March 10, 1959 C. G. MacKAY 2,876,622

CONNECTOR AND FLAME TUBE CONSTRUCTION INCLUDING SUCH CONNECTORS

Filed Dec. 23, 1957 2 Sheets-Sheet 1

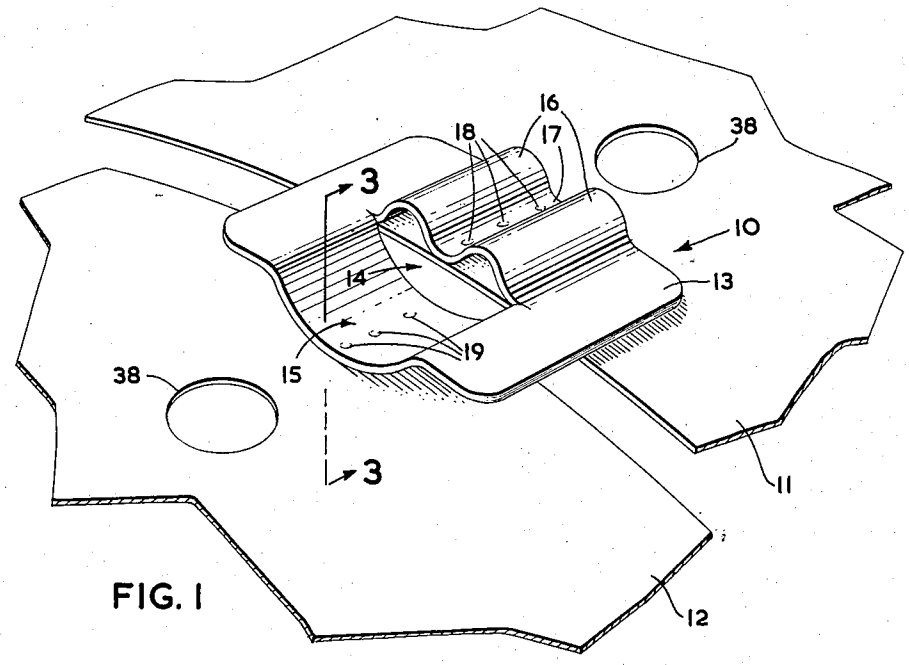


FIG. 1

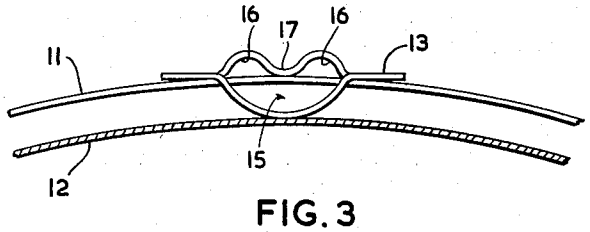


FIG. 3

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CONNECTOR AND FLAME TUBE CONSTRUCTION INCLUDING SUCH CONNECTORS

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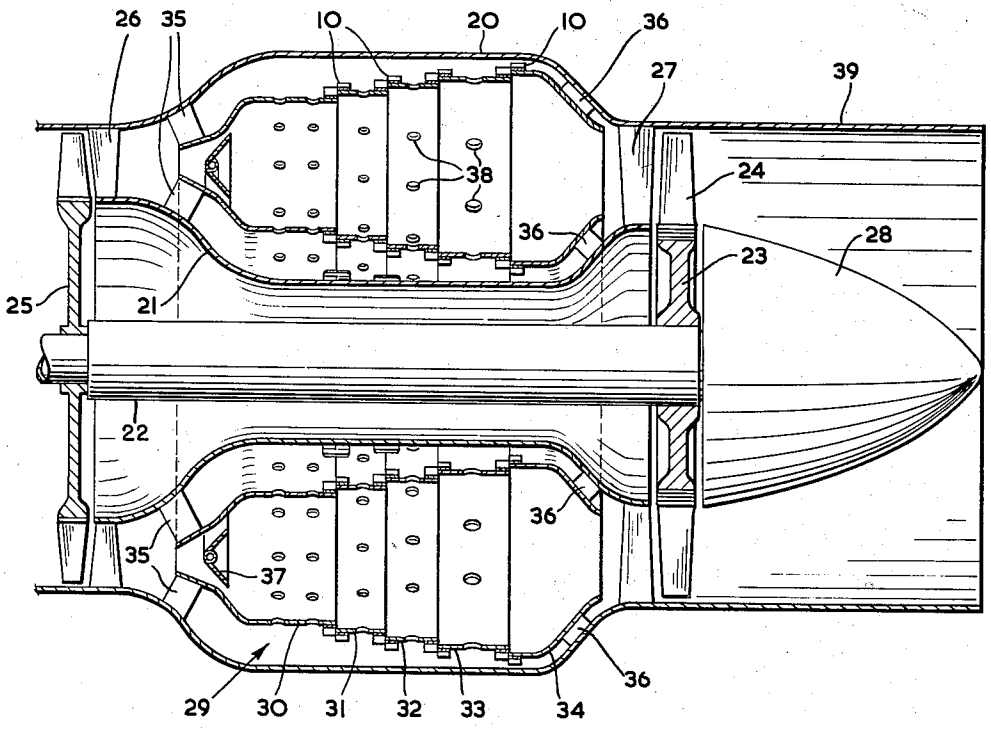


