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Europäisches Patentamt
European Patent Office
Office européen des brevets

11 Publication number:

**0 059 855
B1**

12

EUROPEAN PATENT SPECIFICATION

45 Date of publication of patent specification: **22.05.85**

51 Int. Cl.⁴: **F 23 R 3/40, F 23 C 11/00**

21 Application number: **82101110.3**

22 Date of filing: **16.02.82**

54 **Catalytic combustor having secondary fuel injection for low NOx stationary combustion turbines.**

30 Priority: **05.03.81 US 240695**

43 Date of publication of application:
15.09.82 Bulletin 82/37

45 Publication of the grant of the patent:
22.05.85 Bulletin 85/21

84 Designated Contracting States:
BE CH DE GB LI NL

58 References cited:
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US-A-3 797 231
US-A-3 928 961
US-A-4 072 007
US-A-4 112 675
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Courier Press, Leamington Spa, England.

EP 0 059 855 B1

Description

This invention relates to stationary combustion turbines and more particularly to the implementation of catalytic combustion in such turbines to characterize the turbine operation with low NO_x emissions.

Various schemes have been undergoing development to provide combustion turbines which generate electric power or run industrial processes without exceeding NO_x emission limits. The use of catalytic combustion is a promising approach because catalytic combustion can occur at about 1270°C to 1342°C to produce a high turbine inlet temperature for turbine operating efficiency without any significant side effect NO_x generation from reactions between nitrogen and oxygen. In contrast, conventional flame combustion at about 2468°C results in NO_x generation which typically exceeds the limits set in more restrictive areas such as California and Japan.

In the operation of the conventional turbine combustion process, compressor discharge air is supplied at an elevated temperature to support the combustion of fuel supplied through one or more nozzles at the upstream end of multiple combustor baskets. Combustion products are directed through ducting to the turbine blades.

For catalytic combustion to occur, fuel and air must be mixed and supplied to the entry side of a catalyst unit at an elevated temperature determined by chemical characteristics of the catalyst employed in the catalyst unit. In turn, the temperature of the compressor discharge air used in the fuel-air mix depends on the compression ratio of the compressor which is based on overall turbine design considerations. For any particular compressor design, the compressor discharge temperature also depends on the operating point of the turbine during the startup and load operating modes. Generally, as turbine speed or load increases, the compressor discharge air temperature increases.

Thus, in applying a catalytic combustion process to combustion turbines a need exists to provide for turbine system functioning where compressor discharge air is supplied at a temperature below the minimum temperature needed for catalytic reaction. In the known prior art, US—A—3 928 961 and 4 112 675 appear to address this need with various limitations. Another example of an arrangement similar to prior art cited above is seen in FR—A—2 375 543.

It is an object of this invention to provide a novel catalytic combustion system for a stationary gas turbine with a view to overcoming the deficiencies of the prior art, and such that the secondary nozzles can be disconnected easily without disturbing the rest of the assembly.

With this object in view, the invention relates to a catalytic combustion system for a stationary gas turbine comprising a combustor basket having a tubular side wall defining a primary combustion zone therein, a primary nozzle capable of supplying fuel for combustion in the primary zone, said

combustor basket sidewall defining a secondary zone downstream from the primary zone, the system further comprising secondary injection nozzles located outside of said basket capable of injecting fuel into the secondary zone for mixing with the primary combustion product flow to provide a fuel-air mixture at the combustor basket outlet sufficiently mixed and heated to undergo catalytic reaction, a catalytic unit capable of receiving the outlet flow from said combustor basket, said basket side wall being structured along the primary combustion zone such that the primary zone outlet cross-section is at least as great as the primary zone cross-section over the primary zone upstream of the primary zone outlet, said combustor basket including a downstream diffuser end portion having an end sidewall section which is outwardly flared such that hot gas streams move toward the flared end section side wall, characterized in that said secondary injection nozzles are capable of injecting air into the secondary zone together with the injected fuel and are individually detachably fastened by tongue and groove joints to the combustor basket, said basket having a sidewall which defines an expanding path for the fuel-air mix over the entire secondary zone from the fuel injection plane to the basket outlet, and control means being provided capable of supplying fuel to said primary nozzle and to said secondary injection system.

The invention will become readily apparent from the following description of an exemplary embodiment thereof when read in conjunction with the accompanying drawings, in which:

Figure 1 schematically shows a catalytic combustion system arranged to operate a stationary gas turbine in accordance with a preferred embodiment of the invention;

Figure 2 shows an elevational view of a catalytic combustion system shown in Figure 1;

Figure 3 shows an enlarged view of the combustion system of Figure 1;

Figure 4 shows an enlarged cross-section of secondary nozzle mounting structure taken along reference line IV—IV of Figure 3; and

Figure 5 shows a portion of a vertical section taken through a secondary fuel nozzle shown in Figure 3.

More particularly, there is shown in Figure 1 a generalized schematic representation of the preferred embodiment of the invention.

A turbine or generally cylindrical catalytic combustor 10 is combined with a plurality of like combustors (not shown) to supply hot motive gas to the inlet of a turbine (not shown in Figure 1) as indicated by the reference character 12. The combustor 12 includes a catalytic unit 14 which preferably includes a conventional monolithic catalytic structure having substantial distributed catalytic surface area which effectively supports catalytic combustion (oxidation) of a fuel-air mixture flowing through the unit 14. Typically, the catalytic structure is a honeycomb structure

having its passages extending in the gas flow direction.

