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[54] **FLAME TUBE FOR A GAS TURBINE COMBUSTION EQUIPMENT**

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[51] **Int. Cl.** **F02c 7/18;** F23r 1/10

[58] **Field of Search** 60/39.65, 39.66; 431/350, 431/351, 352

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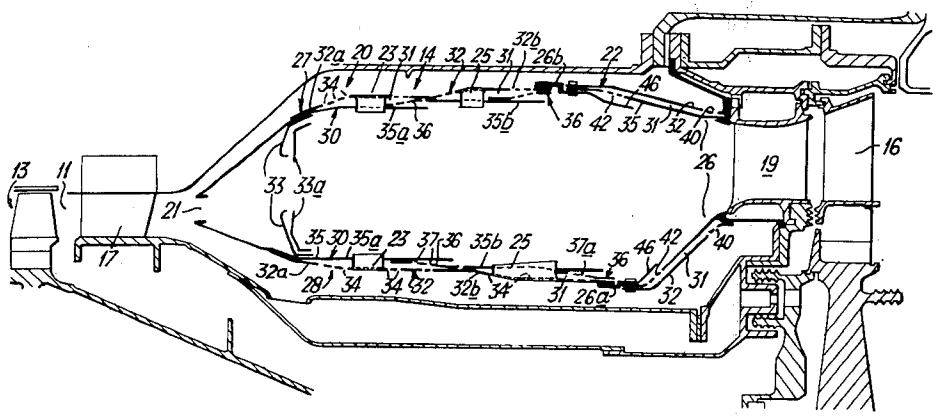
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[57] **ABSTRACT**

A flame tube for gas turbine combustion equipment includes at least one wall of double-skinned construction having internal and external skins throughout the major part of its longitudinal and peripheral extent, the internal skin comprising a plurality of axially consecutive peripherally extending sections attached to the external skin at their upstream ends only and being spaced from the external skin to define respective passages therebetween, each section except the most downstream section extending downstream to the upstream end of the next section, the external skin being apertured to direct in operation jets of cooling air onto the internal skin sections for impingement cooling thereof, said cooling air thereafter flowing through said passages.

