

[54] FLAME TUBES

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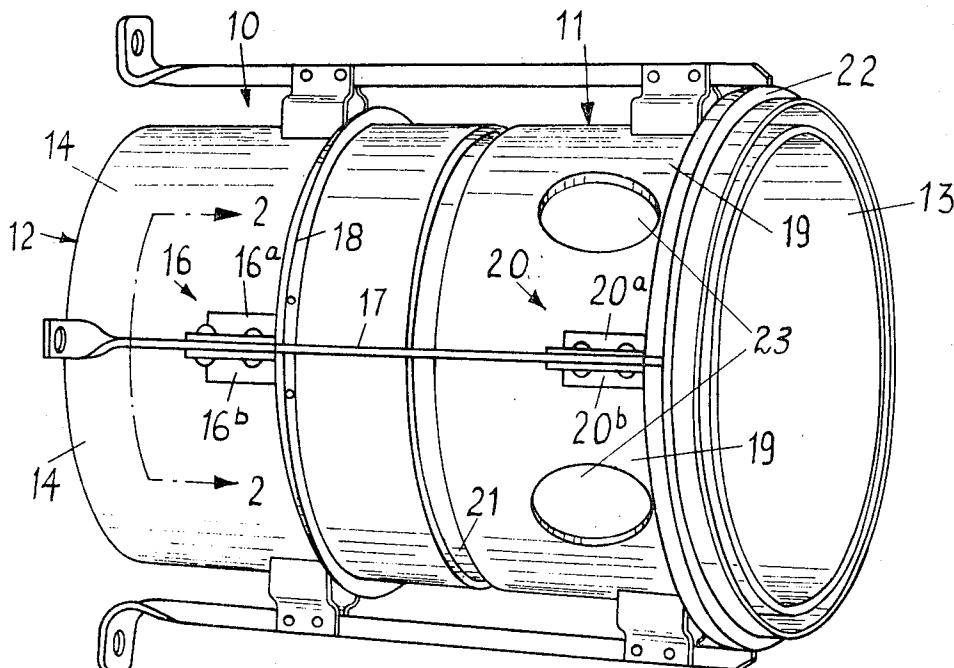
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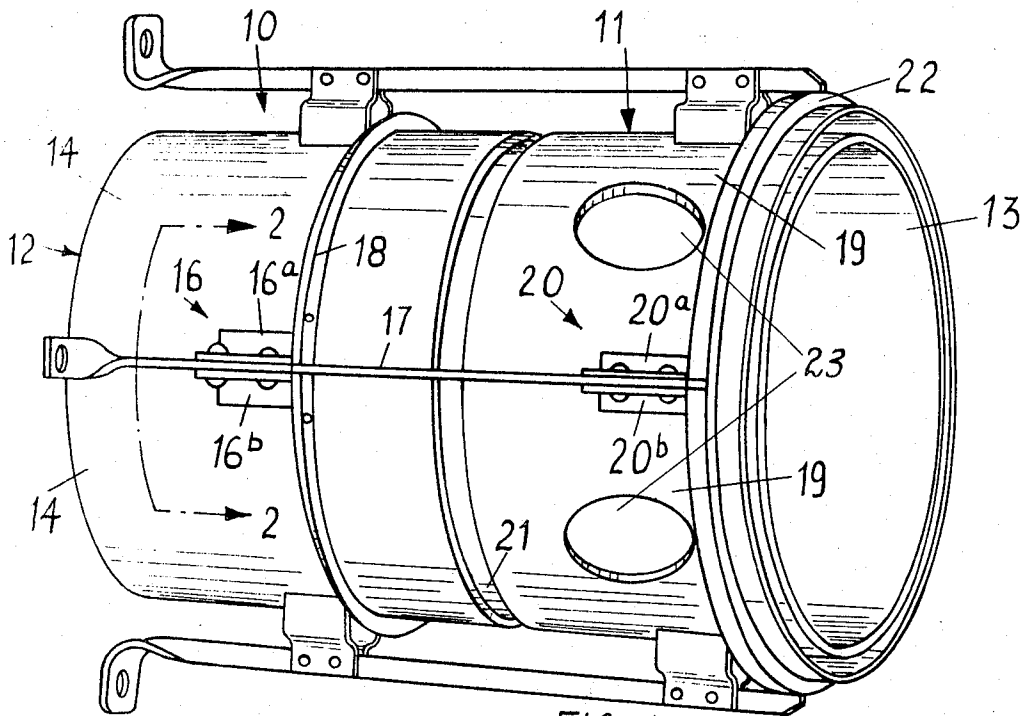
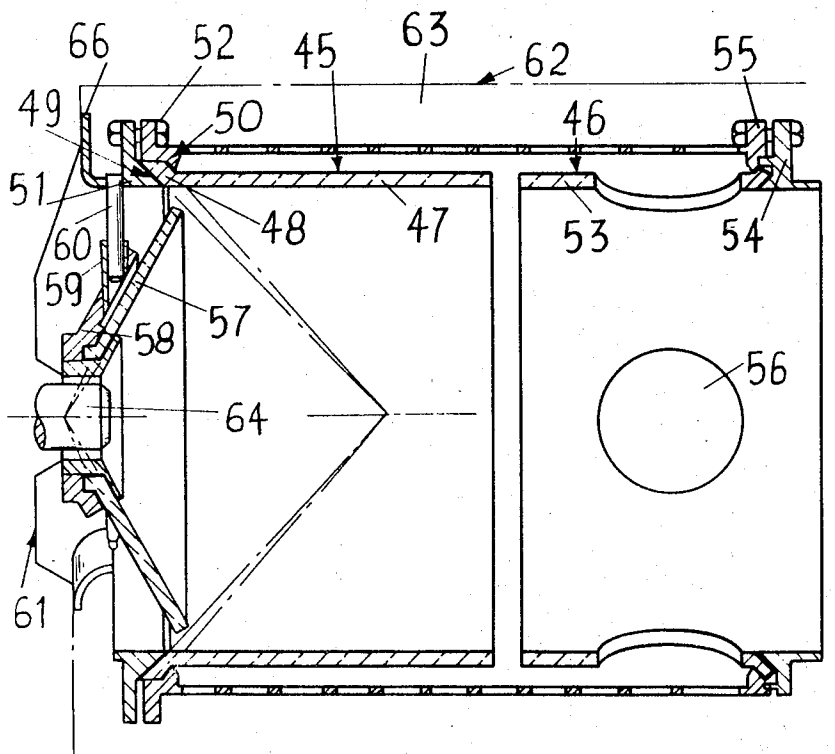
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ABSTRACT

