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(54) **GAS BURNER**

(57) The present invention refers to a gas burner, a burner assembly, a boiler, to the use of the gas burner and the burner assembly in boilers, water heaters and/or

cooking burners, and to the use of the gas burner, the burner assembly or the boiler in hydrogen combustion applications.

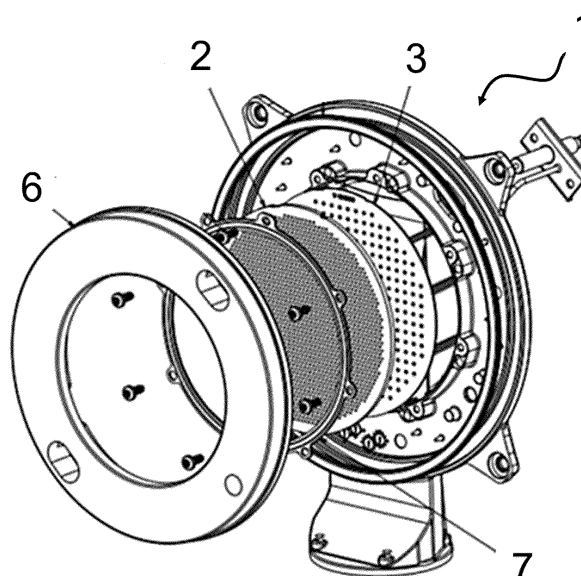


Figure 1

## Description

### FIELD OF THE INVENTION

**[0001]** The present invention relates to the area of gas burners. More specifically, the present invention relates to a gas burner, a burner assembly, a boiler and their uses thereof.

### BACKGROUND

**[0002]** Gas burners are the most commonly used burners. Gas burners generally use a fuel gas mixed with an oxidizer gas, such as air, that burns when a spark or other ignition mean is generated. Gas burners are classified depending on when the mixture of gases is done. Burners in which fuel gas and an oxidizer gas are mixed before combustion reaction occurs are called premix burners and burners in which fuel gas and an oxidizer gas are mixed wherein combustion reaction occurs are usually called diffusion gas burners.

**[0003]** Patent application document EP3336427A1 discloses a diffusion gas burner comprising a structure in which gas distribution means direct a fuel gas, such as hydrogen, and air distribution means direct air, directly to the mixing area. In said gas burner, the fuel gas and air are directed to the mixing area in an independent manner. The gas distribution means of the diffusion gas burner of EP3336427A1 comprise a plurality of main conduits providing a mixing point at the outlet of each main conduit. Thus, the gases in the gas burner of EP3336427A1 are mixed just outside each main distributor conduit. This burner configuration causes poor mixing of the gases and fixed reaction zones.

**[0004]** Therefore, there is a clear need for new diffusion gas burners with better gas mixing, high quality, performance, improved strength and durability as well as with reduced manufacturing cost.

### BRIEF DESCRIPTION OF THE INVENTION

**[0005]** The authors of the present invention have developed a gas burner, a burner assembly, a boiler, the use of the gas burner and the burner assembly in boilers, water heaters and/or cooking burners preferably using a gas or a mixture of gases, and the use of the gas burner and the burner assembly in hydrogen combustion applications.

**[0006]** The gas burner of the invention allows efficiently directing and mixing the required oxidizer gas with the fuel gas so that it burns quickly and effectively after ignition or combustion means, for example a spark generator, are activated. Without being bound to any theory, the authors of the present invention observed that the fact that the oxidizer gas and the fuel gas mix and react in the apertures or pores of the burner surface results in the advantage of eliminating flashback and oxidation in the burner surface.

**[0007]** In addition, since the gas burner of the invention comprises a diffuser between the burner surface and the gas distributors, said diffuser allows that the fuel and the oxidizer gas arrive homogeneously and in an adequate amount to the apertures or pores of the burner surface. During combustion, the flames generated in said burner surface are more homogeneously and adequately distributed leading, thus, to a higher burning efficiency. In addition, the presence of a diffuser between the burner surface and the gas distributors enhances the distribution and mixture of the gases and, thus, the efficiency of the combustion; moreover, it allows defining different flames patterns or logos on the burner surface.

**[0008]** Therefore, a first aspect of the invention is directed to a gas burner (1) comprising

- a) a burner surface (2) comprising apertures or pores;
- b) a diffuser (3) comprising openings adapted for transporting oxidizer gas and openings adapted for transporting fuel gas; and
- c) a first gas distributor (4) adapted for distributing an oxidizer gas, such as air; and, a second gas distributor (5) adapted for distributing a fuel gas, such as hydrogen; wherein diffuser (3) is between the burner surface and the first and the second gas distributors;

wherein the burner surface is in fluidic communication:

- with the first gas distributor (4) through the apertures adapted for transporting an oxidizer gas of the diffuser (3); and
- with the second gas distributor (5) through the apertures adapted for transporting a fuel gas of the diffuser (3).

**[0009]** A second aspect of the invention is directed to a burner assembly comprising

- a housing;
- at least a gas inlet connected to the housing; and
- the gas burner of the invention in any of its particular embodiments.

**[0010]** An additional aspect of the invention is directed to a boiler comprising

- a heat exchanger; and
- the gas burner of the invention in any of its particular embodiments or the burner assembly as defined in any of its particular embodiments.

**[0011]** An additional aspect of the invention is directed to the use of the gas burner of the invention in any of its particular embodiments, in boilers, water heaters and/or cooking burners preferably using a gas or a mixture of gases.

**[0012]** A further additional aspect of the invention is directed to the use of the burner assembly of the invention in any of its particular embodiments, in boilers, water heaters and/or cooking burners preferably using a gas or a mixture of gases

**[0013]** An additional aspect of the invention is directed to the use of the gas burner of the invention in any of its particular embodiments, in hydrogen combustion applications.

**[0014]** A further additional aspect of the invention is directed to the use of the burner assembly of the invention in any of its particular embodiments, in hydrogen combustion applications.

## FIGURES

### [0015]

Figure 1 shows a perspective view of the gas burner according to an embodiment of the invention.

Figure 2 shows a partial exploded view of a second embodiment of a gas burner.