The combustor 10 includes a zone 11 into which fuel, such as oil, is injected by nozzle means 16 from a fuel valve 17 where fuel-air mixing occurs in preparation for entry into the catalytic unit 14. Proper mixing preferably entails vaporization of 80% to 90% of the injected fuel for efficient and effective catalytic reaction.

Typically, the fuel-air mix temperature (for example 427°C) required for catalytic reaction is higher than the temperature (for example 371°C) of the compressor discharge air supplied to the combustors from the enclosed space outside the combustor shells. The deficiency in air supply temperature in typical cases is higher during startup and lower load operation.

A primary combustion zone 18 is accordingly provided upstream from the fuel preparation zone 11 within the combustor 10. Nozzle means 20 are provided for injecting fuel from a primary fuel valve 22 into the primary combustion zone 18 where conventional flame combustion is supported by primary air entering the zone 18 from the space within the turbine casing through openings in the combustor wall.

As a result, a hot gas flow is supplied to the catalytic fuel preparation zone where it can be mixed with the fuel and air mixture in the fuel preparation zone 11 to provide a heated fuel mixture at a sufficiently high temperature to enable proper catalytic unit operation. In this arrangement, the fuel injected by the nozzle means 16 for combustion in the catalytic unit is a secondary fuel flow which is mixed with secondary air and the primary combustion products which supply the preheating needed to raise the temperature of the mixture to the level needed for entry to the catalytic unit.

The catalytic combustion system is operated by a generally conventional analog or digital computer or digital/analog speed and load control 24 which operates the primary and secondary fuel valves 22 and 17 through conventional electro-pneumatic valve controls 26 and 28 respectively. The control 24 is preferably arranged to operate the primary fuel system to energize the turbine through primary combustion only during the startup and, after synchronization, during loading up to a predetermined load level. Thereafter, primary combustion is reduced by primary fuel cutback as secondary fuel flow is initiated by the control 24 to provide for turbine energization primarily through catalytic combustion.

During the higher load catalytic combustion phase of operation, primary combustion occurs at a reduced level to provide secondary fuel-air mixture preheat as previously described. Further, as catalytic activity drops off with turbine operating time, compensator increases in primary combustion are instituted through appropriate offset adjustments in the controls 26 and 28. More description is presented subsequently herein on the coordinated operation of the primary and secondary fuel valves.

During the startup/lower load phase of operation, primary combustion provides the turbine energization needed to drive the turbine operation to the point where motive gas temperatures are sufficient for sustained catalytic combustion operation.

During the higher load phase of operation, fuel flow rates are increased but only a small part of the total fuel is supplied as fuel for primary combustion and the rest of the fuel is supplied as secondary fuel for catalytic combustion. Emission of NO_x during the higher load phase from the relatively small amount of primary fuel combustion used to provide preheating of the secondary fuel-air mixture this is also well below the most restrictive emission limits.

In Figures 2 and 3, there is shown a structurally detailed catalytic combustion system 30 embodying the principles described for the combustor 10 of Figure 1. Thus, the combustion system 30 generates hot combustion products which pass through stator vanes 31 to drive turbine blades (not shown). A plurality of the combustion systems 30 are disposed about the rotor axis within a turbine casing 32 to supply the total hot gas flow needed to drive the turbine.

The catalytic combustor 30 includes a combustor basket 40, a catalytic unit 36 and a transition duct 38 which directs the hot gas to the annular space through which it passes to be directed against the turbine blades.

The combustor basket 40 is mounted on the casing 32 by bolt means 42 and preferably is provided with a primary and plural (six) secondary sidewall fuel nozzles 44 and 46. Fuel supplied through the primary nozzle 44 (readily removable for maintenance) is mixed with primary combustion support air, which enters the basket 40 through sidewall scoops 48 (or openings), and burned in a primary combustion zone 50 to provide hot gas for driving the turbine or preheating a downstream fuel-air mixture to the level required for catalytic reaction. Primary combustion support air also enters the basket 40 in this case through swirlers 52 which are disposed coaxially about the primary nozzle 44. Dilution air enters the zone 50 primarily through scoops 49. The length of the primary zone 50 accordingly is sufficient to provide the space needed for primary combustion to occur followed by the space needed for mixing of the primary combustion products with dilution air. The primary zone sidewall is conventionally structured from a plurality of sidewall rings which are securely held together in a telescopic arrangement by corrugated spacer bands. The spacer bands thus provide an annular slot between adjacent sidewall ring members through which air is admitted to cool the internal sidewall ring surfaces. As a result, the cross-section of the primary zone increases slightly in the downstream direction.

Primary ignition is provided by a conventional spark igniter in a tube 35 in one or more of the combustors 40. Cross flame tube connectors

indicated by reference character 37 are employed to ignite the other combustors 40.

The supplemental use of a conventional burner to produce part of the total fuel combustion in the system 30 enables compensation to be made for dropoff in catalytic activity with turbine operation time. As previously noted, the ratio of conventional combustion to catalytic combustion is sufficient under all higher output operating conditions to achieve the needed combustion assistance without the production of an unacceptable NO_x penalty.

Gases flow downstream within the combustor basket 40 from the primary combustion zone 50 to the entry to a secondary zone 54 where the secondary fuel nozzles 46 inject fuel along an injection plane preferably with respective surrounding jets of air through sidewall scoops 55 for mixing with the primary gas flow. The resultant mix expands as it passes through an outwardly flared diffuser 56 which forms an end portion of the basket 40. It then enters a catalytic reaction element in the catalytic unit 36.

