

[54] **GAS TURBINE TEMPERATURE PROFILING STRUCTURE**

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[51] Int. Cl. F02c 3/14

[58] Field of Search 60/39.74 R, 39.6 G; 239/423, 424, 560, 561

[56] **References Cited**

UNITED STATES PATENTS

3,306,333	2/1967	Mock	60/39.74
3,630,024	12/1971	Hopkins	60/39.74
3,490,747	1/1970	DeCorso et al.	60/39.66
2,992,531	7/1961	Hershey	60/39.74
2,933,259	4/1960	Raskin	239/423

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[57] **ABSTRACT**

An axial flow gas turbine having a structure including

a fuel nozzle for providing any desired turbine inlet temperature profile according to the mechanical stress on the rotating turbine blades. The fuel nozzle may be a combined multiple fuel gas and liquid type or a single fuel type, an important feature of both being the provision of fuel injection asymmetrically into the combustion chamber to establish a desired ignited fuel temperature pattern therein which continues down to the turbine inlet. This asymmetrical fuel supply into the combustion chamber is obtained by providing a number or size of fuel jets according to the temperature desired; for example, to provide a temperature gradient decreasing in an inward turbine radial direction through the combustor to correspond to the desired turbine blade inlet temperature profile. The angular jet direction also may be varied for different parts of the fuel injection pattern to obtain a further spatial control of the fuel injection distribution into the combustor. These fuel distribution control variables may be used singly or in any combination, and the same or different ones may be used for the gas and liquid jets in multiple fuel nozzles. In addition, a further modification of the intake temperature profile may be obtained by providing relatively cool jets of gaseous fluid through spaced orifices in the radially inner sides of the transition passages which direct the high temperature working gas to the turbine blades.

18 Claims, 7 Drawing Figures

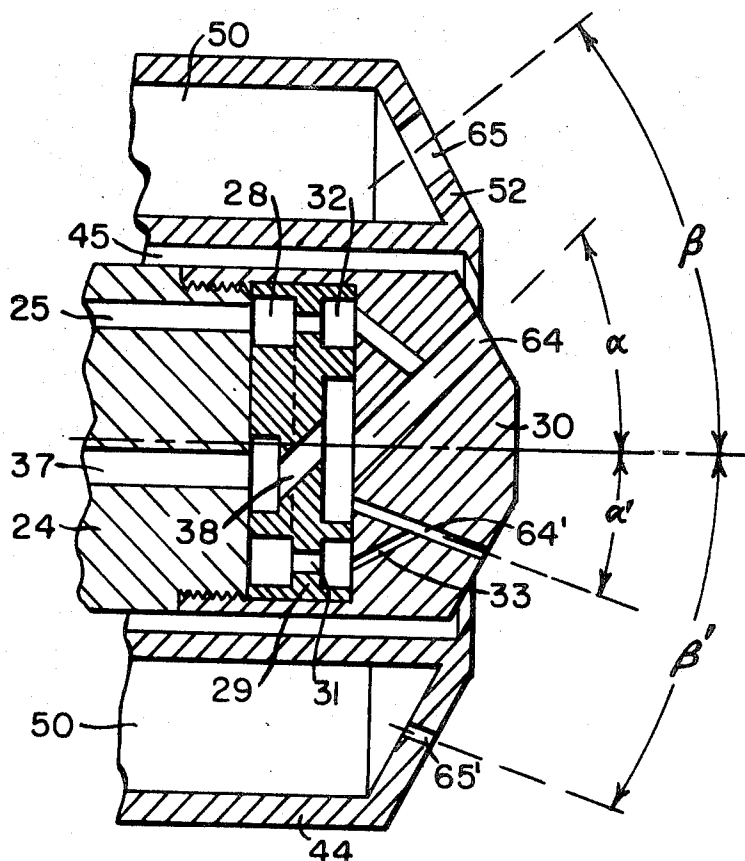
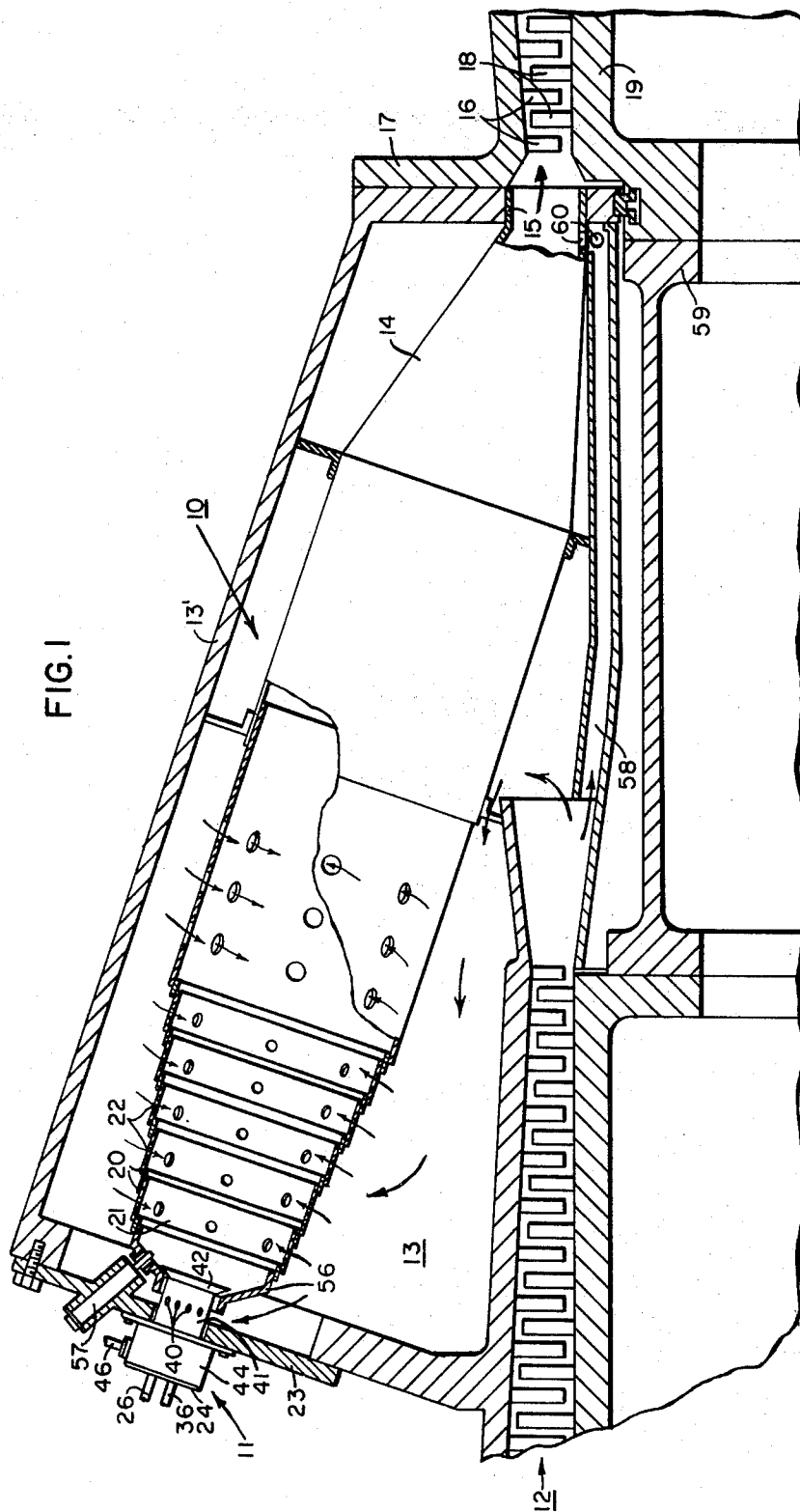