FIG. 2

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CONNECTOR AND FLAME TUBE CONSTRUCTION INCLUDING SUCH CONNECTORS

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6 Claims. (Cl. 60—39.65)

This invention relates to a connector for connecting together in spaced relationship two tubular members of different outer sizes. The connectors are particularly applicable for connecting together the wall sections of flame tubes in gas turbine engines and the invention also includes such flame tubes.

In gas turbine engines it is the usual practice to contain the combustion of the gases within one or more flame tubes situated in spaced relationship between the inner and outer casings of the engine. The walls of the flame tube or tubes are cooled by a stream of air passing through the annular space between the inner and outer engine casings and by a film of air introduced to flow internally over the walls of the flame tube or tubes, thereby affording some degree of insulation from the heat of combustion. A known form of flame tube construction consists of a plurality of circular or annular wall sections arranged coaxially, the cross-sectional area of the upstream end of any one section being greater than the area of the downstream end of the section immediately preceding it. The ends of adjacent wall sections are held in correct radial relationship by connectors spanning the annulus between the adjacent ends. Thus an annular film of air can be introduced, from the cooling air flowing outside the flame tube, to flow over the inner surface of each section. Moreover, the walls of the sections are perforated to induce a further flow of cooling air into the flame tube or tubes.

In one previously known construction of flame tube, the wall sections of the tube are secured together by a corrugated strip inserted between overlapping portions of the wall sections, the troughs and crests of the corrugated strip being secured to the outer surface of the smaller wall section and to the inner surface of the immediately downstream larger wall section, respectively. This construction suffers from the disadvantage that, under the influence of the high temperatures encountered in the combustion chamber, the corrugated strips distort and twist with the result that fractures occur at the points where the strip is secured to the wall sections.

The object of the present invention is to provide a connector for connecting together in spaced relationship two tubular members of different outer sizes in such a manner that differential radial expansion can occur between the members without setting up undue stresses in the connector such as would cause fractures in the connector or at the joints between the connector and the tubular members.

Another object of the invention is to provide a flame tube for a gas turbine engine having wall sections which are connected together by connectors which permit differential radial expansion of the sections under the high temperatures encountered without the connectors distorting to such an extent that they fracture or break away from the wall sections of the flame tube.

Yet another object of the invention is to provide a flame tube construction in which cooling air can enter

the flame tube between adjacent wall sections with the minimum of turbulence.

The invention will be described by way of example with reference to the accompanying drawings in which like reference characters designate like parts throughout the several views and in which:

Figure 1 is a perspective view of a connector according to the invention shown in position between portions of two flame tube wall sections of different outer sizes;

Figure 2 is a longitudinal diagrammatic section of a portion of a gas turbine engine showing a flame tube constructed according to the invention, and

Figure 3 is a transverse section of the structure shown in Figure 1 taken in the direction of the arrows 3—3 in Figure 1.

Referring now to the drawings, the connector is indicated generally at **10** and connects, in spaced relationship, the end portions of two flame tube wall sections **11** and **12** of different outer sizes, the section **11** being of a greater diameter than the section **12**. The connector consists of a plate **13** of generally rectangular configuration having a closed slot **14** therein parallel to one pair of edges of the plate. The term "closed slot" is used to indicate that the ends of the slot do not intersect any of the edges of the plate, the slot being contained wholly within the edges of the plate and having closed ends. The slot provides a discontinuity between two opposed portions of the plate, one of said portions being displaced from the general plane of a plate in a sense normal thereto to provide an open ended trough **15** which runs parallel to one pair of edges of the plate and is perpendicular to the length of the slot **14**. The trough **15** is delimited at one end by the slot **14** and at the other end by an edge of the plate. The other portion of the plate is displaced from the general plane of the plate in the opposite sense to the displacement of the trough **15** to provide a pair of adjacent parallel open ended troughs **16** which run parallel to the trough **15**. The troughs **16** are delimited at one end by the slot **14** and at the other end by an edge of the plate. The portion of the plate **17** between the adjacent parallel edges of the troughs **16** lies in the general plane of the plate, as seen in Figure 3.

