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(54) COMBUSTOR FOR GAS TURBINE ENGINE

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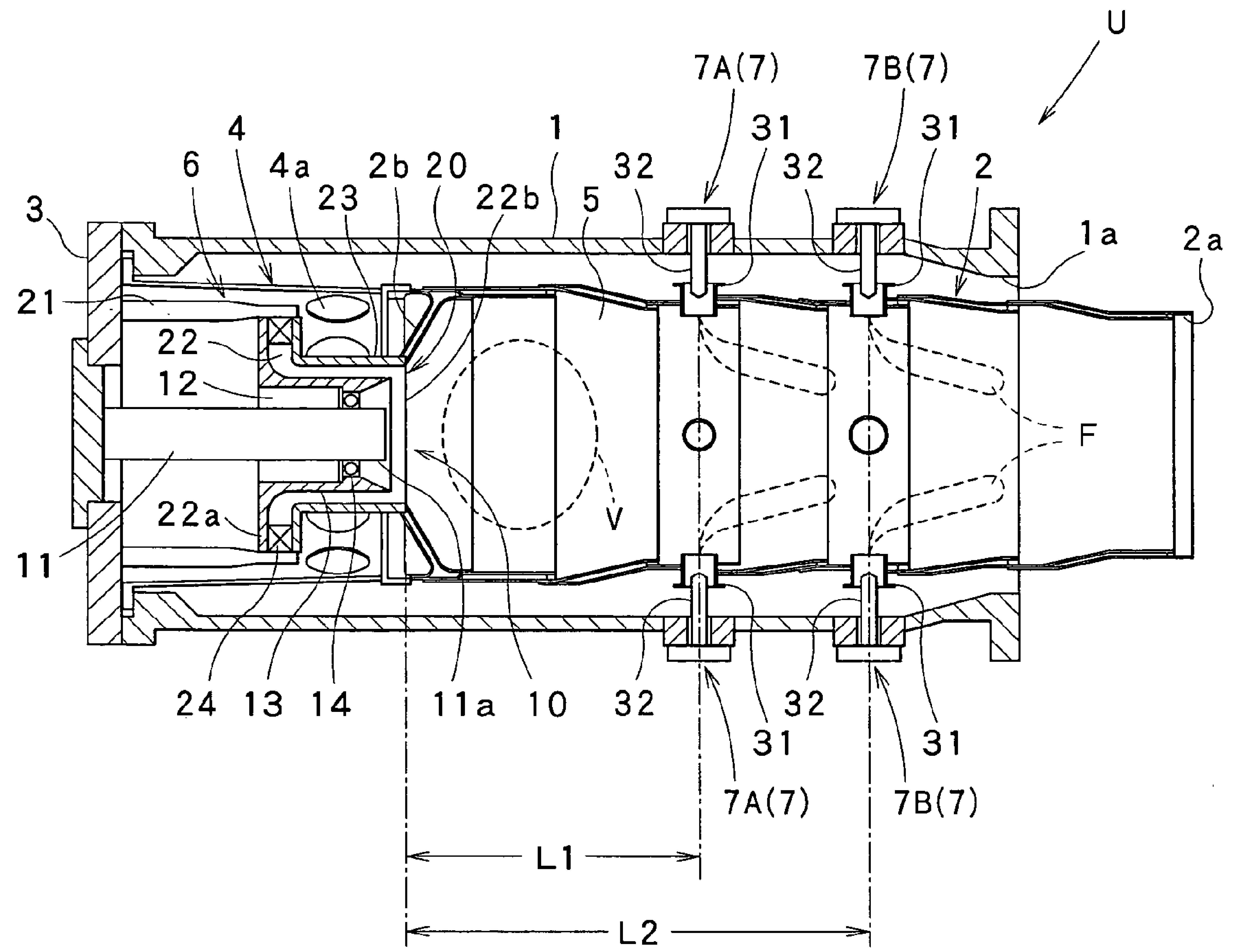
(57) **ABSTRACT**

A combustor for a gas turbine engine of a lean premixed combustion type, includes: a fuel jetting device configured to jet a premixed fuel into a combustion chamber so that the premixed fuel burns in a premixed combustion zone which is formed in the combustion chamber; and an additive fuel supply unit disposed downstream of the premixed combustion zone so as to additionally supply fuel into the combustion chamber. The additive fuel supply unit includes first and second additive fuel supply devices disposed in a two-stage arrangement such that the second additive fuel supply device is positioned downstream of the first additive fuel supply device.