FIG. 1



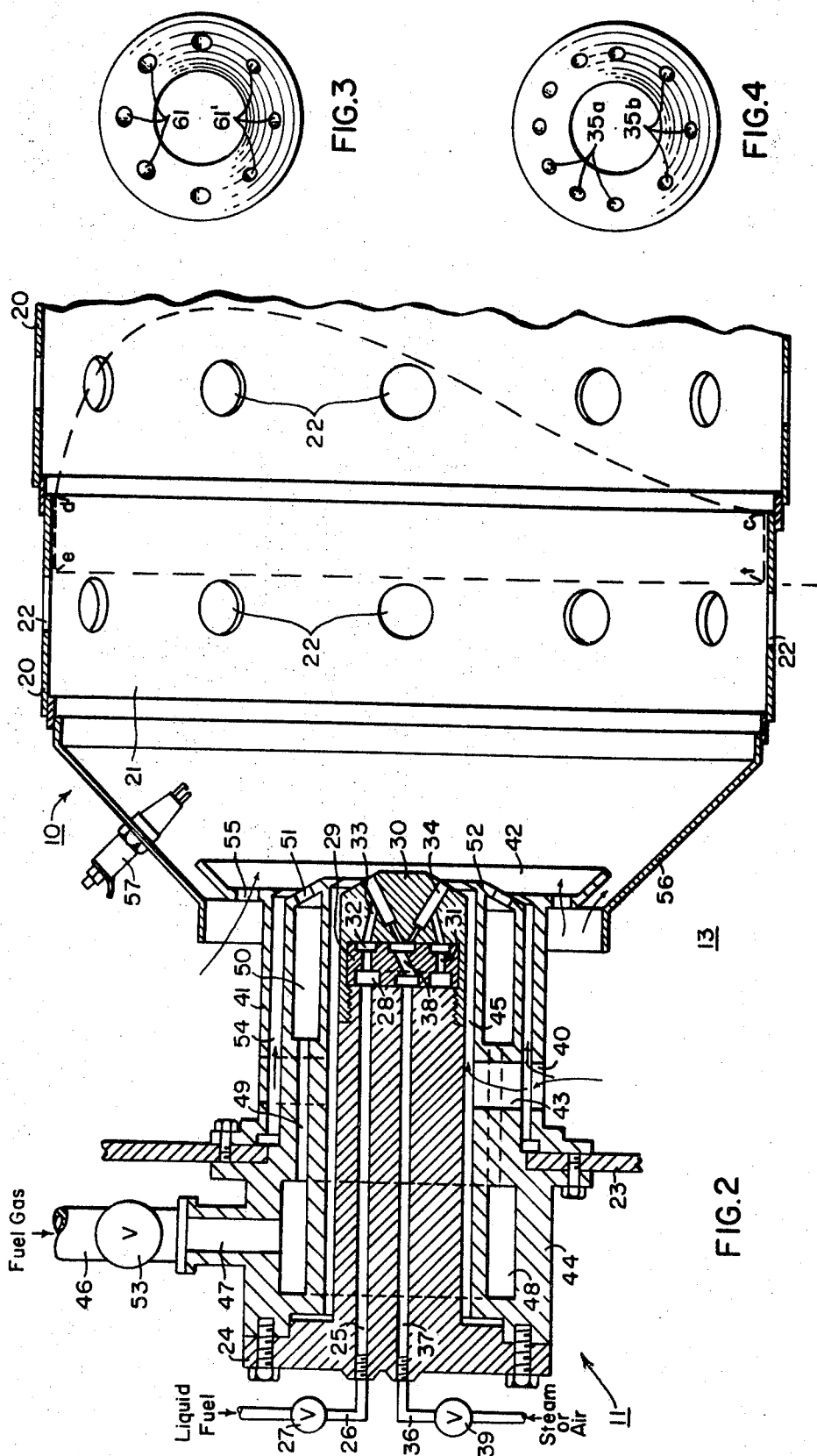


FIG. 2

FIG. 3

FIG. 4

FIG.5

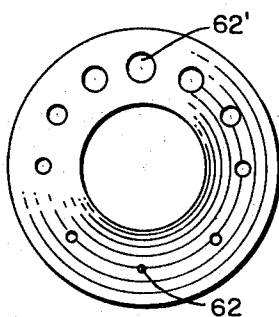


FIG.6

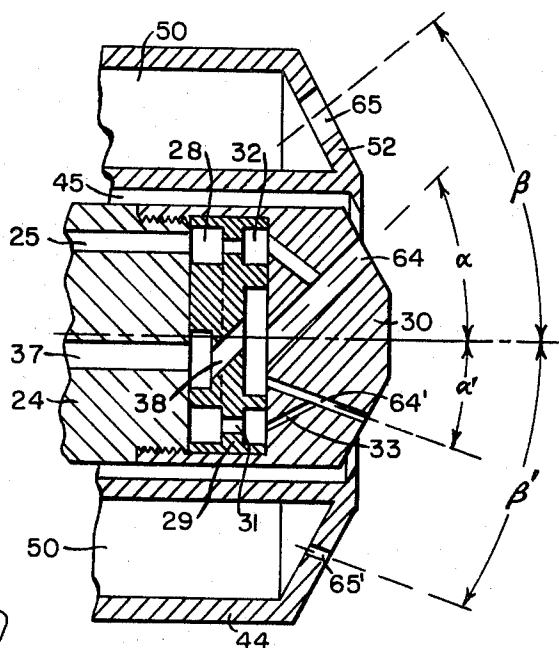
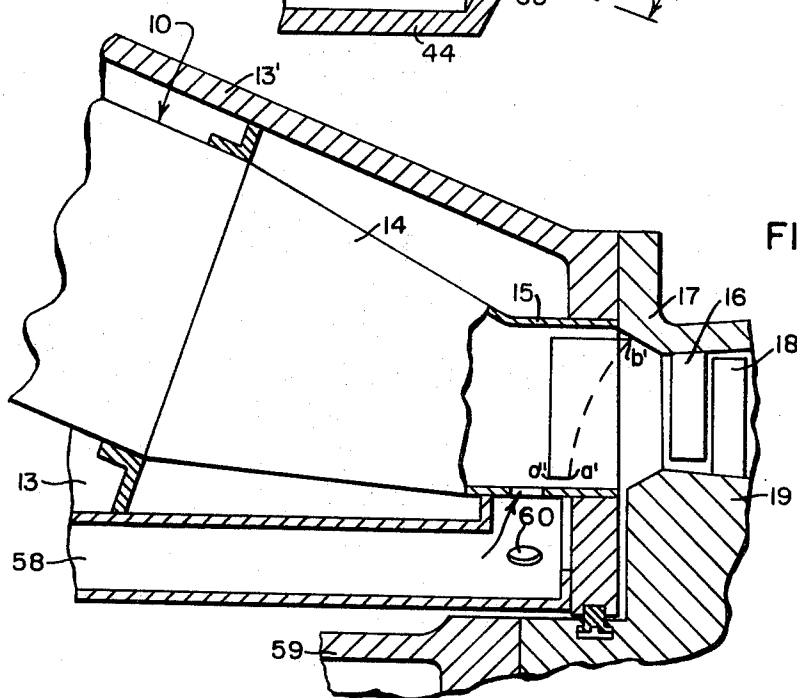


FIG.7



GAS TURBINE TEMPERATURE PROFILING STRUCTURE

BACKGROUND OF THE INVENTION

1. Field of the invention

The present invention relates to improvements in turbine operating with high temperature fluids, and particularly to an arrangement for profiling the temperature of the fluid in accordance with the mechanical stress occurring on rotating blades of the turbine.

