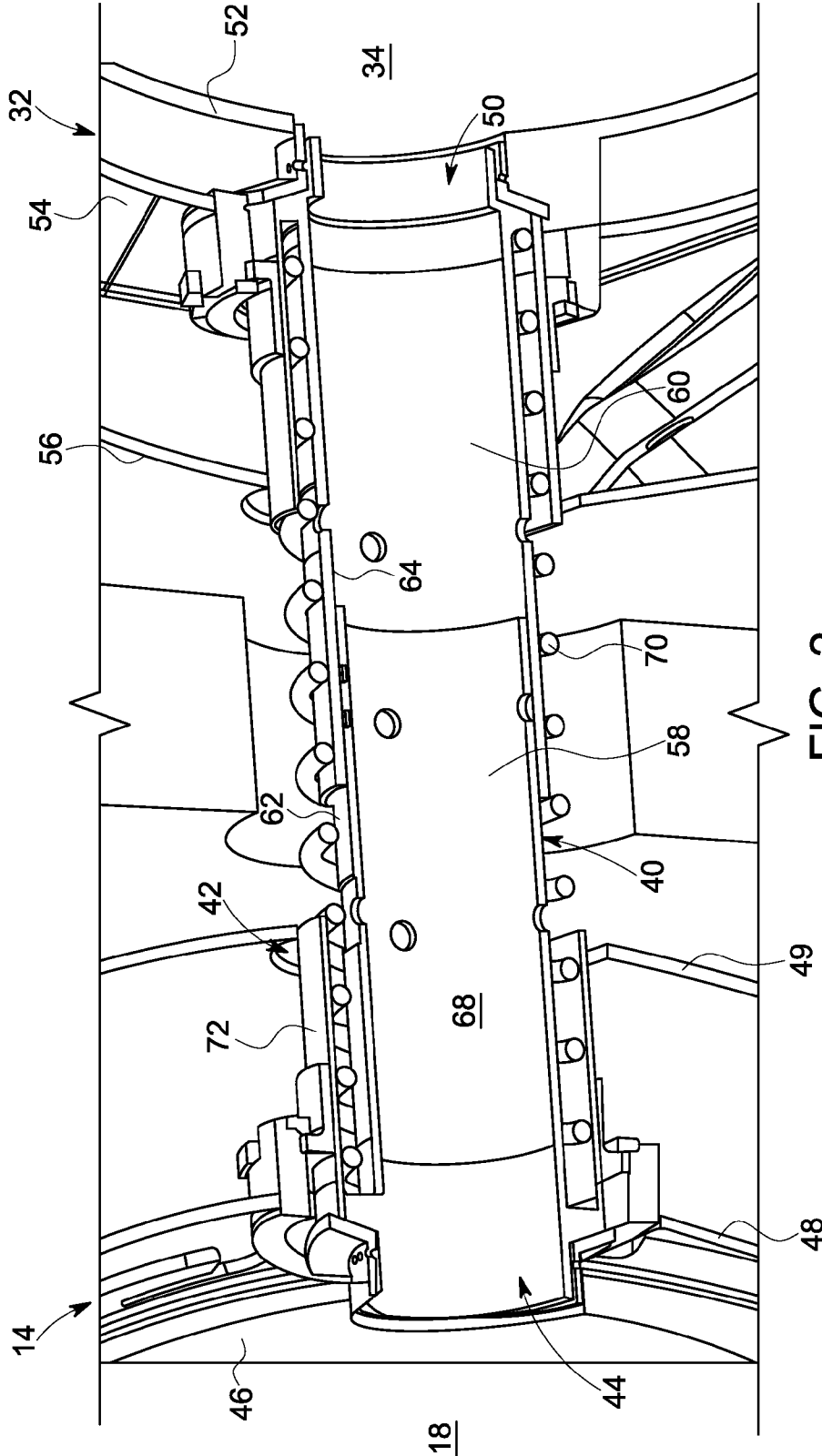


FIG. 1



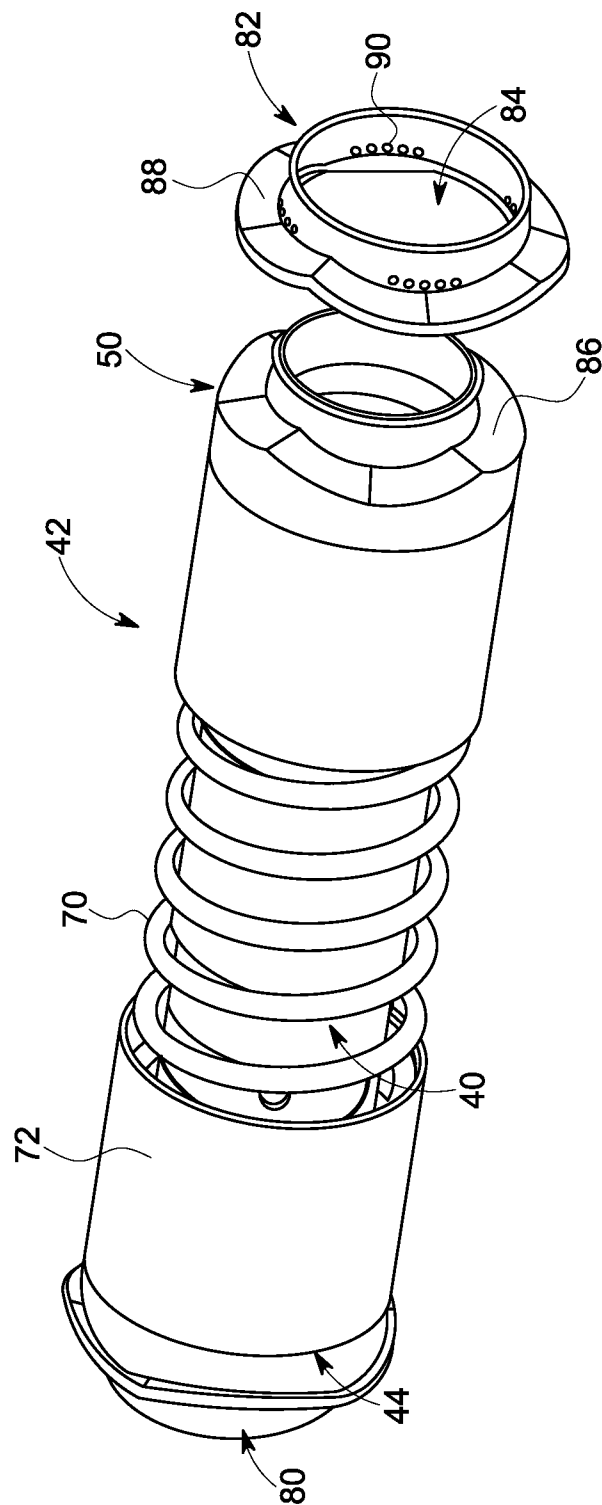


FIG. 3

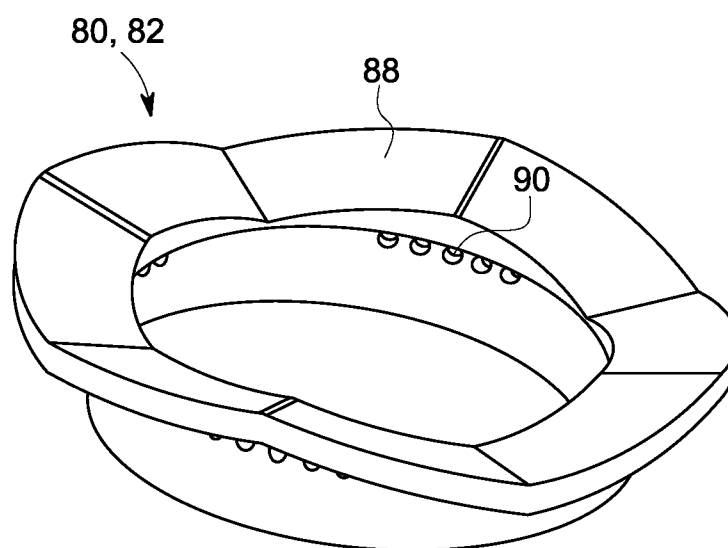


FIG. 4

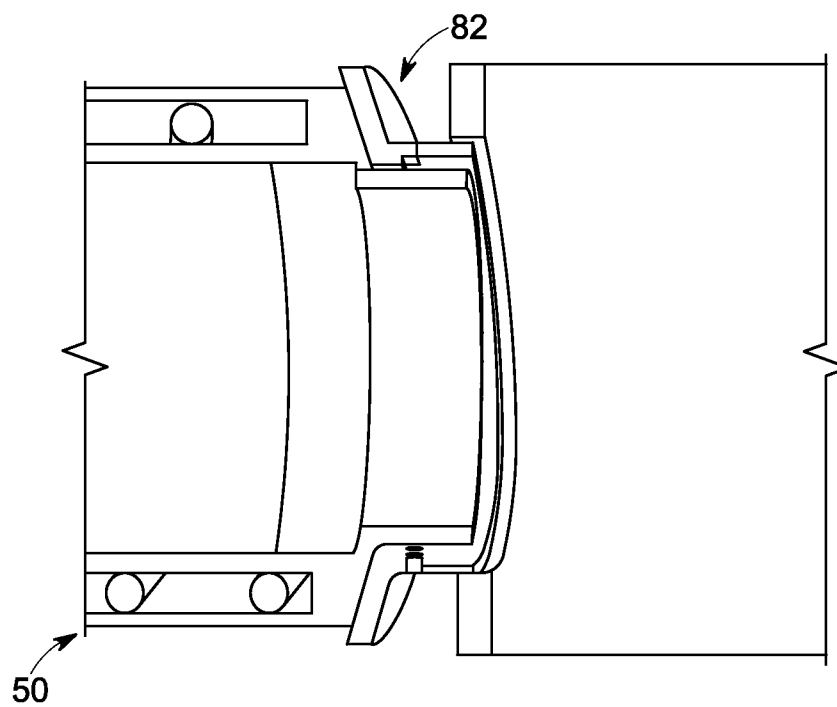


FIG. 5

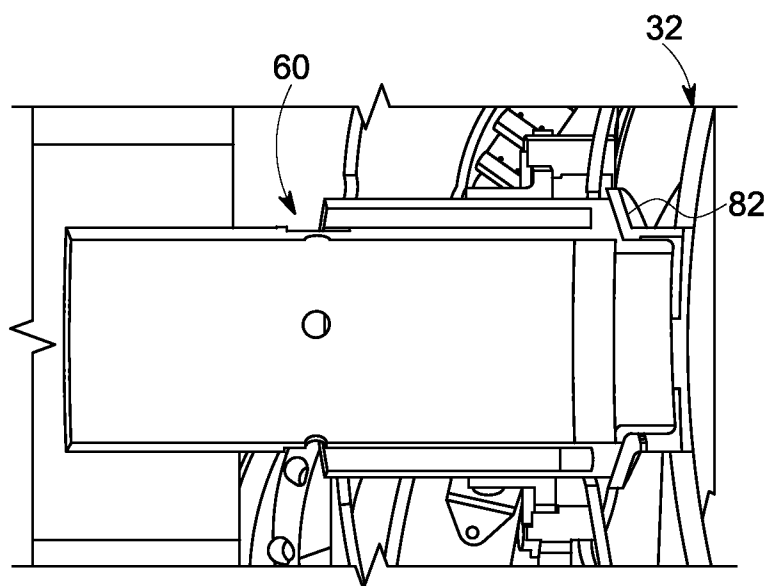


FIG. 6

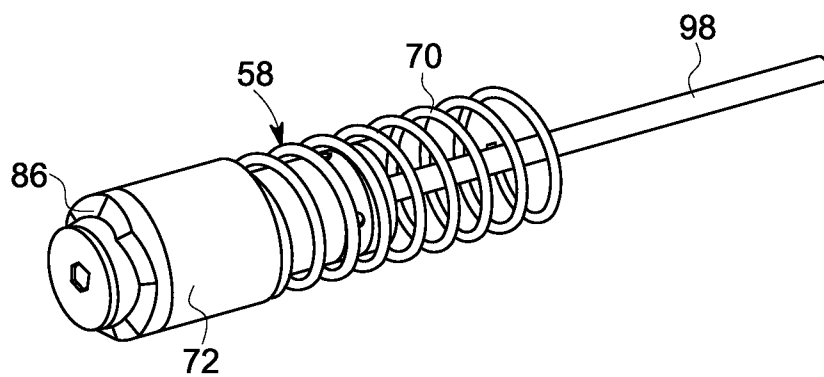


FIG. 7

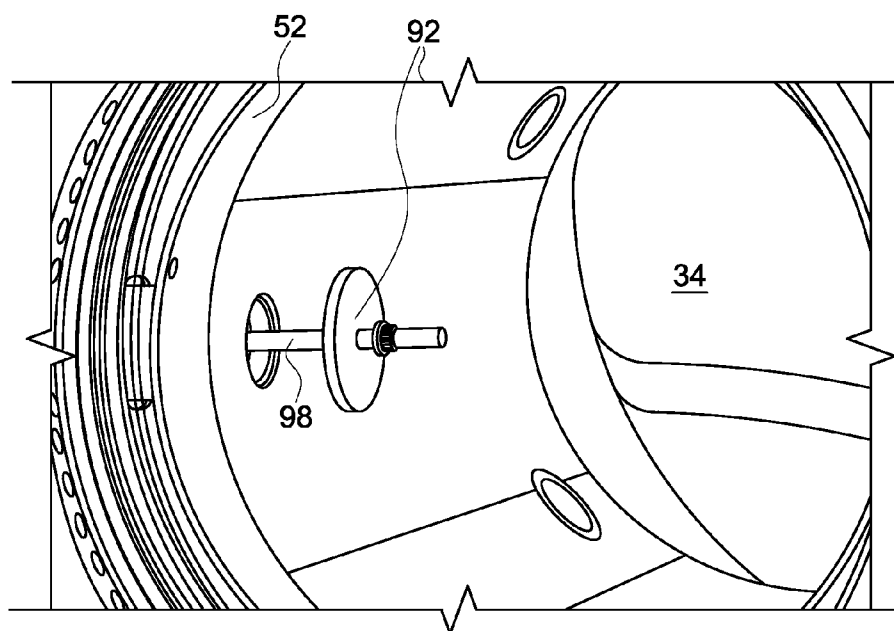


FIG. 8

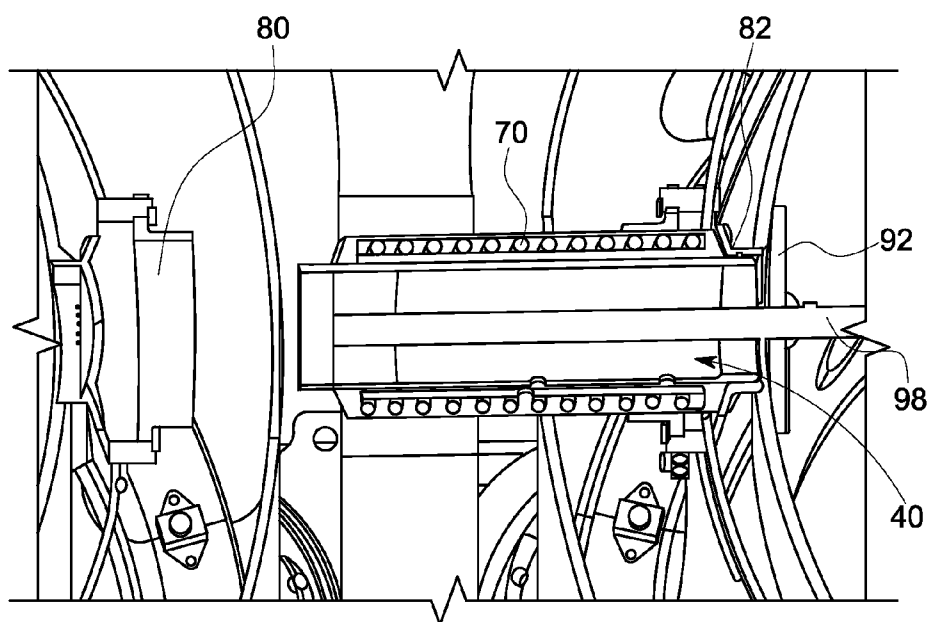


FIG. 9

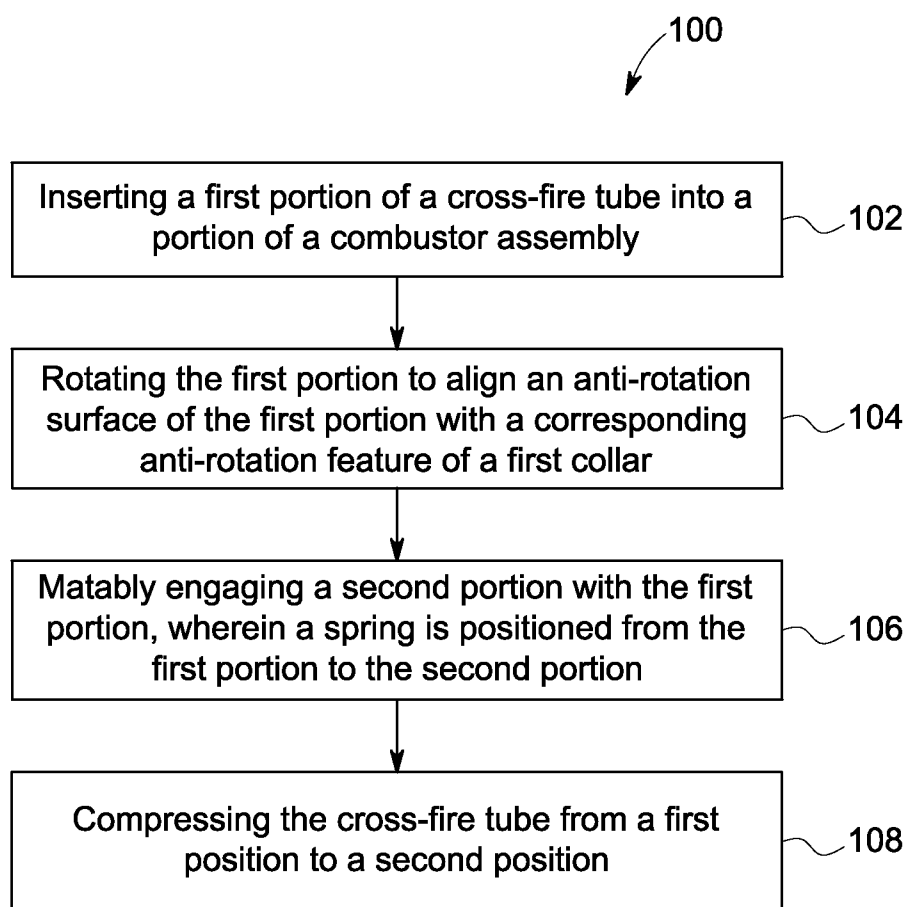


FIG. 10

SUPER TELESCOPING CROSS-FIRE TUBE AND METHOD OF ASSEMBLING A COMBUSTOR STRUCTURE

BACKGROUND OF THE INVENTION

[0001] The subject matter disclosed herein relates to gas turbine systems, and more particularly to a cross-fire tube, as well as a method of assembling a combustor structure.

[0002] Adjacent combustors of a gas turbine engine are typically connected by a cross-fire tube to ensure substantially simultaneous ignition and equalized pressure in all combustor chambers of the gas turbine engine. The cross-fire tube is typically coupled to the adjacent combustors by a variety of retention devices, including