A flame tube for a gas turbine engine includes a pair of axially aligned tube members which are open at both ends, one of the members being of ceramic material. The tube members are clamped together by means which permits differential thermal expansion between the clamping means and the tube members without imparting undue stress to the latter.

23 Claims, 4 Drawing Figures





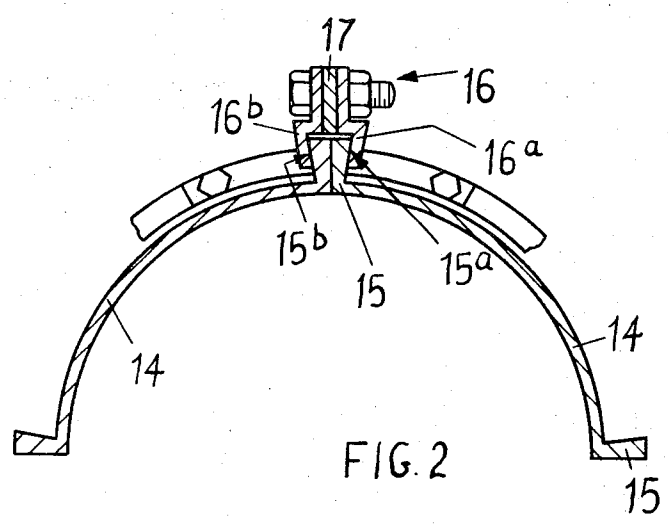


FIG. 2

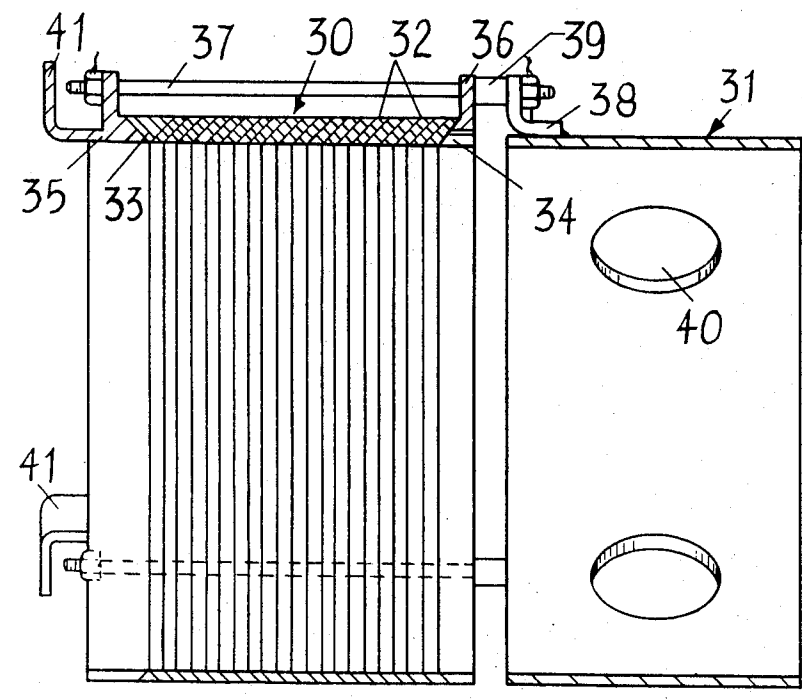


FIG. 3

FLAME TUBES

This invention relates to flame tubes for gas turbine engines and has as an object to provide a flame tube in a convenient form.

A flame tube according to the invention comprises a first tube member of ceramic material having openings at both ends, one of the said openings forming an inlet from the flame tube, a baffle within the inlet and adapted to direct air entering the inlet against the wall of the first tube member, an axially aligned second tube member spaced from the end of the first tube member remote from the said inlet and having at its end remote from the inlet an opening which forms the flame tube outlet, a plurality of passages for air in the wall of the second tube member and clamping means engaging both of the tube members to maintain them in aligned spaced relationship, the said clamping means permitting differential thermal expansion between the clamping means and the tube members without imparting undue stress to the latter.

Examples of flame tubes according to the invention will now be described with reference to the accompanying drawings in which:

FIG. 1 is a pictorial view of a flame tube,

FIG. 2 is a part section on line 2—2 through the flame tube of FIG. 1, and

FIGS. 3 and 4 are longitudinal sections through alternative forms of flame tubes.

The flame tube shown in FIGS. 1 and 2 comprises a pair of axially aligned tube members 10, 11. Openings 12, 13 at the ends of members 10, 11, respectively form an inlet and an outlet for the flame tube. The tube member 10 is formed of four identical quadrant sections 14. Each of the sections 14 has a pair of outwardly extending lugs 15 formed thereon. Adjacent pairs of lugs 15 are engaged by clamp assemblies 16 to urge the sections 14 into close contact. Clamp assemblies 16 comprise opposite handed clamp elements 16a, 16b which are secured to bars 17. Bars 17 extend parallel to the axis of the flame tube. Clamp elements 16a, 16b are also secured to a ring 18 extending around the tube member 10.