Figure 3 shows a perspective view of some of the different parts of gas burner according to an embodiment of the invention: (a) a view of the burner surface (2); (b) the diffuser (3); (c) the second gas distributor (5) adapted for distributing a fuel gas; and (d) the first gas distributor (4) adapted for distributing an oxidizer gas.

## DETAILED DESCRIPTION OF THE INVENTION

**[0016]** Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood to one of ordinary skill in the art to which this disclosure belongs. As used herein, the singular forms "a" "an" and "the" include plural reference unless the context clearly dictates otherwise.

### *Gas burner*

**[0017]** As stated above, a first aspect of the invention is directed to a gas burner (1) comprising

- a) a burner surface (2) comprising apertures or pores;
- b) a diffuser (3) comprising openings adapted for transporting oxidizer gas and openings adapted for transporting fuel gas;
- c) a first gas distributor (4) adapted for distributing an oxidizer gas, such as air; and, a second gas distributor (5) adapted for distributing a fuel gas, such as hydrogen;

wherein the diffuser (3) is between the burner surface (2) and the first and the second gas distributors (4, 5);

wherein the apertures or pores of the burner surface are in fluidic communication:

- with the first gas distributor (4) through the openings adapted for transporting an oxidizer gas of the diffuser (3); and
- with the second gas distributor (5) through the openings adapted for transporting a fuel gas of the diffuser (3).

**[0018]** In an embodiment, the gas burner (1) of the invention is such that the oxidizer gas and the fuel gas are mixed in the apertures or pores of the burner surface.

**[0019]** In a particular embodiment, the diffuser (3) is in contact with the burner surface in the gas burner (1) of the invention; preferably such that the oxidizer gas and the fuel gas are only mixed in the apertures or pores of the burner surface.

**[0020]** In an embodiment, the gas burner is a diffusion gas burner, preferably a diffusion flame gas burner.

### *Burner surface*

**[0021]** In an embodiment, the burner surface is a circular surface such as a disk.

**[0022]** In an embodiment, the burner surface comprises a ceramic material or a metallic material.

**[0023]** In an alternative embodiment, the burner surface consists of a ceramic material or of a metallic material.

**[0024]** In another alternative embodiment, the burner surface comprises a metallic material such as a metal or an alloy.

**[0025]** In another alternative embodiment, the burner surface consists of a metallic material such as a metal or an alloy.

**[0026]** In a particular embodiment, the metallic material is a continuous metallic material, a particulate metallic material such as fibers, particles or a combination thereof, preferably spherical, semispherical particles or a combination thereof.

**[0027]** In a more particular embodiment, the ceramic material is a ceramic oxide, a non-oxide ceramic or combinations thereof. Non-limiting examples of "ceramic oxides" are alumina, alumina-silica, alumina-boria-silica, aluminum borosilicate, alumina-mullite, silica, zirconia, zirconia-silica, titania, titania-silica, rare earth oxides or a combination thereof. Non-limiting examples of "non-oxide ceramics" are silicon carbide, silicon carbonitride, silicon oxycarbide, silicon titanium oxycarbide, silicon nitride, aluminum nitride, silicon titanium, silicon alumina nitride or a combination thereof.

**[0028]** In a particular embodiment, the ceramic material is silicon carbide (SiC), silicon carbonitride (SiCN), alumina (Al<sub>2</sub>O<sub>3</sub>), alumina-mullite, aluminum borosilicate, silica (SiO<sub>2</sub>) or mixtures thereof.

**[0029]** In an embodiment, the ceramic material is in the form of ceramic particles, such as spherical or sem-

ispherical particles, in the form of ceramic fibers or as a combination thereof.

**[0030]** In an embodiment, the burner surface comprises apertures or pores adapted for defining gas mixing zones.

**[0031]** In an embodiment, the burner surface comprises pores adapted for defining gas mixing zones.

**[0032]** In an embodiment, the burner surface is porous; preferably the burner surface has a porosity of at least 2%; preferably of at least 3%, 4% or 5% of the total volume of the burner surface.

**[0033]** In an embodiment, the burner surface is porous; preferably the burner surface has a porosity of between a 2% and a 95% of the total volume of the burner surface; more preferably of between a 3% and a 90%.

**[0034]** In the context of the present invention the expression "porosity", refers to a void fraction created by pores or apertures and it is a fraction of the volume of voids over the total volume expressed as a percentage between 0% and 100%. In addition, the porosity may be calculated by a liquid displacement method, like a water displacement method, as known in the art.

**[0035]** In an embodiment, the burner surface comprises apertures adapted for defining gas mixing zones and/or gas reaction zones, for example, gas reaction zones wherein flames are generated during combustion.

**[0036]** In a particular embodiment, the burner surface comprises at least 100 apertures; preferably at least 300 apertures; more preferably at least 800 apertures.

**[0037]** The number or pattern of apertures in the burner surface may be tailored to provide the desired efficiency for the application.

**[0038]** The apertures of the burner surface are passage apertures (for example, they go from one side to the opposite side of the burner surface). The apertures may have any shape, for example, the apertures may be slits, cylindrical apertures, conical apertures or a combination thereof.

**[0039]** In a particular embodiment, the apertures of the burner surface are slits.

**[0040]** In a more particular embodiment, the apertures of the burner surface have a continuous diameter throughout their length. In another more particular embodiment, the apertures of the burner surface have a discontinuous diameter throughout their length.

**[0041]** In a more particular embodiment, the apertures of the burner surface have a cylindrical shape.

**[0042]** In a more particular embodiment, the apertures of the burner surface have an average diameter of below 2 mm; preferably of below 1.5 mm; more preferably below 1 mm.

**[0043]** In a more particular embodiment, the apertures of the burner surface are less than 60% of the total volume of the burner surface; preferably less than 50%, more preferably less than 40%, even more preferably less than 30%, even much more preferably less than 25%.

**[0044]** In a more particular embodiment, the apertures of the burner surface are between a 15 and a 65% of the

total volume of the burner surface; preferably between a 20 and a 60 % of the volume.