clips, for example. Geometry constraints and spatial limitations may hinder the ability to employ such retention devices. Additionally, the adjacent combustors may be assembled as a module that is inserted as a whole into a combustor structure. Assembly in this manner may limit the retention methods that are commonly required for cross-fire tubes having a relatively rigid construction or one of limited flexibility to accommodate the insertion of the module into the combustor structure, as at least a portion of the cross-fire tube is typically disposed in the space that is to receive the module. Furthermore, installation of the cross-fire tube requires proper positioning of the cross-fire tube, relative to other components, with the positioning left to an installation operator's discretion or manipulating, thereby often leading to human error.

BRIEF DESCRIPTION OF THE INVENTION

[0003] According to one aspect of the invention, a super-telescoping cross-fire tube includes a cross-fire tube including a first portion and a second portion in mating engagement, the cross-fire tube extending from a first end region to a second end region for fluidly connecting a combustor chamber and an adjacent combustor chamber. Also included is an outer shield spaced radially outwardly and surrounding at least a portion of the cross-fire tube. Further included is a spring extending from proximate the first end region to the second end region and disposed between the cross-fire tube and the outer shield, wherein the cross-fire tube is telescopingly moveable between a first position and a second position.

[0004] According to another aspect of the invention, a combustor structure for a gas turbine engine includes a combustor assembly and an adjacent combustor assembly, the combustor assembly comprising a combustor chamber, the adjacent combustor assembly comprising an adjacent combustor chamber. Also included is a first collar operably coupled to the combustor assembly. Further included is a cross-fire tube extending from a first end region disposed adjacent the first collar to a second end region disposed proximate the adjacent combustor assembly. Yet