The tube member 11 is similarly formed of four identical quadrant sections 19 which are secured together by clamp assemblies 20 comprising clamp elements 20a, 20b. Clamp elements 20a, 20b are also secured to the bars 17 to maintain the tube members 10, 11 in a spaced axial relationship defining an annular opening 21 therebetween. The ends of the bars 17 adjacent the clamp assemblies 20 are secured to a ring 22 surrounding the tube member 11. The opposite ends of the bars 17 are formed with flanges by means of which the flame tube may be mounted in a supporting structure, in a manner later to be described.

The flame tube members 10, 11 are formed of a ceramic material, preferably silicon nitride, whereas the clamp assemblies 16, 20, bars 17 and rings 18, 22 are formed of metal, preferably a nimonic alloy. At the temperatures at which the flame tube operates there is a significant difference in thermal expansion between the ceramic and metal components.

As shown in FIG. 2 the faces 15a, 15b of the lugs 15 which lie remote from each other are formed to provide, in combination, a wedge-shaped configuration. The corresponding faces of the clamp elements 16a, 16b have an included angle which is identical to the in-

cluded angle of the faces 15a, 15b. A rise in temperature causes the ring 18 to expand radially to a greater extent than the tube member 10. Similarly the clamp elements 16a, 16b and the bar 17 expand transversely to a greater extent than the corresponding lugs 15. The included angle of the faces 15a, 15b is defined by the difference between the respective radial expansions and transverse expansions of the metal and ceramic parts. As a result of thermal expansion, therefore, a point on the inner face of a clamping element 16a 16b moves, with respect to the adjacent lug 15, along a path defined by the aforementioned included angle. The clamp assemblies 16 thus remain in firm engagement with the lugs 15, at the same time allowing for differential thermal expansion. The clamp assemblies 20 similarly engage lugs on the sections 19 of the tube member 11 so as to allow for differential thermal expansion.

