

[54] COMBUSTION DEVICE

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60/39.65, 39.29

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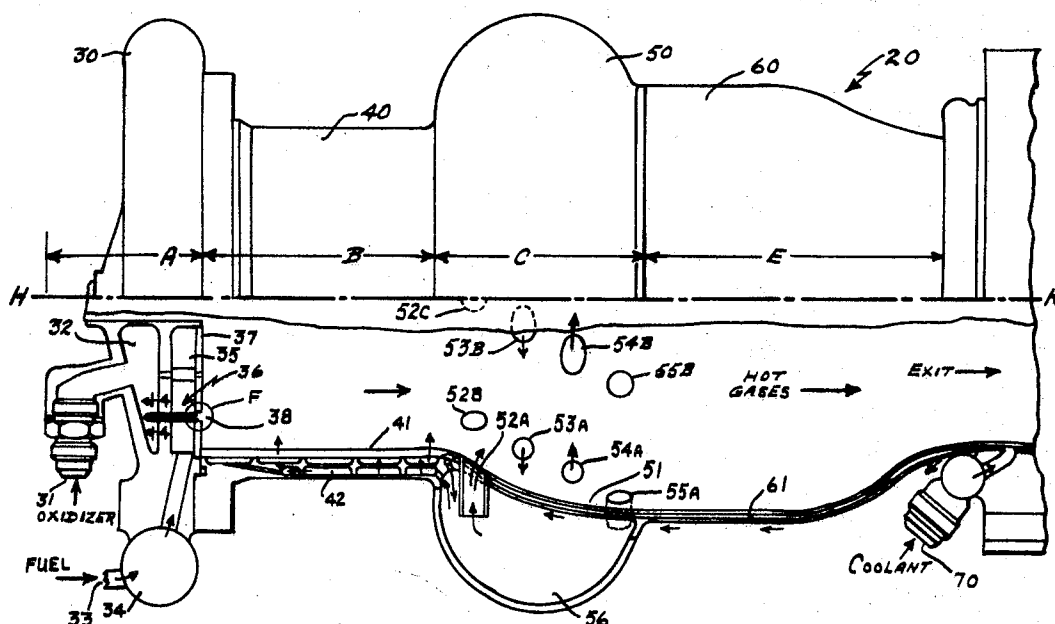
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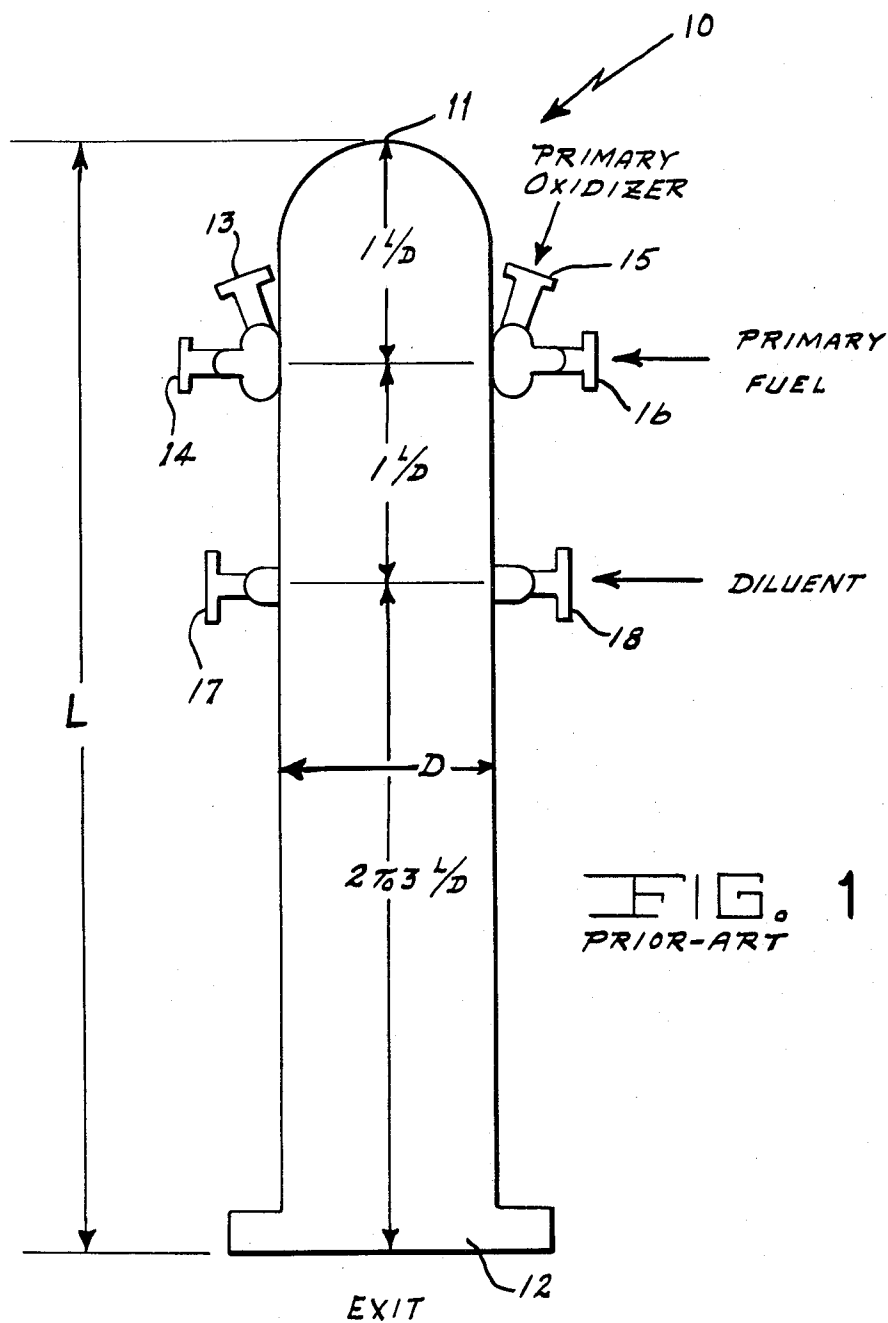
[57] ABSTRACT

