



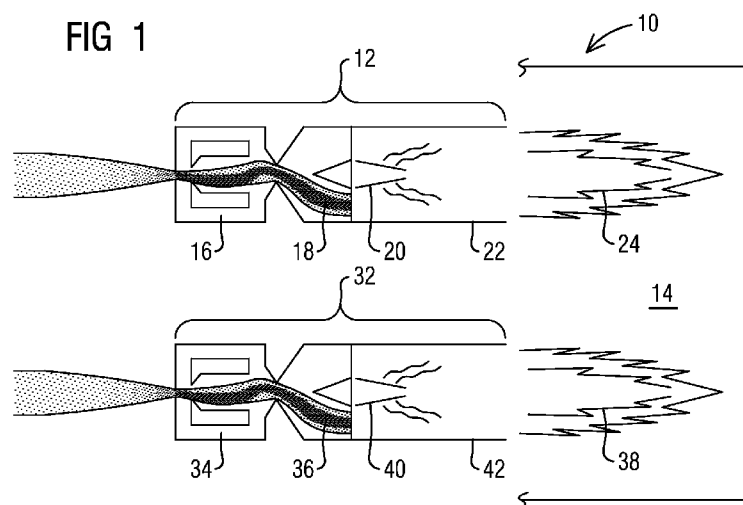
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(54) **Title:** COMBUSTOR SYSTEM AND METHOD FOR REDUCING COMBUSTION RESIDENCE TIME AND/OR DAMPING COMBUSTION DYNAMICS



(57) **Abstract:** Combustor system and method for reducing combustion residence time and/or damping combustion dynamics are provided. The system includes a first main burner (12) that in turn includes a first fluidic nozzle (16) tuned to convey a first flow of a fluid that oscillates at a first oscillation frequency to form a first flame (24). The combustor system further includes a second main burner (32) that in turn includes a second fluidic nozzle (34) tuned to convey a second flow of said fluid that oscillates at a second oscillation frequency to form a second flame (38). The first oscillation frequency and the second oscillation frequency have different values so that respective temporal characteristics of the first and second flames are different relative to one another. Flame-forming cups (22, 42) may be appropriately configured to impart different spatial characteristics to the first and second flames.

COMBUSTOR SYSTEM AND METHOD FOR REDUCING COMBUSTION RESIDENCE TIME AND/OR DAMPING COMBUSTION DYNAMICS

BACKGROUND

1. Field

- 5 Disclosed embodiments are generally related to combustion turbine engines, such as gas turbine engines, and, more particularly, to a combustor system and method that may utilize burners effective for reducing combustion residence time and/or damping combustion dynamics.

2. Description of the Related Art

- 10 A combustion turbine engine, such as a gas turbine engine, comprises for example a compressor section, a combustor section and a turbine section. Intake air is compressed in the compressor section and then mixed with a fuel. The mixture is burned in the combustor section to produce a high-temperature and high-pressure working gas directed to the turbine section, where thermal energy is converted to
15 mechanical energy.

- Emission and performance requirements in the power generation industry tend to drive combustor system design boundaries towards attempting relatively lower combustion residence time as well as higher power outputs. However, such attempts sometimes may exacerbate combustion dynamics instabilities and/or may impact
20 emissions.

BRIEF DESCRIPTION OF THE DRAWINGS

- FIG. 1 illustrates a schematic representation of non-limiting basic building blocks of disclosed main burners that may be used in a combustor system for a combustion
25 turbine engine, such as a gas turbine engine.

FIG. 2 shows a schematic of a disclosed combustor system using respective arrays of main burners, as shown in FIG. 1.

FIG. 3 is another non-limiting embodiment of a main burner embodying further aspects of the present invention.

FIG. 4 is a schematic of one non-limiting conceptual embodiment of different temporal and/or spatial characteristics that may be imparted to respective flames respectively formed by disclosed main burners.

DETAILED DESCRIPTION

5

The inventors of the present invention have recognized that in order to achieve substantially lower combustion residence times in a combustion system, the combustion process may have to rely on the formation of relatively compact flames.

10 The present inventors have further recognized that compact flames, can, however, have a substantially larger power density (i.e., increased heat per unit volume) than what is feasible in known combustors. For example, the elevated flame temperatures resulting from such compact flames could drive combustion dynamics instabilities or affect the level of emissions.