Proper penetration of secondary air jets into the combustor is important from the standpoint of fuel/air mixing because the jets carry the secondary fuel with them. If penetration is excessive, the center of the catalyst element receives too much fuel; if too little penetration is obtained, the edges of the catalyst receive too much fuel. For optimum mixing, the maximum penetration should be 33% of the tubular combustor diameter.

With proper jet penetration, good atomization of secondary fuel (such as 30 μm droplets) is the key to achieving rapid fuel vaporization. With preheat to 427°C, 30 μm fuel droplets are normally complete vaporized within a few centimeters of the injection plane, but even drops as large as 90 μm , of which there would normally be very few, should be more than 99% vaporized at the catalyst inlet.

The diffuser 56 is employed because a smaller path diameter is needed for satisfactory fuel mixing in the combustor basket 40 as compared to the path diameter needed for catalytic combustion. Thus, injection of secondary fuel into a smaller diameter basket provides improved fuel/air mixing and better fuel/air uniformity across the face of the catalyst. On the other hand, the use of a larger basket diameter enables use of a larger catalyst diameter which results in a lower catalyst inlet velocity and produces a lower pressure drop and improved combustion efficiency.

The flared shape of the diffuser 56 is formed to prevent hot gas flow separation (i.e. to prevent turbulent layer formation near the diffuser wall). Back pressure from the catalyst structure provides forces needed to expand gas streamlines out to the diffuser wall and prevent turbulent layer buildup.

To protect the catalytic element and the combustor basket 40, the system operates so that the residence time for the gaseous mixture (in this case, preheated to 427°C) in the secondary fuel

preparation zone 54 is less than the ignition delay time from the primary zone 50. In this way, flame is contained in the primary combustion zone 50 away from the catalytic element. Thus, the secondary fuel injection plane 58 is spaced from the catalyst face by a distance which is sufficient to permit proper fuel mixing (substantial uniformity across the catalyst face) and preparation for the catalyst but which is less than the critical distance which allows the fuel-air mixture to auto-ignite before it crosses the secondary zone 54 into the catalytic element. Normally, the fuel-air mixture is driven across the zone 54 within several milliseconds to avoid auto-ignition.

The secondary fuel nozzles 46 are supported preferably with a predetermined spacing outwardly from the combustor sidewall. In this case, the nozzles are angled for transversely directed fuel injection with a predetermined angle of spread. Each nozzle 46 is connected (see Figure 5) to a tubular fuel supply line 60 which is supported coaxially within an outer tubular air line 62. The air tube 62 in turn is supported by a sliding rail arrangement 64 (see Figure 4) which includes a bracket 65 attached to the sidewall of the combustor basket 40. A flexible joint 69 (Figure 3) provides for longitudinal expansion of the fuel nozzle assembly.

The air tube 62 is supported at its casing entry end by a mounting plate 66 which is bolted to a flange on a sleeve 70 as indicated at 68. The sleeve 70 is secured suitably to the turbine casing 32 and it thus provides an opening through which the fuel nozzle assembly extends into the space within the casing 32. All secondary fuel nozzle assemblies are thus readily removable for maintenance simply by removing the bolts 68 and first sliding the tubular assembly so that mount 63 slides free of the rail bracket 65 and then continuing to slide the assembly until it is removed from the turbine casing.

With the provision of the air supply line 62 about the fuel line 60, air cooling is provided for the fuel as it is delivered to the downstream secondary fuel injection nozzles. By supplying secondary fuel at the secondary nozzles at a temperature lower than what it would otherwise be, added protection is provided against auto-ignition in the fuel preparation zone 54 as a result of added time required to raise the injected fuel to the auto-ignition temperature.

The cooling air also atomizes the fuel to a fuel fog as it is injected through the scoops 55 into the combustor fuel preparation zone 54. An additional air jet joins the nozzle flow in the scoop 55 and provides any additional air needed to achieve the desired fuel-air ratio (preferably lean) in the fuel preparation zone 54. The scoop size and nozzle placement both can be varied to modify the amount of such air jet flow.

The diameter of the catalytic element is determined mainly by the maximum allowable reference gas velocity for complete emissions burnout at an acceptable pressure loss. Higher gas velocities require longer catalyst beds and

result in higher emissions. The mass transfer units required for complete emissions burnout are inversely proportional to the square root of reference velocity in laminar flow, but the effect of reference velocity on the mass transfer rate decreases with an increase in channel Reynolds number. Thus, the maximum allowable reference velocity is limited in turbulent flow by the restric-

tion of pressure losses. However, the low limit boundary of reference velocity for the region of operability may be determined by flashback considerations in the fuel preparation zone.

The catalytic element includes a can within which a catalytic honeycomb structure is conventionally supported by suitable means. The catalyst characteristics can be as follows:

Data for DXE-442 catalyst	
I. Substrate	
Size	(50,8 mm+50,8 mm) long — (6,35 mm gap between two sections)
Material	Zircon Composite
Bulk Density	640,7÷672,8 N/m ³
Cell Shape	Corrugated Sinusoid
Number	39 Channels/cm ²
Hydraulic Diameter	0,98 mm
Web Thickness	0,25 mm±0,05 mm
Open Area	65,5%
Heat Capacity	218 J/kg °C
Thermal Expansion Coefficient	5,55 · 10 ⁻⁶ mm/mm °C
Thermal Conductivity	16 J cm/h cm ² °C
Melting Temperature	1654°C
Crush Strength	
Axial	56,2 N/cm ²
90%	1,76 N/cm ²
II. Catalyst	
Active Component	Palladium
Washcoat	Stabilized Alumina

With operation of the catalytic combustors 30 in the manner described, hot motive gases are supplied to the turbine inlet essentially free of oxides of nitrogen and at efficient operating temperatures above 1291°C. As indicated by the following table, primary combustion occurs

throughout the startup mode and during initial loading until 47% load is reached. At that point, the control sequences the secondary fuel valve into operation and cuts back on the primary fuel supply. Further load increases are then met by increases in secondary fuel.