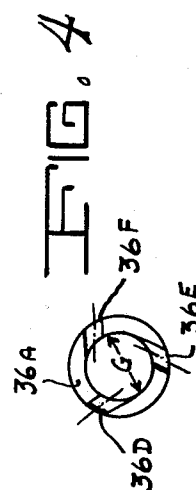
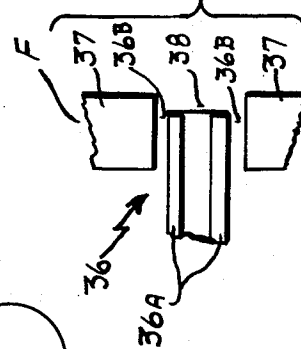
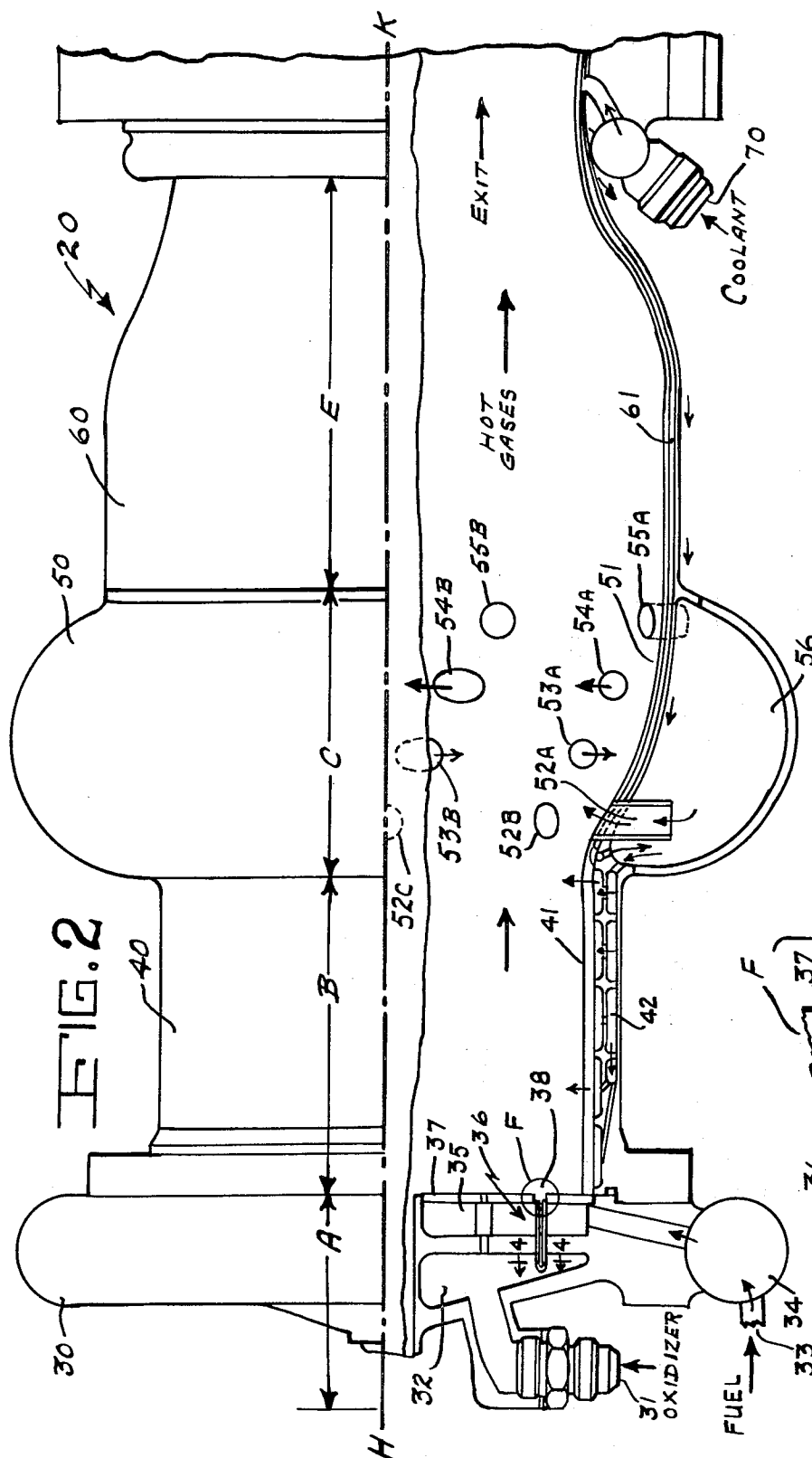
A combustion device adapted for use as an injector and combustor for an advanced combustor rig which is suitably connected to a source of liquid oxidizer, a source of gaseous fuel, and a source of dilution gas coolant, and which has a suitable positioned ignitor