**[0045]** In a particular embodiment, the apertures of the burner surface are distributed in the burner surface following a pattern or a logo. In a more particular embodiment, the pattern or logo of the apertures is adapted for defining gas mixing and/or gas reaction zones. For example, during combustion, each aperture and/or pattern of apertures of the burner surface define a flame or a group of flames.

**[0046]** For example, patterns or logos can be used to adjust the efficiency, change the pressure drop, and/or strengthen the burner surface without changing the overall size of the burner plate.

**[0047]** In particular embodiment, the apertures or pores of the burner surface (2) are distributed through the burner surface forming a concentric pattern; preferably a concentric circular pattern.

**[0048]** In a more particular embodiment, the apertures or pores of the burner surface (2) are distributed through the burner surface forming at least two concentric ring patterns and/or radial patterns; preferably wherein the at least two concentric rings are connected by the radial patterns; more preferably wherein the apertures are slits or cylindrical apertures.

**[0049]** In an embodiment, the apertures or pores of the burner surface are adapted for defining gas mixing zones for the oxidizer gas and the fuel gas.

**[0050]** When gases are flowing through the gas burner, the oxidizer gas and the fuel gas contact and mix between them in the apertures or pores of the burner surface.

**[0051]** In an embodiment, the apertures or pores of the burner surface are also adapted for defining reaction zones. An example of a reaction zone during combustion is a flame or a group of flames; preferably a flame.

**[0052]** Without being bound to any theory in particular, the authors of the present invention observed that when the burner surface comprises a ceramic material the temperature reached by the burner surface during combustion is reduced, and therefore the issues related to oxidation are also reduced or even eliminated. In addition, the working life of the burner surface is extended.

#### *Diffuser*

**[0053]** The diffuser is between the burner surface and the gas distributors. The diffuser of the gas burner of the invention is a gas diffuser.

**[0054]** In an embodiment, the diffuser is a circular surface such a disk and preferably has the same area as the burner surface.

**[0055]** In an embodiment, the diffuser is in contact with the burner surface and/or with the gas distributors.

**[0056]** In another particular embodiment, there is a void or gap between the diffuser and the burner surface and/or the gas distributors; preferably there is a void or gap between the diffuser and the burner surface; more preferably the void or gap has a disk shape.

**[0057]** In a particular embodiment, the diffuser of the gas burner is a diffusing surface comprising openings adapted for transporting oxidizer gas and openings adapted for transporting fuel gas; preferably the diffusing surface is a diffusing disk comprising openings adapted for transporting oxidizer gas and openings adapted for transporting fuel gas. The oxidizer gas only circulates or passes through the diffuser of the gas burner using the openings adapted for transporting oxidizer gas and the fuel gas only circulates or passes through the diffuser using the openings adapted for transporting fuel gas.

**[0058]** In an embodiment, the oxidizer gas and the fuel gas circulate in a direction perpendicular to the diffuser surface.

**[0059]** The diffuser and the first or second gas distributors might be made of any material that is able to withstand the temperatures reached in the gas burner during combustion. In a particular embodiment, the diffuser, the first gas distributor or the second gas distributor comprises ceramic materials, metals, alloys or mixtures thereof. In another particular embodiment, the diffuser, the first gas distributor or the second gas distributor consist of ceramic materials, metals, alloys or mixtures thereof.

**[0060]** The diffuser comprises openings adapted for transporting oxidizer gas and openings adapted for transporting fuel gas; wherein the openings adapted for transporting oxidizer gas and the openings adapted for transporting fuel gas are different openings. The openings of the diffuser are not adapted from transporting fuel gas at the same time than oxidizer gas. In the context of the present invention the term "transporting" regarding the openings of the diffuser is interpreted as circulating and/or as letting circulate a fluid such as a gas; particularly a specific gas.

**[0061]** In a particular embodiment, the diffuser comprises at least 100 openings; preferably at least 300 openings; more preferably at least 800 openings.

**[0062]** The number of openings in the diffuser of the present invention may be tailored to provide the desired efficiency for the application.

**[0063]** The openings of the diffuser are passage openings (for example, they go from one side of the diffuser to the opposite side). The openings of the diffuser may be of any shape, for example they may be slits, cylindrical openings, conical openings or a combination thereof.

**[0064]** In a more particular embodiment, the openings of the diffuser have a continuous diameter throughout its length. In another more particular embodiment, the openings of the diffuser have a discontinuous diameter throughout its length.

**[0065]** In a more particular embodiment, the openings of the diffuser have a cylindrical shape.

**[0066]** In a more particular embodiment, the openings have an average diameter of below 2 mm; preferably of below 1.5 mm; more preferably about 1.2 mm.

**[0067]** In a more particular embodiment, the openings of the diffuser are less than 60% of the total volume of the diffuser; preferably less than 50%, more preferably

less than 40%, even more preferably less than 30%; even much more preferably less than 20%.

**[0068]** In a particular embodiment, the openings of the diffuser form or follow a pattern or a logo.

**[0069]** In a particular embodiment, the openings adapted for transporting oxidizer gas follow a pattern in the diffuser and the openings adapted for transporting fuel gas follow a different pattern in the diffuser.

**[0070]** In a particular embodiment, the pattern followed by the openings adapted for transporting fuel gas in the diffuser is a ring pattern and/or a radial pattern; preferably a concentric ring pattern and/or a radial pattern. In an embodiment, the pattern followed by the openings adapted for transporting fuel gas in the diffuser surface is a ring pattern. In a more particular embodiment, the openings adapted for transporting fuel gas are distributed in the diffuser surface forming at least two concentric ring patterns and radial patterns; preferably wherein the at least two concentric rings are connected by the radial patterns.

**[0071]** In a particular embodiment, the pattern of the openings adapted for transporting fuel gas in the diffuser is a ring pattern and/or partial ring pattern; preferably wherein the ring pattern and/or partial ring pattern are concentrically placed.

**[0072]** In a particular embodiment, the pattern followed by the openings adapted for transporting oxidizer gas in the diffuser (3) coincides and/or overlaps the pattern of the first gas distributor (5) adapted for distributing an oxidizer gas and the pattern followed by the openings adapted for transporting fuel gas in the diffuser (3) coincides and/or overlaps the pattern of the second gas distributor (5) adapted for distributing a fuel gas.