14 Claims, 5 Drawing Figures



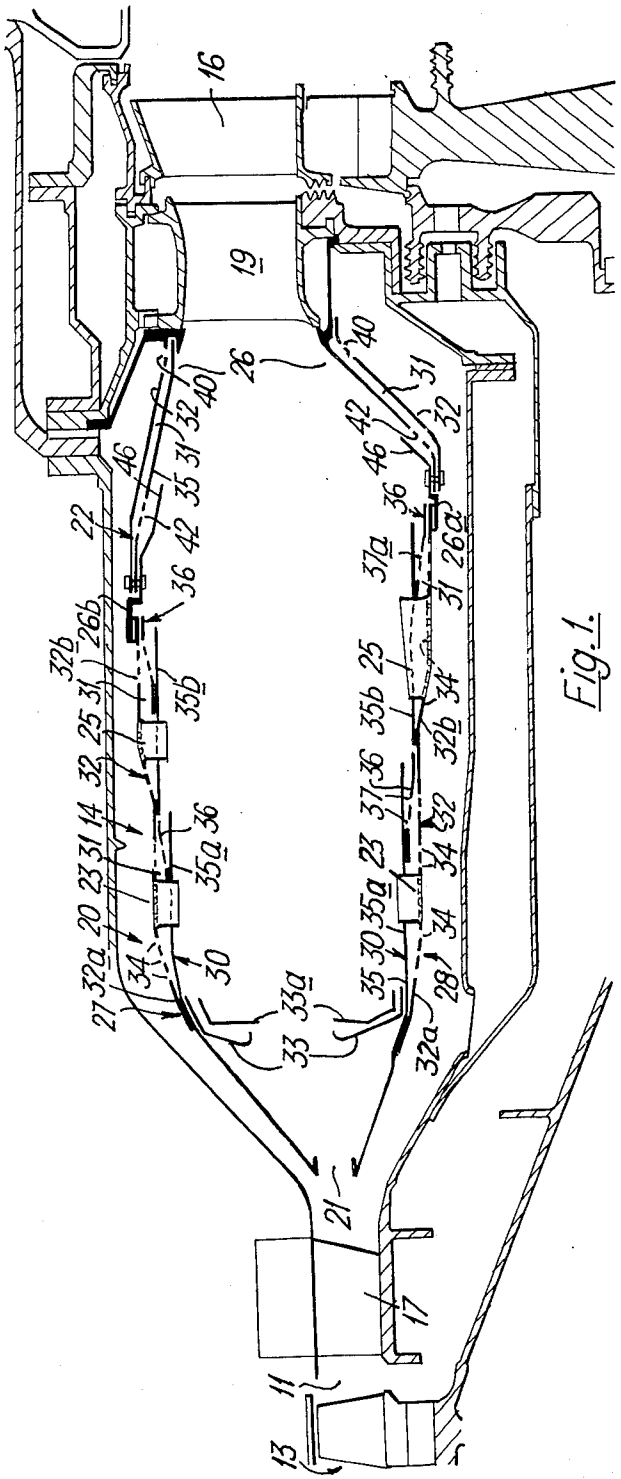


Fig. 1.

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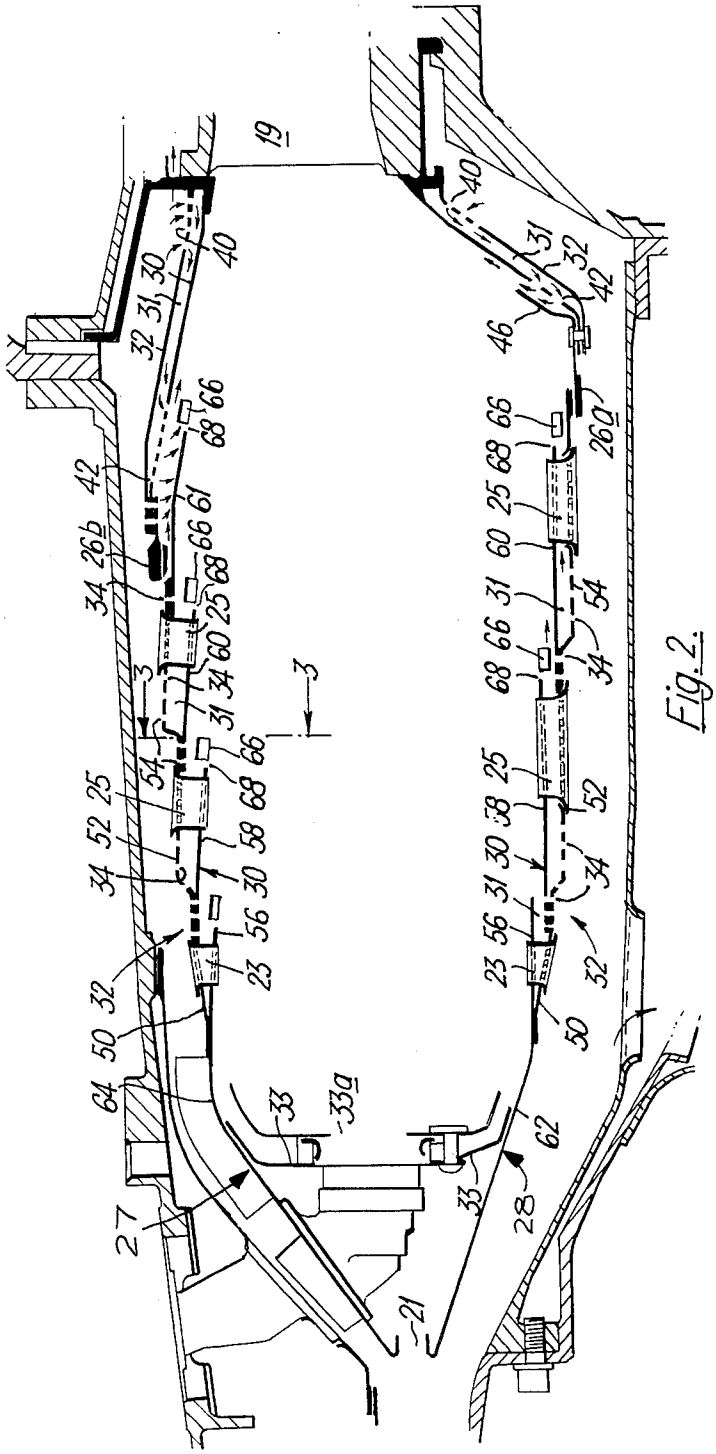


