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Arlington et al.

[11] **3,741,678**

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[54] **COOLING AIR PROFILING STRUCTURES FOR A GAS TURBINE**

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[52] **U.S. Cl.** **415/117**, 415/175, 60/39.66

[51] **Int. Cl.** **F01d 25/12**

[58] **Field of Search** 415/117, 178, 180, 415/175; 60/39.66, 39.65

[56] **References Cited**

UNITED STATES PATENTS

3,490,747	1/1970	DeCorso et al.	415/117
3,594,109	7/1971	Penny	60/39.65

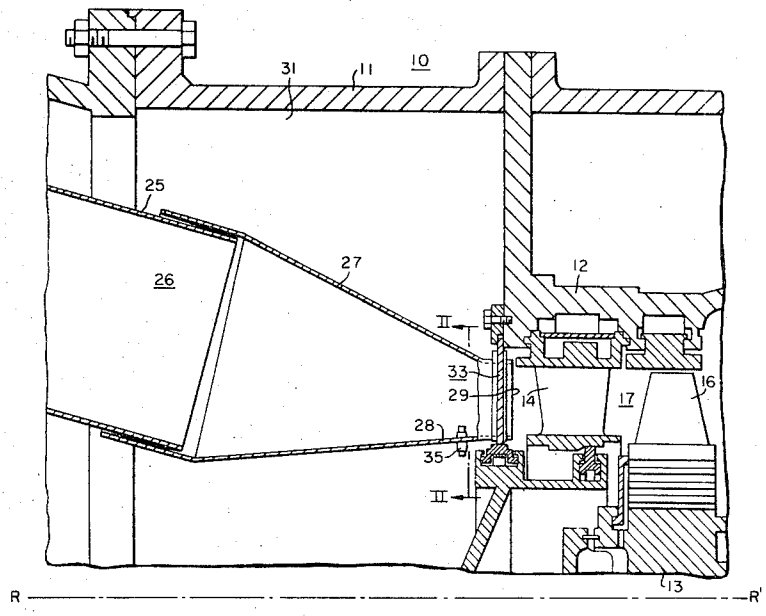
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[57] **ABSTRACT**

A gas turbine power plant having a combustion chamber including a transition portion to direct hot motive gases to the turbine rotor blades. An array of temperature profiling structures radially project into the transition portion to provide cooling fluid to profile the temperature of the hot motive gases. Each structure comprises a tubular support member having longitudinally extending slits for expansion purposes, the member projecting into an aperture in the transition portion and secured thereto. An air supply conduit is disposed within the support member and is fastened thereto outside of the combustion chamber. The profiling structures are securely positioned but allow for thermal expansion due to the relative temperature differentials among the transition portion, the support member, and the air conduit.

