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(54) GAS BURNER MEMBRANE

GASBRENNERMEMBRAN

MEMBRANE DE BRÛLEUR À GAZ

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Description

TECHNOLOGICAL FIELD

[0001] Embodiments of the present disclosure relate to a gas burner membrane. Some relate to a gas burner combustion system comprising the gas burner membrane and some relate to a method of forming the gas burner membrane.

BACKGROUND

[0002] In gas burners used, for instance, in boilers, cookers, gas fires or other systems for combusting gaseous fuels, a burner membrane is usually provided which has a pattern of through holes through which a gas or a mixture of gases passes. The mixture is ignited on an outer side of the membrane. Burner membranes may also be called flame strips, flame skins, burner skins or burner heads.

[0003] Conventionally gases such as methane have been used in gas burners in a number of locations. In some instances, different gases could be used in gas burners, such as pure hydrogen gas or a hydrogen rich gas mixture.

[0004] DE 4433184 C1 discloses a combustion bar for an atmospheric gas burner, comprising a tubular cover of steel plate with a burner surface provided with mixt. outlet apertures. The cover in the area of the mixt. outlet apertures on the outer surface is provided with a coating e.g., of a ceramic basis, which consists of a poorly heat-conductive material or of a good heat-conductive material with underside air enclosures. The coating is provided with holes which correspond to the mixt. outlet apertures. It comprises a porous material and covers the mixt. outlet apertures in the burner surface.

[0005] EP 0536706 A2 discloses a flame holder which comprises a ceramic moulding, which is constructed by the plasma spray method. Through-passages for the fuel/air mixture are drilled in this plasma-ceramic moulding by means of a laser beam.

[0006] EP 0905446 A2 discloses a burner plate which comprises a single stainless steel sheet, which has flame slots within a collar for each gas-air mixer unit. The stainless steel sheet is laser-welded to the burner plate, so that the edges form a grid of mounting slots for the mixers, and hydraulically formed to provide coolant channels. The mixers are free flow units and are separated from the combustion space by the burner plate. The burner plate has a ceramic coating.

BRIEF SUMMARY

[0007] According to various, but not necessarily all, embodiments there is provided a gas burner membrane for use with pure hydrogen gas or a hydrogen blend gas which includes at least 30 vol. % hydrogen gas, the gas burner membrane comprising a sheet of material with a plurality of holes, and wherein a ceramic coating is provided on the sheet of material.

[0008] Possibly, the thickness of the ceramic coating is up to 2000 microns. Possibly, the thickness of the ceramic coating is 30 - 300 microns. Possibly, the thickness of the ceramic coating is 50 - 200 microns. Possibly, the thickness of the ceramic coating is 100 - 150 microns.

[0009] The ceramic coating may comprise zirconium oxide. The ceramic coating may comprise yttrium oxide. The ceramic coating may comprise yttria-stabilized zirconia.

[0010] At least a majority of the holes may have a diameter equal to or less than 1.3 times the thickness of the sheet of material. At least a majority of the holes may have a diameter of between 0.1 and 1 mm.

[0011] The gas burner membrane may include at least 100 holes.

[0012] The coating may be located on the outer surface of the gas burner membrane.

[0013] The gas burner membrane may be a flat gas burner membrane, a linear gas burner membrane or a cylindrical gas burner membrane.

[0014] Possibly, the sheet of material is formed from sheet metal. Possibly, the sheet of material is formed from sheet steel.

[0015] The ceramic coating may cover only a portion of the sheet of material. Substantially all of the holes in the sheet of material may be provided in the portion of the sheet of material covered by the coating.

[0016] According to various, but not necessarily all, embodiments there is provided a gas burner including: the gas burner membrane of any of the preceding paragraphs; and a hydrogen gas supply. The hydrogen gas supply is a pure hydrogen gas supply or a hydrogen blend gas supply which includes at least 30 vol. % hydrogen gas.

[0017] According to various, but not necessarily all, embodiments there is provided a method of forming a gas burner combustion system comprising: providing the gas burner membrane of any of the preceding paragraphs; and providing a hydrogen gas supply.

[0018] The hydrogen gas supply may be a pure hydrogen gas supply or a hydrogen blend gas supply. The hydrogen blend gas supply may include at least 30 vol. % hydrogen gas.

[0019] According to various, but not necessarily all, embodiments there is provided examples as claimed in the appended claims.

BRIEF DESCRIPTION

[0020] Some examples will now be described with reference to the accompanying drawings in which:

Fig. 1 schematically shows a gas burner combustion system according to the disclosure;

Fig. 2 schematically shows a further gas burner combustion system according to the disclosure;

Fig. 3 schematically shows a yet further gas burner combustion system according to the disclosure;
Fig. 4 shows a side view of an example gas burner membrane according to the disclosure;
Fig. 5 shows a cross sectional view of the example gas burner membrane along the line A-A of Fig. 4; and
Fig. 6 shows a magnified cross sectional view of the example gas burner membrane within the circle B of Fig. 5.