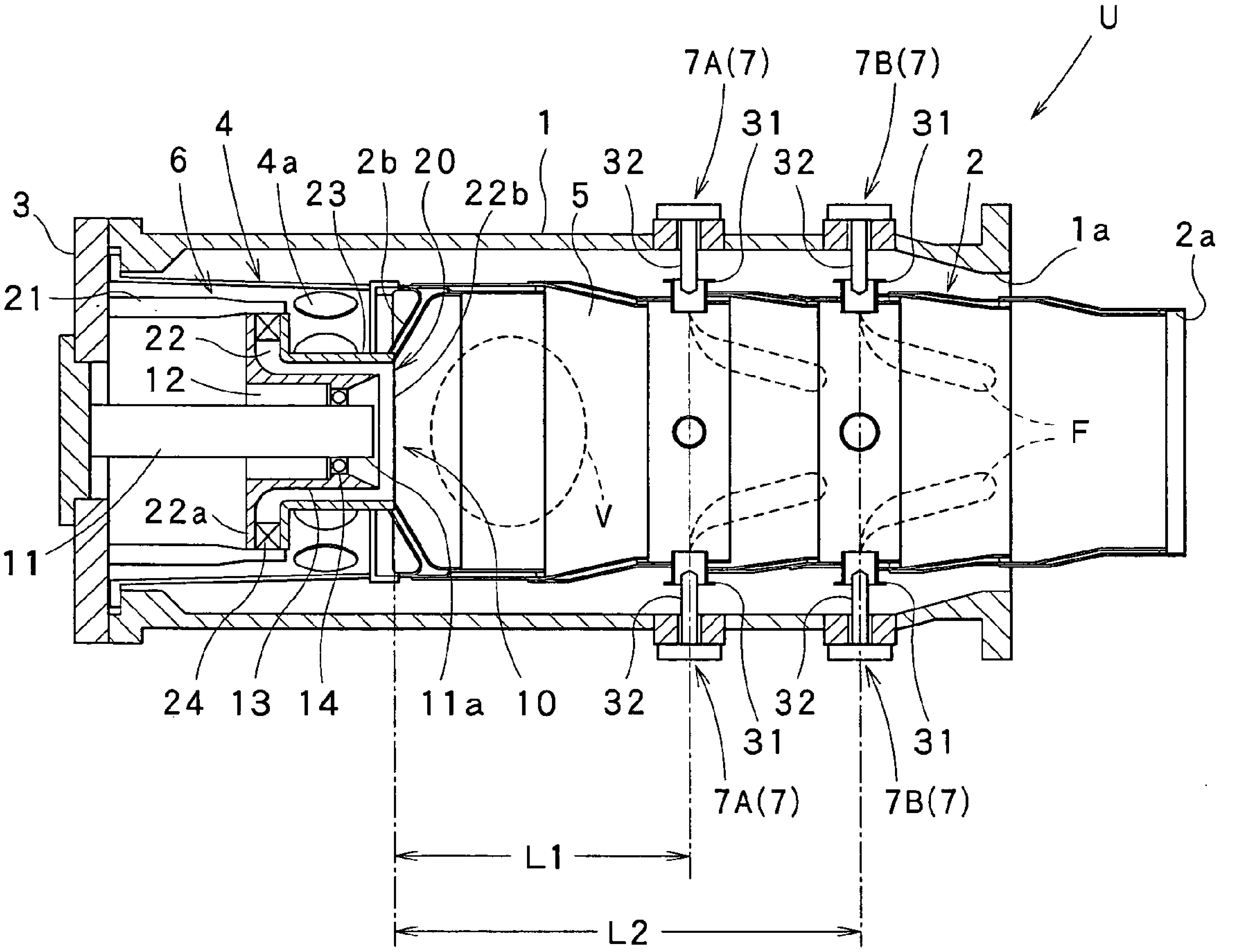

U
7A(7)
7B(7)
4
1
31
31
6
4a
2b
20
32
32
2
3
23
22b
5
1a
2a
21
22
12
F
22a
V
11
24
13
14
11a
10
32
32
31
31
7A(7)
7B(7)
L1
L2