further included is a spring extending from proximate the first end region to the second end region and disposed between the cross-fire tube and an outer shield surrounding at least a portion of the cross-fire tube.

[0005] According to yet another aspect of the invention, a method of assembling a combustor structure is provided. The method includes inserting a first portion of a cross-fire tube into a portion of a combustor assembly. Also included is rotating the first portion of the cross-fire tube to align an anti-rotation surface of the first portion with a corresponding anti-rotation feature of a first collar operably coupled to the combustor assembly. Further included is matably engaging a

second portion of the cross-fire tube with the first portion, wherein a spring is positioned from the first portion to the second portion. Yet further included is compressing the cross-fire tube from a first position to a second position providing clearance for insertion of an adjacent combustor assembly into the combustor structure.

[0006] These and other advantages and features will become more apparent from the following description taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] 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:

[0008] FIG. 1 is a schematic illustration of a gas turbine system;

[0009] FIG. 2 is a perspective, partial cross-sectional view of a combustor structure;

[0010] FIG. 3 is a perspective view of a cross-fire tube of the combustor structure;

[0011] FIG. 4 is a perspective view of a collar of the cross-fire tube;

[0012] FIG. 5 is cross-sectional view of an end region of the cross-fire tube;

[0013] FIG. 6 is a partial cross-sectional view of a portion of the cross-fire tube engaged with the collar;

[0014] FIG. 7 is a perspective view of the cross-fire tube according to another aspect of the invention;

[0015] FIG. 8 is a perspective view of a mechanical fastener for securing the cross-fire tube;

[0016] FIG. 9 is a partial cross-sectional view of the cross-fire tube in a compressed condition; and

[0017] FIG. 10 is a flow diagram illustrating a method of assembling a combustor structure.