DETAILED DESCRIPTION

[0021] Fig. 1 shows a typical gas burner combustion system 10 with a mixing chamber 12 with a burner membrane 14 on top of the mixing chamber 12. Air and gas is blown into the mixing chamber 12 using a fan 20. The gas is supplied to the fan 20 via a pipe 18 from a supply 16. The burner 10 is controlled by a control unit 22. The fan 20 could for instance operate at 2000 rpm at 5 kW.

[0022] Fig. 2 shows a further typical gas burner combustion system 50 with the mixing chamber 12 with the burner membrane 14 on top of the mixing chamber 12. The mixing chamber 12 receives gas directly from a supply 16 via a pipe 19, without passing through the fan 20. Air is blown into the mixing chamber 12 using the fan 20, and the burner 10 is controlled by the control unit 22.

[0023] Fig. 3 shows part of a yet further typical gas burner combustion system 60 with the mixing chamber 12, with the burner membrane 14 on top of the mixing chamber 12. The mixing chamber 12 receives gas from a supply 16 via a pipe 21. In this example, a venturi 23 is provided at the mixing chamber 12 entrance, to cause the gas to accelerate prior to entering the mixing chamber 12. The pressure in a narrow passage of the venturi 23 is lower than atmospheric pressure, which causes air surrounding the venturi 23 to be sucked into the venturi 23 via apertures in the venturi 23, and then into the mixing chamber 12.

[0024] In other examples, the venturi 23 might not be included in the gas burner combustion system 60, so only the gas from the supply is present in the chamber 12. In the examples where the gas burner combustion system 60 of Fig. 3 does not include a venturi 23, no mixing takes place in the chamber 12, and thus the chamber 12 is not referred to as a "mixing" chamber.

[0025] The typical gas burner combustion systems 10, 50, 60 each also include an igniter (not shown) to initiate the burning of the gas. The gas is combusted on the outside (topside in the examples of Figs. 1 to 3) of the burner membrane 14.

[0026] The gas burner combustion systems 10, 50, 60 are intended to be used with hydrogen gas. The term hydrogen gas used herein refers to pure hydrogen gas or hydrogen blend gas (i.e. a mixed gas including at least some hydrogen). Hydrogen has a greater flame velocity than natural gas, which increases the risk of flashback (i.e. an uncontrolled upstream propagation of the flame, due to a local imbalance in the flow velocity and the flame speed). If the exit velocity of an air/fuel mixture through the holes in a burner membrane is lower than the flame speed of hydrogen, there is a risk of flashback. Flashback can be explosive and thus dangerous, especially when hydrogen gas is used as a fuel. Increasing the air/hydrogen ratio can reduce the risk of flashback, but at the expense of combustion efficiency and flame stability.

[0027] It has been found that the size of the holes in the burner membrane is an important factor for reducing the risk of flashback and efficient burning of hydrogen gas. Relatively small holes are required when compared to conventional natural gas burners.

[0028] Fig. 4 shows a side view of an example gas burner membrane 100, which can be used in the example gas burner combustion systems 10, 50, 60 of Figs. 1 to 3. Fig. 5 shows a cross sectional view of the gas burner membrane 100 along the line A-A of Fig. 4. The gas burner membrane 100 comprises a sheet of material 110 with a plurality of holes 120. The section of the sheet of material 110 containing the holes 120 is shaded in Figs. 4 and 5. The gas burner membrane 100 further comprises a ceramic coating 130, which is provided on the sheet of material 110.

[0029] In this example, the gas burner membrane 100 is a flat gas burner membrane. The sheet of material 110 of the example flat gas burner membrane includes a flat section 112 and a raised section 114. The raised section 114 may be in the form of a half-cylinder. In this example, the plurality of holes 120 are provided in the raised section 114. In other examples, the gas burner membrane 100 may be a cylindrical gas burner membrane or a linear gas burner membrane. A cylindrical gas burner membrane includes a sheet of material which is formed into a substantially cylindrical shape.

[0030] It has been surprisingly found that the application of the ceramic coating 130 to the sheet of material 110 with the holes 120 reduces the size of the opening of the holes through the gas burner membrane 100, and enables the size of the opening to be finely tuned. Thus a gas burner membrane 100 with a ceramic coating is able to more efficiently burn hydrogen gas with a lower risk of flashback. The size of the opening to the hole can also be more effectively tailored to a particular hydrogen blend gas or gas burner type using the ceramic coating 130.

[0031] A magnified cross sectional view within the circle B of Fig. 5 is shown in Fig. 6, illustrating the coating 130 on the sheet of material 110. In this example, the ceramic coating 130 is located only on the outer surface of the gas burner membrane 100 (i.e. the ceramic coating 130 is located on the opposite face of the sheet of material 110 to the mixing chamber 12). In other words, the ceramic coating 130 is applied to the same side of the sheet of material 110 as the flame when the gas burner combustion system 10, 50, 60 is in use (i.e., the upper side in Figs. 4 - 6). In other examples, the ceramic coating 130 may be located on the inner surface of the gas burner

membrane 100, or both the inner and outer surfaces of the gas burner membrane 100.