and an exit. The combustion device is preferably structured in successively adjacent, axially aligned, connected sections or regions, e.g., a primary injector section, a primary combustor section, a dilution injector section, and a mixing section which leads to the combustion device exit. A preferred embodiment of the particular adaptation of the inventive device comprises: a primary injector which includes a coaxial injection means, comprising an inner cylindrical oxidizer injection element surrounded by an annulus shaped fuel injection orifice, and which also includes a transpirationally-cooled injector face plate which is preferably made of woven and sintered wire mesh; a primary combustor, in communication with, and rearward of the primary injector; a dilution injector, in communication with, and rearward of, the primary combustor; and a dilutor mixer, in communication with, and rearward of the dilution injector. In essence, the primary injector atomizes the liquid oxidizer and introduces and mixes the atomized liquid oxidizer and the gaseous fuel which, in turn, react within the primary combustor. The dilution injector introduces the dilution gas into the high temperature gases from the primary combustor and generates the turbulence required for thorough mixing; and, the dilutor mixer provides a volume within which mixing between the dilution gas and the high temperature gases occurs. The inventive device, unlike the prior art, permits use of either liquid or gaseous oxidizer; is structurally approximately 40 percent shorter for a given flowrate; results in a more uniformly axial flowfield in the primary combustor, and therefore lower heat fluxes; and, allows for more simple manifolding.