[0018] 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

[0019] Referring to FIG. 1, a gas turbine engine **10** constructed in accordance with an exemplary embodiment of the present invention is schematically illustrated. The gas turbine engine **10** includes a compressor **12** and a plurality of combustor assemblies arranged in a can annular array, one of which is indicated at **14**. As shown, the combustor assembly **14** includes an endcover assembly **16** that seals, and at least partially defines, a combustor chamber **18**. A plurality of nozzles **20-22** are supported by the endcover assembly **16** and extend into the combustor chamber **18**. The nozzles **20-22** receive fuel through a common fuel inlet (not shown) and compressed air from the compressor **12**. The fuel and compressed air are passed into the combustor chamber **18** and ignited to form a high temperature, high pressure combustion product or air stream that is used to drive a turbine **24**. The turbine **24** includes a plurality of stages **26-28** that are operationally connected to the compressor **12** through a compressor/turbine shaft **30** (also referred to as a rotor).

[0020] In operation, air flows into the compressor **12** and is compressed into a high pressure gas. The high pressure gas is supplied to the combustor assembly **14** and mixed with fuel,

for example natural gas, fuel oil, process gas and/or synthetic gas (syngas), in the combustor chamber 18. The fuel/air or combustible mixture ignites to form a high pressure, high temperature combustion gas stream. In any event, the combustor assembly 14 channels the combustion gas stream to the turbine 24 which converts thermal energy to mechanical, rotational energy.

[0021] Referring now to FIG. 2, as noted above, a can annular array of combustor assemblies is arranged in a circumferentially spaced manner about an axial centerline of the gas turbine engine 10. For illustration clarity, a partial view of the can annular array is shown and includes the combustor assembly 14 and an adjacent combustor assembly 32. The combustor chamber 18 of the combustor assembly 14 and an adjacent combustor chamber 34 of the adjacent combustor assembly 32 are fluidly coupled with a cross-fire tube 40 of a cross-fire tube arrangement 42, with the cross-fire tube 40 fixed at a first end region 44 proximate a component of the combustor assembly 14. The component of the combustor assembly 14 to which the first end region 44 is fixed may be a variety of components, including a combustor liner 46, a sleeve 48 that surrounds the combustor liner 46, and/or an air shield 49, each of the sleeve 48 and the air shield 49 spaced radially outwardly of the combustor liner 46. The cross-fire tube 40 is fixed at a second end region 50 proximate a component of the adjacent combustor assembly 32. Similar to the components noted above, the component of the adjacent combustor assembly 32 that the second end region 50 is fixed to may be an adjacent combustor liner 52, an adjacent sleeve 54 and/or an adjacent air shield 56, each spaced radially outwardly of the adjacent combustor liner 52. The cross-fire tube 40 typically includes a first portion 58 and a second portion 60 that are operably coupled to each other. In one embodiment, the first portion 58 is referred to as a male portion that is in mating engagement with the second portion 60 that is referred to as a female portion for receiving the first portion 58. This arrangement provides a telescoping engagement between the first portion 58 and the second portion 60.

[0022] The cross-fire tube 40 includes an outer surface 62 and an inner surface 64, with the inner surface 64 defining an interior region 68 that provides the fluid coupling of the combustor chamber 18 and the adjacent combustor chamber 34, which allows passage of a flame from the combustor chamber 18 to the adjacent combustor chamber 34, or vice versa. Such passage is desirable during light-off of the combustor assemblies of the gas turbine engine 10 and allows for nearly simultaneous ignition or re-ignition of the combustor assemblies.

[0023] Disposed along the outer surface 62 is a spring 70 that extends from proximate the first end region 44 of the cross-fire tube 40 to proximate the second end region 50 of the cross-fire tube 40. The spring 70 is at least partially retained by an outer shield 72 that surrounds the outer surface 62 of the cross-fire tube 40. The outer shield 72 is spaced radially outwardly from the outer surface 62 to accommodate disposal of the spring 70 between the cross-fire tube 40 and the outer shield 72. In the illustrated embodiment, the outer shield 72 is segmented to only surround portions of the cross-fire tube 40 and the spring 70. Specifically, the outer shield 72 surrounds a portion of the first portion 58 and a portion of the second portion 60 of the cross-fire tube 40. However, it is to be understood that the outer shield 72 may extend along an entire, or nearly an entire, length of the cross-fire tube 40. Irrespective of the amount of the cross-fire tube 40 that is

surrounded by the outer shield 72, the spring 70 provides a resilient spring biasing force on the first portion 58 and the second portion 60 of the cross-fire tube 40. The cross-fire tube 40 is telescopingly moveable between a first extended position, as shown, and a second compressed position upon compression of the spring 70. As will be described in detail below, compression of the cross-fire tube 40 and the spring 70 is advantageous during certain phases of assembly of the combustor assembly 14 and the adjacent combustor assembly 32.