[0032] In this example, the ceramic coating 130 covers substantially all of the outer face of the sheet of material 110. In other examples, the ceramic coating 130 may cover only a portion of the sheet of material 110. For instance, the ceramic coating may cover only the raised section 114 of the example sheet of material 110. Substantially all of the holes 120 in the sheet of material 110 may be located in the portion of the sheet of material 110 covered by the ceramic coating 130.

[0033] In some examples, the ceramic coating 130 comprises zirconium oxide (i.e. zirconia). Preferably, the ceramic coating 130 also comprises yttrium oxide (i.e. yttria). Most preferably, the ceramic coating 130 comprises at least 50 wt.% zirconium oxide. The ceramic coating 130 may be yttria-stabilised zirconia, such as 8 % yttria-stabilised zirconia (i.e. 8 mol.% yttrium oxide). Other suitable ceramic materials may be used to provide the ceramic coating 130 in other examples.

[0034] In some examples, the ceramic coating 130 has a thickness of up to 2000 microns (μm). In some examples, the thickness of the ceramic coating 130 is at least 30 microns. In some examples, the thickness of the ceramic coating 130 is 30 - 300 microns. Preferably, the thickness of the ceramic coating 130 is 50 - 200 microns. Most preferably, the thickness of the ceramic coating 130 is 100- 150 microns, such as 125 microns. The coating thickness referred to herein is the average thickness, which could be determined using a coating thickness gauge such as an Elcometer ®. The ceramic coating 130 may be of substantially uniform thickness across the sheet of material 110. Thin ceramic coatings are often prone to cracking. However, it has been found that the gas flow through the burner membrane 100 is able to significantly reduce the incidence of cracking by cooling the ceramic coating 130.

[0035] The burner membrane 100 of Figs. 4 to 6 is a single skin burner membrane. Preferably, the sheet of material 110 onto which the ceramic coating 130 is applied is formed from sheet metal. Most preferably, the sheet of material 110 is formed from sheet steel, such as ferritic stainless steel. Thus, the sheet of material is preferably made from metal, or most preferably is made from steel. The sheet of material 110 may be an impermeable material (i.e. non-porous when discounting the plurality of holes 130 cut into the sheet of material 110). In some examples, the sheet of material 110 has a thickness of at least 0.3 mm. In some examples, the sheet of material 110 has a thickness of up to 3 mm. Preferably, the sheet of material 110 has a thickness of 0.4 - 1.5 mm, such as 0.6 mm.

[0036] The burner membrane 100 includes a pattern of holes 120, which are relatively small holes when compared to those in traditional natural gas (methane) burner membranes. The holes 120 are through holes extending through the sheet of material 110. In some examples, the majority of the holes 120 have a diameter of up to 1 mm, such as 0.1 mm, 0.25 mm, 0.5 mm, 0.75 mm or 1 mm. Preferably, the holes 120 have a diameter of 0.1 mm - 1 mm. Most preferably, the holes 120 have a diameter of 0.25 mm - 0.75 mm. At least a majority of the holes 120 may have a diameter equal to or less than 1.3 times the thickness of the sheet of material 110. Preferably, at least the majority of the holes 120 may have a diameter equal to or less than the thickness of the sheet of material 110. Most preferably, at least the majority of the holes 120 may have a diameter equal to or less than 0.75 times the thickness of the sheet of material 110. The holes 120 may have a substantially circular cross-section.

[0037] In this example, at least 100 holes 120 are provided in the sheet of material 110. In some examples up to 100,000 holes 120 are provided in the sheet of material 110. Preferably between 1000 and 6000 holes are provided in the sheet of material.

[0038] To form the gas burner membrane 100, the holes 120 are formed in the sheet of material 110. The holes 120 could be formed by laser cutting or using a waterjet cutter.

[0039] The laser cutting may comprise laser drilling, such as single pulse or multi beam laser drilling.

[0040] The sheet of material 110 may be formed into a desired shape, for instance by bending sheet metal 110. The sheet of material 110 may be shaped to provide a flat gas burner membrane, a linear gas burner membrane or a cylindrical gas burner membrane. The sheet of material 110 may be formed into the desired shape prior to, or after, the holes 120 are formed in the sheet of material 110.

[0041] The ceramic coating 130 is applied to the sheet of material 110. The coating 130 is preferably applied after the holes 120 have been formed in the sheet of material 110. In some examples, the ceramic coating 130 is applied using thermal spraying. Preferably, the ceramic coating 130 is applied using thermal plasma spraying.

[0042] In this example, thermal plasma spraying comprises introducing the ceramic material into a plasma jet from a plasma torch. The ceramic material may be provided in powder form, and the average particle size of the ceramic powder may be up to 100 microns, when measured by laser diffraction. In this example, the ceramic material is yttria-stabilised zirconia. When introduced into the plasma jet, the ceramic particles in the ceramic powder melt, and are directed towards the sheet of material 110. The molten ceramic particles then solidify and form a deposit on the sheet of material 110, to form the ceramic coating 130 on the sheet of material 110.

[0043] In some examples, the surface of the sheet of material 110 is pre-treated prior to the application of the ceramic coating 130. For instance, the pre-treatment may include at least one of: a cleaning step, a surface roughening step (e.g., grit blasting), or a surface primer step (e.g., the application of an aluminium oxide primer to the sheet of material 110).