4 Claims, 4 Drawing Figures







COMBUSTION DEVICE

BACKGROUND OF THE INVENTION

This invention relates to a novel combustion device and, more particularly, to an adaptation thereof for particular use as an injector and combustor for an advanced combustor rig which is suitably connected to a source of liquid oxidizer, and to a source of gaseous fuel, and also to a source of a dilution gas coolant, and which has a suitably positioned ignitor, an exit, and a longitudinal axis.

The conventional prior art combustor (i.e., combustion device) has at least four separate, distinct, basic, and inherent substantial disadvantages. Firstly, the structure is specific to the use of gaseous reagents solely, and can be adapted for use with gas-liquid reagents only with great difficulty. Secondly, the combustor, especially in the larger flow-rate range, is extremely long, which results in weight and packaging penalties. Thirdly, the combustor flowfield, except near the combustor exit region, is highly turbulent, so that the combustor heat fluxes cannot be predicted. In addition, the heat fluxes are also high due to this turbulence, and the combustor presents a severe cooling problem. Fourthly, the multiplicity of injection ports leads to a highly complex manifolding system, with attendant packing penalties.

Our inventive apparatus eliminates these severe disadvantages; and, therefore, it significantly advances the state-of-the-art.

SUMMARY OF THE INVENTION

This invention pertains to a unique injector and combustor for an advanced combustor rig.

One object of this invention is to permit the use of either liquid or gas oxidizer with, and in, the inventive device.

Another object of this invention is to structure the inventive device so that it will be significantly shorter than the conventional prior art device, for a given flow rate.

Still another object of this invention is to obtain, with the inventive device, a more uniformly axial flowfield in the primary combustor, and therefore lower heat fluxes, than are obtainable in the conventional prior art device.

Yet another object of this invention is to allow for more simple manifolding, as compared to the complex reagent manifold existing in the conventional prior art device.

These objects, and still other related and equally important objects, of our invention will become readily apparent after a consideration of the description of the invention and reference to the drawings.

DESCRIPTION OF THE DRAWING

FIG. 1 is a top plan view, in simplified schematic form and in cross section, of a representative conventional prior art combustor;

FIG. 2 is a side elevation view, in simplified schematic form, partially in cross section and partially fragmented, of a preferred embodiment of our inventive device, as adapted for a particular use, with a portion of a component encircled and generally designated "F" for easy identification, and with the longitudinal axis of the embodiment referenced "H-K";

FIG. 3 is a side elevation view, in cross section and in simplified schematic form, enlarged and in detail, of that portion of a component which is encircled and is designated "F" in FIG. 2; and,

FIG. 4 is a cross sectional view, in simplified schematic form, enlarged and in detail, taken along line 4-4 in FIG. 2, of a component of the preferred embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENT

As a preliminary matter, reference is made to FIG. 1. Therein is shown a conventional prior art combustor (i.e., combustion device) 10. As a matter of convenience, the combustor 10 is shown in a vertical position, rather than the usual horizontal position. The combustor is cylindrical, of constant diameter "D," with one end 11 closed, and with the end 12 open and serving as the exit. The length of the combustor 10, from end 11 to end 12, is designated in FIG. 1 as "L."

Still with reference to FIG. 1, at a distance of about 1 L/D from the closed end 11, a ring of coaxial injection ports, such as 13, 14, 15 and 16, injects the gaseous oxidizer and the gaseous fuel radially inward. More specifically, the gaseous oxidizer, which actually consists of oxidizing gas and an inert diluent (i.e., a dilution gas), is injected for example through ports 13 and 15; and, the gaseous fuel is injected for example through ports 14 and 16. This ring of injection ports (e.g., 13, 14, 15 and 16) usually consists of 3 to 6 injection ports, with each said port directed toward the center of the combustor 10.

Further with reference to FIG. 1, at a distance of about 1 L/D from the ring of coaxial injection ports, such as 13 and 16, a second ring of single ports, such as 17 and 18, injects the remaining diluent. As with the coaxial ports, there are 3 to 6 dilution ports, such as 17, all directed radially inward toward the center of the combustor 10. The remainder of the combustor 10 is 2 to 3 L/Ds long, resulting in a total length "L" of 4 to 5 L/D.