[0024] Referring now to FIGS. 3-5, in conjunction with FIG. 2, the cross-fire tube arrangement 42 includes a first collar 80 fixedly secured to a component of the combustor assembly 14, such as the combustor liner 46, the sleeve 48 that surrounds the combustor liner 46, and/or the air shield 49. Similarly, a second collar 82 is fixedly secured to a component of the adjacent combustor assembly 32. The first collar 80 and the second collar 82 may be welded to the component and is configured to engage the first end region 44 of the cross-fire tube 40 and the second end region 50 of the cross-fire tube 40, respectively. Similar reference numerals will be employed in describing the first collar 80 and the second collar 82, as both are similarly configured and perform similar functions.

[0025] Both the first collar 80 and the second collar 82 include a central opening 84 for receiving the first end region 44 and the second end region 50, respectively, of the cross-fire tube 40. The first end region 44 and the second end region 50 include an anti-rotation surface 86 that corresponds to at least one anti-rotation component 88 of the first collar 80 and the second collar 82. In an exemplary embodiment, the at least one anti-rotation component 88 and the anti-rotation surface 86 comprise corresponding non-planar surfaces each having conical regions. It is to be appreciated that numerous alternative geometries may be employed and furthermore it is contemplated that corresponding protrusions and recesses may be utilized to form the anti-rotation surface 86 and the at least one anti-rotation component 88. Irrespective of the precise configuration of the anti-rotation surface 86 and the at least one anti-rotation component 88, the corresponding features provide a self-aligning aspect for the cross-fire tube arrangement 42. Specifically, disposal of the cross-fire tube 40 into an abutting manner with the first collar 80 and the second collar 82 provides a fixed rotational position of the cross-fire tube 40, thereby reducing judgment of an installation operator.

[0026] During operation of the combustor assembly 14 and the adjacent combustor assembly 32, the first end region 44 and the second end region 50 are particularly susceptible to high temperatures due to exposure to the combustor chamber 18 and the adjacent combustor chamber 34. A plurality of cooling holes 90 are formed in the first collar 80 and the second collar 82 in a region adjacent the first end region 44 and the second end region 50 for cooling purposes. It is noted that the first end region 44 and the second end region 50 are formed of smooth contours, such as circular, elliptical or the like. These smooth contours reduce any disturbance of an airflow passing through an annulus between the combustor liner 46 and the sleeve 48 and/or the air shield 49.

[0027] Referring now to FIGS. 6-9, various installation procedures of the cross-fire tube arrangement 42 are illustrated. As described above, the first end region 44 of the first portion 58 or the second end region 50 of the second portion 60 of the cross-fire tube 40 may be inserted into the central opening 84 of the first collar 80 or the second collar 82, respectively (FIG. 6). Upon contact between the anti-rotation

surface **86** and the at least one anti-rotation component **88**, the cross-fire tube **40** is self-aligned into a fixed rotational position. In the illustrated embodiment, the second portion **60** is shown in engagement with the second collar **82**. The first portion **58** is engaged with the second portion **60**, with the spring **70** sandwiched between the cross-fire tube **40** and the outer shield **72**, as well as between the first end region **44** and the second end region **50**. Engagement between the first portion **58** and the second portion **60** may take place before or after disposal of the second portion **60** with the second collar **82**. Similarly, it is to be appreciated that the first portion **58** may be engaged with the first collar **80** prior to engagement with the second portion **60**. As shown in FIG. 7, a threaded rod **98** may be engaged with either or both of the first portion **58** and the second portion **60** and extends through an aperture of the combustor assembly **14** or the adjacent combustor assembly **32** to receive a mechanical fastener **92** (FIG. 8), such as a washer and nut arrangement, for example. Such an arrangement assists in securing the cross-fire tube **40** in a fixed position.

[0028] To provide clearance for portions of the combustor assembly **14**, such as a module that is inserted into the combustor assembly **14**, the cross-fire tube **40** is moveable between a first position **94**, as shown in FIG. 2, and a second position **96** (FIG. 9). The second position **96** comprises a compressed condition of the spring **70** and the cross-fire tube **40**, such that components of the combustor assembly **14** may be inserted into the overall combustor structure. The resiliency of the spring **70** leads to extension of the cross-fire tube **40** after the components are sufficiently inserted into the combustor assembly **14**. Large distances of compression of the cross-fire tube **40** are typically required to establish necessary clearance for reliable insertion of the combustor assembly **14** components. Disposal of the spring **70** along substantially the entire length of the cross-fire tube **40** allows compression of the cross-fire tube **40** to a large degree.

[0029] As illustrated in the flow diagram of FIG. 10, and with reference to FIGS. 1-9, a method of assembling a combustor structure **100** is also provided. The gas turbine engine **10** and the cross-fire tube arrangement **42** have been previously described and specific structural components need not be described in further detail. The method of assembling a combustor structure **100** includes inserting a first portion of a cross-fire tube into a portion of a combustor assembly **102**. The first portion of the cross-fire tube is rotated to align an anti-rotation surface of the first portion with a corresponding anti-rotation feature of a first collar **104**. A second portion of the cross-fire tube is matably engaged with the first portion **106**, with the spring **70** extended from the first portion **58** to the second portion **60**. The cross-fire tube is compressed from a first position to a second position **108**, thereby providing clearance for insertion of an adjacent combustor assembly or associated components.