[0044] Once the ceramic coating 130 has been applied to the sheet of material 110, the diameter of the opening

of the holes 120 in the sheet of material 110 is reduced by the ceramic coating 130.

[0045] To form a gas burner combustion system, the gas burner membrane 100 is provided and a hydrogen gas supply is provided. The hydrogen gas supply could for instance be a connection to a mains gas supply or a hydrogen gas canister. The hydrogen gas supply may be a pure hydrogen gas supply or a hydrogen blend gas supply. The hydrogen blend gas may include at least 30 vol.% hydrogen gas. The gas burner combustion system could be the example gas burner combustion systems 10, 50, 60 of Figs. 1 to 3.

[0046] There is thus described a gas burner membrane, a gas burner combustion system, and a method of forming a gas burner membrane with a number of advantages. The size of the opening to the holes in the burner membrane can be adjusted to enable hydrogen gas to be burned efficiently with a low risk of flashback. The burner membrane is also more durable due to the heat resistance provided by the ceramic coating.

[0047] Although examples have been described in the preceding paragraphs with reference to various examples, it should be appreciated that modifications to the examples given can be made without departing from the scope of the claims. For instance, the size, shape and pattern of holes can be chosen as required. Different ceramics may be used. The gas burner membrane may be differently shaped. The ceramic coating may be applied using a different method. The burner membrane can be used with pre-mix gas burners, post-mix gas burners or naturally aspirated gas burners. The burner membrane may be for a boiler, cooker, a gas fire or other systems for combusting gaseous fuels.

[0048] The term 'comprise' is used in this document with an inclusive not an exclusive meaning. That is any reference to X comprising Y indicates that X may comprise only one Y or may comprise more than one Y. If it is intended to use 'comprise' with an exclusive meaning then it will be made clear in the context by referring to "comprising only one" or by using "consisting".

[0049] In this description, reference has been made to various examples. The description of features or functions in relation to an example indicates that those features or functions are present in that example. The use of the term 'example' or 'for example' or 'can' or 'may' in the text denotes, whether explicitly stated or not, that such features or functions are present in at least the described example, whether described as an example or not, and that they can be, but are not necessarily, present in some of or all other examples. Thus 'example', 'for example', 'can' or 'may' refers to a particular instance in a class of examples. A property of the instance can be a property of only that instance or a property of the class or a property of a sub-class of the class that includes some but not all of the instances in the class. It is therefore implicitly disclosed that a feature described with reference to one example but not with reference to another example, can where possible be used in that other example as part of a working combination but does not necessarily have to be used in that other example.

[0050] Features described in the preceding description may be used in combinations other than the combinations explicitly described above.

[0051] Although functions have been described with reference to certain features, those functions may be performable by other features whether described or not.

[0052] Although features have been described with reference to certain examples, those features may also be present in other examples whether described or not.

[0053] The term 'a' or 'the' is used in this document with an inclusive not an exclusive meaning. That is any reference to X comprising a/the Y indicates that X may comprise only one Y or may comprise more than one Y unless the context clearly indicates the contrary. If it is intended to use 'a' or 'the' with an exclusive meaning then it will be made clear in the context. In some circumstances the use of 'at least one' or 'one or more' may be used to emphasis an inclusive meaning but the absence of these terms should not be taken to infer any exclusive meaning.

[0054] The presence of a feature (or combination of features) in a claim is a reference to that feature or (combination of features) itself and also to features that achieve substantially the same technical effect (equivalent features). The equivalent features include, for example, features that are variants and achieve substantially the same result in substantially the same way. The equivalent features include, for example, features that perform substantially the same function, in substantially the same way to achieve substantially the same result.

[0055] In this description, reference has been made to various examples using adjectives or adjectival phrases to describe characteristics of the examples. Such a description of a characteristic in relation to an example indicates that the characteristic is present in some examples exactly as described and is present in other examples substantially as described.

Claims

1. A gas burner membrane (14, 100) for use with pure hydrogen gas or a hydrogen blend gas which includes at least 30 vol. % hydrogen gas, the gas burner membrane comprising a sheet of material (110) with a plurality of holes (120), and wherein a ceramic coating (130) is provided on the sheet of material.

2. A gas burner membrane according to claim 1, wherein the thickness of the ceramic coating is up to 2000 microns, and optionally wherein the thickness of the ceramic coating is 30 - 300 microns, and optionally wherein the thickness of the ceramic coating is 50 - 200 microns.

3. A gas burner membrane according to any of the pre-

ceding claims, wherein the ceramic coating comprises zirconium oxide, and optionally wherein the ceramic coating comprises yttrium oxide.

4. A gas burner membrane according to any of the preceding claims, wherein the ceramic coating comprises yttria-stabilized zirconia.

5. A gas burner membrane according to any of the preceding claims, wherein at least a majority of the holes have a diameter equal to or less than 1.3 times the thickness of the sheet of material.

6. A gas burner membrane according to any of the preceding claims, wherein at least a majority of the holes have a diameter of between 0.1 and 1 mm.