60

65

Catalytic combustor operating conditions

Load conditions	Comb. inlet Temp. (°R)	Comb. inlet Press. (Psia)	Comb. air Flow (lb/s)	Pri. fuel Flow (lb/s)	Sec. fuel Flow (lb/s)	Bypass air %	Cat. inlet Temp. (°R)	Cat. exit Temp. (°R)	Comb. exit Temp. (°R)	Cat. inlet Vel. (ft/s)	P comb. %	P cat. %	P total %	I.G.V. position
Cranking Ignition	555	15.7	3.38	0.0	0.0	6.08	555	555	555	30.1	.90	1.29	2.18	22
	565	17.3	2.81	.045	0.0	11.58	1811	1811	1678	70.6	.46	4.13	4.59	22
100 sec	668	25.6	6.38	.104	0.0	8.90	1875	1875	1777	116.6	1.36	6.19	7.55	22
200 sec	786	41.0	11.06	.178	0.0	7.41	1939	1939	1860	133.3	1.94	5.28	7.22	22
300 sec	881	67.9	19.69	.222	0.0	6.46	1691	1691	1641	126.4	2.57	4.54	7.10	22
400 sec	943	89.7	26.25	.255	0.0	6.23	1639	1639	1598	124.1	2.81	4.40	7.21	22
500 sec	1033	121.7	36.88	.238	0.0	5.88	1496	1496	1470	117.9	3.33	4.21	7.53	0
600 sec	1056	134.6	40.56	.253	0.0	5.84	1503	1503	1478	117.8	3.37	4.16	7.52	0
Idle	1092	144.7	44.23	.286	0.0	5.84	1553	1553	1527	123.8	3.58	4.41	7.99	0
20%	1103	153.9	44.23	.416	0.0	6.04	1764	1764	1726	131.9	3.18	4.44	7.63	0
40%	1116	163.1	44.23	.554	0.0	6.23	1983	1983	1932	139.5	2.86	4.47	7.32	0
47% Bef. Trans.	1120	166.1	44.23	.604	0.0	6.30	2060	2060	2004	142.2	2.76	4.48	7.24	0
47% Aft. Trans.	1046	120.9	31.46	.107	.496	6.03	1260	2334	2264	85.5	2.48	3.44	5.92	37
60%	1102	149.7	36.57	.098	.602	5.95	1260	2380	2311	80.3	2.30	3.05	5.35	22
71%	1130	174.4	44.23	.1	.685	5.86	1260	2319	2255	83.5	2.55	3.18	5.73	0
80%	1137	178.7	44.23	.097	.757	5.91	1260	2420	2351	81.4	2.44	3.14	5.58	0
Base	1149	187.3	44.23	.095	.926	6.03	1260	2653	2572	77.7	2.24	3.11	5.35	0
Peak	1155	191.1	44.23	.094	1.005	6.09	1260	2760	2673	76.2	2.16	3.11	5.26	0

ISO Day, Sea Level, No. 2 Fuel Oil
Upstream Effective Area — 45.76 in, Downstream Effective Area — 1.90 in
Catalyst Diameter — 16 inches
Fixed Bypass

Claims

1.⁶ A catalytic combustion system for a stationary gas turbine comprising a combustor basket (40) having a tubular side wall defining a primary combustion zone (18, 50) therein, a primary nozzle (20, 44) capable of supplying fuel for combustion in the primary zone (18, 50), said combustor basket sidewall defining a secondary zone (11, 54) downstream from the primary zone (18, 50), the system further comprising secondary injection nozzles (16, 46) located outside of said basket (40) capable of injecting fuel into the secondary zone (11, 54) for mixing with the primary combustion product flow to provide a fuel-air mixture at the combustor basket outlet sufficiently mixed and heated to undergo catalytic reaction, a catalytic unit (36) capable of receiving the outlet flow from said combustor basket (40), said basket side wall being structured along the primary combustion zone (18, 50) such that the primary zone outlet cross-section is at least as great as the primary zone cross-section over the primary zone upstream of the primary zone outlet, said combustor basket (40) including a downstream diffuser end portion (56) having an end sidewall section which is outwardly flared such that hot gas streams move toward the flared end section side wall, characterized in that said secondary injection nozzles (46) are capable of injecting air into the secondary zone (11, 54) together with the injected fuel and are individually detachably fastened by tongue and groove joints (63, 65) to the combustor basket (40), said basket having a sidewall which defines an expanding path for the fuel-air mix over the entire secondary zone (11, 54) from the fuel injection plane to the basket outlet, and control means (24, 26, 28) being provided capable of supplying fuel to said primary nozzle (20, 44) and to said secondary injection system (16, 46, 55).

2. A catalytic combustion as claimed in claim 1, characterized in that said secondary injection nozzles (46) are spaced circumferentially about said combustor sidewall, a fuel line (60) being connected to each of said secondary nozzles (46) to form a secondary fuel assembly, detachable mounting means (70) being provided for mounting each of said secondary fuel assemblies relative to a casing (32) of the turbine, said tongue and groove joints (63, 65) supporting each of said secondary fuel assemblies releasably relative to said combustor basket (40) so that each secondary fuel assembly can be removed from the casing (32) when the associated mounting means (70) is disconnected from said casing (32).