Fig. 2.

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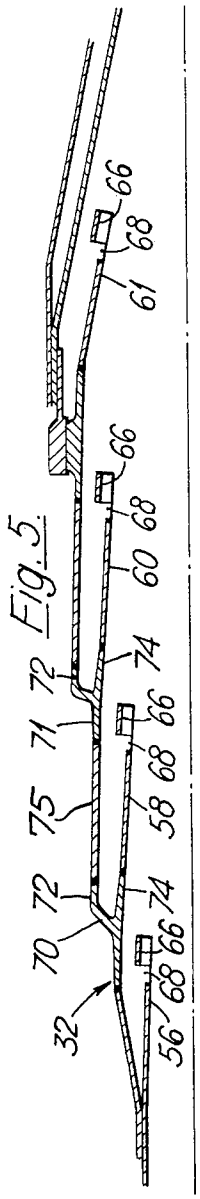


Fig. 5.

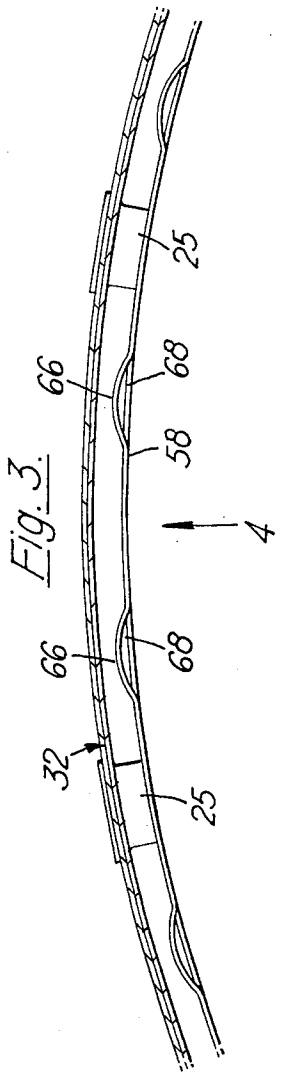


Fig. 3.

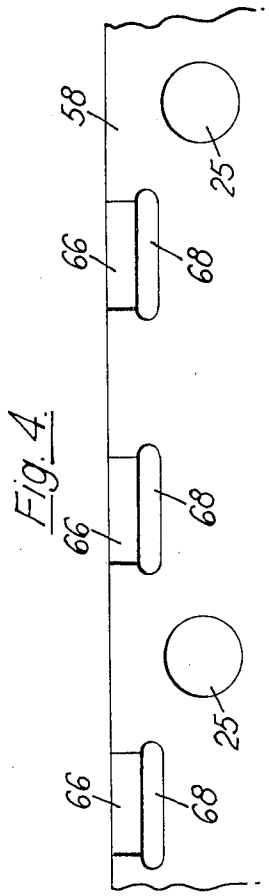


Fig. 4.

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FLAME TUBE FOR A GAS TURBINE COMBUSTION EQUIPMENT

This invention relates to flame tubes for gas turbine engine combustion equipment.

The invention is directed to any novel feature or combination of features herein described and/or shown in the drawings.