15 In view of such recognition, the present inventors propose a combustor system that can reliably and cost-effectively generate certain non-uniformities (e.g., different temporal and/or spatial non-uniformities) in relatively compact flames effective for a relatively low combustion residence time (such as without limitation in a range from approximately 2 msec to approximately 10 msec), without affecting emissions. As elaborated in greater detail below, the present inventors propose an improved
20 combustor system and method that may benefit from utilization of burners with fluidic nozzles appropriately tuned for reducing combustion residence time and/or damping combustion dynamics.

In the following detailed description, various specific details are set forth in order to provide a thorough understanding of such embodiments. However, those skilled in the
25 art will understand that embodiments of the present invention may be practiced without these specific details, that the present invention is not limited to the depicted embodiments, and that the present invention may be practiced in a variety of alternative embodiments. In other instances, methods, procedures, and components, which would be well-understood by one skilled in the art have not been described in
30 detail to avoid unnecessary and burdensome explanation.

Furthermore, various operations may be described as multiple discrete steps performed in a manner that is helpful for understanding embodiments of the present

invention. However, the order of description should not be construed as to imply that these operations need be performed in the order they are presented, nor that they are even order dependent, unless otherwise indicated. Moreover, repeated usage of the phrase "in one embodiment" does not necessarily refer to the same embodiment, although it may. It is noted that disclosed embodiments need not be construed as mutually exclusive embodiments, since aspects of such disclosed embodiments may be appropriately combined by one skilled in the art depending on the needs of a given application.

The terms "comprising", "including", "having", and the like, as used in the present application, are intended to be synonymous unless otherwise indicated. Lastly, as used herein, the phrases "configured to" or "arranged to" embrace the concept that the feature preceding the phrases "configured to" or "arranged to" is intentionally and specifically designed or made to act or function in a specific way and should not be construed to mean that the feature just has a capability or suitability to act or function in the specified way, unless so indicated.

FIG. 1 illustrates a schematic representation of basic building blocks (e.g., constituent structures) of disclosed main burners that may be used in one non-limiting embodiment of a combustor system 10 for a combustion turbine engine, such as a gas turbine engine. Combustor system 10 may include a first main burner 12 arranged in a combustion chamber 14 of combustor system 10. First main burner 12 includes a first fluidic nozzle 16 (also referred to in the art as a fluidic oscillator) tuned to convey a first flow of a fluid 18, such as air, that oscillates at a first oscillation frequency.

As will be appreciated by those skilled in the art, fluidic oscillators are devices that form a self-oscillating flow (e.g., a sweeping jet) with a frequency that depends primarily on the specific fluid dynamics arranged in the device. These devices can provide reliable operation without the need of complicated moving parts, thus ensuring a relatively long operational lifetime in the challenging thermo-mechanical environment of a combustion turbine engine.

First flow of fluid 18 is premixed with fuel and ignited to form a first flame 24. In this embodiment, fuel may be injected by an injector 20 disposed downstream of first fluidic nozzle 16 into a first flame-forming cup 22 (which in this example functions as a premixing cup) connected to an outlet end of first fluidic nozzle 16. First flame-

forming cup 22 comprises a first structural geometry that can impart specific spatial characteristics to first flame 24, e.g., flame size, flame length, flame shaping, etc. It will be appreciated that the injector need not be located downstream of first fluidic nozzle 16. For example, as schematically illustrated in FIG. 3, in one alternative embodiment, an injector 19 may be located upstream of first fluidic nozzle 16, and in this case first flow of fluid 18 may comprise air already premixed with fuel.

Returning to FIG. 1, combustor system 10 may further include a second main burner 32 arranged in combustion chamber 14. Second main burner 32 includes a second fluidic nozzle 34 tuned to convey a second flow of fluid 36 (e.g., air) that oscillates at a second oscillation frequency. Second flow of fluid 36 is premixed with fuel to form a second flame 38. In this embodiment, fuel may be injected by an injector 40 into a second flame-forming cup 42 connected to an outlet end of second fluidic nozzle 34. As discussed above, the injector need not be located downstream of first fluidic nozzle 16.

