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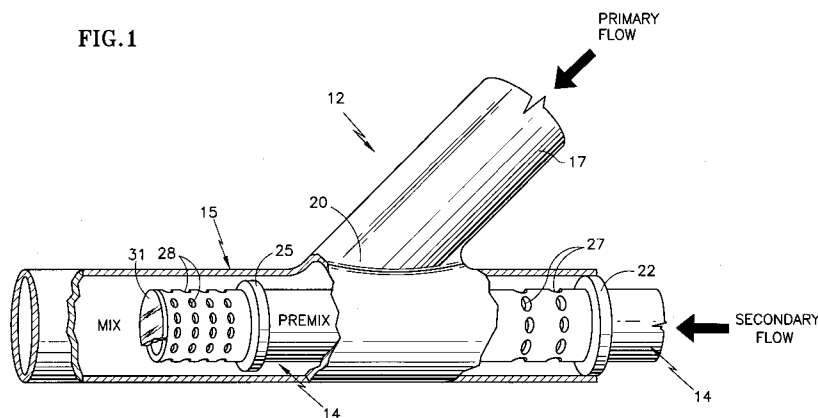
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(54) Title: PRESSURIZED PREMIXING OF GASES IN AN INJECTOR

FIG. 1



(57) Abstract: A pressure induced premixing injector (12) for mixing a secondary gas (14, 14a, 14b) into a primary gas (17, 17a, 17b) includes a flow restriction (25, 33, 42) in the primary conduit with premix holes (27, 34, 35) upstream thereof allowing a portion of primary gas to flow into secondary gas to form a premix gas and injector holes (28, 37, 43) downstream thereof allowing premix gas to flow into the unmixed portion of primary gas.

Pressurized Premixing of Gases in an Injector

Technical Field

[0001] A primary gas is injected into and mixed with a secondary gas in response to pressure of the primary gas forcing it through premix holes into the secondary gas upstream of the injector holes, which provides a high degree of mixing at relatively low pressure drop across a wide range of flow rates.

Background Art

[0002] An example of the mixing of two gases is the mixing of air with fuel cell power plant anode exhaust for combustion in a downstream catalytic burner. The normal method of mixing these gases is to use a static mixing device downstream of the injection location, to mix the gases well. Suitable commercial static mixers are costly. An alternative method is to inject the gas through many small holes at high velocity, relying on the number of holes and the velocity to mix the flows. However, this results either in a large pressure drop at the highest injection flow rates, or it results in poor mixing at the lowest injection rates, depending on how the holes are sized. It is desirable to have a mixing injector for two gases that operates within the necessary parameters across a wide range of operating conditions which are likely to occur in the environment of use.

Summary

[0003] An injector mixes a secondary gas, such as fuel cell power plant anode exhaust, with a primary gas, such as air, for combustion in a catalytic burner in a fuel processing system. The mixing injector disclosed herein uses an excess of pressure in the primary flow versus secondary flow to force some primary flow into the secondary flow, upstream of the point of injecting the secondary flow into the primary flow through the injector holes.

[0004] A back pressure is provided to the primary stream by restricting the flow of the primary stream just upstream of the injector, by means of some form of blockage which is described in more detail with respect to

the figures, hereinafter. The premixing injector system improves mixing in two ways. First, the premixing itself provides additional mixing of the primary gas and the secondary gas. Second, the premixed secondary gas, having itself more flow momentum than the primary gas causes the combined primary gas and secondary gas mixture in the injector to have a greater flow momentum than would the secondary gas by itself. Therefore, the gas passing through the injector holes has a greater cross-flow penetration, which provides an additional improvement in mixing.

[0005] The amount of premixing is a function of how much primary gas is forced to mix with the secondary gas upstream of the injector holes. This can be controlled several ways: by the relative size difference of the two pipes, the number and size of premixer holes, and pressure differentials between the primary gas and the secondary gas, such as by blockage in the primary gas flow. Ultimately, all of the primary gases can be forced into the secondary gas, improving mixing at a cost of increased pressure drop, allowing control over the degree of mixing versus the allowable pressure drop.