2. Prior Art

It is known that higher initial operating temperatures in a turbine, such as an axial flow gas turbine, will provide higher thermal efficiency and specific power output. It is also known that the allowable stress to which the blades can be subjected for a given blade life decreases with increasing temperatures. Thus the main limiting factor in raising gas turbine operating temperatures, and thereby raising turbine efficiency and power output, is the physical capability of the rotating blades, the blades being highly stressed during turbine operation.

Rotating turbine blades are usually made individually and attached to the rim of a turbine wheel so that they extend radially outwardly. On rotation, the blades are subjected to a tensile stress in a radial direction due to the centrifugal force thereon which is a function of the weight of the blade. This stress is greatest near the root or hub portion of the blade where it is attached to the turbine wheel, and the stress decreases outwardly to the tip of the blade, reaching zero at the blade tip.

In most prior gas turbine designs, the temperature of the working gas flow is generally uniform along the radial height of the turbine blades. Since the root portion of the blade is stressed the greatest, and since an essentially uniform gas temperature flow sets the allowable stress for a particular blade and blade material, the root portion stress at a specified temperature is generally taken as the reference point in fixing the temperature at which the turbine blades are designed to operate for an efficient use of the energy from the gas flow. This is so, even though the outer radial portion of the blades can effectively handle higher temperatures because of the lower stresses thereon.

This prior approach in designing gas turbines is inherently wasteful of the potential capabilities of the outer, lesser stressed portions of the rotating blades to withstand higher temperatures and thereby increase the efficiency and power output of the turbine. U.S. Pat. No. 3,490,747—DeCorso and Carlson, illustrates one type of improved arrangement for improving the intake gas temperature profile for increasing the efficiency of this type turbine.

SUMMARY OF THE INVENTION

According to the present invention, a gas turbine inlet temperature profile may be obtained having any desired shape, the particular shape corresponding to the mechanical stress occurring in a particular set of rotating turbine blades. This is attained by providing a fuel nozzle which supplies the heat producing materials to the combustor according to a predetermined distribution pattern which approximates the asymmetrical temperature profile to be supplied to the turbine blade intake. Various factors are disclosed for obtaining the desired combustor fuel intake pattern; such as, a predetermined angular liquid fuel spray orifice spacing ar-

angement, a predetermined spray orifice size arrangement, a predetermined relative spray orifice supply passage angular direction for forming the spray pattern, combination of these features, use of a multiple fuel supply including any of the foregoing liquid fuel spray features combined with any fuel gas supply utilizing any of the liquid spray features to control the fuel gas pattern to provide the desired temperature profile, and use of asymmetrical nozzle combustor sweep air supply for efficiently burning the fuel to provide the desired profile. The final turbine blade intake temperature profile may be further modified to obtain the desired profile by directing a relatively cool or lower temperature gaseous fluid, such as air, through suitably spaced orifices in the radially inner sides of transition passage members which direct the high temperature working gas to the turbine blades from the combustor. The cooler gas moderates the working gas temperature further to assure the flow of the cooler gas past the radially inner root portions of the rotating blades where the stresses are the highest and the flow of the highest temperature gas over the radially outer tips of the rotating blades, where the centrifugal blade stresses are the lowest. This provides for the most efficient use of the blade structure by permitting the operation of the rotating blades at a more uniform stress and at the maximum practical operable stress throughout the blade rather than at a stress limited solely by the blade root stress. This latter feature of cool gaseous fluid supply to the transition passage to the turbine blade intake can utilize cool gas jets in connection with the illustrated orifices, such as the jet structures disclosed in U.S. Pat. No. 3,490,747—DeCorso and Carlson, where the refinements of such jets may be of additional use in providing the desired intake temperature profile.

BRIEF DESCRIPTION OF THE FIGURES OF THE DRAWINGS

In the drawings:

FIG. 1 is a longitudinal sectional view of the upper half of a gas turbine provided with a combustion apparatus incorporating the present invention;

FIG. 2 is a longitudinal sectional view of part of the gas turbine combustion chamber shown in FIG. 1, including a fuel nozzle incorporating an embodiment of the present invention;

FIG. 3 is an end view of the liquid fuel spray forming portion of a nozzle such as that shown in FIG. 2;

FIG. 4 is an end view similar to FIG. 2, illustrating another embodiment of the end of the liquid fuel spray forming portion thereof;

FIG. 5 is an end view similar to FIGS. 3 and 4, illustrating a further embodiment of the fluid spray forming portion of the nozzle;

FIG. 6 is a fragmentary axial sectional view of yet another embodiment of the nozzle, illustrating variations in the fuel and air nozzle orifice supply passages; and

FIG. 7 is a longitudinal sectional view of a part of an axial flow gas turbine showing an embodiment of a further temperature profiling means according to this invention for use with nozzles of the types shown in FIGS. 2-6.