**[0073]** The oxidizer gas is a gas or a gas mixture.

**[0074]** In the context of the present invention, the term "oxidizer" refers to an oxidizing agent, in particular to an oxidizing gas for example a gas that has the ability to oxidize other substances. Non-limiting examples of oxidizers are oxygen, ozone, air or mixtures thereof.

**[0075]** In a particular embodiment the oxidizer gas is an oxidizing gas; preferably oxygen, ozone, air or mixtures thereof; more preferably air. In the context of the present invention, air is understood as known in the art.

**[0076]** In a particular embodiment the oxidizer gas comprises or consist of air.

**[0077]** In the context of the present invention, the term "fuel gas" might be also referred to as a combustible gas.

**[0078]** Non-limiting examples of fuel gas are those comprising:

- hydrocarbon gases such as methane, butane or propane;
- manufactured fuel gases;
- hydrogen;
- carbon monoxide or
- mixtures thereof.

**[0079]** In the context of the present invention, the term

"manufactured fuel gases" are those known in the art, in particular those produced through an artificial process, usually gasification. Non-limiting examples of manufactured fuel gases are coal gas, water gas, producer gas, syngas, wood gas, biogas, blast furnace gas, acetylene or mixtures thereof.

**[0080]** In a particular embodiment, the fuel gas comprises: hydrocarbon gases such as methane, butane or propane, manufactured fuel gases, hydrogen, carbon monoxide or mixtures thereof.

**[0081]** In another particular embodiment, the fuel gas consists of: hydrocarbon gases such as methane, butane or propane, manufactured fuel gases, hydrogen, carbon monoxide or mixtures thereof.

**[0082]** In a particular embodiment, the fuel gas comprises hydrogen; preferably wherein the hydrogen is over 95 vol.% of the total volume of the fuel gas; more preferably over 96 vol.%; much more preferably over 97 vol.%; even much more preferably over 98 vol.%; even much more preferably over 99 vol.%.

**[0083]** In a more particular embodiment, the fuel gas consist of hydrogen.

#### *Gas distributors*

**[0084]** The gas burner of the invention comprises two gas distributors, named as a first and second gas distributors in order to distinguish them. Alternatively, the gas distributors of the gas burner of the invention could be named as gas distributor A and gas distributor B.

**[0085]** The first gas distributor of the gas burner of the invention is adapted for distributing an oxidizer gas. The second gas distributor of the gas burner of the invention is adapted for distributing a fuel gas.

**[0086]** In an embodiment, the first and the second gas distributors are placed below the diffuser; preferably in contact with the diffuser (i.e. the diffuser is between the first and the second gas distributors and the burner surface).

**[0087]** In a particular embodiment, the first gas distributor comprises an oxidizer gas inlet.

**[0088]** In a particular embodiment, the second gas distributor comprises a fuel gas inlet.

**[0089]** In a particular embodiment, the burner surface and the diffuser surface are parallel, preferably are parallel disks; more preferably are parallel disks with the same area.

**[0090]** In an embodiment, the gas distributors of the gas burner of the invention comprise means for directing the gases. In a particular embodiment, the gas distributors of the gas burner of the invention comprise means for directing and/or distributing the gases for example channels or conducts.

**[0091]** In a particular embodiment, the means for directing and/or distributing the gases of the gas distributors of the gas burner of the invention form patterns in said gas distributors.

**[0092]** In particular embodiment, the openings of the

diffuser (3) adapted for transporting oxidizer gas form patterns or logos in said diffuser that at least partially overlap or match the pattern of the means for directing and/or distributing the gases of the first gas distributor and/or the openings adapted for transporting fuel gas of the diffuser form a pattern or logo in said diffuser that at least partially match or overlap the means for directing and/or distributing the gases of the second gas distributor.

**[0093]** In a more particular embodiment, the gas distributors of the gas burner of the invention comprise means for directing the gases perpendicularly to the burner surface and the diffuser surface.

**[0094]** In an embodiment, the first gas distributor comprises means for directing the oxidizer gas in a direction perpendicular to burner surface and the second gas distributor comprises means for directing the fuel gas in a direction perpendicular to the burner surface.

**[0095]** In an embodiment, the diffuser of the gas burner of the invention is a diffuser surface; the first gas distributor comprises means for directing the oxidizer gas in a direction perpendicular to the diffuser surface and the second gas distributor comprises means for directing the fuel gas in a direction perpendicular to the diffuser surface.

**[0096]** In a particular embodiment, the burner surface and the diffuser surface are parallel.

**[0097]** In a more particular embodiment, the means for directing the gases of the gas distributors of the gas burner of the invention are also adapted for distributing the gases; particularly for distributing the gases through different areas of the distributor.

**[0098]** In an embodiment, the means for directing the gases of the gas distributors of the gas burner are channels or conducts; preferably open channels or conducts.

**[0099]** In a particular embodiment, the first gas distributor comprises an oxidizer gas inlet in fluidic communication with means for directing the oxidizer gas perpendicularly to the burner surface and/or the diffuser surface; and the second gas distributor comprises an oxidizer gas inlet in fluidic communication with the means for directing the fuel gas perpendicularly to the burner surface and/or the diffuser surface.

#### *Frame*

**[0100]** In an embodiment, the burner surface, the diffuser, the first gas distributor and the second gas distributor of the gas burner of the invention are attached to a frame with a gas-proof sealing. In an embodiment, the frame is adapted for directing the gases in a direction perpendicular to the gas burner surface and/or the diffuser.

**[0101]** In an embodiment, the burner surface, the diffuser, the first gas distributor and the second gas distributor of the gas burner of the invention are attached to a frame by any means for attachment known in the art such as screws or bolts.

**[0102]** The gas-proof sealing does not allow the oxidizer gas or the fuel gas to exit the frame (for example, through voids in the frame or between the frame and the burner surface, the diffuser, the first gas distributor and the second gas distributor), therefore, the gases pass through the gas burner following a direction mostly perpendicular to the burner surface. In addition, said gas-proof sealing may be of any material known in the art, for example of a polymeric material.