[0030] 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. A super-telescoping cross-fire tube comprising:

a cross-fire tube including a first portion and a second portion in mating engagement, the cross-fire tube extending from a first end region to a second end region for fluidly connecting a combustor chamber and an adjacent combustor chamber;

an outer shield spaced radially outwardly and surrounding at least a portion of the cross-fire tube; and

a spring extending from proximate the first end region to the second end region and disposed between the cross-fire tube and the outer shield, wherein the cross-fire tube is telescopically moveable between a first position and a second position.

2. The super-telescoping cross-fire tube of claim 1, further comprising a first collar operably coupled to a combustor assembly component, the first collar including at least one anti-rotation component for engaging a corresponding anti-rotation surface proximate at least one of the first end region and the second end region of the cross-fire tube.

3. The super-telescoping cross-fire tube of claim 2, wherein the at least one anti-rotation component comprises a non-planar geometry and the corresponding anti-rotation surface comprises a corresponding non-planar geometry.

4. The super-telescoping cross-fire tube of claim 2, wherein the first collar is operably coupled to the combustor assembly component proximate the first end region, wherein the first collar comprises a plurality of cooling holes for cooling the first end region.

5. The super-telescoping cross-fire tube of claim 4, further comprising a second collar operably coupled to an adjacent combustor assembly component proximate the second end region of the cross-fire tube.

6. The super-telescoping cross-fire tube of claim 2, wherein the at least one anti-rotation component comprises a plurality of conical regions, wherein the corresponding anti-rotation surface comprises a plurality of corresponding conical regions.

7. The super-telescoping cross-fire tube of claim 2, wherein the first collar is welded to the combustor assembly component.

8. The super-telescoping cross-fire tube of claim 2, wherein the combustor assembly component comprises at least one of a combustor liner, a sleeve surrounding the combustor liner, and an air shield surrounding the sleeve.

9. A combustor structure for a gas turbine engine comprising:

a combustor assembly and an adjacent combustor assembly, the combustor assembly comprising a combustor chamber, the adjacent combustor assembly comprising an adjacent combustor chamber;

a first collar operably coupled to the combustor assembly;

a cross-fire tube extending from a first end region disposed adjacent the first collar to a second end region disposed proximate the adjacent combustor assembly; and

a spring extending from proximate the first end region to the second end region and disposed between the cross-fire tube and an outer shield surrounding at least a portion of the cross-fire tube.

10. The combustor structure of claim 9, wherein the cross-fire tube comprises a first portion and a second portion in

ating engagement, the cross-fire tube telescopingly moveable between a first extended position and a second compressed position.

11. The combustor structure of claim **9**, wherein the first collar comprises at least one anti-rotation component for engaging a corresponding anti-rotation surface proximate the first end region.

12. The combustor structure of claim **11**, wherein the at least one anti-rotation component comprises a non-planar geometry and the corresponding anti-rotation surface comprises a corresponding non-planar geometry.

13. The combustor structure of claim **9**, wherein the first collar comprises a plurality of cooling holes for cooling the first end region.

14. The combustor structure of claim **9**, further comprising a second collar operably coupled to the adjacent combustor assembly proximate the second end region of the cross-fire tube.

15. The combustor structure of claim **11**, wherein the at least one anti-rotation component comprises a plurality of conical regions, wherein the corresponding anti-rotation surface comprises a plurality of corresponding conical regions.

16. The combustor structure of claim **9**, wherein the first collar is welded to the combustor assembly.

17. The combustor structure of claim **9**, wherein the first collar is welded to at least one of a combustor liner, a sleeve surrounding the combustor liner, and an air shield surrounding the sleeve.

18. A method of assembling a combustor structure comprising:

inserting a first portion of a cross-fire tube into a portion of a combustor assembly;

rotating the first portion of the cross-fire tube to align an anti-rotation surface of the first portion with a corresponding anti-rotation feature of a first collar operably coupled to the combustor assembly;

matatably engaging a second portion of the cross-fire tube with the first portion, wherein a spring is positioned from the first portion to the second portion; and

compressing the cross-fire tube from a first position to a second position providing clearance for insertion of an adjacent combustor assembly into the combustor structure.

19. The method of claim **18**, further comprising mechanically fastening the first portion to the combustor assembly.

20. The method of claim **18**, further comprising extending the cross-fire tube to the first position subsequent to insertion of the adjacent combustor assembly.

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