DETAILED DESCRIPTION OF THE INVENTION

Referring to the drawings, the upstream end portion of a combustion chamber 10 of a gas turbine is shown in longitudinal section in FIG. 2, for a turbine of the

type shown in section in FIG. 1, provided with a multiple fuel nozzle 11 incorporating one embodiment of an improved nozzle according to the present invention. The illustrated gas turbine is of the axial flow type having the usual multi-stage axial flow compressor 12 for supplying air under pressure to the combustion apparatus through a plenum chamber 13, partially defined by wall structure 13', FIGS. 1 and 7, of a turbine housing in which a plurality of combustion chambers or combustors 10 are arranged in conventional angularly spaced relation around the longitudinal axis of the turbine, such as is illustrated in U.S. Pat. No. 3,169,367—Hussey. The hot gases from the combustion chambers 10 are fed to the turbine through a plurality of circumferentially spaced transition members 14, FIG. 7, of the type disclosed in U.S. Pat. No. 3,490,747—DeCorso et al., each combustion chamber having its own transition member. The transition member has an end portion 15 axially spaced from and leading to an annular group of circumferentially spaced stationary blades 16 mounted on a stationary turbine housing 17. Immediately downstream of the stationary blades 16 are a corresponding number of rotor blades 18 suitably mounted in an annular array on the periphery of a rotor wheel 19, alternately longitudinally spaced between sets of the stationary blades.

The transition members 14 direct the flow of hot gases from the combustion chambers 10 to the turbine blades 16 and 18. As previously explained, the rotating blades 18 are subjected to tensile stress which is greatest at the roots, where they are attached to the turbine wheel 19, and decreases outwardly to the tips of the blades. Since the allowable safe operating stress on the rotating blades 18 for efficient blade life, for blades of a particular material and design, varies according to the turbine power output, which varies according to the initial gas temperature to the blades, the most efficient use of the blades would be attained by varying the initial input gas temperature profile inversely to the centrifugal force stress profile thereof.

According to this invention, a close approximation to the desired hot gas temperature profile can be attained in the combustion chamber by controlling the amount and direction of the combustion materials supplied into the combustor. This combustor hot gas temperature profile may be represented by the curve $t-c-d-e$, superimposed on the combustor shown in FIG. 2, illustrating the average diametrical temperature across the combustor, wherein the abscissas, reading from t as zero on the curve, represent the average temperatures across the combustor on a diameter thereof extending outwardly from any point t in the combustor along a longitudinal line joining the inner peripheral points thereof nearest to the longitudinal axis of the turbine, and the ordinates $t-e$ represent the points along the diameter as shown. The burning and burned materials then pass longitudinally from the fuel supply end of the combustor to the transition member 14 with this substantially desired hot gas temperature profile. A final refinement of this profile can be made in passing the gases through the transition into the intake to the gas turbine blade section to provide a gas temperature blade intake profile corresponding to the desired profile $O''-a'-b'$, superimposed on the structure shown in FIG. 7, as will be explained later.

In the FIG. 2 embodiment of this invention, the illustrated combustor is of the canister type and comprises

a plurality of cylindrical combustion basket or liner members 20 of graduated cross-sectional area, disposed in slightly overlapping relation and forming a primary combustion zone 21. Each basket or liner member 20 has an array of circumferentially spaced apertures or primary air holes 22 for admitting primary combustion air from the plenum chamber 13 into the combustion zone 21 to support combustion of fuel injected thereinto by a fuel supply system comprising the nozzle 11 mounted on a cover plate 23 of the upstream part 13' of the main turbine housing 17. The illustrated fuel supply nozzle 11 is of the multiple fuel type and includes a central liquid fuel spray body member formed by a central axially extending supply passage body 24 defining a liquid fuel passage 25 therein, to which liquid fuel is supplied under pressure from a suitable source, not shown, by a conduit 26. The amount and pressure of the liquid fuel supplied to the nozzle may be controlled in any suitable manner, as by a control valve 27 in the conduit 26. Liquid fuel passes through the supply passage 25 into an annular manifold distribution chamber 28 in a manifold unit 29, fitted in fluid-tight engagement with the inner end face of the body 24 and held rigidly in position by a nozzle orifice spray cap 30, tightly secured to the body 24 in any suitable manner, as by tightly drawn up threaded engagement therewith. A plurality of circumferentially angularly spaced fuel distribution passages 31 extend through the manifold unit 29 from the distribution chamber 28 to the opposite inner end face of the unit. Each manifold passage 31 preferably has an enlarged mouth 32 communicating with a fuel outlet passage 33 in the spray cap 30 by way of a passage 34.