Although not so restricted thereto, the invention provides in one aspect a flame tube for gas turbine combustion equipment, the flame tube including at least one wall of double-skinned construction having internal and external skins throughout the major part of its longitudinal and peripheral extent, the internal skin comprising a plurality of axially consecutive peripherally extending sections attached to the external skin at their upstream ends only and being spaced from the external skin to define respective passages therebetween, each section except the most downstream section extending downstream to the upstream end of the next section, the external skin being apertured to direct in operation jets of cooling air onto the internal skin sections for impingement cooling thereof, said cooling air thereafter flowing through the said passages.

The passages may be open at their downstream ends to direct said flow of cooling air across the internal surface of the flame tube wall to effect film cooling thereof.

There may be spacers adapted to maintain the downstream ends of the said sections of internal skin spaced from the external skin whilst permitting sliding movement of said downstream ends relative to the external skin and relative to other sections of internal skin.

Each spacer may be peripherally substantially coextensive with a respective internal skin section by which it is carried and may be apertured to permit said flow of cooling air.

Alternatively, the spacers may comprise for each said section a plurality of angularly spaced apart protuberances on a said skin which project towards the other said skin.

The protuberances may be blisters on the sections of internal skin, there being apertures to permit the flow of cooling air in the said passage to pass both internally and externally of the blisters.

The inner skin may be made of a porous material for effusion or transpiration cooling thereof.

The external skin may comprise a plurality of axially consecutive rings a downstream ring being of diameter such that it is disposed outwardly, with respect to the interior of the flame tube, of an immediately upstream ring, the downstream ring having axially aligned therewith a said internal skin section which is attached only to the said immediately upstream ring.

Alternatively, the external skin may comprise a plurality of axially spaced rings each integrally formed and bifurcated at its downstream end to provide a respective pair of radially spaced axially extending annular flanges, the outer flange of at least one ring, relative to the interior of the flame tube, being attached to the upstream end of the next downstream ring, the other flange of the at least one ring having fixedly attached thereto the upstream end of a said internal skin section.

There may be radially extending flanges at the upstream end of the flame tube which are adapted to support fuel injector means, said flanges being provided with a downstream-facing heat shield.

The flame tube may be provided at its downstream end with a discharge nozzle of double-skinned construction having internal and external skins.

There may be apertures to permit cooling air to pass in an upstream direction between the internal and external skins of the discharge nozzle to effect cooling thereof and means to thereafter direct said cooling air downstream across the internal surface of the discharge nozzle wall to effect cooling thereof.

The most downstream internal skin section of the flame tube wall may overlap a spigot connection between the flame tube and the discharge nozzle, to shield it from the interior of the flame tube.

The invention also provides in another aspect, to which it is not restricted, a gas turbine engine having a flame tube as set forth above.

The invention will be described, merely by way of example, with reference to the accompanying drawings, wherein:

FIG. **1** is a longitudinal section of part of a gas turbine engine having a flame tube according to the invention,

FIG. **2** is a similar section through a different form of flame tube according to the invention,

FIG. **3** is a scrap section on line **3—3** of FIG. **2**,

FIG. **4** is a view on arrow **4** of FIG. **3**, and

FIG. **5** is a scrap longitudinal section of a further flame tube according to the invention.

Referring to FIG. **1**, a gas turbine engine (not shown complete) has a main flow duct **11** in which is mounted, in axial flow series, compressor means of which the downstream-most rotor stage **13** is shown, combustion equipment **14** and a turbine stage **16** which is drivingly connected with the compressor **13** by means of conventional shafting (not shown). Axially between the compressor stage **13** and the combustion equipment **14** there is provided a ring of outlet guide vanes **17**, and upstream of the turbine stage **16** there is provided a ring of inlet guide vanes **19**.