[0006] In one sample application using the device illustrated in Fig. 1, it was shown that the disparity (unmixedness) at entrance to the diffuser (31, Fig. 1) decreases by about 70% with a pressure drop increase of only 14%, compared to when the secondary gas is injected without pressure-induced premixing of the primary gas.

[0007] The pressurized premixing injector may be used in a large variety of manners. For instance, the primary gas stream may be the anode effluent, and the secondary gas stream be the air to mix therewith, for combustion. Also, the primary stream may be high pressure air and the secondary stream might be the output of a shift converter, to provide a gas mixture for processing in a preferential oxidizer (PROX). And if desired in any given utilization, the roles of primary gas flow and secondary gas flow may be reversed. Normally, the primary gas flow is the higher pressure fluid.

[0008] In the pressure-induced premixing injector, the sizing of the premix holes and the injector holes are the critical performance features in determining the amount of premixing and hence the performance

improvement. This sizing can be achieved using pressure drop calculations of the different flow streams to determine the flow through the premixer holes.

[0009] Other variations will become more apparent in the light of the following detailed description of exemplary embodiments, as illustrated in the accompanying drawings.

Brief Description of the Drawings

[0010] Fig. 1 is a partially broken away perspective view of a first premixing injector embodiment.

[0011] Fig. 2 is a partially broken away perspective view of a second premixing injector embodiment.

[0012] Fig. 3 is a highly simplified schematic diagram of a third embodiment.

Mode(s) of Implementation

[0013] Referring to Fig. 1, a first embodiment of a premixing injector 12 includes a secondary flow conduit or pipe 14 that is disposed within an injector conduit or pipe 15 that is fed primary gas flow from a primary flow conduit or pipe 17 which is connected to the injector pipe 14 at a Y-joint 20. The secondary flow pipe 14 is sealed within the injector pipe 15 at the inlet end of the pipe, such as a ring 22 bonded to the injector pipe 14 and 15 in any suitable fashion. Not shown for simplicity are spacers to maintain the central spacing of the secondary flow pipe 14 within the injector pipe 15.

[0014] To maintain pressure within the injector, suitable to cause premixing, a blockage 25 is disposed on the injector pipe 14. The primary gas flow, being obstructed by the blockage 25, creates a greater pressure upstream of the blockage 25 (to the right as seen in Fig. 1) in contrast with the primary gas stream pressure downstream of the blockage 25. This forces some of the primary flow through premixing passages, such as holes 27 in the secondary flow pipe 14. The portion of primary gas flow that enters the injector pipe through the holes 27 is mixed with the secondary flow as it proceeds toward the injector passages, such as holes 28 provided in the secondary flow pipe 14.

[0015] The secondary flow pipe 14 is blocked off in any suitable fashion, such as by an end plate 31 suitably bonded thereto by any appropriate process; the end plate 31 acts as a diffuser. The premixture flowing within the secondary flow pipe 14 is injected outwardly into the primary gas that flows past the obstruction 25 so as to cause significant additional mixing. The obstruction 25 causes a portion of the primary flow to enter through the premix holes 27 to mix with the secondary flow and thus have a somewhat higher secondary mass flow, so the premixed gas reaching the injector holes 28 has a higher ratio of momentum relative to the primary gas flow passing the obstruction 25. This provides greater cross flow penetration resulting in better mixing. Thus, the premixing itself provides more thorough mixing of the primary gas and the secondary gas, but in addition, the combined primary and secondary gas mixture in the injector has an increased momentum ratio relative to the primary flow just outside the injector holes 28, so a greater cross flow penetration results in better mixing, as well.

[0016] A simpler embodiment is illustrated in Fig. 2. Therein, the primary flow pipe 17a is unaltered except for allowing the secondary flow pipe 14a to be inserted within the primary flow pipe 17a. The secondary flow pipe 14a has an increased diameter premix/injector section 30 which is blocked off at its end 31. At the upstream end, the premix/injector section 30 has a ring 33 of premix holes 34. The ring 33 also provides an obstruction to the primary flow to increase the upstream pressure above the pressure downstream of the injector section 30 sufficiently to cause significant flow through the premix holes 34 into the premixer 30. The premix gas in the injector 30 is injected into the primary flow through injection holes 37. As before, the premixing not only provides more thorough mixing, but it also increases the flow penetration through the injector holes due to the increased pressure.