3. A catalytic combustion system as claimed in claim 2, characterized in that each of said fuel supply lines (60) comprises an inner fuel supply tube (60) and a coaxial outer tube (62) through which air flows to cool said inner tube (60) and the fuel supplied therethrough, said inner and outer tubes (60, 62) being connected to the associated nozzle (46) to supply air and fuel thereto to provide an air-assisted fuel injection spray.

4. A catalytic combustion system as claimed in claim 3, characterized in that each of said mounting means (70) is flexible to permit thermal expansion of the associated secondary fuel assembly.

5. A catalytic combustion system as claimed in any of the preceding claims, characterized in that said control means comprise a speed and load control (24), a primary fuel control (26) connected to said speed and load control (24), a primary fuel valve (22) connected to said primary fuel control (26) and to said primary nozzle (20, 44), a secondary fuel control (28) connected to said speed and load control (24) and a secondary fuel valve (17) connected to said secondary fuel control (28) and to said secondary injection nozzles (16, 46).

Patentansprüche

1. Katalytische Brenneinrichtung für stationäre Gasturbinen, mit einer Brennkammer (40) mit einer rohrförmigen Seitenwand, die eine primäre Verbrennungszone (18, 50) begrenzt, einer Hauptdüse (20, 44) zur Brennstoffzufuhr für die Verbrennung in der Primärzone (18, 50), wobei die Seitenwand der Brennkammer stromab der Primärzone (18, 50) eine Sekundärzone (11, 54) begrenzt und die Einrichtung außerdem außerhalb der Brennkammer (40) angeordnete sekundäre Einspritzdüsen (16, 46) zum Einspritzen von Brennstoff in die Sekundärzone (11, 54) zur Vermischung mit der Produktströmung aus der primären Verbrennung aufweist, um ein Brennstoff-Luft-Gemisch am Auslaß der Brennkammer zu erzeugen, das ausreichend durchmischt und erwärmt ist, um einer katalytischen Reaktion unterzogen zu werden, und mit einer katalytischen Einheit (36), welche die Auläßströmung von der Brennkammer (40) erhält, wobei die Brennkammerseitenwand entlang der primären Verbrennungszone (18, 50) so ausgebildet ist, daß der Auslaßquerschnitt der Primärzone mindestens so groß wie der Querschnitt der Primärzone im Bereich der Primärzone stromauf des Primärzonenauslasses ist, und wobei die Brennkammer (70) einen stromabseitigen Diffusorendteil (56), aufweist, dessen Endquerschnitt nach außen erweitert ist, so daß die heißen Gasströme sich zu dem erweiterten Endquerschnitt hin bewegen, dadurch gekennzeichnet, daß die sekundären Einspritzdüsen (46) zusammen mit dem eingespritzten Brennstoff Luft in die Sekundärzone (11, 54) einleiten können und einzeln mittels Nut-Feder-Verbindungen (63, 65) lösbar an der Brennkammer (40) befestigt sind, daß weiter die Seitenwand der Brennkammer über die gesamte Sekundärzone (11, 54) von der Brennstoffeinspritzebene bis zum Brennkammerauslaß einen sich erweiternden Strömungsweg für das Brennstoff-Luft-Gemisch bildet, und daß Steuermittel (24, 26, 28) für die Brennstoffzufuhr zur Hauptdüse (20, 74) und zum Sekundäreinspritzsystem (16, 46, 55) vorgesehen sind.

2. Katalytische Brenneinrichtung nach Anspruch 1, dadurch gekennzeichnet, daß die sekundären Einspritzdüsen (46) mit gegenseitigen Umfangsabständen um die Seitenwand der Brennkammer herum angeordnet sind, daß weiter mit jeder der sekundären Düsen (46) eine Brennstoffleitung (60) zur Bildung einer sekundären Brennstoffeinheit verbunden ist, das ferner lösbare Montagemittel (70) zur Montage jeder der sekundären Brennstoffeinheiten mit Bezug auf das Turbinengehäuse (32) vorgesehen sind, und daß die genannten Nut-Feder-Verbindungen (63, 65) jede der sekundären Brennstoffeinheiten lösbar mit Bezug auf die Brennkammer (40) halten, so daß jeder sekundäre Brennstoffeinheit vom Gehäuse (32) abgenommen werden kann, wenn die zugehörigen Montagemittel (70) vom Gehäuse (32) gelöst werden.

3. Katalytische Brenneinrichtung nach Anspruch 2, dadurch gekennzeichnet, daß jede der genannten Brennstoffzufuhrleitungen (60) ein inneres Brennstoffzufuhrrohr (60) und ein koaxiales äußeres Rohr (62) aufweist, durch welches Luft zur Kühlung des inneren Rohres (60) und des dadurch zugeführten Brennstoffs strömt, und daß das innere und das äußere Rohr (60, 62) mit der zugehörigen Düse (46) verbunden sind, um Luft und Brennstoff zu dieser zuzuführen und einen luftunterstützten Brennstoffeinspritznebel zu erzeugen.

4. Katalytische Brenneinrichtung nach Anspruch 3, dadurch gekennzeichnet, daß die genannten Montagemittel (70) jeweils flexibel sind, um eine Wärmedehnung der zugehörigen sekundären Brennstoffeinheit zu ermöglichen.