FIG. 1

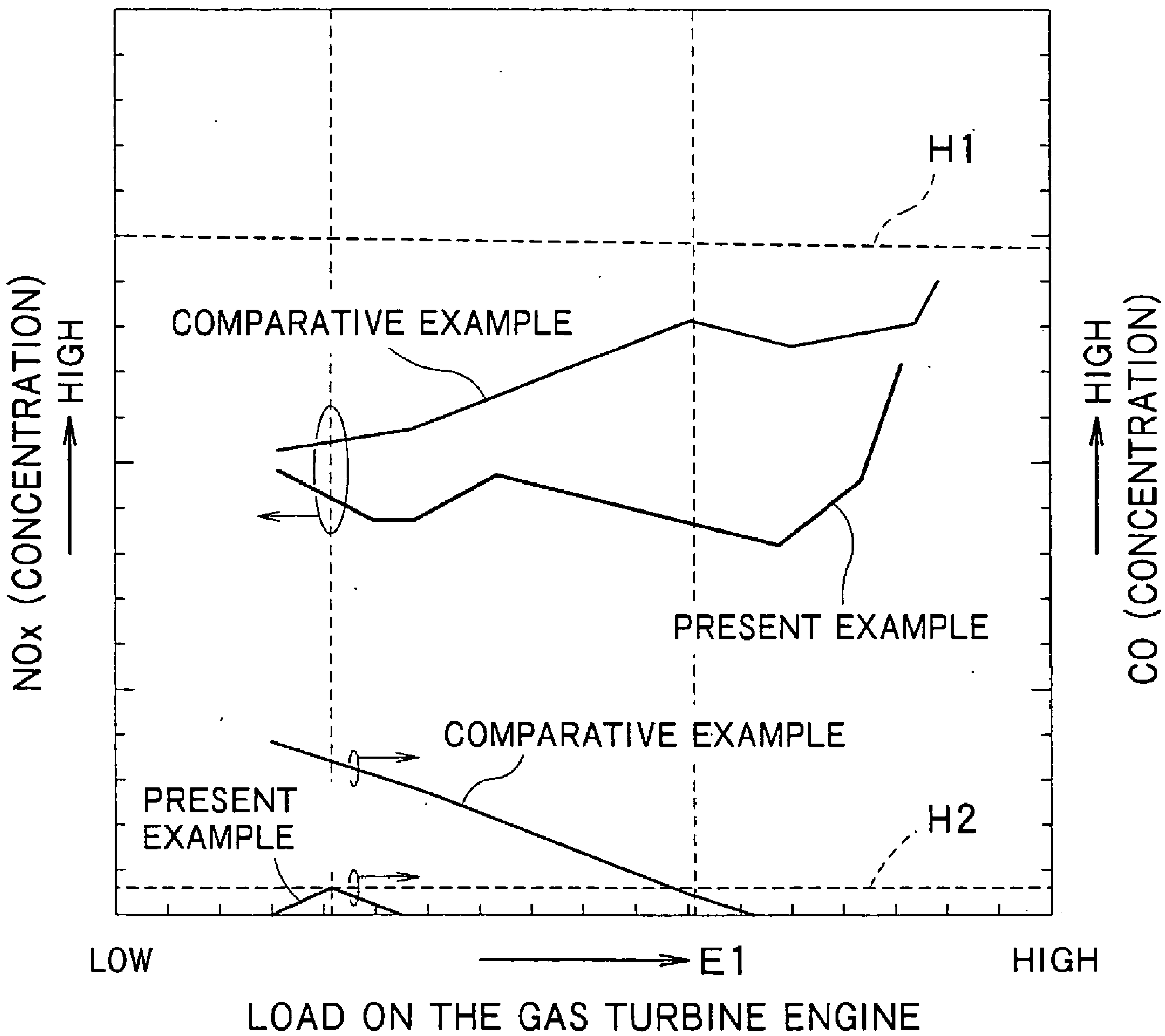

H1
COMPARATIVE EXAMPLE
NOx (CONCENTRATION) → HIGH
CO (CONCENTRATION) → HIGH
PRESENT EXAMPLE
COMPARATIVE EXAMPLE
PRESENT EXAMPLE
H2
LOW
E1
HIGH
LOAD ON THE GAS TURBINE ENGINE

FIG. 2

COMBUSTOR FOR GAS TURBINE ENGINE

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is based upon the prior Japanese Patent Application No. 2005-308380 filed on Oct. 24, 2005, the entire contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a combustor for a gas turbine engine. More specifically, the present invention relates to a combustor for a gas turbine engine, capable of making the combustor of the gas turbine engine achieve desired stable, low-pollution combustion under partial load.

[0004] 2. Description of the Related Art

[0005] Private power generation equipment has progressively come into wide use recently, and gas turbine engines are used widely as power units for private power generation equipment. Different time zones have different power demands, respectively, on private power generation equipment. Therefore, private power generation equipment does not operate always in a maximum-load operating mode and are often required to operate in a partial-load operating mode.

[0006] Consequently, the gas turbine engine for private power generation equipment is required to maintain satisfactorily stable combustion and to reduce the rate of emission of harmful gases including NO_x (nitrogen oxides) and CO (carbon monoxide) for environmental conservation.

[0007] In order to meet the requirements, some techniques have been proposed previously, such as a first method that injects water or steam into a combustion chamber and a second method that reduces air for lean premixed combustion through engine extraction.

[0008] The first method needs an additional mechanism for injecting water or steam into the combustion chamber. The additional mechanism enlarges the gas turbine engine and the gas turbine engine cannot reduce the rate of NO_x emission greatly so as to compensate for the disadvantage of the additional mechanism.