The connector is attached to the plate **11** by spot-welds **18** situated in the portion **17**. The connector is attached to the tubular member **12** by stop-welds **19** at the bottom of the troughs **15**. The spot-welds **18** and **19** are in line and provide virtually line attachment between the connector and the tubular members **11** and **12** as will be seen from Figure 3.

Differential radial expansion of the members **11** and **12** will be accommodated, on the one hand, by distortion of the trough **15** and, on the other hand, by distortions of the troughs **16**. Since the connector is attached to each wall section along a single line the distortions of the troughs **15** and **16** will not tend to fracture the connector or to detach the connector from the tubular members since no stresses will be set up between restrained portions of the connector.

Referring now to Figure 2, there is shown a portion of a gas turbine engine having an annular flame tube according to the invention. The engine consists of an outer casing **20** and an inner casing **21** concentric therewith. A shaft **22** runs longitudinally through the engine and is supported in bearings (not shown). At one end the shaft carries a turbine rotor **23** having blades **24** while at the other end it carries a compressor, one stage of which is indicated at **25**. The last stage of blades of the compressor stator is indicated at **26** and blades of the turbine stator are indicated at **27**. A tail cone **28** is positioned at the downstream end of the shaft.

An annular combustion chamber is indicated generally

at 29 and consists of five annular wall sections each having a larger cross-sectional area than the section immediately upstream. The upstream or first wall section is indicated at 30, the second wall section at 31, the third wall section at 32, the fourth wall section at 33 and the final wall section at 34. The flame tube is held in the annular space between the inner and outer engine casings by struts 35 attached to the wall section 30 and by struts 36 attached to the wall section 34. An annular fuel injection duct and gutter 37 is arranged at the upstream end of the first wall section 30. The wall sections are connected together by connectors 10 similar to those shown in Figure 1. The connectors are attached to the wall sections, and a plurality of connectors are spaced around the periphery of adjacent wall sections and hold the wall sections in coaxial alignment as shown in Figure 2.

The walls of the flame tube are apertured as at 38 to permit the entry of air into the flame tube from the annular space between the inner and outer engine casings.

In operation the compressor 25 delivers air under pressure to the annular space between the inner and outer engine casings, and some of the air enters the flame tube and is mixed with fuel ejected from the fuel duct 37 and is ignited. The flame thus produced travels downstreamly along the flame tube and air is induced through the holes 38 and also between the spaced apart ends of the wall sections of the flame tube. Further air passes around the outside of the flame tube and the air serves to cool the flame tube and also to mix with the fuel to provide a combustible mixture. The hot gases are discharged into the turbine and hence into the jet pipe 39.

Radial expansion of the sections of the flame tube is permitted by the connectors 10 in the manner described with reference to Figure 1. The connectors, while allowing radial expansion of the wall sections, do not distort in such a manner that they tend to break away from the wall sections since the distortion of the connectors takes place in portions which are unconstrained so that no stresses are induced between the connectors and the wall sections tending to fracture the joint between the sections and the connectors.

It will be seen that the invention provides a connector for two tubular members of different outer sizes which will permit differential radial expansion between the tubular members without causing a fracture of the connectors or break away of the connectors from the tubular member. The invention also provides a flame tube for a gas turbine engine in which the stresses induced between the parts due to thermal expansion are reduced to a minimum.

It will be understood that the form of the invention herewith shown and described is a preferred example and various modifications can be carried out without departing from the spirit of the invention or the scope of the appended claims.

What I claim as my invention is:

1. A connector for connecting together in spaced relationship two tubular members of different outer sizes, the connector consisting of a plate having a closed slot therein which provides a discontinuity between two opposed portions of the plate, one of said portions being displaced from the general plane of the plate in a sense normal thereto to provide an open ended trough which is delimited at one end by the slot, and the other portion being displaced from the general plane of the plate in the opposite sense to the displacement of said first mentioned portion to provide a pair of adjacent, parallel, open ended troughs which are parallel to said first mentioned trough and are delimited at one end by the slot, the portion of the plate between the adjacent parallel edges of the pair of troughs lying in the general plane of the plate, said portion providing attachment points for one of the tubular members, and the bottom of said first mentioned trough providing attachment points for the other of the tubular members.