5. Katalytische Brenneinrichtung nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß die Steuermittel einen Drehzahl- und Lastregler (24), einen mit dem Drehzahl- und Lastregler (24) verbundenen Hauptbrennstoffregler (26), ein mit dem Hauptbrennstoffregler (26) und der Hauptdüse (20, 44) verbundenes Hauptbrennstoffventil (22), einen mit dem Drehzahl- und Lastregler (24) verbundenen Sekundärbrennstoffregler (28) und ein mit dem Sekundärbrennstoffregler (28) und den Sekundäreinspritzdüsen (16, 46) verbundenes Sekundärbrennstoffventil (17) aufweisen.

Revendications

1. Système de combustion catalytique pour turbine à gas fixe, comprenant un panier d'appareil de combustion (40) comportant une paroi latérale tubulaire formant une zone de combustion primaire (18, 50), un premier injecteur (20, 44) pouvant fournir du combustible en vue de la combustion dans la zone primaire (18, 50), la paroi latérale de ce panier d'appareil de combustion formant une zone secondaire (11, 54) en aval de la zone primaire (18, 50), ce système comprenant en outre des injecteurs secondaires (16, 46) localisés à l'extérieur du panier (40) et pouvant injecter du combustible dans la zone secondaire (11, 54) en vue d'un mélange avec le

courant de produit de combustion primaire pour former, à la sortie du panier d'appareil de combustion, un mélange de combustible air suffisamment mélangé et chauffé pour subir une réaction catalytique, une unité catalytique (36) pouvant recevoir le courant sortant du panier d'appareil de combustion (40), la paroi latérale de ce panier étant d'une structure telle, le long de la zone de combustion primaire (18, 50), que la section transversale de la sortie de la zone primaire soit au moins aussi grande que la section transversale de la zone primaire se situant en amont de la sortie de cette zone, le panier d'appareil de combustion (40) comprenant une partie extrême formant diffuseur aval (56) comportant une section de paroi latérale terminale qui est évasée de manière que les courants de gas chauds se déplacent vers la paroi latérale de cette section terminale évasée, caractérisé en ce que les ajutages d'injection secondaire (46) sont capables d'injecter de l'air dans la zone secondaire (11, 54) en même temps que le combustible injecté, et sont attachés individuellement de façon amovible, par des joints à emboîtement mâle et femelle (63, 65) au panier d'appareil de combustion (40), ce panier comportant une paroi latérale qui crée un parcours de détente pour le mélange de combustible-air sur la totalité de la zone secondaire (11, 54) à partir du plan d'injection de combustible vers la sortie du panier, des moyens de commande (24, 26, 28) étant prévus pour pouvoir fournir du combustible à l'injecteur primaire (20, 44) et au système d'injecteurs secondaires (16, 46, 55).

2. Système de combustion catalytique suivant la revendication 1, caractérisé en ce que les injecteurs secondaires (46) sont espacés suivant la circonférence tout autour de la paroi latérale de l'appareil de combustion, un conduit de combustible (60) étant connecté à chacun des ajutages secondaires (46) pour former un assemblage de combustible secondaire, des moyens de montage amovibles (70) étant prévus pour monter chacun des assemblages à combustible secondaire par rapport à un carter (32) de la turbine, les joints à emboîtement mâle et femelle (63, 65) supportant chacun des assemblages à combustible secondaire, de façon amovible, par rapport au panier d'appareil de combustion (40), de sorte que chaque assemblage à combustible secondaire peut être retiré du carter (32) lorsque les moyens de montage associés (70) sont libérés du carter (32).

3. Système de combustion catalytique suivant la revendication 2, caractérisé en ce que chacun des conduits d'alimentation de combustible (60) comprend un tube interne d'alimentation de combustible (60) et un tube externe coaxial (62) à travers lequel de l'air circule pour refroidir le tube interne (60) et le combustible qui est alimenté à travers celui-ci, ces tubes interne et externe (60, 62) étant connectés à l'injecteur associé (46) pour lui fournir de l'air et du combustible afin de créer une pulvérisation d'injection de combustible, aidée par air.

4. Système de combustion catalytique suivant la revendication 3, caractérisé en ce que chacun des moyens de montage (70) est flexible pour permettre une dilatation thermique de l'assemblage à combustible secondaire associé.

5. Système de combustion catalytique suivant l'une quelconque des revendications précédentes, caractérisé en ce que les moyens de commande comprennent un système de commande de vitesse et de charge (24), un système de commande de combustible primaire (26) con-

necté au système de commande de vitesse et de charge (24), une vanne de combustible primaire (22) connectée au système de commande de combustible primaire (26) et à l'injecteur primaire (20, 44), un système de commande de combustible secondaire (28) connecté au système de commande de vitesse et de charge (24), et une vanne de combustible secondaire (17) connectée au système de commande de combustible secondaire (28) et aux injecteurs secondaires (16, 46).