[0009] Although the second method can reduce the rate of NO_x emission in a wide range of load on the gas turbine engine even in lean premixed combustion having a narrow stable combustion range, work necessary for extraction reduces the thermal efficiency of the gas turbine engine.

[0010] The previously proposed techniques are described in JP-A 8-261468, JP-A 10-196909 and JP-A 2000-274689.

SUMMARY OF THE INVENTION

[0011] The present invention has been made in view of those problems in the related art and it is therefore an object of the present invention to provide a combustor for a gas turbine engine, capable of achieving stable combustion and of reducing the rate of emission of harmful substances, such as NO_x and CO, in a wide range of load without enlarging the gas turbine engine, without complicating the constitution of the gas turbine engine and without reducing the thermal efficiency of the gas turbine engine.

[0012] A combustor for a gas turbine engine of a lean premixed combustion type according to the present invention includes: a fuel jetting device configured to jet a premixed fuel into a combustion chamber so that the premixed fuel burns in a premixed combustion zone which is formed in the combustion chamber; and an additive fuel supply unit disposed downstream of the premixed combustion zone so as to additionally supply fuel into the combustion chamber, the additive fuel supply unit including first and second additive fuel supply devices disposed in a two-stage arrangement such that the second additive fuel supply device is positioned downstream of the first additive fuel supply device.

[0013] In the combustor according to the present invention for a gas turbine engine, it is preferable that a main air passage formed in a liner head to supply air into the premixed combustion zone has a sectional area not lager than a sum of sectional areas of air passages in the first and second additive fuel supply devices of the additive fuel supply unit.

[0014] In the combustor according to the present invention for a gas turbine engine, it is preferable that a sectional area of an air passage in the first additive fuel supply device is not larger than a sectional area of an air passage in the second additive fuel supply device.