2. A connector for connecting together in spaced relationship two tubular members of different outer sizes, the connector consisting of a plate having a closed slot therein which provides a discontinuity between two opposed portions of the plate, one of said portions being displaced from the general plane of the plate in a sense normal thereto to provide an open ended trough which is delimited at one end by the slot and at the other end by an edge of the plate, and the other portion being displaced from the general plane of the plate in the opposite sense to a displacement of said first mentioned portion to provide a pair of adjacent, parallel, open ended troughs which are parallel to said first mentioned trough and are delimited at one end by the slot and at the other end by an edge of the plate, the portion of the plate between the adjacent parallel edges of the pair of troughs lying in the general plane of the plate, said portion providing attachment points for one of the tubular members, and the bottom of said first mentioned trough providing attachment points for the other of the tubular members.

3. A connector for connecting together in spaced relationship two tubular members of different outer sizes, the connector consisting of a generally rectangular plate having a closed slot therein parallel to one pair of sides of the plate, the slot providing a discontinuity between two opposed portions of the plate, one of said portions being displaced from the general plane of the plate in a sense normal thereto to provide an open ended trough which runs parallel to the other pair of edges of the plate, the trough being delimited at one end by the slot and at the other end by an edge of the plate, the other portion being displaced from the general plane of the plate in the opposite sense to the displacement of said first mentioned portion to provide a pair of adjacent, parallel, open ended troughs which are parallel to said first mentioned trough, the pair of troughs being delimited at one end by the slot and at the other end by an edge of the plate, the portion of the plate between the adjacent parallel edges of the pair of troughs lying in the general plane of the plate, said portion providing attachment points for one of the tubular members and the bottom of said first mentioned trough providing attachment points for the other of the tubular members.

4. A flame tube comprising a first wall section, a second wall section having an end portion adjacent to an end portion of the first wall section, the end portions having a common longitudinal axis and defining between them a space through which air can flow into the second wall section and the flame tube, and a plurality of connectors spaced apart around the peripheries of the end portions of the sections, each connector consisting of a plate having a closed slot therein which provides a discontinuity between two opposed portions of the plate, one of said portions being displaced from the general plane of the plate in a sense normal thereto to provide an open ended trough which is delimited at one end by the slot, and the other portion being displaced from the general plane of the plate in the opposite sense to the displacement of said first mentioned portion to provide a pair of adjacent, parallel, open ended troughs which are parallel to said first mentioned trough and are delimited at one end by the slot, the portion of the plate between the adjacent parallel edges of the pair of troughs lying in the general plane of the plate, said portion of each connector being secured to the outer surface of the end portion of the second wall section and the bottom of the first mentioned trough of each connector being secured to the outer surface of the end portion of the first wall section.

5. A flame tube comprising a first wall section, a second wall section having an end portion adjacent to an end portion of the first wall section, the end portions having a common longitudinal axis and defining between them a space through which air can flow into the second wall section and the flame tube, and a plurality of connectors spaced apart around the peripheries of the end

portions of the sections, each connector consisting of a plate having a closed slot therein which provides a discontinuity between two opposed portions of the plate, one of said portions being displaced from the general plane of the plate in a sense normal thereto to provide an open ended trough which runs parallel to said common longitudinal axis and which is delimited at one end by the slot, and the other portion being displaced from the general plane of the plate in the opposite sense to the displacement of said first mentioned portion to provide a pair of adjacent, parallel, open ended troughs which are parallel to said first mentioned trough and are delimited at one end by the slot, the portion of the plate between the adjacent parallel edges of the pair of troughs lying in the general plane of the plate, said portion of each connector being secured to the outer surface of the end portion of the second wall section, and the bottom of the first mentioned trough of each connector being secured to the outer surface of the end portion of the first wall section.

6. A flame tube comprising a first wall section, a second wall section having an end portion adjacent to an end portion of the first wall section, the end portions having a common longitudinal axis and defining between them a space through which air can flow into the second wall section and the flame tube, and a plurality of connectors spaced apart around the peripheries of the end portions of the sections, each connector consisting of a generally rectangular plate having a closed slot therein

parallel to one pair of edges of the plate and perpendicular to said common longitudinal axis, the slot providing a discontinuity between two opposed portions of the plate, one of said portions being displaced from the general plane of the plate in a sense normal thereto to provide an open ended trough running parallel to said common longitudinal axis, the trough being delimited at one end by the slot and at the other end by an edge of the plate, and the other portion being displaced from the general plane of the plate in the opposite sense to the displacement of said first mentioned portion to provide a pair of adjacent parallel open ended troughs which are parallel to said first mentioned trough, the pair of troughs being delimited at one end by the slot and at the other end by an edge of the plate, the portion of the plate between the adjacent parallel edges of the pair of troughs lying in the general plane of the plate, said portion of each connector being secured to the outer surface of the end portion of the second wall section, and the bottom of the first mentioned trough of each connector being secured to the outer surface of the end portion of the first wall section.

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