In order to atomize the liquid fuel spray into minute droplets to facilitate ignition thereof, steam or air under pressure from a suitable source, not shown, is supplied through a conduit 36 into an atomizing fluid supply passage 37 extending longitudinally through the nozzle body 24. This passage 37 communicates, at its inner end, with a distribution passage 38 extending through the manifold unit 29. The flow and pressure of the atomizing fluid may be controlled in any suitable manner, as by a valve 39 in the conduit 36, and may be varied according to the rate of supply of the liquid fuel to assure the most efficient atomization thereof. The atomizing fluid is sprayed out of the nozzle through the terminal spray orifices 35 of the spray passages 34 in which it is mixed with the liquid fuel from the passages 33.

In order to obtain the desired temperature profile of the hot gaseous products of combustion of the burned fuel in the combustor, the fuel nozzle features can be varied so as to provide desired fuel distribution patterns which will produce this profile. One of these variables is the fuel supply spray passages and the terminal orifices in the spray cap 30. As shown in FIGS. 2 and 4, the spray passages 34 and orifices 35 may be of uniform size and the passages 34 may extend angularly at the same angle with reference to the center line of the nozzle, FIG. 2, so that these factors will not vary the spray pattern or the temperature profile in this embodiment. As shown in FIG. 4, the number and spacing of spray passages and orifices may be defined by the spray cap 30 to provide the desired fuel spray pattern. For example, the spray passages and orifices 35a in the radially outer semicircle or 180° of arc of the nozzle spray face relative to the longitudinal axis of the turbine, corre-

sponding substantially to the radially outer half of the turbine blades 18, are substantially uniformly spaced at a predetermined angle circumferentially, illustrated at 30°, but any other suitable angle could be used. The spray passages and orifices 35b in the inner semicircle or 180° of arc of the nozzle face complementary to the set of orifices 35a also are defined by the spray cap 30 substantially uniformly angularly spaced, but at a larger angle than the spacing of the orifices 35a, and are shown spaced at 45°, although any other suitable angle could be used. This definition of the spray passages and orifices provides a predetermined larger fuel injection into the combustor toward the outer side thereof relative to the longitudinal axis of the turbine and a lesser fuel injection toward the opposite inner side thereof. The provision of a suitable supply of air and ignition of the fuel thus supplied will provide the desired temperature profile.

Primary combustion air is supplied into the combustion chamber 10 through the primary air holes 22. An additional air supply is provided in this nozzle through passages 40 in the cylindrical support 41 of a combustion baffle 42, and passages 43, aligned with passages 40 and extending through a fuel gas nozzle body 44, from which it passes axially of the nozzle through a cylindrical chamber 45 between the liquid fuel nozzle body member 24 and the fuel gas nozzle body 44, and is blown into the combustion chamber peripherally around the complete circumference of the spray cap 30. This air further aids in providing an intimate combustible mixture of the atomized liquid fuel.

In a multiple fuel type nozzle, as illustrated, the fuel gas is supplied under pressure from a suitable source, not shown, through a conduit 46 connected to an inlet passage 47 defined by the fuel gas nozzle body 44. Fuel gas passes from the passage 47 into a manifold chamber 48, from which it is fed by passages 49 to a distribution chamber 50 and out through terminal orifices 51 defined by the face portion 52 of the nozzle body 44. The flow and pressure of the fuel gas can be controlled in any suitable manner, as by a valve 53 in the supply conduit 46, so that the most desirable and efficient proportion of fuel gas to liquid fuel can be attained. All fuel gas orifices 51 may extend as passages through the face 52 at substantially equal angles relative to the center line of the nozzle and be of substantially the same size, as shown in FIG. 2. Also, these orifices may be equally angularly spaced circumferentially or they may be spaced in the same angular arrangement as the orifices 35a and 35b, shown in FIG. 4, in order to accentuate the larger fuel injection into the outer semicircle or 180° of arc of the combustor relative to the longitudinal axis of the turbine and the lesser fuel injection into the opposite side thereof. Improved mixture of the fuel and air is provided by supplying combustion air admitted by passages 40 and through a cylindrical chamber 54, extending between the radially spaced walls of the fuel gas nozzle body 44 and the combustion baffle supporting wall 41, and blown into the combustion chamber peripherally around the complete circumference of the fuel gas nozzle body face 52. Additional combustion sweep air is introduced under pressure from the plenum chamber 13 through a plurality of angularly spaced passages 55 through the combustion baffle 42 and peripherally around the outwardly flared sides of the combustion baffle and inner side of the combustion dome 56 of the combustion chamber.

In starting up combustion, the fuel is ignited in any conventional manner, as by a suitable igniter or spark plug 57, suitably mounted with its spark gap in the path of the injected fuel and air in the combustion chamber.

In order further to refine the temperature profile of the hot gases as they pass from the transition member 14 to the turbine blades, to jets of relatively cool gas are directed into the discharge end portion 15 of the transition member. The turbine air compressor 12 discharges relatively cool air under high pressure into the plenum chamber and partly into an axially extending passage 58, FIG. 7, between the combustor 10 and transition member 14 and the compressor drive shaft coupling 59 to the turbine rotor wheel 19. As shown in FIG. 7, the inner side of the end portion 15 of the transition member defines a plurality of circumferentially spaced orifices 60 through which the cool pressurized air is blown outwardly into the path of the hot gas discharge. These jets of relatively cool air modify the temperature profile from that of *t-c-d-e*, FIG. 2, to that of *O''-a'-b'*, FIG. 7. These cool air jets may, in some instances, be further modified in accordance with the teaching of U.S. Pat. No. 3,490,747—DeCorso and Carlson.