4 Claims, 3 Drawing Figures



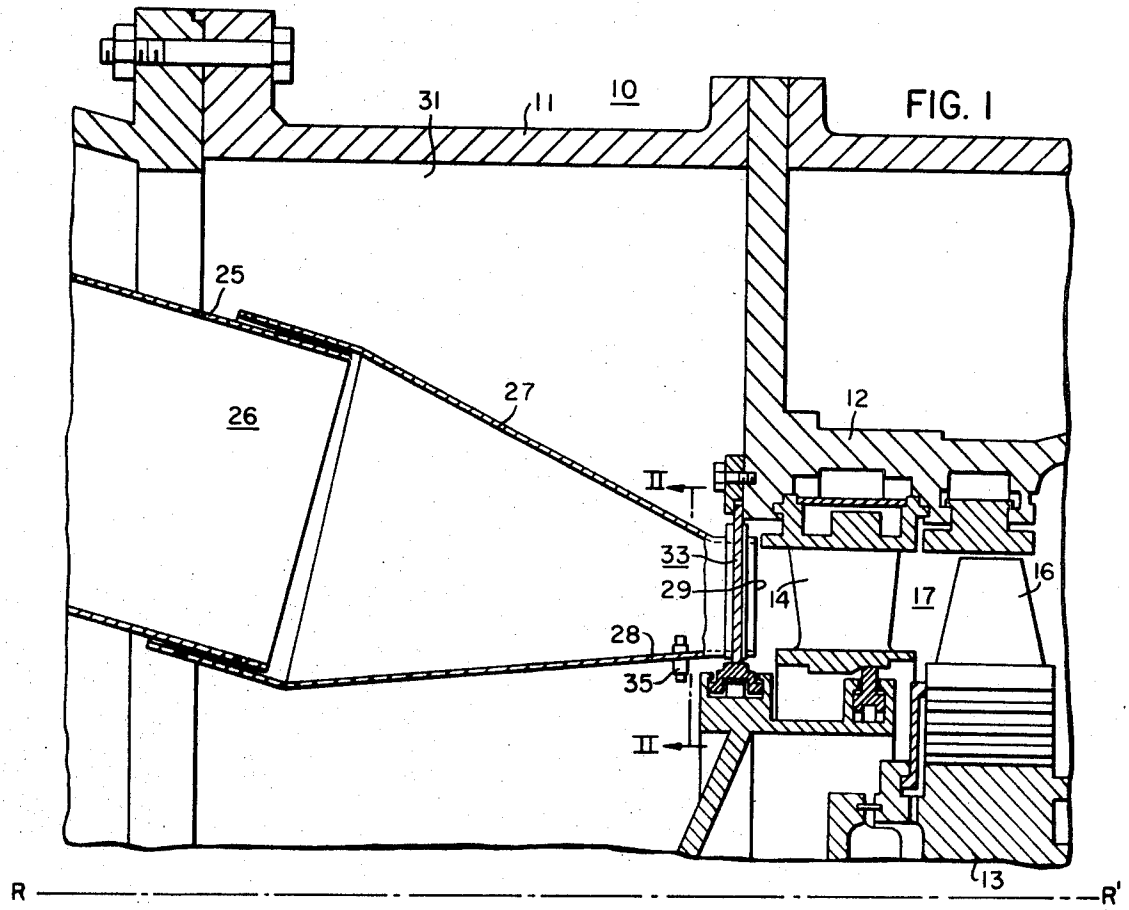


FIG. 1

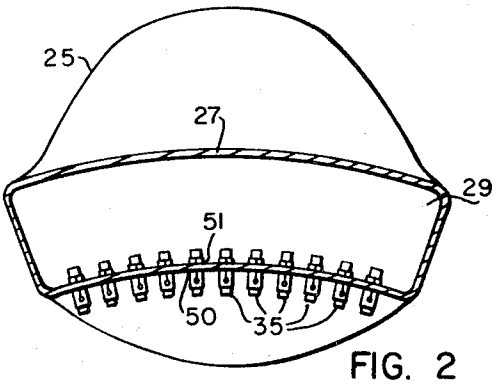


FIG. 2

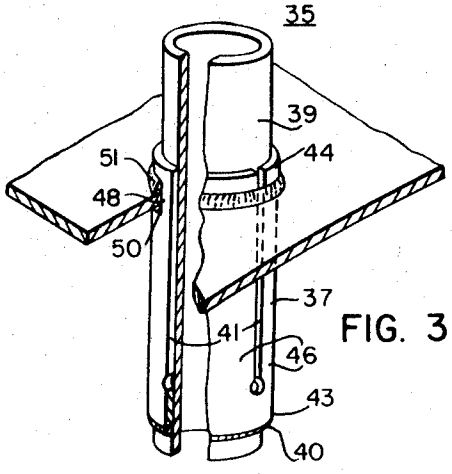


FIG. 3

COOLING AIR PROFILING STRUCTURES FOR A GAS TURBINE

BACKGROUND OF THE INVENTION

In gas turbine power plants, it is well known that the higher the operating temperatures are, the higher the thermal efficiency of the power plant. However, it is also well known that the higher the temperature, the more thermal stress to which the blades are subjected. Furthermore, the rotatable blades are subjected to a tensile stress in the radial direction due to the centrifugal force, with the stress being greatest near the root or hub portions of the blades attached to the turbine rotor. Therefore, more recently in gas turbine designs, the temperature of the working fluid is profiled by introducing cooling fluid into the transition portion of the combustion chamber, before contacting the radially inner portions or root portions of the turbine rotor blades, where the stresses are the greatest. This moderates the temperature of the fluid to produce a working fluid temperature profile having decreasing temperature values in an inward radial direction. This, in turn, permits a higher temperature working fluid to be employed against the radially outer portions of the blades, where the stresses are not as great so that more energy can be extracted toward the tips of the blades and thereby increasing turbine efficiency.