With reference to FIG. 2, therein is shown a preferred embodiment 20 of our inventive device, as adapted for use as an injector and combustor rig. This adaptation is by way of illustration only, and not by way of any limitation.

Embodiment 20 is preferably structured in successively adjacent, axially aligned, connected sections or regions, e.g., a primary injector section (generally designated "A"), a primary combustor section (generally designated "B"), a dilution injector section (generally designated "C"), and a dilutor mixing section or mixer (generally designated "E").

The embodiment 20 is assumed to be, and in operation is in fact, suitably connected to a source of liquid oxidizer, and to a source of gaseous fuel, and also to a source of dilution gas coolant; and, said embodiment is also assumed to have a suitably positioned conventional ignitor and also to have an exit and a longitudinal axis. Neither the sources, nor the ignitor, are shown in FIG. 3 in the interest of maintaining simplicity of the drawing. In addition, neither the sources, nor the ignitor, form any part of the inventive device. The exit is designated by a legend to that effect and a directional arrow.

Still with reference to FIG. 2, the preferred embodiment 20 of the particular adaptation of the inventive device includes a primary injector 30 having an oxidizer inlet 31 which is in connection with an oxidizer plenum chamber 32, and also having a fuel inlet 33 in connection with a fuel supply manifold 34 which in turn is in connection with a fuel plenum chamber 35, and further having a coaxial injection means generally designated by reference numeral 36 with a portion thereof encircled for easy identification and designated "F," and further also having a transpirationally cooled injector faceplate 37 with an opening 38, which said faceplate 37 is made of course of material that permits transpiration cooling, preferably a woven and sintered wire mesh material.

Now, with reference to FIG. 3, therein is shown a side elevation view, enlarged and in detail, of that portion of coaxial injection means 36 which is encircled and is designated "F" in FIG. 2. As can be easily seen, coaxial injection means 36 includes a hollow inner cylindrical oxidizer injection element 36A, and also includes an annulus shaped fuel injection orifice 36B which surrounds element 36A. Also shown in FIG. 3 is a portion of faceplate 37 and of opening 38 thereof, depicted in positional relationship to oxidizer injection element 36A and to fuel orifice 36B. It is to be noted that coaxial injection means 36 (i.e., more specifically, a portion of element 36A thereof) leads into, enters into, and almost passes through opening 38 of faceplate 37.

Now, with reference to FIG. 4, therein is shown, in cross-section, enlarged and in detail, a representative portion of oxidizer injection element 36A, FIG. 3, of coaxial injection means 36, as viewed and taken along line 4-4 in FIG. 2. The oxidizer injection element 36A is preferably of the tangential-entry, single-piece construction type with a plurality of slots, such as 36D, 36E and 36F which are formed (e.g., by machining) and positioned tangentially to the inner diameter "G" of the injection element 36A.

Again with reference to FIG. 2, the coaxial injection means 36 also leads from (i.e., is in connection with) the oxidizer plenum chamber 32 and the fuel plenum chamber 35.

Still with reference to FIG. 2, the preferred embodiment 20 also includes: a primary combustor 40, in communication with, rearward of (i.e., aft, downstream, and the like), and in axial alignment with the primary injector 30; a dilution injector 50, in communication with, rearward of, and in axial alignment with primary combustor 40; and, a mixing section (i.e., a dilutor mixer) 60, in communication with, rearward of, and in axial alignment with the dilution injector 50.

Primary combustor 40 preferably is cylindrical in shape and has a transpirationally cooled liner 41 which or course is made of material which permits transpiration cooling. The lining 41 is in connection with a compartmented dilution gas coolant supply manifold 42, which is in turn connected through other components to the source of dilution gas coolant (not shown), such as a source of nitrogen.