In accordance with this invention, the desired combustor temperature profile *t-c-d-e*, FIG. 2, can also be obtained by defining the fuel inlet orifices of the nozzle substantially uniformly angularly spaced, as shown in FIG. 3, and of a larger substantially uniform size for all orifices 61 in substantially the outer semicircle or 180° of arc of the nozzle spray face corresponding to the radially outer half of the turbine blades, and of a smaller substantially uniform size for orifices 61' in the complementary inner semicircle or 180° of arc of the nozzle spray face. These two sets of different size orifices can be used for the liquid fuel spray orifices combined with two similar sets of correspondingly arranged different size orifices for the fuel gas, or the fuel gas orifices may be of size and spacing types similar to FIGS. 4 or 5, or even uniform in size and spacing. In some instances, it may be found that the latter can be used advantageously to provide a large part of the heat represented by *t-c* and *e-d* in the temperature profile, FIG. 2. All of these nozzle orifice combinations provide for a substantially predetermined larger fuel injection toward the side of the combustor corresponding to the radially outer ends of the turbine blades and lesser fuel injection toward the opposite side, corresponding to the inner ends or roots of the blades.

Another embodiment of an improved nozzle according to this invention is illustrated by FIG. 5. In this nozzle, the main body defines the fuel inlet orifices in a progressively graduated size from the smallest orifice 62 at the innermost position of the nozzle orifices relative to the longitudinal axis of the turbine to the largest orifice 62' at the outermost position of the orifices relative to the longitudinal axis of the turbine. In this type of structure, the fuel injection pattern is controlled primarily by the relative size arrangement of the orifices, and it may be used for both the liquid fuel nozzle orifices and the fuel gas orifices, or the latter may be either the FIG. 3 or FIG. 4 types or of uniform size.

A yet further embodiment of an improved nozzle according to this invention is illustrated in FIG. 6 in which parts corresponding to those of FIGS. 1 and 2 BEAR the same reference numbers. The relative size arrangement bear be any of the other types. In addition, the

fuel injection angle is modified for the different orifices by the provision of fuel passages leading to these orifices which extend at predetermined different angles relative to the center line of the nozzle to provide a predetermined larger fuel injection into the combustor toward the outer side thereof relative to the longitudinal axis of the turbine and a lesser fuel injection toward the opposite inner side thereof. As shown in FIG. 6, the angle α of the outer spray passage 64 is larger than the angle α' of the inner spray passage 64'. These two passages could respectively correspond to those leading to the orifices 62' and 62 of FIG. 5, or 61 and 61' of FIG. 3. Furthermore, the angle α' may be progressively enlarged from its innermost orifice to the outermost orifice angle α . The same relative change in the angle β for the passage 65 for the outermost fuel gas orifice to the smaller angle γ' for the innermost fuel gas orifice passage 65' may be used. As shown, the variation in the angles for the liquid fuel passages need not be the same as for the fuel gas passages.

In all of the illustrated nozzles, the air flow through and around the nozzle may be of the type shown in FIG. 2, and the pressurized air or steam flow for atomizing the liquid fuel spray from the nozzle preferably also is of the type explained with reference to FIG. 2. Also, the refinement of the temperature profile as explained with reference to FIG. 7 to obtain a profile $O''-a'-b'$, preferably is used with all types of nozzles disclosed, and may be of the types disclosed in U.S. Pat. No. 3,490,747—DeCorso and Carlson.

While particular embodiments of this invention have been illustrated and described, modifications thereof will occur to those skilled in the art. It is to be understood, therefore, that the invention is not to be limited to the exact details disclosed.

The invention claimed is:

1. A high temperature gas supply system for an axial flow turbine having turbine blades arranged to be driven by the high temperature gases and having a combustor with means for igniting fuel supplied thereto, including a fuel supply nozzle comprising a body having a member defining a plurality of fuel outlet spray passages each having a terminal orifice for injecting fuel into the combustor, said terminal orifices being so proportioned that the orifice disposed at the greatest distance from the axis of turbine is larger than the orifice disposed closest to the axis of the turbine and including means for defining a fuel injection pattern for the nozzle of fuel injected into the combustor from said nozzle orifices to provide a substantially predetermined asymmetrical spatial fuel injection pattern transversely of the combustor and a consequent temperature profile of ignited fuel in the combustor.

2. A fuel nozzle for a turbine combustor adapted to supply hot gases to blades of a gas turbine, comprising a body having a member with a spray face and defining a plurality of angularly outwardly extending fuel outlet spray passages each having a terminal orifice in said spray face for injecting fuel into the combustor, said terminal orifices being so proportioned that the orifice disposed at the greatest distance from the axis of the turbine is larger than the orifice disposed closest to the axis of the turbine and said member defining said orifices arranged relative to each other so as to provide a substantially predetermined asymmetrical fuel injection pattern and a consequent temperature profile of ignited fuel transversely of the combustor.