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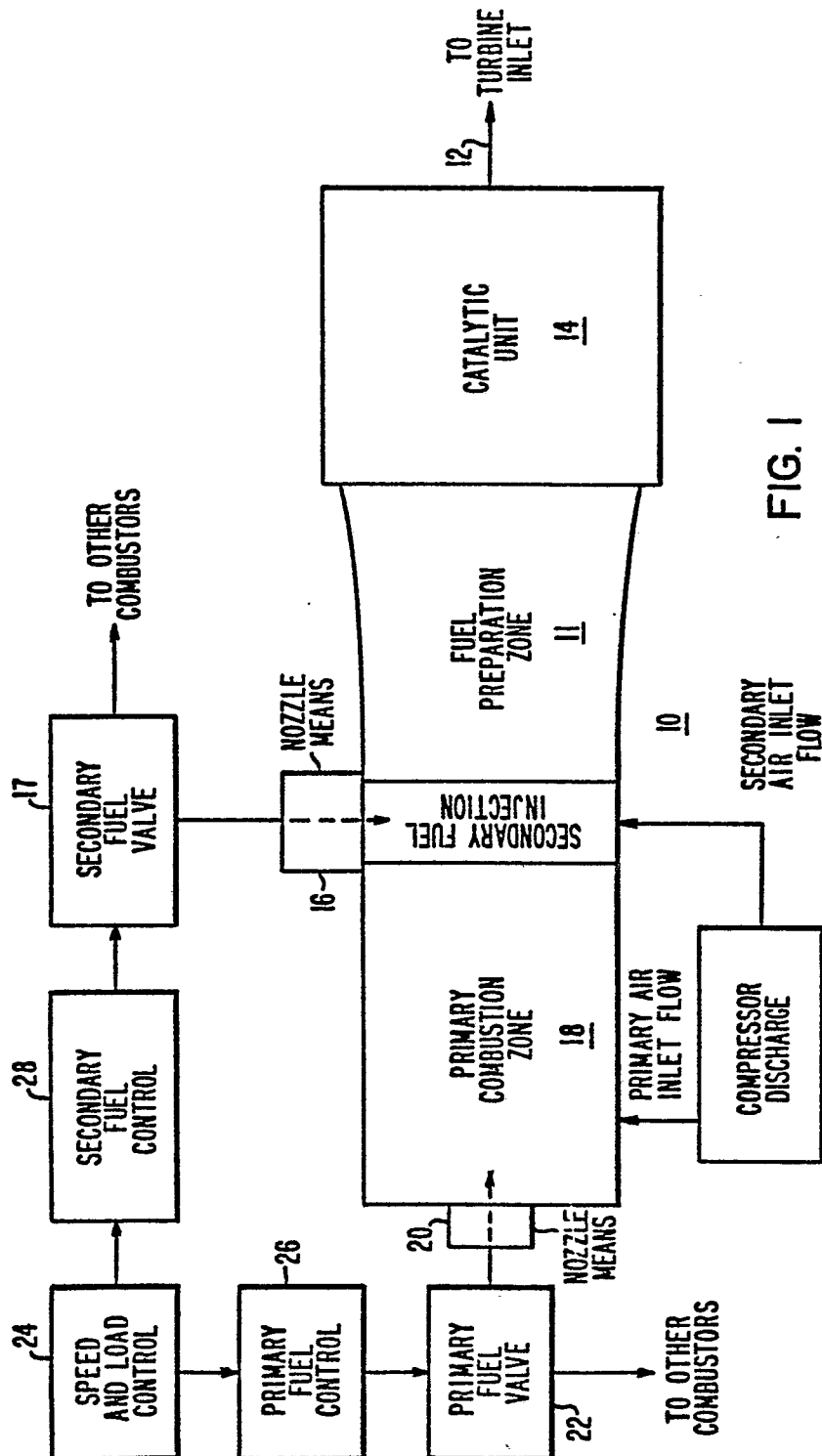