Dilution injector 50 includes a divergent duct 51, a plurality of dilution injection ports, such as 52 A-C, 53 A&B, 54 A&B, and 55 A&B, and a diluent distribution manifold 56. The dilution injection ports preferably are short tubes which are arranged in a plurality of rows, preferably four rows. The first row (which includes ports 52 A-C) and the fourth row (which includes

ports 55 A&B) are directed in a purely radial direction, at right angles to longitudinal axis H-K of the combustion device 20, which said axis H-K is also the coincident resultant axis of the longitudinal axis of the primary injector 30, of the longitudinal axis of the primary combustor 40, of the longitudinal axis of the dilution injector 50, and of the longitudinal axis of the dilutor mixer 60, which said longitudinal axes are not shown, since axis H-K depicts their coincidence. Axis H-K is also the center line of the combustion device 20. In contrast to the first and fourth row, the second row (which includes ports 53 A&B) and the third row (which includes ports 54 A&B) are directed in a tangential direction, with the flow from said second row being directed tangentially opposite with respect to the flow from said third row. Stated another way, if the position of the second row is assumed to result in a clockwise flow therefrom, then the position of the third row is such that the flow therefrom is counterclockwise. The above-described arrangement of the dilution injection ports, such as 52 A-C, 53 A&B, 54 A&B, and 55 A&B generates a high degree of turbulence and evenly distributes the diluent throughout the hot-gas flow area.

Dilution injector 50 also includes a diluent distribution manifold 56 which is in connection with the compartmented dilution gas coolant supply manifold 42, and which is also in connection with the dilution injection ports, such as 52 A-C, 53 A&B, 54 A&B, and 55 A&B.

The mixing section (i.e., the dilutor mixer) 60 is sized for the same hot-gas velocity as in the primary combustor 40 and the dilution injector 50. The dilutor mixer 60 has a convectively cooled liner 61 which is preferably of a nontubular milled passage type construction, and which is in connection with the diluent distribution manifold 56. The mixer 60 decreases in cross sectional area at the exit of the combustion device 20.

MODE OF OPERATION OF THE PREFERRED EMBODIMENT

The mode of operation of the preferred embodiment 20 of our inventive device is easily understood from the foregoing description, coupled with reference to FIGS. 1-4, inclusive.

Succinctly, and in essence, the primary injector 30 atomizes the liquid oxidizer and introduces and mixes the atomized liquid oxidizer and the gaseous fuel which, in turn, react within the primary combustor 40. The dilution injector 50 introduces the dilution gas into the high temperature gases flowing from the primary combustor 40 and generates the turbulence required for thorough mixing; and, the dilutor mixer 60 provides a volume within which mixing between the dilution gas and the high temperature gases occur.

More specifically, the oxidizer enters oxidizer injection element 36A through the slots, such as 36D, 36E and 36F. The high shear forces created within the oxidizer fluid by the strong vortex flow causes atomization of the liquid into very fine droplets as it leaves injection element 36A. Further atomization results from the shearing action between the oxidizer and the high velocity fuel gas within the combustion chamber.

Additionally, it is to be noted that a portion of the gaseous fuel passes through faceplate 37 and provides cooling of the faceplate.

As previously indicated, the primary combustor 40 provides the volume within which the injected fuel and oxidizer burn to close to 100 percent combustion efficiency. The primary combustor 40 is cooled by transpirationally cooled liner 41 which is supplied with the dilution gas coolant from the compartmented supply manifold 42. The compartments of the supply manifold 42 distribute the flow to the liner 41 as indicated by the arrows in FIG. 2; and, in the event of damage to a portion of liner 41, the compartments will not divert flow of the dilution gas coolant from the other compartments of the manifold 42.

The dilution injector 50 introduces the majority of the diluent gas, less the primary combustor cooling flow, into the high-temperature gases (i.e., the "primary" gases) from the primary combustor 40. The diluent gas is injected from large, discrete jets which penetrate the hot gases and generate the high levels of turbulence required to mix thoroughly the primary gases with the diluent.

The divergent duct 51 of the dilution injector 50 is contoured to give a constant hot-gas velocity to enhance the penetration of the dilution jets. Without an increase in area, the hot-gas velocity would increase due to the greatly increased mass flow and the penetration of the dilution jets would be reduced, resulting in a reduction of mixing efficiency.

The diluent distribution manifold 56 collects the diluent gas from the mixing section liner 61 and distributes the diluent into transpirationally cooled liner compartmented supply manifold 42 and also into the dilution injection ports, such as 52A-C, 53 A&B, 54 A&B, and 55 A&B. This advantageously eliminates external diluent transfer lines. Once the diluent is introduced into the combustion device 20, it is handled entirely within the envelope of the combustion device.

