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(54) **GAS PREMIX BURNER**

GASVORMISCHUNGSBRENNER

BRÛLEUR À PRÉMÉLANGE GAZEUX

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Description

Technical Field

[0001] The invention relates to a gas premix burner with a fiber based burner deck. An ionization pen measuring the flame current is used to determine the air to gas ratio. The air to gas ratio of the gas premix burner according to the invention can be controlled over a broader burner load range by means of a control system using an ionization pen as sensor. Such gas premix burner can e.g. be used in boilers or in instantaneous water heaters.

Background Art

[0002] Detection of the ionization current in the flame of a gas premix burner by means of an ionization pen is commonly used as a way to detect whether or not ignition has occurred. However, in a growing number of gas premix burners, the ionization current is not only used to detect burner ignition, but its value is also used as a means for flame control, and more precisely for the control of the air to gas premix ratio. As an example, DE19632983 discloses an ionization pen to measure the flame current and an associated regulating device in a gas burner, wherein an air to gas ratio reference value for low emissions is set by means of an ionization electrode.

[0003] Gas premix burners with fiber based burner decks are known in the state of the art. Such burners can have a metal fiber based knitted or woven fabric as burner deck positioned on a perforated plate or woven screen which is acting as gas distribution plate. It is a benefit of such burners that the metal fiber based burner deck (e.g. a knitted or woven fabric) can freely expand when hot. Such burners are e.g. known from US4657506 and WO2004/092647. Document US 4900245 discloses a gas premix burner according to the preamble of claim 1.

[0004] For use in combustion control the ionization current of gas premix burners should be readily and reliably measurable over the load range of the burner. It is a problem, also with gas premix burners with a fiber based burner deck, that in the low power range of the burner the ionization current drops drastically which is rendering flame control by means of ionization current measurement unreliable in the low power range of gas premix burners. For a number of applications it is desirable that burners can operate in a broad load range, and that air to gas ratio control by means of measurement of ionization current with an ionization pen can be performed over the broad load range.

Disclosure of Invention

[0005] The primary objective of the invention is to provide a gas premix burner with a fiber based burner deck that is allowing control of air to gas ratio over a broad load range of the burner by means of the ionization cur-

rent as measured by an ionization pen.

[0006] The objective is achieved by a gas premix burner comprising:

- a perforated plate, a woven wire mesh or expanded metal sheet. The perforated plate, the woven wire mesh or the expanded metal sheet are preferably perforated in a uniform way over the full surface of the burner. The premix of air and gas will be distributed from a mixing chamber through the perforated plate, the woven wire mesh or the expanded metal sheet.
- a fiber based burner deck placed on the perforated plate, woven wire mesh or expanded metal sheet. Preferably, the fiber based burner deck is showing a three dimensional porosity with open cell pores. The gas premix is flowing first through the perforated plate, woven wire mesh or the expanded metal sheet and then through the fiber based burner deck after which the gas is combusted. It is a benefit that the fiber based burner deck can freely expand when the burner is in operation while the perforated plate, the woven wire mesh or the expanded metal sheet are remaining sufficiently cool.
- an ionization pen. The ionization pen is used to measure the ionization current over the flame of the gas premix burner.

The fiber based burner deck is thicker in at least part of the region where the ionization pen is located compared to other regions of the fiber based burner deck. This characterizing feature ensures that ionization current measurement by means of the ionization pen can be used in a broad load range of the burner as a reliable indication of the air to gas ratio of the gas premix burner and hence as input for the modulation of the air to gas ratio supplied to the gas premix burner.

[0007] In a preferred embodiment the fiber based burner deck is thicker in a region of at least 5 mm, preferably in a region of at least 8 mm, more preferably in a region of at least 12 mm, at both sides of at least 50%, and preferably of at least 65%, more preferably of at least 85% of the length of the perpendicular projection of the ionization pen onto the burner deck. And even more preferably the fiber based burner deck is thicker in the indicated regions around the full length of the ionization pen and even more preferred over 120% of the length of the ionization pen.

[0008] In a preferred embodiment the fiber based burner deck has a same mass per surface area over the full surface of the burner deck. The burner deck is less compressed in the at least part of the region where the ionization pen is located compared to other regions of the fiber based burner deck, resulting in it that the fiber based burner deck is thicker in the at least part of the region where the ionization pen is located compared to other regions of the fiber based burner deck. "Less compressed" includes that the burner deck can be not com-

pressed in the at least part of the region where the ionization pen is located and compressed in other regions of the fiber based burner deck. It also includes that the burner deck is compressed to a lesser degree in the at least part of the region where the ionization pen is located compared to other regions of the fiber based burner deck.

[0009] In a preferred embodiment, the thickness of the fiber based burner deck in at least part of the region where the ionization pen is located is at least 40%, preferably at least 50%, even more preferably at least 60% higher, even more preferably at least 100% higher and still even more preferred 150% higher than the average of the thickness outside said at least part of said region where the ionization pen is located.

A larger difference in thickness increases the positive effects of the invention. Such effects are especially remarkable as of a 40% higher thickness of the fiber based burner deck at the ionization pen; and even more pronounced as of a 60% higher thickness; and still even more pronounced as of 100% higher thickness and yet even more pronounced as of a 150% higher thickness.

[0010] In another preferred embodiment, the porosity of the fiber based burner deck where it is thicker in at least part of the region where the ionization pen is located is less than 92%. It is a benefit of this feature that risk is absent of flashback of the flame into the mixing chamber under the fiber based burner deck and under the perforated plate, woven wire mesh or expanded metal sheet.