The sections 19 are formed with holes 23 and a ceramic baffle ring (not shown) is supported within the inlet 12 in a manner later to be described.

The alternative form of flame tube shown in FIG. 3 has a first tube member 30 and a second axially aligned tube member 31, substantially as previously described. Tube member 30 includes a plurality of aligned frusto-conical ceramic rings 32. A pair of ceramic rings 33, 34, at respective ends of the tube member 30 are adapted to be engaged by metal clamp rings 35, 36. Clamp rings 35, 36 are urged towards one another by threaded rods 37 at equi-spaced locations around the circumference of the tube member 30.

The mating surfaces of the ceramic rings 33, 34 and the respective clamp rings 35, 36 are frusto-conical. The cone angles of the mating surfaces are such that differential radial expansion between the ceramic rings 32, 33, 34 and the clamp rings 35, 36 and differential axial expansion between the ceramic rings and the rods 37 allows a constant clamping force to be maintained at elevated temperatures, in a like manner to that described with reference to FIGS. 1 and 2, the apices of the cones being coincident with the axis of the rings 35, 36.

Tube member 31 is formed with lugs 38 which engage the rods 37 and is maintained in spaced relationship with respect to tube member 30 by means of sleeves 39 on the rods 37. Tube member 31 is formed with a plurality of equispaced holes 40 and a ceramic baffle (not shown) is mounted within the flame tube at the end adjacent the clamp ring 35. Clamp ring 35 carries lugs 41 by means of which the flame tube may be mounted in a supporting structure in a manner later to be described with reference to FIG. 4.

A further alternative form of flame tube is shown in FIG. 4 and has, as before, tube members 45, 46 in spaced, axially aligned relationship. Tube member 45 includes a tubular ceramic element 47 having an outwardly directed flange 48. The flange 48 is formed with a pair of co-axial frusto-conical surfaces 49, 50.

The flange 48 is engaged by a pair of metal clamping rings 51, 52 which are respectively formed with frusto-conical surfaces engaging the surfaces 49, 50. The included angles of the frusto-conical surfaces of the rings 51, 52 are identical to the included angles of the respective mating surfaces 49, 50, the apices of the cones being coincident with each other and with the axis of element 47.

The axial dimension of ring 51 within ring 52 is less than the axial dimension of ring 52 itself. During ther-

mal expansion, therefore, the clamping face of ring 52 moves away from the clamping face of ring 51. The radial expansion of rings 51, 52 is greater than that of the ceramic element 47. The included angles of the frusto-conical clamping surfaces are such that the rings 51, 52 maintain the flange 48 in clamping engagement with a constant clamping force, substantially as described with reference to FIGS. 1 to 3.

Tube member 46 has a tubular ceramic element 53 secured by clamping rings 54, 55 as previously described. Rings 52, 55 are secured together by a cylinder of expanded metal mesh, such as that commercially available under the name of "Expamet". Element 53 is formed with a plurality of equi-spaced holes 56.

A ceramic baffle 57 is mounted within the ring 51. The baffle 57 is clamped to a metal carrier 58 by an arrangement allowing for differential thermal expansion, as described above. The carrier 58 is secured to the ring 51 by means of a plurality of radially outwardly-extending tubes 59 which are slidable on inwardly extending rods 60 secured to the ring 51. Lugs 66 are secured to the ring 51 and serve to mount the flame tube on an end plate 61 which forms part of a supporting structure, shown generally at 62. The structure 62 defines an annular space 63 around the flame tube.

In any of the embodiments described a suitable packing material may be interposed between mating ceramic and metal surfaces. Such packing material is commercially available under the trade names "Fibrefax" and "Kao-Wool".

The operation of a flame tube according to the invention will be described with reference to FIG. 4, it being understood that the other embodiments described operate, in use, in a similar manner.