[0015] In the combustor according to the present invention for a gas turbine engine, it is preferable that the first and second additive fuel supply devices of the additive fuel supply unit are respectively provided with diffusion nozzles to supply fuel.

[0016] The combustor according to the present invention for a gas turbine engine achieves desired stable, low-pollution combustion under load varying in a wide load range and discharges an exhaust gas including reduced amount of harmful substances, such as NO_x and CO.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] The above and other objects, features and advantages of the present invention will become more apparent from the following description taken in connection with the accompanying drawings, in which:

[0018] FIG. **1** is a schematic sectional view of a combustor U in a preferred embodiment according to the present invention for a gas turbine engine; and

[0019] FIG. **2** is diagram comparatively showing the respective load characteristics of harmful gas emissions of a combustor in a present example of the present invention and of a combustor in a comparative example.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0020] A combustor in a preferred embodiment according to the present invention will be described by way of example with reference to FIGS. **1** and **2**.

[0021] Referring to FIG. **1** showing a combustor U in a preferred embodiment according to the present invention included in a gas turbine engine, the combustor U has a combustor casing including a flow sleeve **1**, namely, an outer sleeve, and an inner tube **2**, namely, an inner sleeve, extended inside the flow sleeve **1**.

[0022] One end of the flow sleeve **1** and one end of the inner tube **2** are closed by an end wall **3**. The other end of the flow sleeve **1** is an air inlet **1***a* and the other end of the inner tube **2** is an exhaust outlet **2***a*.

[0023] The interior of the inner tube **2** is divided into a liner head **4** on the side of the end wall **3** and a combustion chamber **5** on the side of the exhaust outlet **2***a* by a partition wall **2***b* having a shape resembling an annular plate disposed at a predetermined longitudinal position.

[0024] The liner head **4** is provided with a predetermined number of openings **4***a* through which combustion air taken through the air inlet **1***a* into the flow sleeve **1** flows into the inner tube **2**. A fuel jetting device **6** is disposed inside the liner head **4**. The fuel jetting device **6** prepares a premixed fuel by mixing fuel supplied by a fuel supply system, not shown, and combustion air and jets the premixed fuel into the combustion chamber **5**. The premixed fuel jetted by the fuel jetting device **6** burns in a predetermined premixed combustion zone V in the combustion chamber **5**.

[0025] The combustor U is provided with a two-stage additive fuel supply unit **7** in addition to the fuel jetting device **6**. The two-stage additive fuel supply unit **7** supplies fuel additionally into the combustion chamber **5** while the gas turbine engine is in a partial-load operation. In FIG. **1**, a character F indicates diffusion flames, namely, premixed flames.

[0026] The fuel jetting device **6** includes a pilot combustion unit **10** in a central part of an inner opening of the partition wall **2***b* disposed on the upstream side of the combustion chamber **5**, and a main combustion unit **20** surrounding the pilot combustion unit **10**.

[0027] The pilot combustion unit **10** has a central pilot fuel nozzle **11**, and a combustion air passage **12** surrounding the pilot fuel nozzle **11**. A premixed fuel produced by mixing fuel jetted through the pilot fuel nozzle **11** and combustion air is jetted into the combustion chamber **5**.

[0028] The pilot fuel nozzle **11** has a closed end and a side wall provided with radial jetting holes **11***a*. Fuel is jetted radially through the radial jetting holes **11***a*. The combustion air passage **12** is defined by the outside surface of the pilot fuel nozzle **11** and the inside surface of an inner hat-shaped tube **13** surrounding the pilot fuel nozzle **11**. A swirler **14** is disposed at a predetermined position in the combustion air passage **12**. The fuel jetted into the combustion air passage **12** through the pilot fuel nozzle **11** is mixed into swirling combustion air currents produced by the swirler **14**. The premixed fuel flows into the combustion chamber **5**.

[0029] The main combustion unit **20** includes a main fuel nozzle **21** and a main premixed fuel passage **22**. A premixed fuel produced by mixing the fuel jetted through the main fuel nozzle **21** and combustion air flows through the main premixed fuel passage **22** into the combustion chamber **5**.