7. A gas burner membrane according to any of the preceding claims, wherein the coating is located on the outer surface of the gas burner membrane.

8. A gas burner membrane according to any of the preceding claims, wherein the gas burner membrane is a flat gas burner membrane, a linear gas burner membrane or a cylindrical gas burner membrane.

9. A gas burner membrane according to any of the preceding claims, wherein the sheet of material is formed from sheet metal, and optionally wherein the sheet of material is formed from sheet steel.

10. A gas burner membrane according to any of the preceding claims, wherein the ceramic coating covers only a portion of the sheet of material, and optionally wherein substantially all of the holes in the sheet of material are provided in the portion of the sheet of material covered by the coating.

11. A gas burner combustion system (10, 50, 60) including:

the gas burner membrane (14, 100) of any of the preceding claims; and
a hydrogen gas supply (16), wherein the hydrogen gas supply is a pure hydrogen gas supply or a hydrogen blend gas supply which includes at least 30 vol. % hydrogen gas.

12. A method of forming a gas burner combustion system (10, 50, 60) comprising:

providing the gas burner membrane (14, 100) of any of the preceding claims; and
providing a hydrogen gas supply (16), wherein the hydrogen gas supply is a pure hydrogen gas supply or a hydrogen blend gas supply which includes at least 30 vol. % hydrogen gas.

Patentansprüche

1. Gasbrennermembran (14, 100) zur Verwendung mit reinem Wasserstoffgas oder einem Wasserstoffmischgas, das mindestens 30 Vol.-% Wasserstoffgas beinhaltet, wobei die Gasbrennermembran eine Materialbahn (110) mit einer Vielzahl von Löchern (120) umfasst und wobei auf der Materialbahn eine Keramikbeschichtung (130) bereitgestellt ist.

2. Gasbrennermembran nach Anspruch 1, wobei die Dicke der Keramikbeschichtung bis zu 2000 Mikrometer beträgt und wobei die Dicke der Keramikbeschichtung optional 30-300 Mikrometer beträgt und wobei die Dicke der Keramikbeschichtung optional 50-200 Mikrometer beträgt.

3. Gasbrennermembran nach einem der vorhergehenden Ansprüche, wobei die Keramikbeschichtung Zirconiumdioxid umfasst und wobei die Keramikbeschichtung optional Yttriumoxid umfasst.

4. Gasbrennermembran nach einem der vorhergehenden Ansprüche, wobei die Keramikbeschichtung yttriumstabilisiertes Zirconiumdioxid umfasst.

5. Gasbrennermembran nach einem der vorhergehenden Ansprüche, wobei mindestens ein Großteil der Löcher einen Durchmesser aufweist, der gleich dem 1,3-fachen der Dicke der Materialbahn oder kleiner als dies ist.

6. Gasbrennermembran nach einem der vorhergehenden Ansprüche, wobei mindestens ein Großteil der Löcher einen Durchmesser zwischen 0,1 und 1 mm aufweist.

7. Gasbrennermembran nach einem der vorhergehenden Ansprüche, wobei sich die Beschichtung auf der Außenfläche der Gasbrennermembran befindet.

8. Gasbrennermembran nach einem der vorhergehenden Ansprüche, wobei die Gasbrennermembran eine flache Gasbrennermembran, eine lineare Gasbrennermembran oder eine zylindrische Gasbrennermembran ist.

9. Gasbrennermembran nach einem der vorhergehenden Ansprüche, wobei die Materialbahn aus Metallblech gebildet ist und wobei die Materialbahn optional aus Stahlblech gebildet ist.

10. Gasbrennermembran nach einem der vorhergehenden Ansprüche, wobei die Keramikbeschichtung nur einen Abschnitt der Materialbahn bedeckt und wobei optional im Wesentlichen alle der Löcher in der Materialbahn in dem Abschnitt der Materialbahn bereitgestellt sind, der von der Beschichtung bedeckt ist.

11. Gasbrenner-Verbrennungssystem (10, 50, 60), beinhaltend:

die Gasbrennermembran (14, 100) nach einem der vorhergehenden Ansprüche; und
eine Wasserstoffgaszufuhr (16), wobei die Wasserstoffgaszufuhr eine Zufuhr reinen Wasserstoffgases oder eine Zufuhr einer Wasserstoffmischgases ist, das mindestens 30 Vol.-% Wasserstoffgas beinhaltet.

12. Verfahren zum Bilden eines Gasbrenner-Verbrennungssystems (10, 50, 60), umfassend: Bereitstellen der Gasbrennermembran (14, 100) nach einem der vorhergehenden Ansprüche; und Bereitstellen einer Wasserstoffgaszufuhr (16), wobei die Wasserstoffgaszufuhr eine Zufuhr reinen Wasserstoffgases oder eine Zufuhr einer Wasserstoffmischgases ist, das mindestens 30 Vol.-% Wasserstoffgas beinhaltet.

Revendications

1. Membrane de brûleur à gaz (14, 100) destinée à être utilisée avec du gaz hydrogène pur ou un mélange de gaz hydrogène qui comprend au moins 30 % en volume de gaz hydrogène, la membrane de brûleur à gaz comprenant une feuille de matériau (110) avec une pluralité de trous (120), et dans laquelle un revêtement céramique (130) est prévu sur la feuille de matériau.