A fuel atomizing device 64 is mounted axially within the baffle 57. Air under pressure is supplied to the annular space 63 and passes between the baffle 57 and the element 47. Air also enters the flame tube through the gap between the first and second tube members. The airstreams co-operate to form vortices within the first tube member 45, within which vortices combustion takes place. Gases passing through the second tube member 46 are diluted by air flowing through the holes 56.

We claim:

1. A flame tube for a gas turbine engine, comprising a first tube member of ceramic material having openings at both ends, one of the said openings forming an inlet for the flame tube, a baffle within the inlet and adapted to direct air entering the inlet against the wall of the first tube member, an axially aligned second tube member spaced from the end of the first tube member remote from the said inlet and having at its end remote from the inlet an opening which forms the flame tube outlet, a plurality of passages for air in the wall of the second tube member, and clamping means engaging both of the tube members to maintain them in aligned spaced relationship, the said clamping means permitting differential thermal expansion between the clamping means and the tube members.

2. The flame tube according to claim 1 in which the first tube member comprises a plurality of arcuate sections secured together.

3. The flame tube according to claim 2 in which the first tube member comprises four substantially identical quadrant sections.

4. The flame tube according to claim 2 in which the sections have pairs of outwardly extending lugs, each lug abutting a lug on an adjacent section.

5. The flame tube according to claim 4 in which the remote surfaces of pairs of abutting lugs define a wedge shape whose apex is directed inwardly of the flame tube.

6. The flame tube according to claim 5 in which the clamping means comprises pairs of elements in clamping engagement with respective pairs of lugs, and a plurality of axially extending members respectively secured to said pairs of elements and to the second tube member.

7. The flame tube according to claim 6 in which the clamping means further includes a support ring secured to said elements and surrounding said first tube member.

8. The flame tube according to claim 6 in which the second tube member is formed of ceramic material and comprises a plurality of arcuate sections secured together by said clamping means.

9. The flame tube according to claim 8 in which the number of sections in the second tube member is the same as the number of sections in the first tube member.

10. The flame tube according to claim 8 in which the sections of the second tube member have pairs of outwardly extending lugs, each lug abutting a lug on an adjacent section.

11. The flame tube according to claim 10 in which the remote surfaces of pairs of abutting lugs define a wedge shape whose apex is directed inwardly of the flame tube.

12. The flame tube according to claim 11 in which the clamping means includes pairs of elements in clamping engagement with the respective pairs of lugs on the second tube member, and secured to the axially extending members.

13. The flame tube according to claim 11 in which the clamping means further includes a ring secured to the axially extending members and surrounding the second tube member.

14. The flame tube according to claim 1 in which the first tube member comprises a plurality of axially aligned frusto conical rings which are urged together by securing means.

15. The flame tube according to claim 14 in which the first tube member has at one end thereof a ring having a first frusto-conical surface engaging the surface of an adjacent frusto-conical ring and a second frusto conical surface whose apex is directed axially of the flame tube in the opposite direction to the apices of the said frusto-conical rings.

16. The flame tube according to claim 14 in which the securing means comprises a pair of clamp rings respectively engaging the end rings of the first tube member and means for urging the clamp rings towards one another.

17. The flame tube according to claim 16 in which the securing means forms part of the said clamping means, the means for urging the said clamp rings together comprising a plurality of rods which are also secured to the second tube member.

18. The flame tube according to claim 1 in which the first tube member has a flange formed with a pair of substantially coaxial frusto conical surfaces having apices which are substantially coincident with each other

5

and with the flame tube axis, and in which the clamping means includes first and second rings coaxial with the first tube member and having frusto conical surfaces whose included angles are substantially equal to the included angles of the respective surfaces of the flange, and means securing the rings together.

19. The flame tube according to claim 18 in which the clamping means included a substantially cylindrical perforated sheet surrounding the tube members, said sheet being secured to one of the said rings and supporting the second tube member.

20. The flame according to claim 18 in which the second tube member is formed of ceramic material and has a flange formed with a pair of substantially coaxial frusto conical surfaces having apices which are sub-

6

stantially coincident with each other and with the flame tube axis, and in which the clamping means includes third and fourth rings coaxial with the second tube member and having frusto conical surfaces whose included angles are substantially equal to the included angles of the respective surfaces of the associated flange, and means securing the third and fourth rings together.

21. The flame tube according to claim 20 in which the ceramic material is silicon nitride.

22. The flame tube according to claim 1, in which the material of the first tube member is silicon nitride.

23. The flame tube according to claim 1, in which the baffle is formed of a ceramic material.

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