One such turbine profiling structure is shown and described in S. M. DeCorso and C. E. Carlson U.S. Pat. No. 3,490,747 patented Jan. 20, 1970, and assigned to the present assignee. In this structure, a plurality of tubular shaped nozzle structures are secured to an annular support structure disposed adjacent the downstream portion of the transition member and are in fluid communication with the compressor section of the power plant through an annular passageway. Cooling air from the compressor flows through the axial passageway into a chamber defined by the support structure and, because of the pressure differential, flows into the path of the hot combustion gases to profile the temperature thereof before contacting the turbine rotor blades. This type of profiling structure has commerically proven operable but problems have been encountered. The annular support structure is a separate and independent element of the power plant which is relatively expensive to manufacture and install, because it is a relatively heavy structure since it must support the air profiling structures, it must withstand the forces from the pressurized cooling fluid therein, and it must also withstand the high temperature differentials to which it is exposed, i.e. at one end it is exposed to the hot combustion gases, and at the other end, it is exposed to the compressor cooling air. In operation, the support structures have warped, thereby creating problems associated with maintaining the proper positioning of the profiling structures.

Another proposed solution is disclosed in J. A. Laurelli and R. S. Adelizzi copending application Ser. No. 103,331, filed Jan. 14, 1971, now abandoned and assigned to the present assignee. The profiling structure there disclosed is an annular segmented support structure having radially extending cooling tubes projecting into slots in the transition member. However, this profiling structure is also subjected to warping since no provisions are made for providing for the temperature differentials among the cooling tubes, the transition member, and the support structure. Furthermore, the support structure is also a separate element which must be constructed and inserted into the power plant at additional cost and requires relatively close tolerances.

What is desired then, is temperature profiling means for supplying cooling air to the flow path of hot combustion products, which profiling means would eliminate the heavy annular supporting structures presently used for supporting and retaining the cooling air conduits in place, and furthermore, provide means for allowing thermal expansion among the transition member, the supporting structure, and the air supply conduit to allow for increased reliability of the profiling means.

SUMMARY OF THE INVENTION

The following relates to a gas turbine power plant and more specifically to apparatus for profiling the temperature of hot combustion products flowing to the turbine.

An annular array of profiling temperature structures radially project into a transition portion of a combustion chamber to provide cooling fluid from the compressor to profile the temperature of the hot motive gases.

In accordance with the invention, each profile structure is secured directly to the transition portion of the combustion chamber and comprises a tubular support member having longitudinal slits extending to one end of the support member. That end of the support member projects into a corresponding aperture in the transition portion and is secured thereto. An air supply conduit is disposed concentrically within the support member and is fastened thereto at the opposite end, outside of the combustion chamber.

The slits in the support member allow the member to expand and contract relative to thermal conditions and the member also firmly maintains the air conduit in proper position. The annular support structures shown and described in the above cited patent and copending application are eliminated and a more economical and reliable temperature profiling structure results.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a view showing a partial longitudinal section of an axial flow gas turbine having temperature profiling structures formed in accordance with this invention;

FIG. 2 is a view taken along line II—II in FIG. 1; and

FIG. 3 is an enlarged isometric view of the profiling structure shown in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings in detail, and particularly to FIG. 1, there is shown a portion of an axial flow gas turbine **10**. The turbine **10** comprises an outer casing **11** of generally tubular shape, an inner casing **12** of tubular shape encompassed by the outer casing **11** and a rotor structure **13** rotatably supported within the inner casing **12** in any suitable manner (not shown). At least one annular row of rotating blades **16** (only one row being shown) extend radially outward from the rotor structure **13**. Cooperatively associated with the rotating blades to form a stage for motive fluid expansion is at least one annular row of stationary blades **14** (only one row being shown) which are supported within the inner casing **12**. The first stationary row of blades **14**

and the first rotating row **16** is defined as the first stage **17**.

Hot motive fluid, such as pressurized combustion gas is generated in a plurality of circumferentially disposed combustion chambers **25**, (only one being shown). The chambers **25** are of the well known canister type having cylindrical portions at the upstream end **26** and transition duct portions **27** at the downstream end **28**. The transition duct portions **27** change in cross sectional shape from circular cross section at the jointure with the cylindrical portion to generally arcuate cross section at the outlet **29** (FIGS. **1** and **2**). The outlets **29** are in a closely spaced annular relation and jointly form an annular outlet to direct the hot motive gases to the first stage **17** of the turbine in a full and continuous peripheral stream. The gases flow past the stationary blades **14** and the rotary blades **15** with resulting expansion of the gases to rotate the rotor structure **13** about its rotational axis R—R¹.