2. Membrane de brûleur à gaz selon la revendication 1, dans laquelle l'épaisseur du revêtement céramique mesure jusqu'à 2000 microns, et éventuellement dans laquelle l'épaisseur du revêtement céramique mesure de 30 à 300 microns, et éventuellement dans laquelle l'épaisseur du revêtement céramique mesure de 50 à 200 microns.

3. Membrane de brûleur à gaz selon l'une quelconque des revendications précédentes, dans laquelle le revêtement céramique comprend de l'oxyde de zirconium, et éventuellement dans laquelle le revêtement céramique comprend de l'oxyde d'yttrium.

4. Membrane de brûleur à gaz selon l'une quelconque des revendications précédentes, dans laquelle le revêtement céramique comprend de la zircone stabilisée à l'yttrium.

5. Membrane de brûleur à gaz selon l'une quelconque des revendications précédentes, dans laquelle au moins une majorité des trous ont un diamètre égal ou inférieur à 1,3 fois l'épaisseur de la feuille de matériau.

6. Membrane de brûleur à gaz selon l'une quelconque des revendications précédentes, dans laquelle au moins une majorité des trous ont un diamètre compris entre 0,1 et 1 mm.

7. Membrane de brûleur à gaz selon l'une quelconque des revendications précédentes, dans laquelle le revêtement est situé sur la surface extérieure de la membrane de brûleur à gaz.

8. Membrane de brûleur à gaz selon l'une quelconque des revendications précédentes, dans laquelle la membrane de brûleur à gaz est une membrane de brûleur à gaz plate, une membrane de brûleur à gaz linéaire ou une membrane de brûleur à gaz cylindrique.

9. Membrane de brûleur à gaz selon l'une quelconque des revendications précédentes, dans laquelle la feuille de matériau est formée d'une feuille métallique, et éventuellement dans laquelle la feuille de matériau est formée d'une feuille d'acier.

10. Membrane de brûleur à gaz selon l'une quelconque des revendications précédentes, dans laquelle le revêtement en céramique ne recouvre qu'une partie de la feuille de matériau, et éventuellement dans laquelle la quasi-totalité des trous dans la feuille de matériau sont prévus dans la partie de la feuille de matériau recouverte par le revêtement.

11. Système de combustion à brûleur à gaz (10, 50, 60) comprenant : la membrane de brûleur à gaz (14, 100) selon l'une quelconque des revendications précédentes ; et une alimentation en gaz hydrogène (16), dans lequel l'alimentation en gaz hydrogène est une alimentation en gaz hydrogène pur ou une alimentation en mélange de gaz hydrogène qui comprend au moins 30 % en volume de gaz hydrogène.

12. Procédé de formation d'un système de combustion de brûleur à gaz (10, 50, 60) comprenant

la fourniture de la membrane de brûleur à gaz (14, 100) selon l'une quelconque des revendications précédentes ; et
la fourniture d'une alimentation en gaz hydrogène (16), dans lequel l'alimentation en gaz hydrogène est une alimentation en gaz hydrogène pur ou une alimentation en mélange de gaz hydrogène qui comprend au moins 30 % en volume de gaz hydrogène.