**[0103]** In a particular embodiment, the frame is adapted to hold the burner surface, the diffuser, the first gas distributor and the second gas distributor of the gas burner, preferably by using attaching means.

**[0104]** In an embodiment, the frame has a central circular aperture; preferably wherein the aperture has the area of the burner surface (2). In particular, the aperture is adapted to allow the flames being generated.

**[0105]** In a particular embodiment, the frame is adapted to cover the laterals of the burner surface, the diffuser, the first gas distributor and the second gas distributor of the gas burner; preferably the frame only covers the laterals.

**[0106]** The apertures or pores of burner surface of the gas burner of the invention are in fluidic communication:

- with the first gas distributor (4) through the openings adapted for transporting an oxidizer gas of the diffuser (3); and
- with the second gas distributor (5) through the openings adapted for transporting a fuel gas of the diffuser (3).

**[0107]** Moreover, the oxidizer gas and the fuel gas mix in the apertures or pores of the burner surface. In addition, during combustion, the oxidizer gas and the fuel gas mix and react in the apertures or pores of the burner surface creating flames.

**[0108]** In an embodiment, the apertures of the burner surface are larger than the openings of the gas diffuser surface; preferably the diameters of the apertures of the burner surface are larger than the diameters of the openings of the gas diffuser surface.

**[0109]** Without being bound to any theory in particular, the authors of the present invention observed that the fact that the oxidizer gas and the fuel gas mix and react in the apertures or pores of the burner surface gas burner has the advantage of eliminating flashback and reducing oxidation issues in the burner surface.

**[0110]** In a particular embodiment, the openings adapted for transporting oxidizer gas of the diffuser are distributed in said diffuser following a pattern and the openings adapted for transporting fuel gas are distributed in said diffuser following a different pattern; wherein the pattern of the openings adapted for transporting oxidizer gas matches or overlaps the means for directing the oxidizer gas in the first gas distributor; and wherein the pattern of the openings adapted for transporting fuel gas matches or overlaps the means for directing the fuel gas in the

second gas distributor.

**[0111]** In addition, the authors of the present invention have observed that the presence of a diffuser between the burner surface and the gas distributors of the gas burner of the invention, has the advantage of allowing the gas fuel and the oxidizer gas arriving in a controlled and homogeneous manner to the apertures or pores adapted for defining gas mixing zones of the burner surface, during combustion. This leads to more homogeneous flames and higher burning efficiency. This advantage is highlighted when the patterns of the openings in the diffuser match or overlap with the patterns of the means for directing the gases in the distributors, for each specific gas.

#### *Cooling means*

**[0112]** In a particular embodiment, the gas burner of the invention comprises cooling means or means adapted for cooling the flames generated in/on the burner surface (8) during combustion (i.e. means adapted for reducing the temperature reached by the generated flames in at least a 10%).

**[0113]** In a more particular embodiment, the cooling means or means adapted for cooling the flames generated in/on the burner surface (8) are at least one flat surface placed on top of the burner surface; preferably wherein said at least one flat surface is perpendicular to the burner surface.

**[0114]** In a more particular embodiment, the cooling means or means adapted for cooling the flames generated in/on the burner surface are two flat surfaces placed on top of the burner surface; preferably wherein said two flat surfaces are perpendicular to the burner surface; preferably wherein said two flat surfaces are also mutually perpendicular, for example forming a cross.

**[0115]** In a particular embodiment, the at least one flat surface have any shape, for example it may have a rectangular shape, an arch shape, a tied arch shape or a half-disk shape.

**[0116]** In a particular embodiment, the at least one flat surface only contacts the burner surface in two or three points, preferably by projecting portions.

**[0117]** In a particular embodiment, the at least one flat surface comprises an aperture; preferably the at least one flat surface contacts the burner surface in two or three points by projecting portions and the aperture is defined between the projecting portions.

**[0118]** In a particular embodiment, the at least one flat surface is a fin or a flipper.

**[0119]** In a particular embodiment, the at least one flat surface is attached to the diffuser; preferably in two or three points.

**[0120]** In an embodiment, the additional surface comprises a ceramic material, a metallic material or a mixture thereof. In another embodiment, the additional surface consists of a ceramic material, a metallic material or a mixture thereof.

**[0121]** In an embodiment, the additional surface comprises pores and/or apertures.

**[0122]** Without being bound to any theory in particular, the authors of the present invention observed that the presence of cooling means in the gas burner has the advantage of reducing the temperature of the flames created during combustion of the burner leading to an undesired emissions reduction.

#### *Other products*

**[0123]** A second aspect of the invention is directed to a burner assembly comprising

- a housing;
- at least a gas inlet connected to the housing; and

the gas burner of the invention in any of its particular embodiments.

**[0124]** In a particular embodiment, the housing comprises the gas burner of the invention in any of its particular embodiments, connected to at least one gas inlet.

**[0125]** An additional aspect of the invention is directed to a boiler comprising

- a heat exchanger; and
- the gas burner of the invention in any of its particular embodiments or the burner assembly as defined in any of its particular embodiments.

**[0126]** In an embodiment, the boiler is a water boiler and/or the heat exchanger is adapted for circulating water.

**[0127]** In a particular embodiment, the gas burner of the invention in any of its particular embodiments or the burner assembly as defined in any of its particular embodiments generate heat under combustion that heats the water inside the heat exchanger.

#### *Uses*

**[0128]** An additional aspect of the invention is directed to the use of the gas burner of the invention in any of its particular embodiments, in boilers, water heaters and/or cooking burners preferably using a gas or a mixture of gases.

**[0129]** A further additional aspect of the invention is directed to the use of the burner assembly of the invention in any of its particular embodiments, in boilers, water heaters and/or cooking burners preferably using a gas or a mixture of gases.

**[0130]** An additional aspect is directed to a method comprising a step of using the gas burner or the burner assembly of the invention in any of its particular embodiments in boilers, water heaters and/or cooking burners preferably using a gas or a mixture of gases.

**[0131]** An additional aspect of the invention is directed

to the use of the gas burner of the invention in any of its particular embodiments, in hydrogen combustion applications.