[0017] Perhaps the simplest embodiment is that illustrated, in schematic form, in Fig. 3. In Fig. 3, the secondary gas flow pipe 14b is fitted with the primary gas flow pipe 17b, and is blocked off at its downstream end 39 so as to form an injector 40. A pressure restriction 42 may be a plate with holes in it, or some other combination of flow inhibitors,

to ensure that the pressure upstream thereof is higher than the pressure of the primary flow at the injector holes 43. At the higher pressure, some of the primary flow will pass through the premix holes 45 and the premixture will thereafter be injected downstream of the pressure restriction 42 through the premix holes 43. The effects are the same as with the previous embodiments.

[0018] As the terms are used herein, the term "primary flow" means the one that will be injected into the other one by means of the pressure differential at the premixing holes, and the secondary flow is defined as the one that, following being mixed with the primary flow, is injected into the primary flow. Which of two gases will be chosen as primary, and which of two gases will be chosen as secondary depends much on the purposes, gas characteristics and pressure considerations of the particular use.

[0019] Instead of flow restrictions 25, 33, 42, the requisite amount of pressure may be created by adjusting sizes of the pipes involved. However, it is possible that pipe size restrictions might impede the free premixing and injection processes thereby reducing the mixing value of the configuration.

Claims

1. A method of mixing a secondary gas flow from a secondary gas conduit (14, 14a, 14b) into a primary gas flow provided by a primary gas conduit (17, 17a, 17b),
characterized by:
- 5 partially obstructing (25, 33, 42) the primary gas flow and conducting (27, 33, 45) a portion of the primary gas flow, from a point upstream of where the primary gas flow is partially obstructed, into the secondary gas flow at a point downstream of where the primary gas flow is partially obstructed, to form a premixed gas flow; and
- 10 injecting (28, 37, 43) the premixed gas flow into a non-mixed portion of the primary gas flow.
2. A method according to claim 1 further characterized in that:
said step of injecting comprises injecting (28, 37, 43) the premixed gas flow into a non-mixed portion of the primary gas flow at a point downstream of where the primary gas flow is partially obstructed.
3. Apparatus comprising:
a primary conduit (17, 17a, 17b) for a primary gas flow;
a secondary conduit (14, 14a, 14b) for a secondary gas flow;
an injector (15, 30, 40) having injection passages (28, 37, 43)
5 configured to inject said secondary gas flow into said primary gas flow;
characterized by:
a flow restriction (25, 33, 42) in said primary conduit; and
a plurality of premix passages (27, 34, 45) configured to flow a portion
of said primary gas upstream of said flow restriction into said flow of
10 secondary gas downstream of said flow restriction;
said injection passages being disposed downstream of said flow restriction.
4. Apparatus according to claim 3 further characterized in that:

said secondary conduit (14) is disposed within said injector (15) and has a fluid seal (22) to the injector at the upstream end of the injector;
said primary conduit (17) directing the primary gas flow into space
5 between said injector and said secondary conduit;
said flow restriction comprising a ring (25) extending outward from the secondary conduit;
the premix passages (27) being upstream of the ring;
the secondary conduit being sealed off (31) at its downstream end with
10 the injector passages (28) located between the ring and the downstream end.

5. Apparatus according to claim 3 further characterized in that:
the secondary conduit (14a) comprises an elbow terminating within the primary conduit (17a);
the injector (30) comprises an extension of the secondary conduit
5 having a diameter larger than the secondary conduit but smaller than the primary conduit, forming the flow restriction (33) and the premix passages (34) in a ring extending between the secondary conduit and the injector;
the injector having a fluid seal (31) at its downstream end with the injection passages (37) being adjacent the seal.