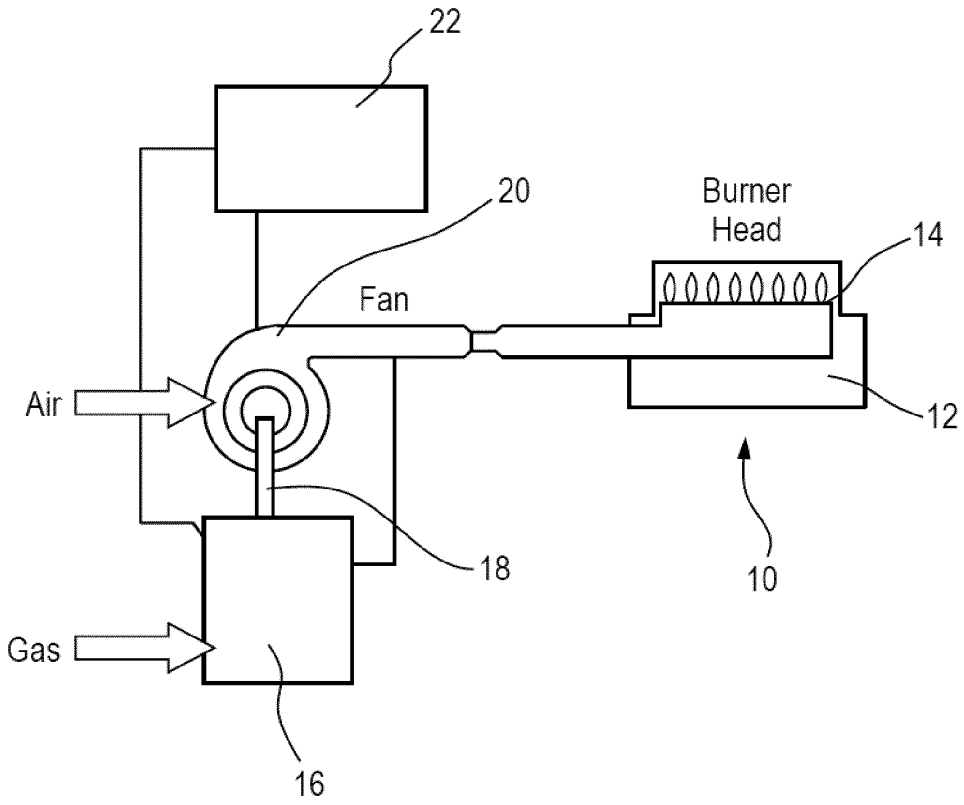

22
20
Burner
Head
14
Fan
Air
12
18
10
Gas
16

FIG. 1

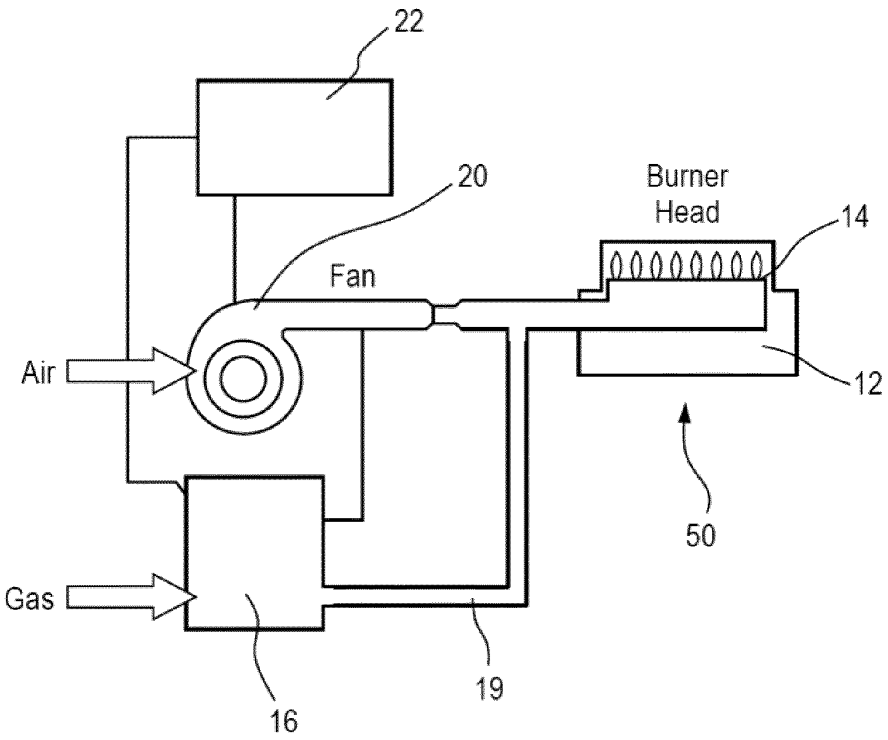

22
20
Burner
Head
14
Fan
Air
12
50
Gas
19
16

FIG. 2

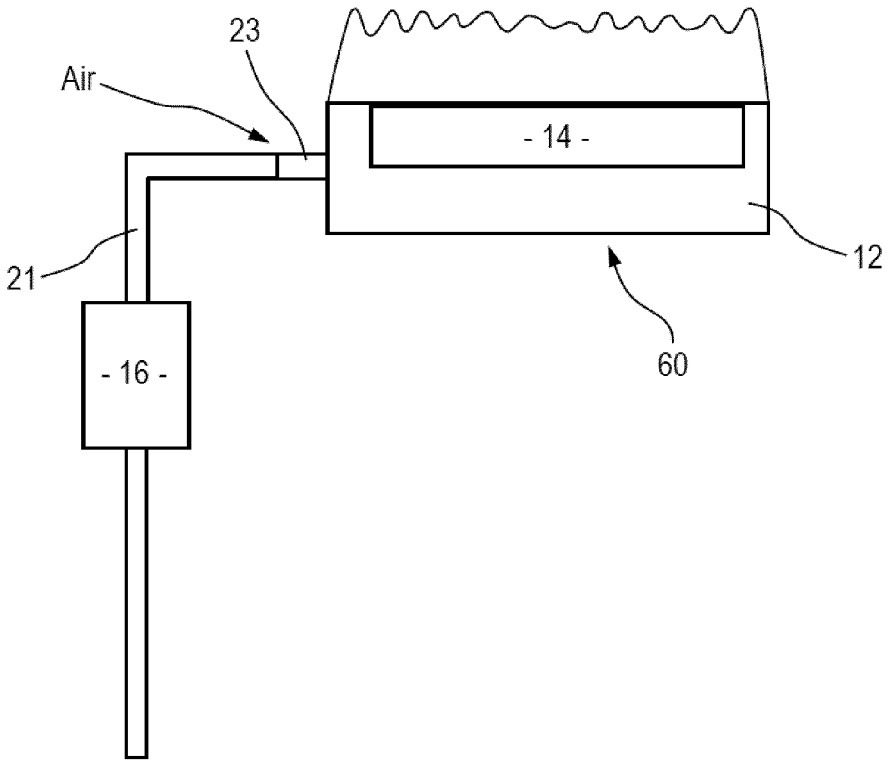


FIG. 3