In accordance with aspects of disclosed embodiments, the first oscillation frequency and the second oscillation frequency imparted by first and second fluidic nozzles 16, 34 may be respectively tuned to have different values so that respective temporal characteristics (e.g., oscillatory characteristics) of the first and second flames are different relative to one another. Second flame-forming cup 42 may comprise a second structural geometry that can impart specific spatial characteristics to second flame 38. In accordance with further aspects of disclosed embodiments, the second structural geometry of second flame-forming cup 42 may be different than the first structural geometry of first flame-forming cup 22 so that the respective spatial characteristics of the first and second flames 24, 38 are different relative to one another. Non-limiting features of the respective structural geometries of the first and second flame-forming cups may include cup axial length, cup shape, cup diameter, and combinations of two or more of such features.

The different temporal and/or spatial characteristics of the first and second flames 24, 38 imparted by the first and second fluidic nozzles 16, 34 and/or the first and second flame-forming cups 22, 42 may be effective to reduce combustion instabilities and therefore allow the use of flames with low residence times. Moreover, the different temporal and/or spatial characteristics of the first and second flames 24, 38 may also

be effective to dampen predefined vibrational modes of the combustor system.

FIG. 2 shows a schematic of a combustor system 50 using respective arrays of main burners 52, 54, such as discussed above. In one non-limiting embodiment, the respective arrays of main burners 52, 54 may be annularly disposed about a centrally-disposed pilot burner 56. In one non-limiting embodiment, the annular arrangement of burner mains may comprise at least two concentric annuli of mains. It will be appreciated that aspects of the present invention are not limited to any specific arrangement for the respective arrays of burner mains or any specific number of burner mains. For example, the number of burner mains may be chosen based on the needs of a given application, such as based on a desired mass flow rate of the combustor system and/or flame configuration, flame length, etc. The high-temperature and high-pressure working gases generated in combustion chamber 14 may be conveyed to the turbine section (not shown) by way of a transition duct 58.

FIG. 4 shows one non-limiting conceptual embodiment of different temporal and/or spatial characteristics that may be imparted to the respective flames respectively formed by main burners 55, 57, 59, 60. These actions may be performed by appropriately tuning the fluidic nozzles at different frequencies and/or appropriately configuring the structural geometries of the flame-forming cups. In this non-limiting example, as illustrated in block 62, the respective fluidic nozzles of burners 55 and 59 may be tuned at a frequency f_1 while the respective fluidic nozzles of burners 57 and 60 may be tuned at a different frequency f_2 . Additionally, as illustrated in block 64, the respective flame-forming cups of burners 55 and 59 may be configured to have a structural geometry S_1 while the respective flame-forming cups of burners 57 and 60 may be configured with a different structural geometry S_2 . It will be appreciated that aspects of the present invention are not limited to burners having two different frequencies, or having two different structural geometries, or to any specific grouping of main burners since such structural and/operational relationships may be tailored based on the needs of a given application.

In operation, disclosed embodiments are expected to form relatively compact and non-uniform flames (e.g., having different temporal and/or spatial characteristics) effective for reducing combustion residence time with practically no impact on emissions. Broadly, depending on the needs of a given application, the respective

arrays of burner mains may be appropriately tailored to damp any desired vibrational modes as may be defined by their appropriate eigenvectors, or to reduce vibrational mode interactions (e.g., inter-mode coupling) that could arise under a given combustion dynamics.

- 5 While embodiments of the present disclosure have been disclosed in exemplary forms, it will be apparent to those skilled in the art that many modifications, additions, and deletions can be made therein without departing from the spirit and scope of the invention and its equivalents, as set forth in the following claims.

What is claimed is:

1. A combustor system for a combustion turbine engine, the combustor system comprising:

5 a first main burner (12) in a combustion chamber of the combustor system, the first main burner comprising:

a first fluidic nozzle (16) tuned to convey a first flow of a fluid that oscillates at a first oscillation frequency, the first flow of said fluid being premixed with fuel to form a first flame (24);

10 a second main burner (32) in the combustion chamber of the combustor system, the second main burner comprising:

a second fluidic nozzle (34) tuned to convey a second flow of said fluid that oscillates at a second oscillation frequency, the second flow of said fluid being premixed with fuel to form a second flame (38),

15 wherein the first oscillation frequency and the second oscillation frequency have different values so that respective temporal characteristics of the first and second flames are different relative to one another.