**[0132]** A further additional aspect of the invention is directed to the use of the burner assembly of the invention in any of its particular embodiments, in hydrogen combustion applications.

**[0133]** An additional aspect is directed to a method comprising the step of using the gas burner or the burner assembly of the invention in any of its particular embodiments in hydrogen combustion applications.

#### *Particular embodiments*

**[0134]** Figure 1 shows a first embodiment of a gas burner (1) according to the invention. Said burner 1 comprises a burner surface (2) comprising apertures or pores adapted for defining gas mixing zones; a diffuser (3) below the burner surface (2), comprising openings adapted for transporting oxidizer gas and openings adapted for transporting fuel gas; a first gas distributor (4) adapted for distributing an oxidizer gas, such as air; and a second gas distributor (5) adapted for distributing a fuel gas, such as hydrogen; wherein the first and the second gas distributors are placed below the diffuser (3). The first and second gas distributors are not showed in Figure 1.

**[0135]** The burner surface (2), the diffuser (3), the first gas distributor (4) and the second gas distributor (5) of the embodiment of Figure 1 are attached to a frame (6) with a gas-proof sealing (7) using means adapted for attaching such as screws. The frame (6) has a central circular aperture with an area similar to the one of the burner surface (2) (it only covers partially the burner surface). The burner surface of the gas burner of the embodiment is in fluidic communication with the first gas distributor (4) through the openings adapted for transporting an oxidizer gas of the diffuser (3); and with the second gas distributor (5) through the openings adapted for transporting a fuel gas of the diffuser (3); such that when the gases flow through the gas burner, the oxidizer gas and the fuel gas are mixed in the apertures or pores of the burner surface. The gas burner has also gas inlets (not showed in Figure 1), in particular, a fuel gas inlet and an oxidizer gas inlet comprising fuel gas an oxidizer gas conduits respectively. The fuel gas inlet is at least partially housed in the first gas distributor and the oxidizer gas inlet is at least partially housed in the second gas distributor. The first and second gas distributors (4, 5) are independent from each other, i.e. the fuel gas and oxidizer gas are transported in an independent manner. In addition, the openings adapted for transporting oxidizer gas and openings adapted for transporting fuel gas of the diffuser (3) are also independent from each other.

**[0136]** The presence of a diffuser (3) between the burner surface (2) and the gas distributors (4, 5) of the gas burner (1) of the embodiment allows the necessary amount of oxidizer gas and fuel gas required for gas combustion to occur, reaching each mixing zone in each of



the apertures of the burner surface (2).

**[0137]** In addition, the diffuser (3) of the embodiment allows that the same amount of gas (either oxidizer or fuel gas) reaches all the gas mixing zones (apertures of the burner surface) equally, leading to the production of similar flames and to an homogenous distribution of flames in the burner surface (2). In addition, the gas burner allows tuning the respective amounts of oxidizer gas and fuel gas (ratio fuel:oxidizer) that reach the flames.

**[0138]** Figure 2 shows a partial exploded view of a second embodiment of a gas burner (1). Said burner 1 comprises a burner surface (2) comprising several slits (forming concentric and radial patterns) adapted for defining gas mixing zones; a diffuser (3) below the burner surface (2) and not in contact with said burner surface (3), comprising cylindrical openings adapted for transporting oxidizer gas and cylindrical openings adapted for transporting fuel gas; a first gas distributor (4) adapted for distributing an oxidizer gas, such as air; and a second gas distributor (5) adapted for distributing a fuel gas, such as hydrogen; wherein the first and the second gas distributors are placed below the diffuser (3). The first and second gas distributors are not showed in Figure 2 but may be seen in Figure 3.

**[0139]** The burner surface (2), the diffuser (3), the first gas distributor (4) and the second gas distributor (5) of the embodiment of Figure 1 are attached to a frame (6) with a gas-proof sealing (7) using means for attaching such as screws. The frame (6) has a central circular aperture with an area similar to the one of the burner surface (2) (it only covers partially the burner surface). The burner surface of the gas burner of the embodiment is in fluidic communication with the first gas distributor (4) through the openings adapted for transporting an oxidizer gas of the diffuser (3); and with the second gas distributor (5) through the openings adapted for transporting a fuel gas of the diffuser (3). The gas burner has also gas inlets (not showed in Figure 1), in particular a fuel gas inlet and an oxidizer gas inlet comprising fuel gas an oxidizer gas conduits respectively. The fuel gas inlet is at least partially housed in the first gas distributor and the oxidizer gas inlet is at least partially housed in the second gas distributor. The first and second gas distributors (4, 5) are independent from each other, i.e., the fuel gas and oxidizer gas are transported in an independent manner. In addition, the openings adapted for transporting oxidizer gas and openings adapted for transporting fuel gas of the diffuser (3) are also independent from each other.

**[0140]** The presence of a diffuser (3) between the burner surface (2) and the gas distributors (4, 5) of the gas burner (1) of the embodiment allows the necessary amount of oxidizer gas and fuel gas required for gas combustion to occur, reaching each mixing zone in each of the apertures of the burner surface (2).

**[0141]** In addition, the diffuser (3) of the embodiment allows that the same amount of oxidizer gas and fuel gas reaches all the gas mixing zones (apertures of the burner surface) equally, leading to the production of similar

flames and of an homogenous distribution of flames in the burner surface (2). The respective amounts of oxidizer gas and fuel gas (ratio fuel:oxidizer) that reach the flames can be tuned.

**[0142]** Figure 2 also shows cooling means or means adapted for cooling the flames and/or the burner surface during combustion (8), which in this embodiment are two rectangular flat surfaces or plates each of them comprising at least an aperture, situated perpendicular to the burner surface (2) and also mutually perpendicular (forming a cross) which are attached to the diffuser (3) in two or three points by projecting portions, wherein the apertures are defined between the projecting portions.