3. A fuel nozzle as defined in claim 2 wherein said member defines said orifices substantially uniformly circumferentially angularly spaced and of a larger size for all orifices in substantially the outer semicircle of the spray face corresponding to substantially the outer half of turbine blades fed by the hot gases from said combustor and of a smaller size for orifices in the complementary inner semicircle of the spray face.

4. A fuel nozzle as defined in claim 2 wherein said member defines said orifices in a progressively graduated size from the smallest at the innermost position of the nozzle orifices relative to the radially inner ends of the turbine blades to the largest orifice at the outermost position of the nozzle orifices relative to said inner ends of the turbine blades.

5. A fuel nozzle as defined in claim 2 wherein said member defines said spray passages at predetermined different outwardly extending angles relative to the longitudinal center line of the nozzle to provide a predetermined larger fuel injection into the combustor toward the outer side thereof relative to the radially inner ends of the turbine blades and a graduated lesser fuel injection toward the opposite side of the combustor.

6. A fuel nozzle as defined in claim 2 wherein said member defines said orifices to provide a substantially larger fuel injection by orifices in the outer semicircle of the spray face relative to the radially inner ends of the turbine blades and a predetermined lesser fuel injection by orifices in the complementary semicircle of the spray face.

7. A fuel nozzle as defined in claim 2 wherein said member defines said orifices to provide a predetermined graduated increase in fuel injection into the combustor from the side thereof nearest to the longitudinal axis of the turbine toward the opposite side thereof.

8. A fuel nozzle as defined in claim 4 wherein said member defines said orifices substantially uniformly circumferentially angularly spaced at a predetermined angle in the outer semicircle of the spray face relative to the longitudinal axis of the turbine and substantially uniformly circumferentially angularly spaced at a larger angle than said predetermined angle in the complementary semicircle of the spray face.

9. A fuel nozzle as defined in claim 5 wherein said member defines said orifices substantially uniformly circumferentially angularly spaced and of a larger substantially uniform size for all orifices in substantially the outer semicircle of the spray face corresponding to substantially the radially outer half of turbine blades fed by hot gases from said combustor and of a smaller substantially uniform size for orifices in the complementary inner semicircle of the nozzle spray face.

10. A fuel nozzle as defined in claim 5 wherein said orifices are arranged in a progressively graduated size from the smallest at the innermost position of the nozzle orifices relative to the longitudinal axis of the turbine to the largest at the outermost position of the nozzle orifices to said turbine axis.

11. A fuel nozzle as defined in claim 5 wherein said member defines said orifices substantially uniformly circumferentially angularly spaced at a predetermined angle in the outer semicircle of the spray face relative to the longitudinal axis of the turbine and substantially uniformly circumferentially angularly spaced at a larger angle than said predetermined angle in the complementary inner semicircle of the spray face.

12. A fuel nozzle as defined in claim 5 wherein said spray passage angles are a substantially uniform predetermined value relative to the said nozzle center line in the outer semicircle of the spray face relative to the longitudinal axis of the turbine and are a substantially uniform lesser value than said predetermined value in the complementary inner semicircle of the spray face.

13. A fuel nozzle as defined in claim 5 wherein said spray passage angles are of progressively graduated values from the smallest angle at the innermost passage relative to the longitudinal axis of the turbine to the largest angle at the outermost passage in the nozzle relative to said turbine axis.

14. A fuel nozzle as defined in claim 2 having a second body surrounding and radially spaced from at least a part of the longitudinal sides of said first mentioned member and defining a cylindrical air flow passage therebetween, means providing for the supply of pressurized air to said cylindrical passage, and means for directing pressurized air from said cylindrical passage around fuel injected into the combustor from said spray passage orifices.

15. A fuel nozzle as defined in claim 14 wherein said second body includes means defining a plurality of fuel gas outlet passages each having an orifice for injecting pressurized fuel gas into the combustor around fuel in-

jected thereinto from said spray passage orifices, and means for supplying fuel gas to said fuel gas outlet passages.

16. A fuel nozzle as defined in claim 15 wherein said fuel gas orifices defining means defines said orifices relative to each other to provide a substantially predetermined asymmetrical fuel gas injection pattern and consequent temperature profile of ignited fuel in the combustor.

17. A turbine high temperature gas supply system as defined in claim 1 having a plurality of combustors arranged in an annular array and having a plurality of transition structures for transmitting the high temperature gases from the combustors to the turbine blades, said transition structures defining a plurality of circumferentially spaced relatively cool pressurized fluid supply passages for directing relatively cool fluid into the high temperature gases to moderate the temperature profile thereof.

18. A turbine high temperature gas supply system as defined in claim 20 having means for directing relatively cool fluid into said transition structures' cool fluid supply directing passages for progressively decreasing the temperature of the high temperature gas in an inward direction radially of the turbine.

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