[0030] The main fuel nozzle **21** surrounds the inner hat-shaped tube **13**. The fuel is jetted through the main fuel nozzle **21** toward the inlet **22***a* of the premixed fuel passage **22**.

[0031] The main premixed fuel passage **22** is defined by the outside surface of the inner hat-shaped tube **13** and an outer hat-shaped tube **23** of a diameter greater than that of the inner hat-shaped tube **13**. A space between the flanges of the hat-shaped tubes **13** and **23** forms the inlet **22***a* of the premixed fuel passage **22**.

[0032] A swirler **24** is disposed in the inlet **22***a* of the premixed fuel passage **22**.

[0033] The open end of the outer hat-shaped tube **23** is joined to the inside edge of the partition wall **2***b* disposed inside the inner tube **2** to form a premixed fuel outlet **22***b*, namely, the outlet of the main premixed fuel passage.

[0034] A premixed fuel produced by mixing the fuel jetted through the main fuel nozzle **21** and combustion air is swirled. The swirling premixed fuel is jetted through the premixed fuel outlet **22***b* into the premixed combustion zone V.

[0035] Combustion air taken through the openings **4***a* of the liner head **4** into the inner tube **2** flows through the main premixed fuel passage **22** and the swirler **14** into the premixed combustion zone V. The present specification defines the sum of the respective sectional areas of the main premixed fuel passage **22** and the swirler **14** as a main air passage area S.

[0036] Generally, there are limited lean air-fuel ratios that enable the gas turbine engine to achieve stable combustion at low rate of emission of NO_x and CO under low loads. According to the present embodiment, the main air passage area S is determined such that the air-fuel ratio of the premixed fuel in the premixed combustion zone V while the gas turbine engine is in a partial-load operation under a predetermined load, such as a load equal to 50% of a maximum load, is nearly equal to the limited air-fuel ratio for an operation under a predetermined load nearly equal to a maximum load, such as a load equal to 80% of the maximum load. The main air passage area S is smaller than an ordinary main air passage area.

[0037] The two-stage additive fuel supply unit **7** supplies fuel additionally for after burning into a predetermined zone downstream of the premixed combustion zone V, in which stable low-NO_x, low-CO combustion is carried out, in the combustion chamber **5** during a partial-load operation to suppress the generation of NO_x. The two-stage additive fuel supply unit **7** has a predetermined number of additive fuel supply tubes **31** penetrate parts corresponding to the predetermined zone of the inner tube **2** defining the combustion chamber **5**, and additive fuel supply nozzles **32** having end parts of a predetermined length inserted into the additive fuel supply tubes **31**.

[0038] The additive fuel supply nozzles **32** may be either of diffusion nozzles as shown in FIG. **1** and premixed combustion nozzles, not shown.

[0039] The two-stage additive fuel supply unit **7** includes a first additive fuel supply device 7A and a second additive fuel supply device 7B. The first additive fuel supply device **7***a* and the second additive fuel supply device **7**B are disposed at a first longitudinal distance L**1** and a second longitudinal distance L**2**, respectively, from the premixed fuel outlet **22***b*. The distance L**2** is greater than the distance L**1**.

[0040] The first distance L1, the second distance L2, the numbers of the tubes 31 and the additive fuel supply nozzles 32 of the additive fuel supply devices 7*a* and 7B, the pattern of arrangement, such as a straight pattern or a zigzag pattern, of the additive fuel supply nozzles 32, the ratio between the main air passage area S and the sum of the sectional areas of the air passages of the two-stage additive fuel supply unit 7, and the ratio between the respective sectional areas of the first additive fuel supply device 7A and the second additive fuel supply device 7B are selectively determined so that the rate of emission of NO_x and CO may be small and stable combustion can be achieved.

[0041] The ratio D1 of the main air passage area S to the total sectional area of the two-stage additive fuel supply unit 7 is, for example, 5/5, and the ratio D2 of the total sectional area of the first additive fuel supply device 7A to the total sectional area of the second additive fuel supply device 7B is, for example, 4/6.