The combustion equipment **14** comprises an annular combustion chamber **20** in which is located an annular flame tube **22**. In operation, compressed air from the compressor means **13** enters the combustion chamber **20**, after having passed through the outlet guide vanes **17**, and passes into the flame tube **22** through conventional primary, secondary and tertiary air inlet chutes **21**, **23** and **25** respectively. Fuel is injected into the flame tube **22** in operation by one or more injector nozzles (not shown), and the fuel and air mixture is ignited. The products of combustion leave the flame tube **22** at its downstream and via a discharge nozzle **26** and pass to the inlet guide vanes **19** of the turbine **16**. The discharge nozzle **26** is connected to the flame tube via radially inner and outer stellite-coated spigot rings **26***a*, **26***b* which permit relative movement of the flame tube and the discharge nozzle.

During the combustion of the fuel air mixture, the flame tube walls get extremely hot, and flame tubes **22** of conventional materials have a limited life.

In order to increase the operational lifetime of a flame tube, the flame tube **22** including its discharge nozzle **26** is provided with a double-skinned construction substantially throughout its length and periphery. The annular flame tube **22** has a radially outer wall **27** and a radially inner wall **28**, each having a respective internal skin **30** and an external skin **32**.

The upstream end of each internal skin **30** is provided with a radially extending flange or flanges **33** be-

tween which may be located a fuel injector (not shown) and through which primary air may pass into the interior of the flame tube **22**. Moreover, if desired, swirl vanes may also be mounted from the flanges **33**. A downstream-facing heat shield **33***a* is provided to protect the flanges **33**, which otherwise would be exposed to high temperatures as well as the stresses involved in supporting the injectors,

It is to be noted that the double-skinned construction of the flame tube **22** extends between the radial planes of the upstream-most parts of the flanges **33** and the plane just upstream of, or substantially coplanar with, the upstream edge of the inlet guide vanes **19**.

The internal skins **30** comprise a plurality of axially consecutive portions **35** the upstream end only of each of which is attached, preferably by welding, to the respective external skins **32**. The external skins **32** each consist of two axially consecutive rings **32***a*, **32***b*, the downstream ring being of a diameter such that it is disposed outwardly with respect to the flame tube of the immediately upstream ring **32***a*. In this embodiment the rings are integrally formed with each other.

There are upstream and downstream internal skin sections **35**, referenced as **35***a*, **35***b*. The upstream sections **35***a* extend downstream to the upstream end of the downstream section **35***b*. The downstream sections **35***b* are aligned with the downstream external skin rings **32***b* and are attached to the downstream ends of the upstream rings **32***a* only.

The internal skin sections **35** are spaced from the external skin to define passages **31** therebetween. In this embodiment, the spacing is maintained at not less than a minimum amount by means of spacers **36** which are carried by and are peripherally coextensive with the internal skin sections **35**. Each spacer **36** is integrally formed with the skin section **35** by which it is carried. If the spacers were not provided, there may be a tendency for one or more of the passages **31** to be closed up if the flame tube were to distort due to a 'hot spot' therein.

The spacers **36** are not attached to the respective outer skins **32** but are fitted by an interference fit sliding joint and are provided with a coating, e.g. a plasma-sprayed stellite coating. This allows relative thermal expansion between the respective inner and outer skins, and assures good resistance to frettage-wear.

The external skins **32** are provided with a large number of apertures **34** which are adapted to direct a flow of cooling air so as to impinge on the radially outer surfaces of the internal skins **30** via the passages **31**. The apertures **34** direct jets of cooling air onto the surface of the internal skins **30** at a substantial angle thereto, thereby to effect impingement cooling of the skins **30**.

The spacers **36** are also provided with a number of apertures **37**, **37***a* to allow the cooling air to pass therethrough and into the interior of the flame tube **22** from the passages **31**. The apertures **37** direct cooling air emerging therefrom across and along the internal surface of the internal skin section **35***b* to effect film cooling thereof. Likewise, the apertures **37***a* direct cooling air across and along the internal surface of the flame tube to effect film cooling thereof.

The external skin **32** of the discharge nozzle **26** is provided at least at its downstream end with apertures **40** which permit cooling air to pass into the passages **31** between the skins of the discharge nozzle wall to effect cooling thereof. The apertures **40** are preferably such that said cooling is effected at least partially by impingement cooling of the internal skin **30**.