The mixing section (or dilutor mixer) 60 provides additional volume, within which the turbulence that is generated in the dilution injector 50 mixes the hot gas from the primary combustor 30 and the diluent from the dilution injector 50; and it 60 is sized for the same hot-gas velocity as in the primary combustor 40 and the dilution injector 50, thereby allowing the mixing to proceed at a high rate, so that uniform species concentration, temperature, and total profiles are attained in an advantageously short length. The previously mentioned decrease in cross sectional area of the mixer 60 at the exit end of the combustion device 20, is for compatibility with the remainder of the hot-gas manifolding. The coolant, such as nitrogen, is introduced into the mixer liner 60 at, or near the, exit of the combustion device 20; and, the coolant flows (as indicated by the arrows) toward the dilution injector 50, in the direction opposite to that of the hot gases. The coolant inlet is designated with reference numeral 70 in FIG. 2.

CONCLUSION

It is clear from the foregoing description, and from the drawings herein, that the desired objects of our inventive device have been attained. In addition, our inventive device has the very desirable advantage of being highly amenable to scaling and to performance analysis, and of eliminating external diluent transfer lines.

It is emphasized that, while there have been shown and described the fundamental unique features of our invention, as applied to a preferred embodiment

adapted for a particular use, it is to be understood that various other embodiments, substitutions, additions, omissions, adaptations, and the like, can be made by those of ordinary skill in the art, without departing from the spirit of the invention.

What we claim is:

1. A combustion device adapted for use as an injector and combustor for an advanced combustor rig which is suitably connected to a source of liquid oxidizer, and to a source of gaseous fuel, and also to a source of a dilution gas coolant, and which said combustion device has a suitably positioned ignitor, and has an exit, and also has a longitudinal axis, comprising:

- a. a primary injector having an oxidizer inlet in connection with an oxidizer plenum chamber, and having a fuel inlet in connection with a fuel supply manifold which is in connection with a fuel plenum chamber, and also having a coaxial injection means, for injecting oxidizer and fuel from their respective sources, leading from said oxidizer plenum chamber and also leading from said fuel plenum chamber, wherein said coaxial injection means includes an inner cylindrical oxidizer injection element with an inner diameter, which said oxidizer injection element is surrounded by an annulus shaped fuel injection orifice, and with said primary injector further having a transpirationally cooled injector faceplate made of material which permits transpiration cooling, and with said injector faceplate having an opening into which said coaxial injection means leads, and into which said opening a portion of said coaxial injection means enters;
 - b. a primary combustor, in communication with, rearward of, and in axial alignment with said primary injector, with said primary combustor having a transpirationally cooled liner made of material which permits transpiration cooling, and with said primary combustor liner in connection with a compartmented dilution gas coolant supply manifold in connection with said source of dilution gas coolant;
 - c. a dilution injector, in communication with, rearward of, and in axial alignment with said primary combustor, with said dilution injector having a divergent duct, and also having a plurality of dilution injection ports with some of said ports disposed radially and some tangentially, and further having a diluent distribution manifold in connection with said compartmented dilution gas coolant supply manifold and also in connection with said dilution injection ports;
 - d. and, a dilutor mixer, in communication with, rearward of, and in axial alignment with said dilution injector and the exit of the combustion device, with said dilutor mixer having a convectively cooled liner in connection with said diluent distribution manifold, and with said dilutor mixer decreasing in cross sectional area at the exit of the combustion device.
2. A combustion device, as set forth in claim 1, wherein said oxidizer injection element of said coaxial injection means of said primary injector is of the tangential-entry, single-piece construction type, with a plurality of slots positioned tangentially to the inner diameter of said oxidizer injection element.
3. A combustion device, as set forth in claim 1, wherein said transpirationally cooled faceplate of said

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primary injector is made of woven and sintered wire mesh.

4. A combustion device, as set forth in claim 1, wherein said dilution injection ports are arranged in four rows, with the first and fourth rows directed in a

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radial direction and with the second and the third rows directed in a tangential direction, whereby a high degree of turbulence is created with the resultant even distribution of the diluent.

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