2. The combustor system of claim 1, wherein the first main burner further comprises a first flame-forming cup (22) connected to an outlet end of the first fluidic
20 nozzle to configure the first flame, wherein the first flame-forming cup has a first structural geometry.

3. The combustor system of claim 2, wherein the second main burner further comprises a second flame-forming cup (42) connected to an outlet end of the second fluidic nozzle to configure the second flame, wherein the second flame-
25 forming cup has a second structural geometry different than the first structural geometry so that respective spatial characteristics of the first and second flames are different relative to one another.

4. The combustor system of claim 3, wherein features of the respective structural geometries of the first and second flame-forming cups (22, 42) are selected
30 from the group consisting of cup axial length, cup shape, cup diameter, and

combinations of two or more of said features.

- 5 5. The combustor system of claim 3, wherein the different temporal and/or spatial characteristics of the first and second flames imparted by the first and second fluidic nozzles (16, 34) and/or the first and second flame-forming cups (22, 42) are effective to reduce a combustion residence time of the combustor system.

 6. The combustor system of claim 3, wherein the different temporal and/or spatial characteristics of the first and second flames imparted by the first and second fluidic nozzles (16, 34) and/or the first and second flame-forming cups (22, 42) are effective to dampen predefined vibrational modes of the combustor system.

- 10 7. The combustor system of claim 3, wherein the different temporal and/or spatial characteristics of the first and second flames imparted by the first and second fluidic nozzles (16, 34) and/or the first and second flame-forming cups (22, 42) are effective to reduce a combustion residence time of the combustor system and are further effective to dampen predefined vibrational modes of the combustor system.

- 15 8. The combustor system of claim 1, wherein the first main burner further comprises a respective fuel injector to inject fuel, wherein said fuel injector is disposed upstream or downstream relative to the first fluidic nozzle.

9. The combustor system of claim 8, wherein, when the fuel injector of the first main burner is disposed downstream relative to the first fluidic nozzle, the first flow of the fluid comprises air to be premixed with the fuel; or, when the fuel injector is disposed upstream relative to the first fluidic nozzle, the first flow of the fluid comprises air premixed with the fuel.
- 20

10. The combustor system of claim 1, wherein the second main burner further comprises a respective fuel injector to inject fuel, wherein said fuel injector is disposed upstream or downstream relative to the second fluidic nozzle.
- 25

11. The combustor system of claim 10, wherein, when the fuel injector of the second main burner is disposed downstream relative to the second fluidic nozzle, the second flow of the fluid comprises air to be premixed with the fuel; or, when the fuel injector is disposed upstream relative to the first fluidic nozzle, the second flow of the fluid comprises air premixed with the fuel.
- 30

12. The combustor system of any of the preceding claims, comprising a respective array of first main burners in combination with a respective array of second main burners.

13. A method for a combustion turbine engine, the method comprising:

5 conveying a first flow of a fluid by way of a first fluidic nozzle (16) tuned to oscillate the first flow of fluid at a first oscillation frequency,

premixing the first flow of said fluid with fuel to form a first flame (24);

conveying a second flow of fluid by way of a second fluidic nozzle (34) tuned to oscillate the second flow of fluid at a second oscillation frequency;

10 premixing the first flow of said fluid with fuel to form a second flame (38);

respectively tuning the first oscillation frequency and the second oscillation frequency to have different values so that respective temporal characteristics of the first and second flames (24, 38) are different from one another.

14. The method of claim 13, further comprising connecting a first flame-forming cup (22) to an outlet end of the first fluidic nozzle, and configuring the first flame based on a first structural geometry of the first flame-forming cup.

15. The method of claim 14, further comprising connecting a second flame-forming cup (42) to an outlet end of the second fluidic nozzle, and configuring the second flame based on a second structural geometry of the second flame-forming cup, wherein the second structural geometry is different than the first structural geometry so that respective spatial characteristics of the first and second flames are different.

16. The method of claim 15, further comprising dampening predefined vibrational modes of the combustor system based on the different temporal and/or spatial characteristics of the first and second flames imparted by the first and second fluidic nozzles (16, 34) and/or the first and second flame-forming cups (22, 42).

17. The method of claim 15, further comprising reducing a combustion residence time in a combustion chamber of the combustor system based on the different temporal and/or spatial characteristics of the first and second flames imparted by the first and second fluidic nozzles (16, 34) and/or the first and second flame-forming cups (22, 42).