## Claims

1. A gas burner (1) comprising:

- a) a burner surface (2) comprising apertures or pores;
- b) a diffuser (3) comprising openings adapted for transporting oxidizer gas and openings adapted for transporting fuel gas; and
- c) a first gas distributor (4) adapted for distributing an oxidizer gas, such as air; and a second gas distributor (5) adapted for distributing a fuel gas, such as hydrogen;

wherein the diffuser (3) is between the burner surface (2) and the first and the second gas distributors (4, 5);

wherein the apertures or pores of the burner surface are in fluidic communication:

- with the first gas distributor (4) through the openings adapted for transporting an oxidizer gas of the diffuser (3); and
- with the second gas distributor (5) through the openings adapted for transporting a fuel gas of the diffuser (3).

2. The gas burner (1) according to claim 1, wherein the burner surface comprises or consists of a ceramic material.

3. The gas burner (1) according to claim 2, wherein the ceramic material is a ceramic oxide, a non-oxide ceramic or combinations thereof.

4. The gas burner (1) according to claim 3, wherein the ceramic material is silicon carbide (SiC), silicon carbonitride (SiCN), alumina (Al<sub>2</sub>O<sub>3</sub>), alumina-mullite, aluminum borosilicate, silica (SiO<sub>2</sub>) or mixtures thereof.

5. The gas burner (1) according to any of claims 1 to 4, wherein the burner surface has a porosity of be-

tween a 2% and a 95% of the total volume of the burner surface; wherein the porosity refers to a void fraction created by pores or apertures that is a fraction of the volume of voids over the total volume expressed as a percentage between 0% and 100%.

6. The gas burner (1) according to any of claims 1 to 5,

wherein the first gas distributor (4) comprises an oxidizer gas inlet and means for directing the oxidizer gas perpendicularly to the burner surface; wherein the oxidizer gas inlet is in fluidic communication with means for directing the oxidizer gas perpendicularly to the burner surface (2); and

wherein the second gas distributor (5) comprises an oxidizer gas inlet and means for directing the oxidizer gas perpendicularly to the burner surface, wherein the oxidizer gas inlet is in fluidic communication with means for directing the fuel gas perpendicularly to the burner surface.

7. The gas burner (1) according to any of claims 1 to 6, wherein the diffuser (3) comprises areas wherein the openings adapted for transporting oxidizer gas are grouped forming a logo or pattern, and areas wherein the openings adapted for transporting fuel gas are grouped forming a logo or pattern.

8. The gas burner (1) according to any of claims 1 to 7, further comprising cooling means (8) on top of the burner surface (2).

9. The gas burner (1) according to claim 8, wherein the cooling means (8) comprises at least one flat surface perpendicular to the burner surface (2).

10. A burner assembly comprising:

- a housing;
- at least a gas inlet connected to the housing;
- and
- the gas burner as defined in any of claims 1 to 9.

11. A boiler comprising:

- a heat exchanger; and
- the gas burner as defined in any of claims 1 to 9 or the burner assembly as defined in claim 10.

12. Use of the gas burner according to any of claims 1 to 9 or of the burner assembly according to claim 10, in boilers, water heaters and/or cooking burners preferably using a gas or a mixture of gases.

13. The use according to claim 12, wherein the gas or a mixture of gases comprises hydrogen.

14. The use according to claim 12, wherein the hydrogen is over 95 % in volume of the total volume of the mixture of gases.

15. Use of the burner as defined in any of claims 1 to 9, the burner assembly according to claim 10, or the boiler according to claim 11, in hydrogen combustion applications.