Further apertures **42** are provided in the upstream portions of the internal skins **30** of the discharge nozzle walls. Cooling air passes via the apertures **42** from the passages **31** in the discharge nozzle walls into the interior of the flame tube where it is directed by deflector plates **46** to pass downstream across the internal surface of the discharge nozzle walls to effect cooling, preferably film cooling thereof, additionally to cooling which may be effected by cooling air leaving the apertures **37***a*.

Referring to FIG. **2**, there is shown a different flame tube according to the invention. Parts similar to those of FIG. **1** carry the same reference numerals and will not be described again. Only the points of difference will be detailed.

The FIG. **2** embodiment differs from the FIG. **1** embodiment in that there are three axially consecutive rings **50, 52, 54** in the radially outer and radially inner walls, each having a respective internal skin section **56**, 58, 60 aligned therewith. There is also an additional internal skin section **61** at the downstream radially outer end of the flame tube.

A short length **62, 64** of both the radially outer and radially inner flame tube walls **27, 28** at the upstream ends thereof are of single-skin instead of double-skin construction, because in this version it is considered preferable to rely at this region on the external convective cooling provided by the air flowing to the secondary and tertiary air chutes **23, 25** since here there is insufficient pressure difference between the inside and the outside of the flame tube to permit efficient impingement cooling.

Instead of the peripherally coextensive spacers **36** there are provided a plurality of angularly spaced apart protuberances on the inner skin, in the form of part-cylindrical blisters **66**, best seen in FIG. **3**. The blisters all project towards the outer skin **32**, and a respective aperture **68** is provided in the internal skin sections immediately upstream of each blister to permit the flow of cooling air in the passages **31** to pass both internally and externally of the blisters **66** to film-cool them. The slots bite into the adjacent blisters so that, as can be seen from FIG. **2**, the leading faces of the blisters act as scoops.

The additional internal skin section **61** is provided instead of one of the deflector plates **46** of the FIG. **1** embodiment. The section **61** is similar to the sections **56, 58, 60,** and not only directs the cooling air issuing from the apertures **42**, but also shields the radially outer spigot ring **26***b* which at this part of the flame tube forms the radially outer external skin. A similar extra internal skin section may if desired be provided in place of the radially inner plate **46**.

FIG. **5** shows an alternative form of the flame tube according to the invention. The external skin **32**, of which the radially outer one only is shown in FIG. **5**, comprises a plurality of integrally formed (e.g. machined) rings **70, 71** each bifurcated at its downstream end to provide a respective pair of axially extending radially spaced annular flanges **72, 74**. The outer flange **72** (relative to the interior of the flame tube) of the ring **70** is butt-welded to a cylindrical section **75** which itself is butt-welded to the upstream end of the ring **71**. The flanges **74** each support an internal skin section **58, 60** etc., being butt-welded thereto.

In any of the described embodiments, the internal skins 30 of the flame tube, including those of the discharge nozzle 26, may be made of a porous material so as to allow these skins to be effusion or transpiration cooled in addition to the impingement cooling described so far. Effusion or transpiration cooling may be considered to be more efficient than merely impingement cooling because its mechanism may be separated into two parts, namely a heat exchange between the porous material and the coolant as the latter permeates through the porous material, and an insulation effect which results from the mass transfer across the boundary of the material.

Preferably, most of the pressure drop across the flame tube wall is arranged to occur across the outer skin. The consequent relatively small pressure drop across the internal skin means that pressure stresses in the hot internal skin are much reduced or minimised. This in turn results in an increase in the life of the flame tube, or alternatively it allows the operating temperature of the internal skin to be increased. It also may improve the impingement cooling efficiency.

It will be appreciated that although the invention has been described with reference to annular flame tubes, it is also applicable to the can-type of flame tube.