As seen in FIG. **1**, the combustion chambers **25** are disposed within the outer casing **11** in a plenum chamber **31** which is pressurized by air from a compressor (not shown). The pressurized air is directed into the combustion chambers **25** to mix with the fuel to form a combustible mixture which is burned to provide the hot motive gases. A sealing structure generally designated **33** is provided at the downstream end **28** of the transition portion **27**, between each pair of adjacent transition portions, to partially define the plenum chamber **31** and to prevent pressurized air from leading into the turbine stages. The sealing structure **33** may preferably be of the type described and shown in copending application by G. M. Mierley and T. J. Rahaim, application Ser. No. 32,926, filed Apr. 29, 1970 now U.S. Pat. No. 3,609,968.

In accordance with the principles of this invention, there is provided an annular array of temperature profiling structures **35** radially projecting into the transition portion **27** of the combustion chamber **25**. The profiling structures **35** are located at the downstream end **28** of the transition member **27** and upstream of the outlets **29**, and are disposed on the radially inner side of the member **27** (FIGS. **1** and **2**) relative to the rotational axis R—R¹ of the turbine.

Since the profiling structures **35** are substantially identical to each other, only one will be described. As best seen in FIG. **3**, the profiling structure **35** is comprised of two members. The first is a tubular support member or sleeve **37** and the second is a cooling fluid supply member or conduit **39**.

The sleeve **37** has a larger diameter than the corresponding conduit **39** and the conduit **39** is telescopically disposed within the sleeve. A plurality of slits **41** extend longitudinally on the body of the sleeve **37**. The slits **41** extend from a set longitudinal distance from one end **43** (the radially inner end) of the sleeve **37** to the outer end **44** (the radially outer end) and cut the end **44**. The slits **44** define a corresponding number of longitudinally extending fingers **46**. The fingers **46** provide the needed flexibility to allow for thermal expansions and contractions.

The conduit **39** is disposed within the larger sleeve **37** and is longer than the sleeve so that one end (the radially outer end) projects substantially beyond the sleeve. The conduit **39** is secured at the radially inner end **43** of the sleeve by any suitable means such as by welding **40**. The radially outer end of the conduit **39** is not fastened to the radially outer end **44** of the sleeve **37** but is supported thereby.

A plurality of apertures **48** are on the radially inner wall member of each transition portion **27**, one aperture **48** corresponding to each profiling structure **35**. Each profiling structure **35** is inserted radially relative to the rotational axis of the turbine **10** into the corresponding aperture **48** and into engagement with the transition portion **27**. The radially outer end **44** of the sleeve **37** is firmly fastened to the transition member **27** by any suitable means such as by welding, and as shown in FIGS. **2** and **3**, is welded on the inner and outer surfaces **50** and **51** respectively, of the radially inner portion of the transition member **27**.

In operation, combustion gases are generated in the combustion chambers **25** and are directed by the transition portions **27** to the turbine rotor structure **13**. Air from the compressor (not shown) pressurizes the plenum chamber **31** and because of the pressure differential between the plenum chamber and the combustion chamber, pressurized cooling air is forced through the temperature profiling structures **45** to profile the hot combustion gases before they reach the turbine blades **14**, and **16** to provide a more effective extraction of energy, as previously explained.

During the initial turbine start up period, the conduit **39** extending radially into the hot gaseous flow path heats up more quickly than the wall of the combustion chamber **25**. Therefore, during this transient condition, the conduit **39** thermally expands more rapidly than the transition member **27**. In the circumferential direction, conduit **39** grows larger. The fingers **46** of the support member **37** can expand circumferentially because of the slits **41** and therefore the energy due to the circumferential expansion of the conduit **39** is substantially transferred to the support structure **37** and dissipated. The structure **37** therefore exerts no thermal stress on the welds **50** and **51** and no rupturing of the welds **50** and **51** occurs.

In the normal operating condition, or the stable condition, the transition portion **27** is substantially hotter than the temperature profiling structure **35**, since the relatively cool air is flowing through the supply conduit **39**, convectively cooling it (FIG. **3**). Therefore, the transition member has greater thermal expansion than the respective conduit **39**. Since the support structure or sleeve **37** is welded to the transition member **27**, it expands circumferentially therewith, due to the flexibility in the fingers **46**, thereby leaving a small annular gap between the conduit **39** and the support member **37** at the radially outer end **44**. However, the conduit **39** is secured to the support member **37** at the radially inner end **43** thereof, which is outside of the combustion chamber **26** at a sufficient radial distance so that the radially inner end of both the conduit and the support structure are substantially at the same temperature. The support member **37** expands longitudinally in a radially inner direction and conduit **39** expands longitudinally in a radially outer direction so that neither member **37** nor conduit **39** is subject to thermal stress. Therefore, there is no thermal stress on the weld **40** at the radially inner end of the profiling structure **35** and furthermore, the structure is still properly maintained in its profiling position relative to the combustion chamber **25**, since the longitudinal expansion of the support member **37** substantially cancels the opposite expansion of the conduit **39**.