6. Apparatus according to claim 3 further characterized in that:
the primary flow conduit (17b) includes an elbow leading it into an end of the secondary conduit (14b), the end of the secondary conduit being sealed (39) to the primary conduit;
5 the flow restriction (42) being disposed between the premix passages (45) upstream thereof and the injection passages (28, 37, 43) downstream thereof.

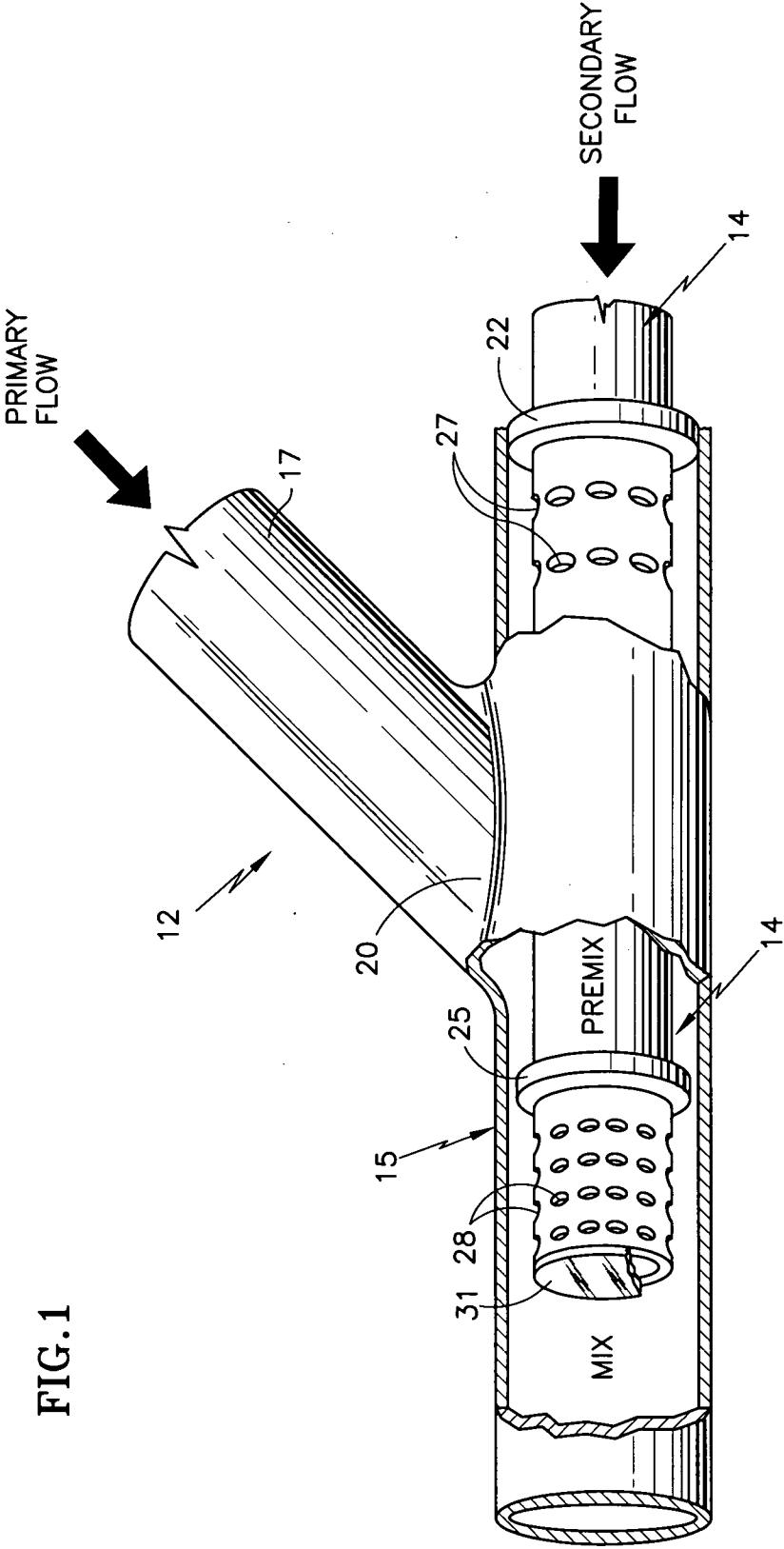


FIG. 1

FIG.2

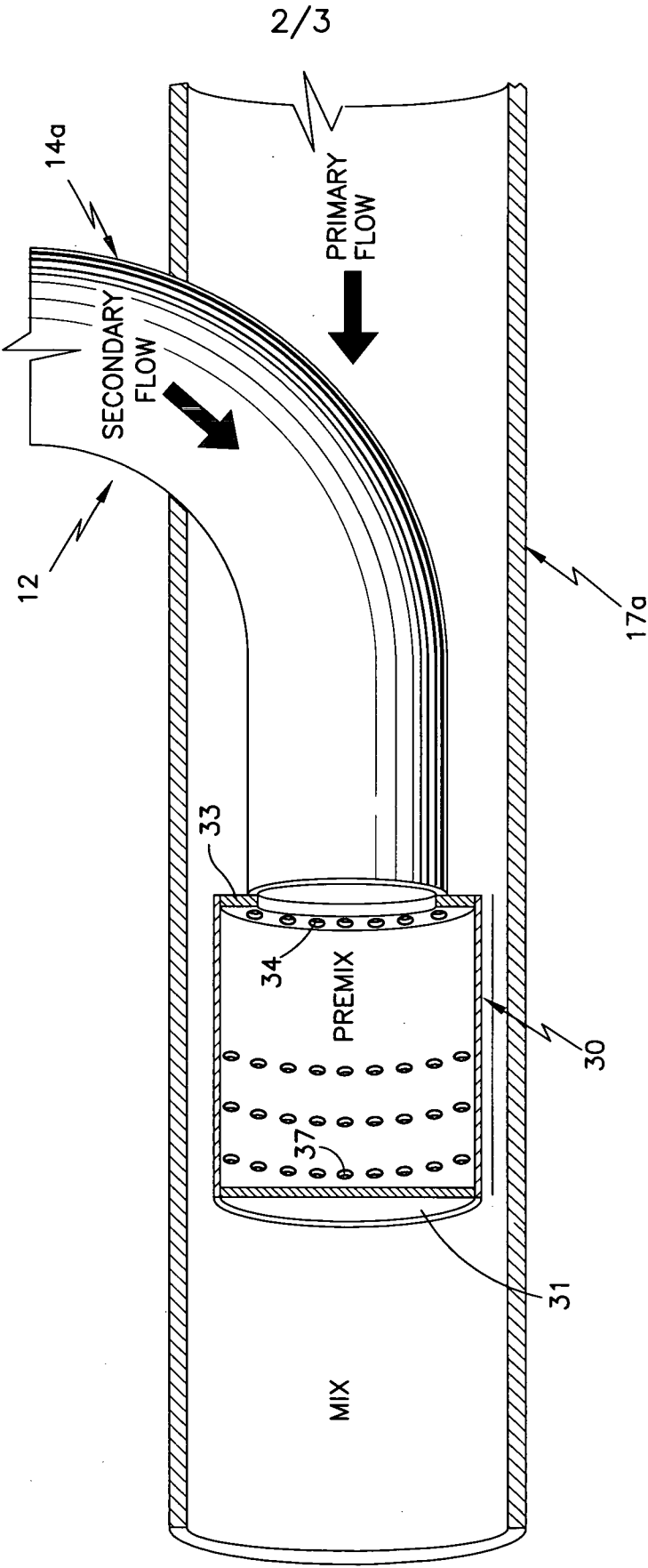
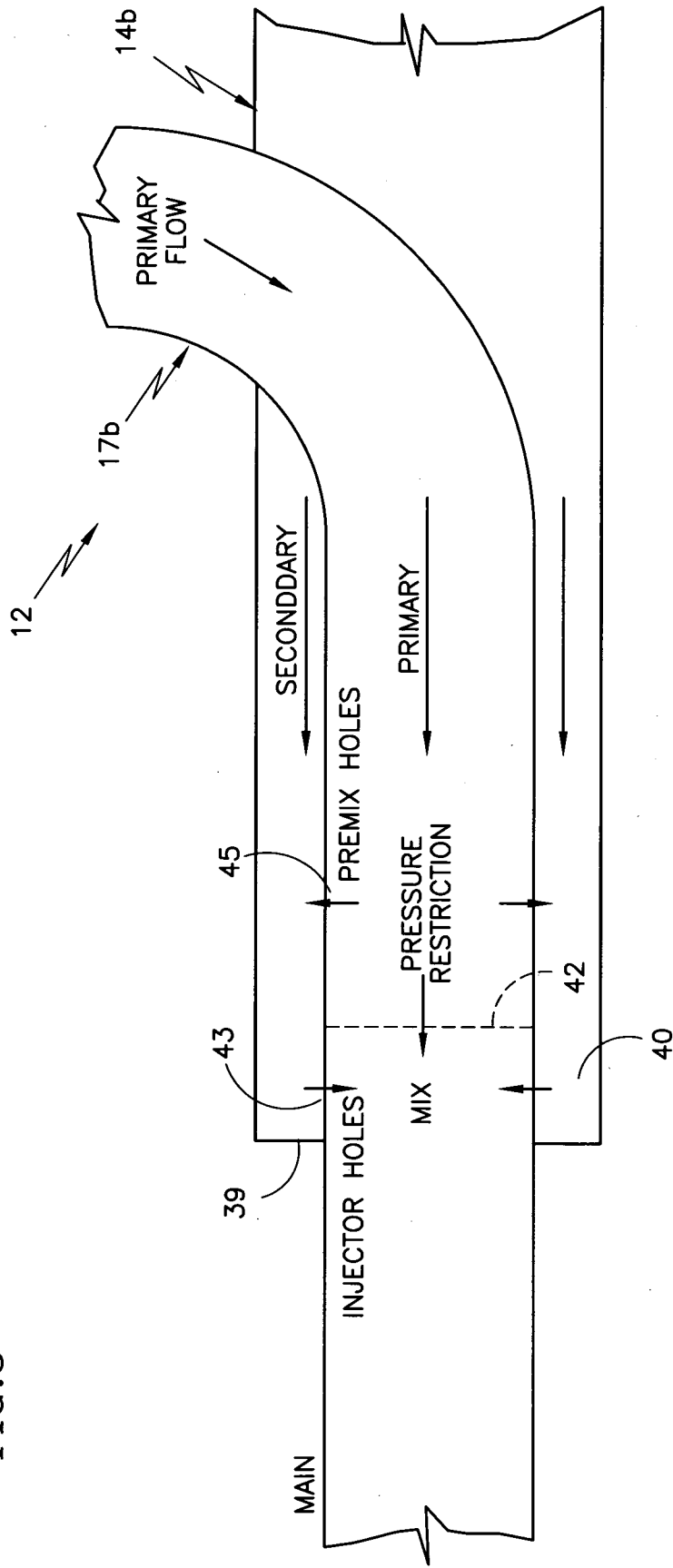


FIG.3



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2009/006037**A. CLASSIFICATION OF SUBJECT MATTER****H01M 8/04(2006.01)i, B01F 5/04(2006.01)i**

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)

IPC : H01M, C01B

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

Korean utility models and applications for utility Models

Japanese utility models and applications for utility Models

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

eKOMPASS (KIPO internal) and keywords: "mixing, injector, premix, flow restriction, elbow, burner, reformer, fuel cell, and similar terms"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6303243 B1 (Schuler) 16 October 2001 See abstract, Figures 1 to 3, column 2 line 16 to column 3 line 45, claims 1-9	1-6
A	JP 09-045350 A (TOSHIBA CORP) 14 February 1997 See abstract, Figures 1 and 2, paragraphs [0030] to [0043], claims 1-11	1-6
A	JP 2008-533656 A (WEBASTO AG) 21 August 2008 See abstract, Figure 1, paragraphs [0031] to [0034], claims 1-7	1-6
A	KR 2008-0038229 A (ENERDAY GMBH) 02 May 2008 See abstract, Figures 1-2, paragraphs [0029] to [0034], claims 1-17	1-6

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

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Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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