I claim:

1. A flame tube for gas turbine combustion equipment, the flame tube including at least one wall of double-skinned construction having internal and external skins throughout the major part of its longitudinal and peripheral extent, the internal skin comprising a plurality of axially consecutive peripherally extending sections, means attaching each section by its upstream end only to the external skin, each section being spaced from the external skin to define respective passages therebetween, each section except the most downstream section extending downstream to the upstream end of the next section, the external skin having apertures therein, said apertures directing jets of cooling air onto the internal skin sections for impingement cooling thereof, the passages accommodating a flow of said cooling air which has cooled the internal skin sections.

2. A flame tube as claimed in claim 1 wherein the internal skin sections and the external skin define openings at the downstream ends of said passages, said openings directing said flow of cooling air across the internal surface of the flame tube wall, effecting film cooling thereof.

3. A flame tube as claimed in claim 1 comprising spacers maintaining downstream ends of the said sections of internal skin spaced from the external skin while permitting sliding movement of said downstream ends relative to the external skin and relative to the other sections of internal skin.

4. A flame tube as claimed in claim 3 wherein each spacer is peripherally substantially coextensive with a respective internal skin section, said respective internal skin section supporting the spacer coextensive therewith, the spacers having apertures therein permitting said flow of cooling air.

5. A flame tube as claimed in claim 3 wherein the spacers comprise for each said section a plurality of angularly spaced apart protuberances on a said skin which project towards the other said skin.

6. A flame tube as claimed in claim 5 wherein the protuberances are blisters on the sections of internal skin, the sections of internal skin having apertures permitting the flow of cooling air in the said passage to pass both internally and externally of the blisters.

7. A flame tube as claimed in claim 1 wherein the inner skin is made of a porous material for effusion or transpiration cooling thereof.

8. A flame tube as claimed in claim 1 wherein the external skin comprises a plurality of axially consecutive rings, a downstream ring being of diameter such that it is disposed outwardly, with respect to the interior of the flame tube, of an immediately upstream ring, a said internal skin section being axially aligned with the downstream ring, and having means attaching it only to the said immediately upstream ring.

9. A flame tube as claimed in claim 1 wherein the external skin comprises a plurality of axially spaced rings each integrally formed and bifurcated at its downstream end to provide a respective pair of radially spaced axially extending annular flanges, means attaching the outer flange relative to the interior of the flame tube, of at least one ring, to the upstream end of the next downstream ring, and means attaching the other flange of the at least one ring to the upstream end of a said internal skin section.

10. A flame tube as claimed in claim 1 comprising radially extending flanges at the upstream end of the flame tube which are adapted to support fuel injector means, said flanges being provided with a downstream-facing heat shield.

11. A flame tube as claimed in claim 1 and provided at its downstream end with a discharge nozzle of double-skinned construction having internal and external skins.

12. A flame tube as claimed in claim 11 wherein the discharge nozzle has apertures to permit cooling air to pass in an upstream direction between the internal and external skins of the discharge nozzle, effecting cooling thereof, and means to thereafter direct said cooling air downstream across the internal surface of the discharge nozzle wall, effecting cooling thereof.

13. A flame tube as claimed in claim 11 comprising a spigot connection between the flame tube and the discharge nozzle, the most downstream internal skin section of the flame tube wall overlapping said connection, shielding it from the interior of the flame tube.

14. A gas turbine comprising in flow series compressor means, combustion equipment and turbine means, the combustion equipment comprising a flame tube including at least one wall of double-skinned construction having internal and external skins throughout the major part of its longitudinal and peripheral extent, the internal skin comprising a plurality of axially consecutive peripherally extending sections, means attaching each section by its upstream end only to the external skin, each section being spaced from the external skin to define respective passages therebetween, each section except the most downstream section extending downstream to the upstream end of the next section, the external skin having apertures therein, said apertures directing jets of cooling air onto the internal skin sections for impingement cooling thereof, the passages accommodating a flow of said cooling air which has cooled the internal skin sections.

* * * * *