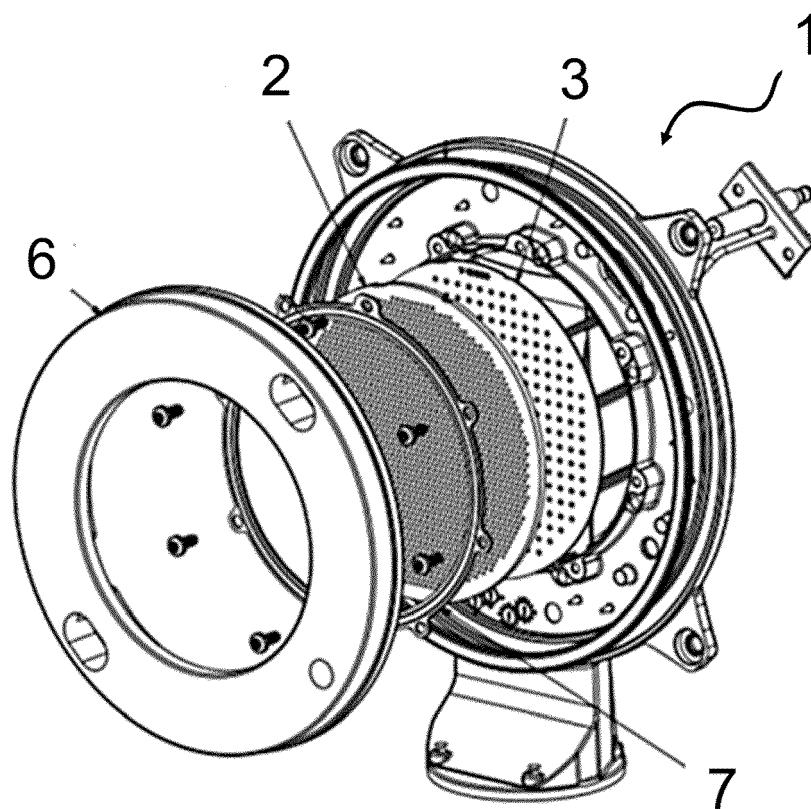


Figure 1

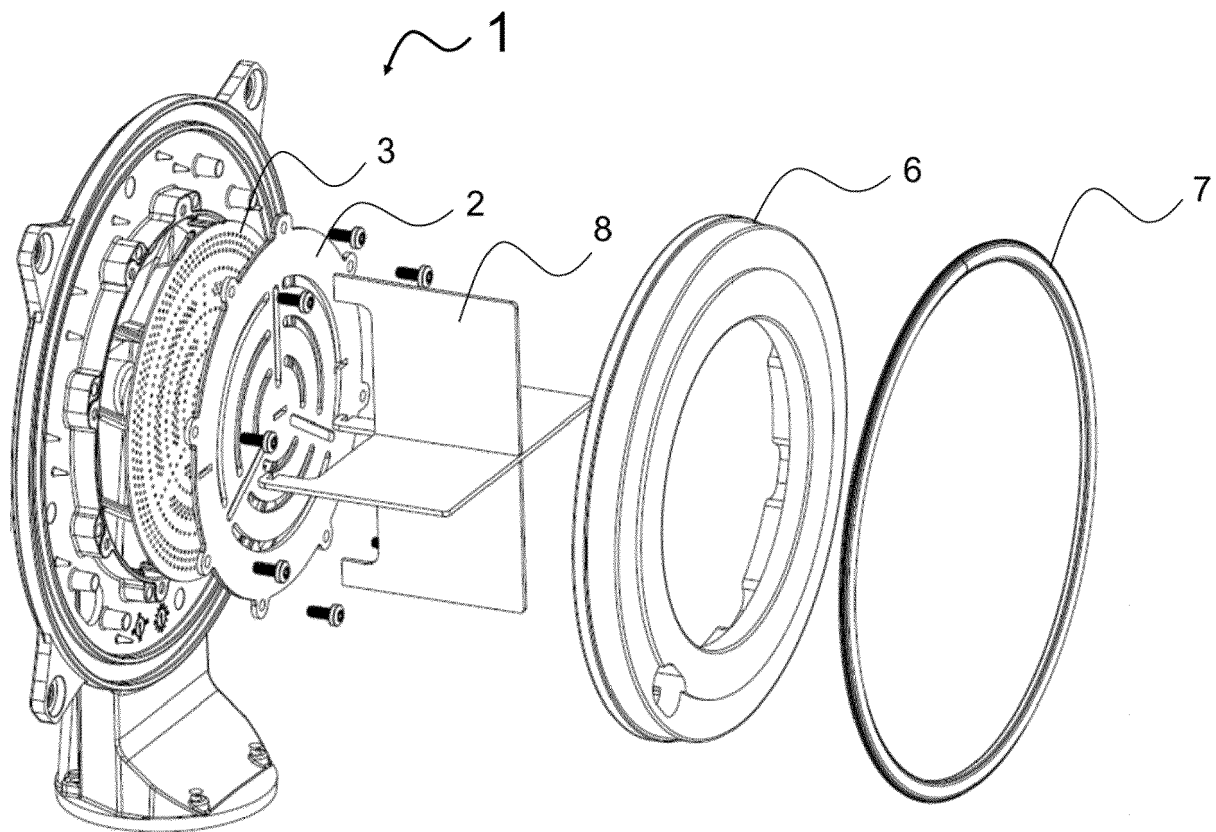


Figure 2

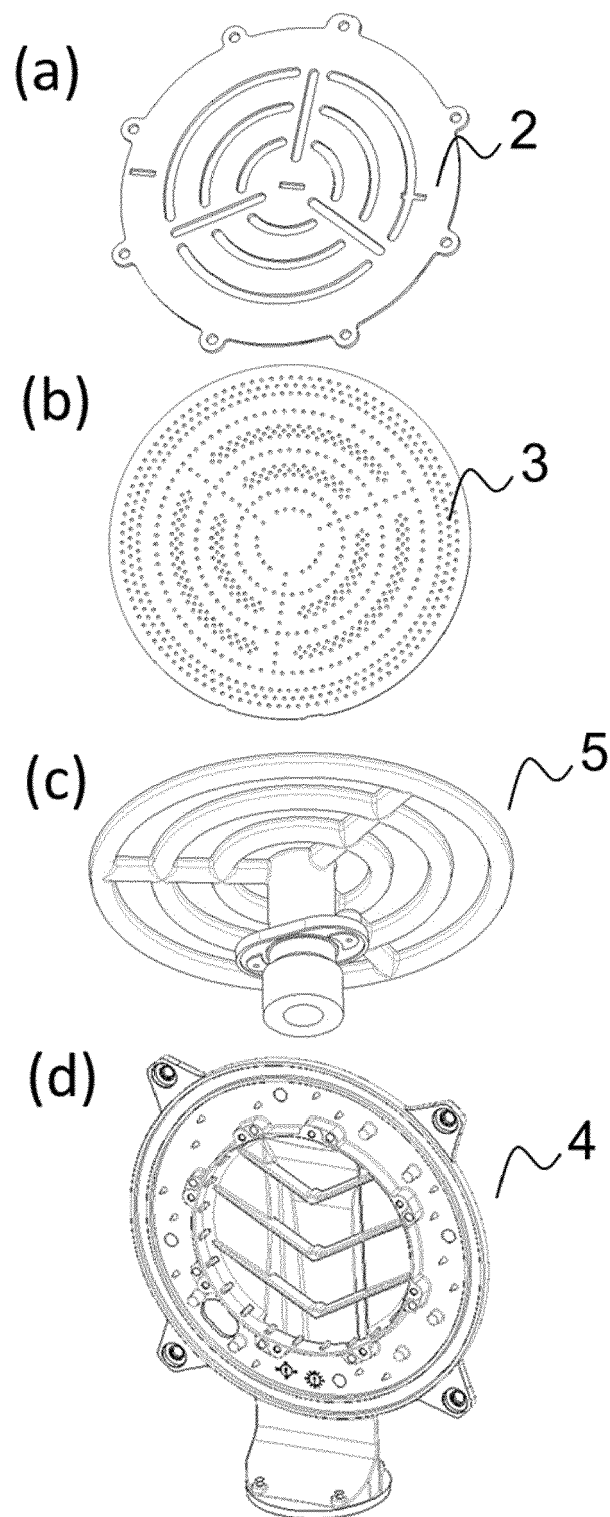


Figure 3



## EUROPEAN SEARCH REPORT

Application Number

EP 22 38 2283

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			TECHNICAL FIELDS SEARCHED (IPC)
			F23D F23C
The present search report has been drawn up for all claims			
Place of search <b>Munich</b>		Date of completion of the search <b>20 September 2022</b>	Examiner <b>Vogl, Paul</b>
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ..... & : member of the same patent family, corresponding document	

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**REFERENCES CITED IN THE DESCRIPTION**

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