18. The method of claim 15, further comprising, based on the different temporal and/or spatial characteristics of the first and second flames imparted by the first and second fluidic nozzles (16, 34) and/or the first and second flame-forming cups (22, 42), reducing a combustion residence time in a combustion chamber of the combustor system and dampening predefined vibrational modes of the combustor system.

19. The method of claim 13, wherein the premixing of the first flow of said fluid with fuel is performed upstream or downstream relative to the first fluidic nozzle, wherein, when the premixing is performed downstream relative to the first fluidic nozzle, the second flow of the fluid comprises air to be premixed with the fuel; or, when the premixing is performed upstream relative to the first fluidic nozzle, the first flow of the fluid comprises air premixed with the fuel.

20. The method of claim 19, wherein the premixing of the second flow of said fluid with fuel is performed upstream or downstream relative to the second fluidic nozzle, wherein, when the premixing is performed downstream relative to the second fluidic nozzle, the second flow of the fluid comprises air to be premixed with the fuel; or, when the premixing is disposed upstream relative to the second fluidic nozzle, the second flow of the fluid comprises air premixed with the fuel.

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FIG 1

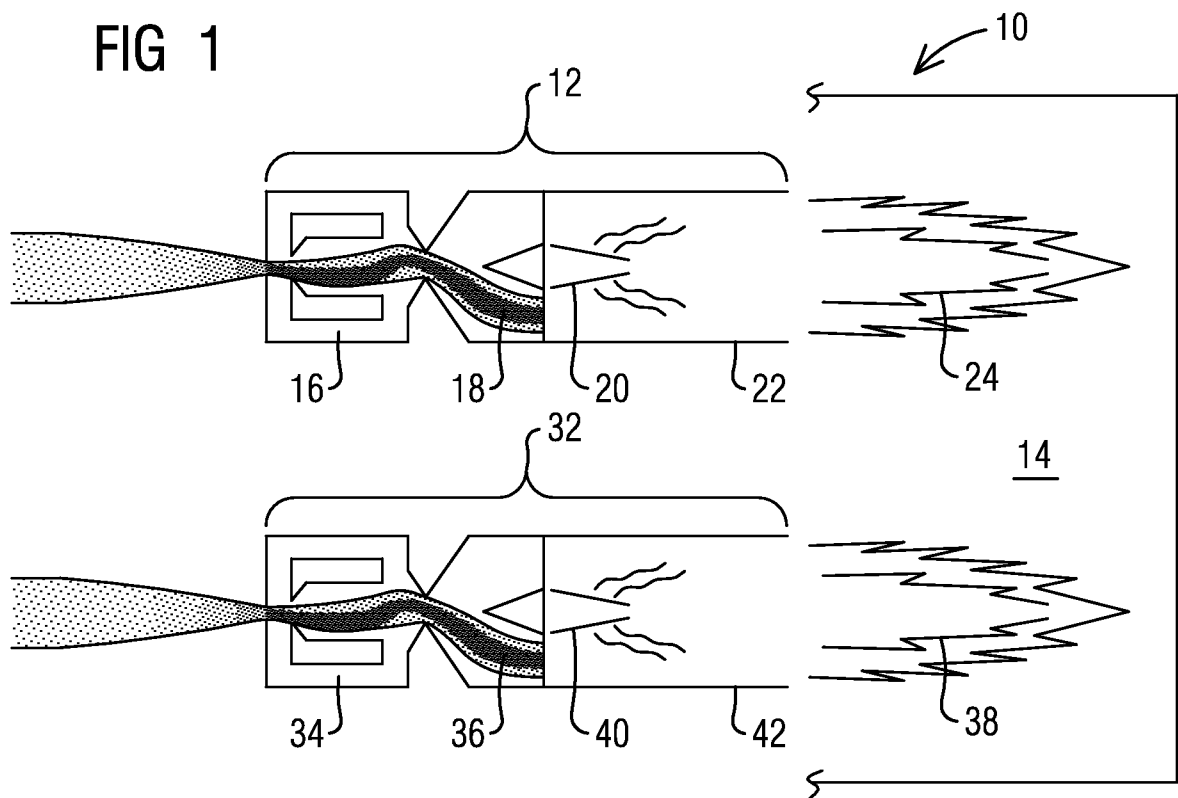


FIG 2

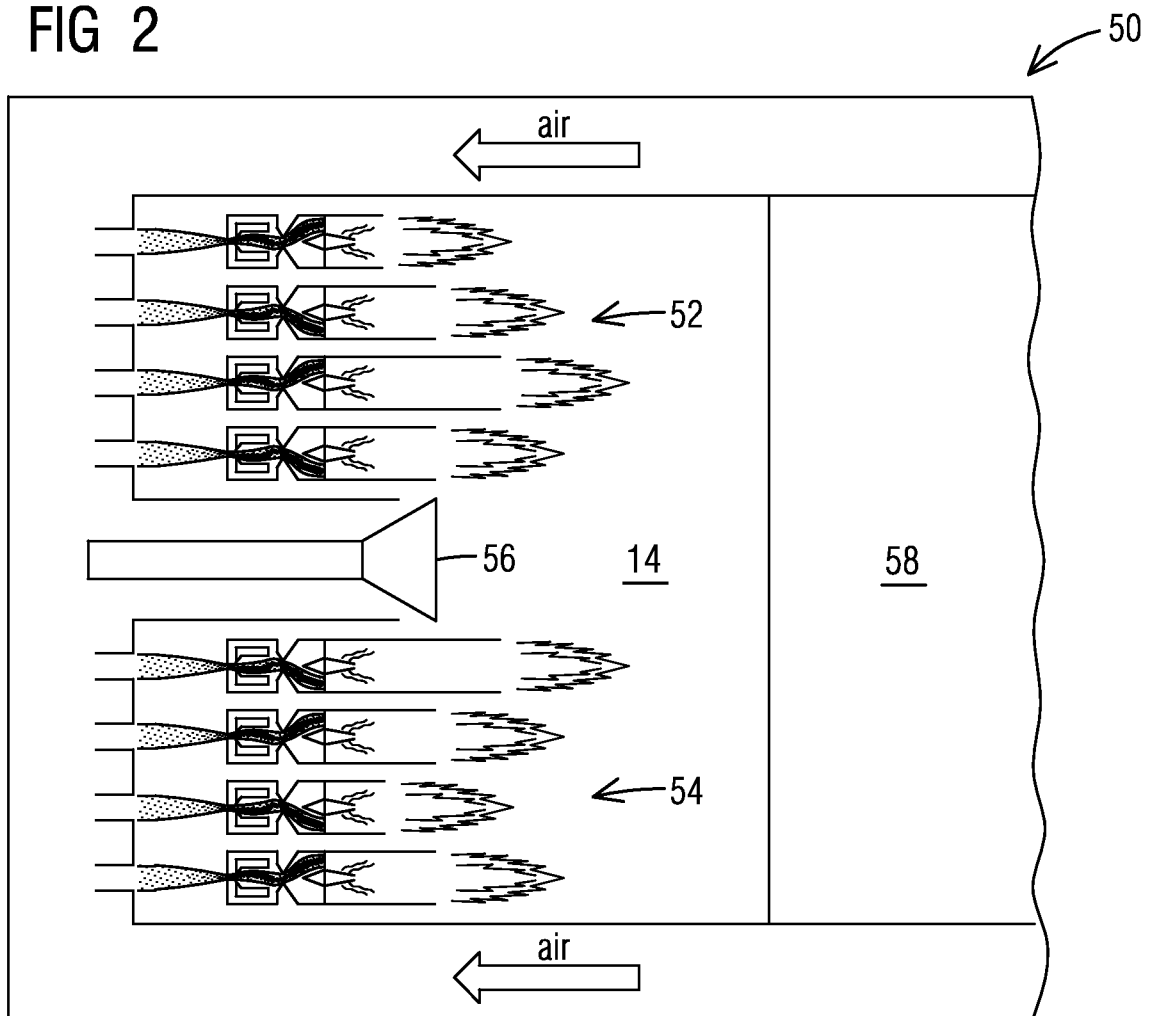


FIG 3

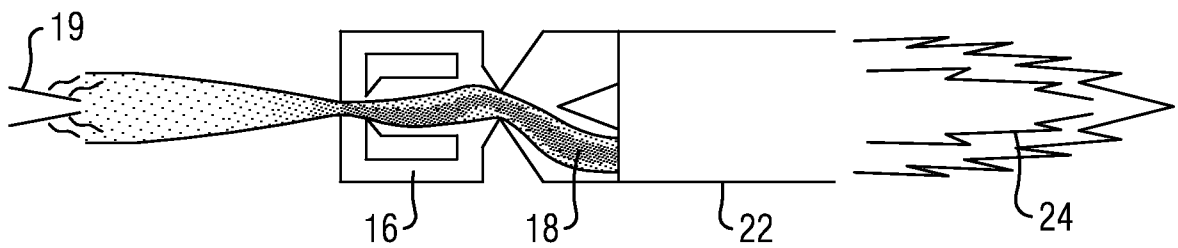
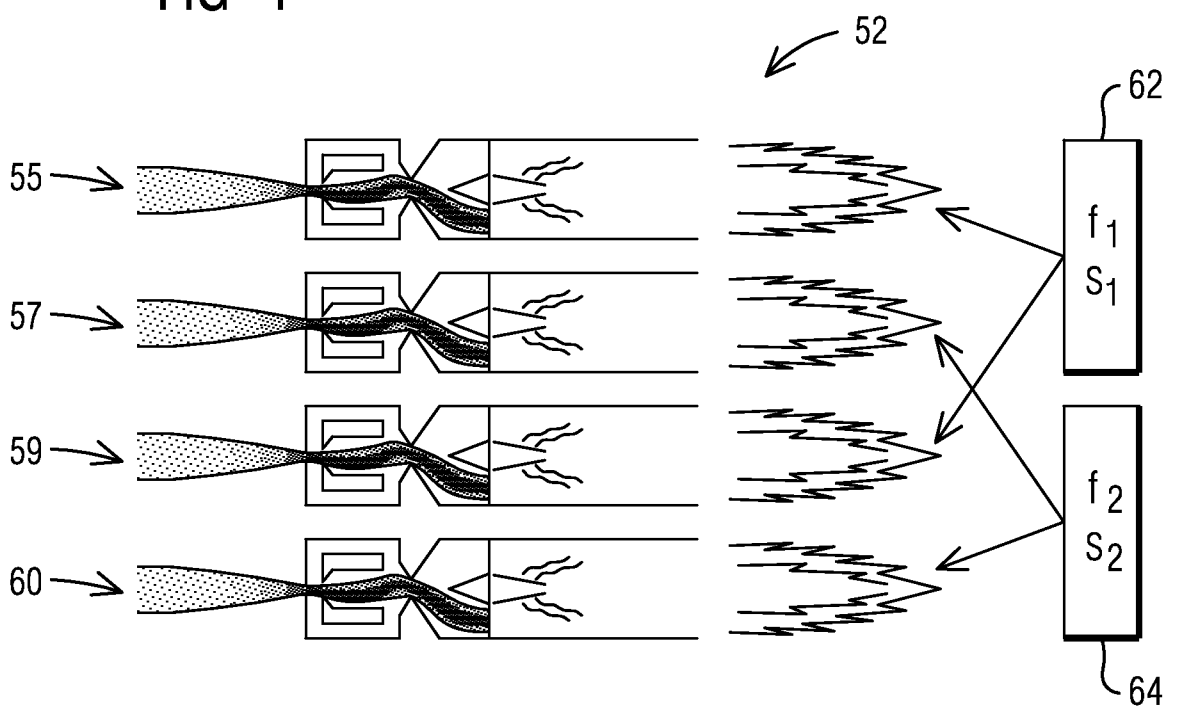


FIG 4



INTERNATIONAL SEARCH REPORT

International application No

PCT/US2015/041952

A. CLASSIFICATION OF SUBJECT MATTER
 INV. F23N5/24 F23R3/44
 ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
 F23N F23R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 449 951 B1 (JOOS FRANZ [DE] ET AL) 17 September 2002 (2002-09-17) column 1, line 8 - line 27; figure 1 column 2, line 61 - column 3, line 20 column 3, line 64 - column 4, line 25 column 4, line 65 - column 5, line 62 -----	1-20
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X	EP 2 230 459 A1 (MITSUBISHI HEAVY IND LTD [JP]) 22 September 2010 (2010-09-22) paragraph [0001]; figures 7-10 paragraphs [0052], [0053] -----	1-13, 17-20



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2015/041952

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