These profiling structures **35** provide substantial advantages over present profiling structures wherein relatively heavy annular support structures are used to support the plurality of profiling structures. Eliminating the support structures provides for substantial economic advantages in the saving of materials, the time for erection, and the associated decrease in the turbine structure necessary to support the heavy annular structure. Furthermore, means are provided for the non-uniform thermal expansion among the transition member, the support member, and the conduit so that ruptures due to thermal stress and strains are eliminated.

Though the invention has been described with a certain degree of particularity, modifications are possible without departing from the spirit and scope of the invention. For example, the profiling structures **35** may be inserted to extend to various radial heights and may be inclined at various angles relative to the combustion chamber **25**. Furthermore, although the profiling structures **35** are shown inserted in the radially inner wall of the transition member **27** at the downstream end **28** thereof, the invention is not limited thereto.

I claim as my invention:

1. In a gas turbine power plant, having a bladed rotor portion and a combustion chamber where hot products of combustion are formed and directed to the rotor portion to motivate the same, at least one temperature profiling structure for directing cooling fluid into the path of the combustion products, said profiling structure comprising:

a cooling fluid conduit;

means for supporting said conduit relative to said combustion chamber;

said profiling structure extending into said combustion chamber;

means providing for relative thermal expansion among said combustion chamber, said supporting member, and said conduit;

said supporting means secured to said conduit and said combustion chamber and comprising a tubular sleeve member encompassing the cooling fluid conduit;

and said expansion means comprising a plurality of longitudinally extending slits along the sleeve member;

said slits defining a plurality of longitudinally extending fingers;

said fingers being flexible to allow for relative thermal expansion.

2. In a gas turbine power plant, having a bladed rotor portion and a combustion chamber where hot products of combustion are formed and directed to the rotor portion to motivate the same, at least one temperature profiling structure for directing cooling fluid into the path of the combustion products, said profiling structure comprising:

a cooling fluid conduit;

means for supporting said conduit relative to said combustion chamber;

said supporting means secured to said conduit and said combustion chamber;

said profiling structure extending radially into said combustion chamber;

means providing for relative thermal expansion among said combustion chamber, said supporting member, and said conduit;

the support means comprising a tubular support member encompassing the cooling fluid conduit;

the radially inner end of said support member being secured to the radially inner end of the conduit;

the expansion means including a plurality of slots extending longitudinally along the support member and disposed in a radial direction;

said slots extending to the radially outer end of said support member;

said slots thereby defining a plurality of longitudinally extending flexible finger structures;

and said radially outer end of said support member being secured to the inner wall of the combustion chamber.

3. In an axial flow elastic fluid utilizing machine, said machine having a turbine portion and a combustion portion, said combustion portion having an outer wall structure partially defining a pressurized plenum chamber, an annular array of combustion chambers equally spaced from each other and from the rotational axis of the machine disposed within said plenum chamber, said combustion chambers each having a transition portion defining a flow path to supply hot products of combustion to said turbine portion, a plurality of temperature profiling structures for directing cooling fluid from within said plenum chamber into the path of the combustion products within the transition portion, said profiling structure comprising:

a tubular cooling fluid conduit radially extending into an inner wall of said transition member;

a large diameter tubular sleeve member encompassing said conduit for support thereof,

said conduit and sleeve member being fastened together at their radially inner ends,

the radially outer end of said sleeve member being securely fastened to the inner wall of the transition member,

each of said sleeve members being free to expand in a radially inward direction and each of said conduit members being free to expand in a radially outer direction so that the expansions tend to negate each other resulting in said profiling structures remaining substantially in the same radial positions.

4. The structure recited in claim **3** wherein:

a plurality of longitudinally slots extending along the sleeve member to the radially outer end of said sleeve member,

said slots thereby defining a plurality of flexible finger structures,

said finger structures providing for relative thermal expansion among said transition portion, said sleeve member, and said cooling fluid conduit in a circumferential direction.

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