FIG. 1

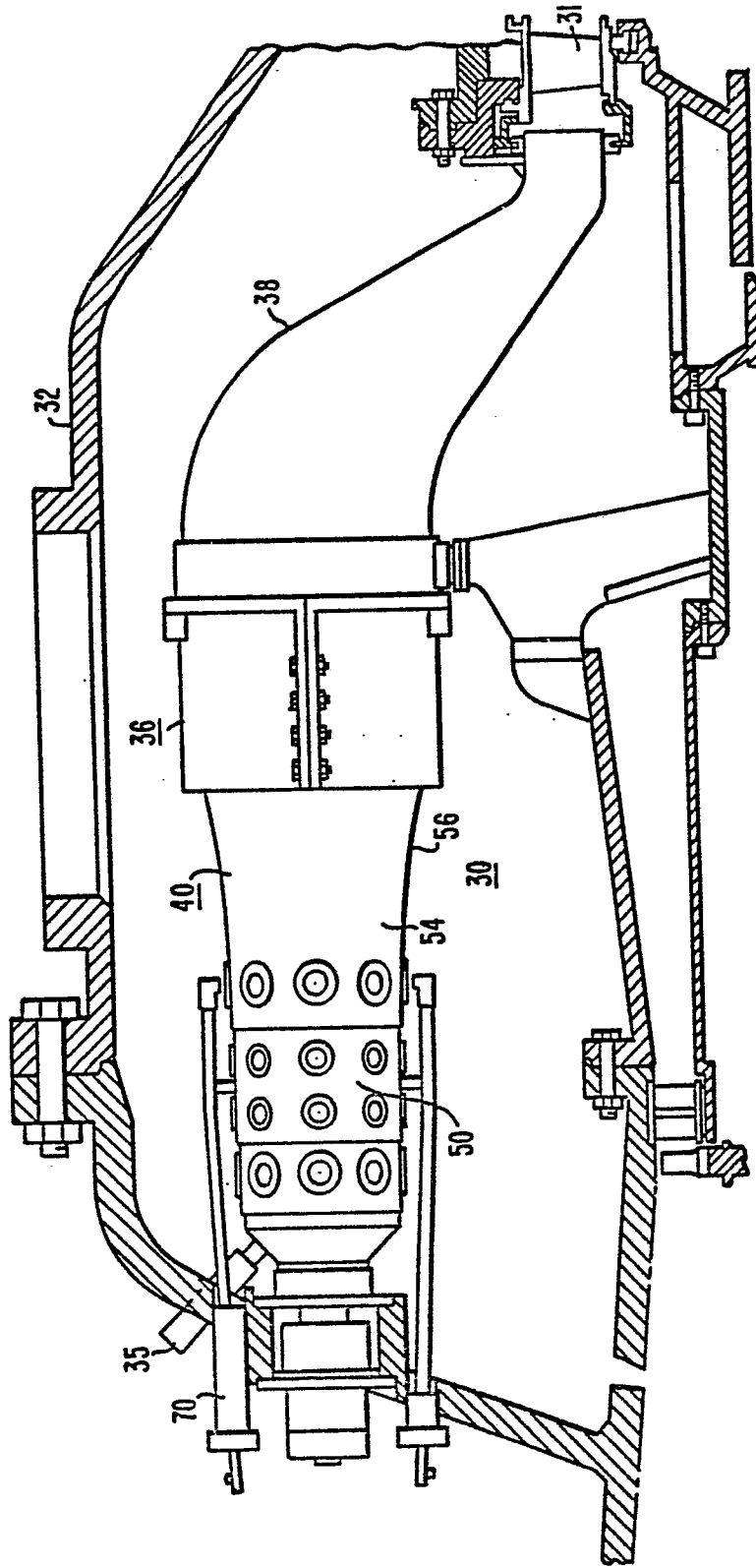


FIG. 2

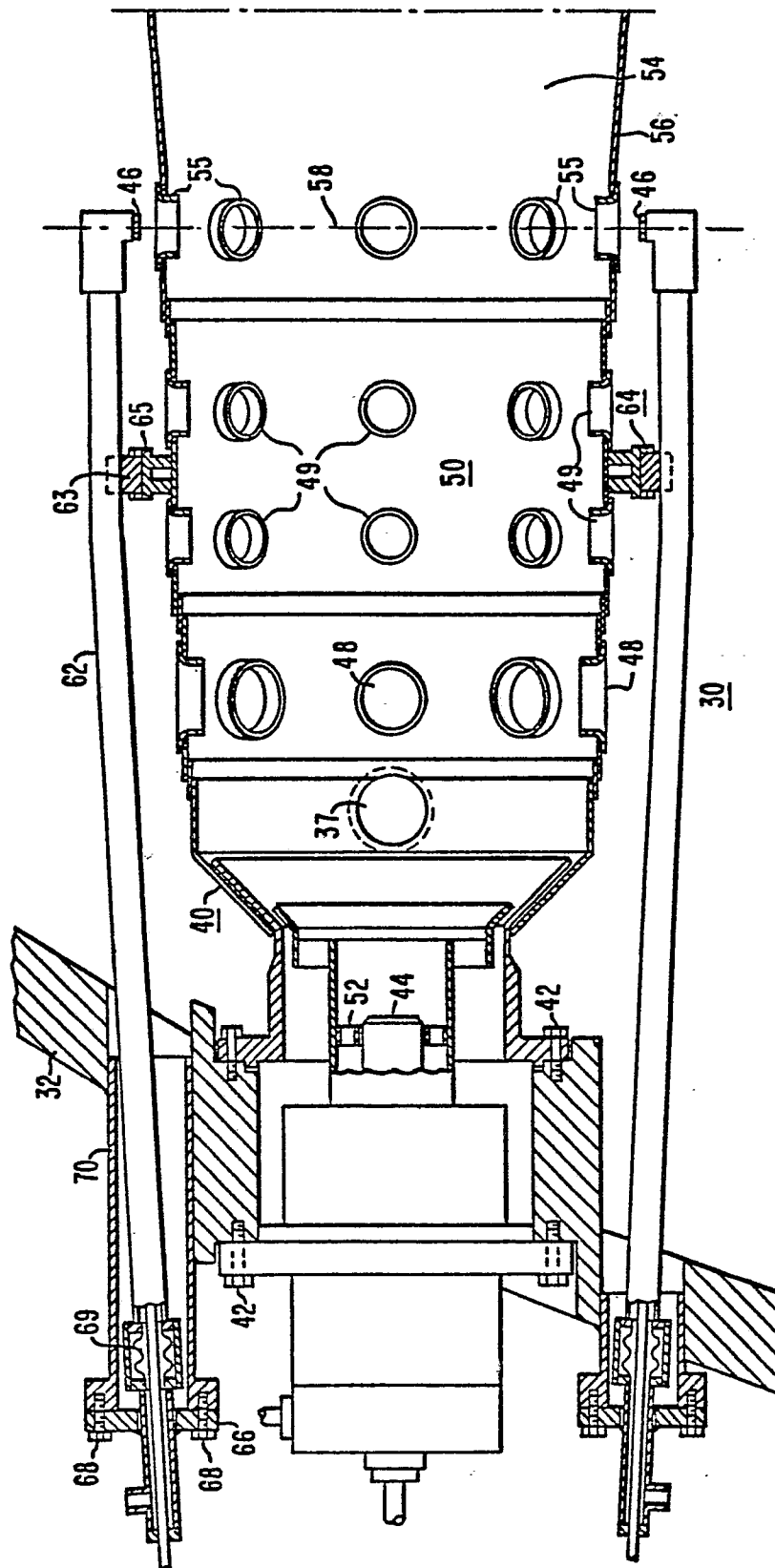


FIG. 3