[0042] The ratio D1 is reduced to 4/6 or such to widen the range of low-load operation.

[0043] The ratio D2 is reduced to 3/7 or such to widen the range of low-load operation.

[0044] The main air passage area S of the combustor U in this embodiment is determined so that the combustor U can achieve stable combustion at a low rate of emission of NO_x and CO while the gas turbine engine is in a partial-load operation, and the fuel additionally supplied by the two-stage additive fuel supply unit 7 burns in the combustion chamber 5. Therefore, a proper air-fuel ratio in accordance with a given load can be determined so that the generation of NO_x and CO can be suppressed.

[0045] Thus the combustor U can maintain stable combustion at a low rate of emission of NO_x and CO for the operation of the gas turbine in a wide load range.

[0046] Performance of combustors in a present example according to the present invention and a comparative example will be described in connection with FIG. 2. Shown in FIG. 2 are load characteristics of NO_x and CO concentrations of the exhaust gas discharged from a combustor in the comparative example provided with only the first additive fuel supply device 7A and load characteristics of NO_x and CO concentrations of the exhaust gas discharged from a combustor in the present example provided with the first additive fuel supply device 7A and the second additive fuel supply device 7B. In FIG. 2, H1 shows the allowable upper limit of NO_x concentration, and H2 shows the allowable upper limit of CO concentration.

[0047] As obvious from FIG. 2, the NO_x concentration of the exhaust gas discharged from the combustor in the present example is lower than that of the exhaust gas discharged from the combustor in the comparative example in the entire load range.

[0048] It is known from FIG. 2 that the additive fuel supply devices 7A and 7B are effective in reducing the NO_x and the CO concentration of the exhaust gas. The CO concentration of the exhaust gas discharged from the combustor in the present example is below the allowable upper limit H2 of CO concentration in the entire load range, which proves that the additive fuel supply devices 7A and 7B are effective in reducing the CO concentration of the exhaust gas. The CO concentration of the exhaust gas generated by the combustor in the comparative example is higher than the allowable upper limit H2 of CO concentration at loads below a predetermined load E1. Therefore, the combustor in the comparative example should not be operated at loads below the predetermined load E1 from the viewpoint of environmental conservation. Thus the two-stage additive fuel supply unit 7 including the additive fuel supply devices 7A and 7B expands the load range in which the combustor can operate without causing problems in environmental conservation.

[0049] Although the invention has been described in its preferred embodiment with a certain degree of particularity, obviously many changes and variations are possible therein. It is therefore to be understood that the present invention may be practiced otherwise than as specifically described herein without departing from the scope and spirit thereof.

What is claimed is:

1. A combustor for a gas turbine engine of a lean premixed combustion type, comprising:

a fuel jetting device configured to jet a premixed fuel into a combustion chamber so that the premixed fuel burns in a premixed combustion zone which is formed in the combustion chamber; and

an additive fuel supply unit disposed downstream of the premixed combustion zone so as to additionally supply fuel into the combustion chamber, the additive fuel supply unit including first and second additive fuel supply devices disposed in a two-stage arrangement such that the second additive fuel supply device is positioned downstream of the first additive fuel supply device.

2. The combustor for a gas turbine engine according to claim 1, wherein a main air passage formed in a liner head to supply air into the premixed combustion zone has a sectional area not lager than a sum of sectional areas of air passages in the first and second additive fuel supply devices of the additive fuel supply unit.

3. The combustor for a gas turbine engine according to claim 1, wherein a sectional area of an air passage in the first additive fuel supply device is not larger than a sectional area of an air passage in the second additive fuel supply device.

4. The combustor for a gas turbine engine according to claim 2, wherein a sectional area of an air passage in the first additive fuel supply device is not larger than a sectional area of an air passage in the second additive fuel supply device.

5. The combustor for a gas turbine engine according to claim 1, wherein the first and second additive fuel supply devices of the additive fuel supply unit are respectively provided with diffusion nozzles to supply fuel.

* * * * *