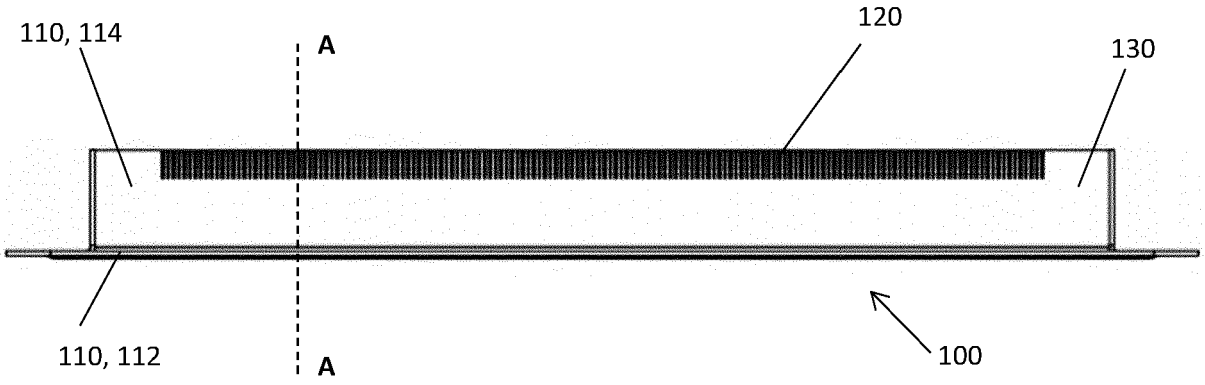


FIG. 4

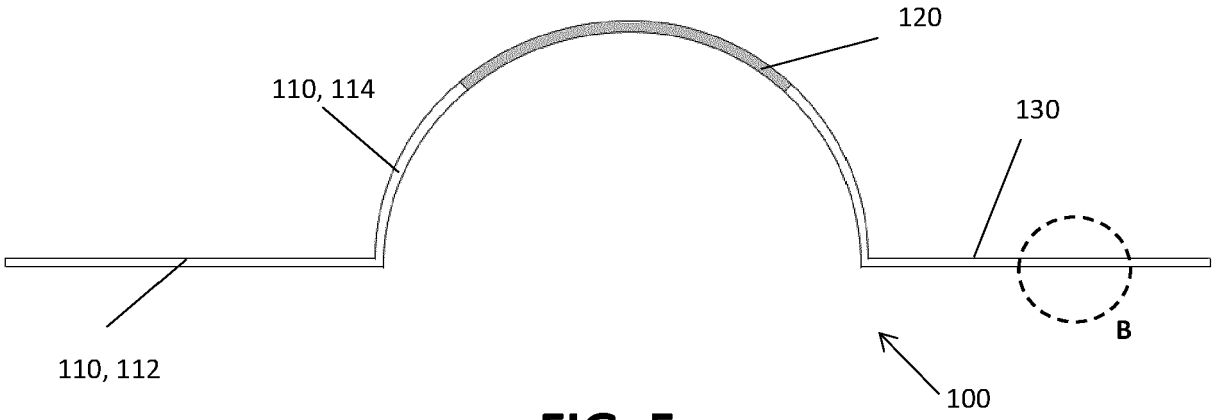


FIG. 5

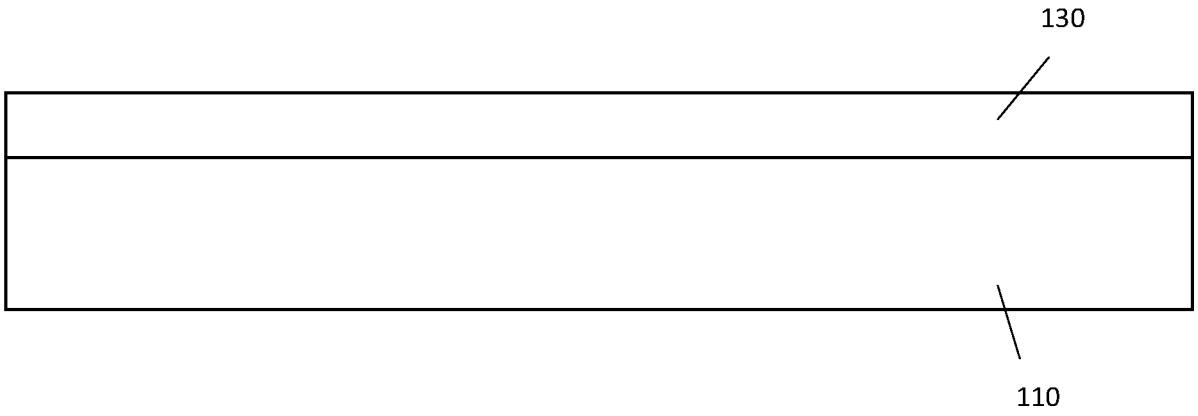


FIG. 6

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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