[0011] Preferred is when the average porosity of the fiber based burner deck outside the at least part of the region where the ionization pen is located, is higher than 75%, but preferably below 85%. This range of porosities has the benefit that good and clean combustion with low emissions (of NOX) is obtained. When having the porosity less than 85% the burner load range over which the ionization pen can be used to modulate the air to gas ratio is further extended in a synergetic way, as the burner can be operated at higher loads by this feature.

[0012] The fiber based burner deck can comprise metal fibers. Examples of preferred ranges of metal fibers are stainless steel fibers. A specifically preferred range of stainless steel fibers are chromium and aluminium comprising stainless steel fibers as in DIN 1.4767, e.g. as are known under the trademark FeCrAlloy.

[0013] Metal fibers for the burner deck, e.g. stainless steel fibers, with a diameter less than 40 micrometers, e.g. less than 25 micrometers, can be obtained by a bundle drawing technique. This technique is disclosed e.g. in US-A-2050298, US-A-3277564 and in US-A-3394213. Metal wires are forming the starting material and are covered with a coating such as iron or copper. A bundle of these covered wires is subsequently enveloped in a metal pipe. Thereafter the thus enveloped pipe is reduced in diameter via subsequent wire drawing steps to come to a composite bundle with a smaller diameter. The subsequent wire drawing steps may or may not be alternated with an appropriate heat treatment to allow further drawing. Inside the composite bundle the initial wires have

been transformed into thin fibers which are embedded separately in the matrix of the covering material. Such a bundle preferably comprises no more than 2000 fibers, e.g. between 500 and 1500 fibers. Once the desired final diameter has been obtained the covering material can be removed e.g. by solution in an adequate pickling agent or solvent. The final result is the naked fiber bundle.

[0014] Alternatively metal fibers for the burner deck, such as stainless steel fibers can be manufactured in a cost effective way by machining a thin plate material. Such a process is disclosed e.g. in US-A-4930199. A strip of a thin metal plate is the starting material. This strip is wound around the cylindrical outer surface of a rotatably supported main shaft a number of times and is fixed thereto. The main shaft is rotated at constant speed in a direction opposite to that in which the plate material is wound. A cutter having an edge line expending perpendicularly to the axis of the main shaft is fed at constant speed. The cutter has a specific face angle parallel to the axis of the main shaft. The end surface of the plate material is cut by means of the cutter.

[0015] Yet an alternative way of producing metal fibers for the burner deck is via extracting or extrusion from a melt.

[0016] Another alternative way of producing metal fibers is machining fibers from a solid block of metal.

[0017] As an alternative for or in combination with metal fibers, ceramic fibers can be used in the fiber based burner deck.

[0018] The fiber based burner deck can e.g. comprise or be a woven fabric or a knitted fabric or a braided fabric comprising yarns with e.g. metal fibers, preferably stainless steel fibers. The yarns can be spun from stretchbroken fibers (such as bundle drawn stretch broken fibers) or yarns made from shaved or machined fibers. The yarns can be plied yarns, e.g. two ply, three ply... Preferred fabrics made from metal fibers have a weight of between 0.6 and 3 kg/m²; preferably between 0.7 and 3 kg/m², even more preferred between 1.2 and 2.5 kg/m².

Alternative fiber based burner decks that can be used in the invention can comprise or can be nonwovens, e.g. comprising metal fibers (preferably stainless steel fibers). The nonwovens can be consolidated by different techniques (e.g. needle punching) and can be sintered or not sintered.

[0019] The gas premix burner according to the invention can be provided in a wide range of different shapes. Examples are flat burners, cylindrical burners and burners that have a conical or frustoconical shape. As known by the person skilled in the art a flat burner can have and mostly has a curved shape or can even have an undulated shape. The class of flat burners is distinguished from the other main class of gas premix burners comprising burners that have a conical, cylindrical or frustoconical shape.

[0020] In a preferred embodiment, the gas premix burner comprises a control system. The control system uses the ionization current measured by the ionization

pen as indication for the gas to air ratio and as input value to modulate the air to gas ratio of the premix supply to the burner.

The ionization current depends on the burner load (as determined by the amount of gas supply) and the air to gas ratio in the gas premix supply. When the ionization current can be reliably measured, and knowing the burner load (amount of gas supply) the air to gas ratio of the premix can be derived from the ionization current as measured by the ionization pen. A correct air to gas ratio of the burner is required to obtain clean combustion. The modulation of the premix supply can e.g. be performed by means of volume control of the supply of or air to the premix in order to obtain for each burner load (determined by the amount of gas supply) the correct air to gas ratio leading to clean and optimum combustion.

[0021] A second aspect of the invention is a method to control the air to gas ratio of a gas premix burner, wherein a gas premix burner is used as in the first aspect of the invention and wherein the ionization current measured by means of the ionization pen is used in a control system to modulate the air to gas ratio.

[0022] In a preferred method to control the air to gas ratio of a gas premix burner installed in a boiler, the ratio of the ionization current at maximum load of the gas premix burner installed in the boiler is less than 50% higher than the ionization current at minimum load of the gas premix burner installed in the boiler. It is a further benefit of this embodiment that even better control possibility exist, as the ionization signal is less dependent from the burner load and more constant at a high level over a broad range of the burner load.

[0023] A third aspect of the invention relates to the use of the burner of the first aspect of the invention. Examples of use are boilers or instantaneous water heaters that comprise a gas premix burner as in the first aspect of the invention and/or that is using a method as in the second aspect of the invention to control the air to gas ratio supplied to the gas premix burner. The hot flue gas generated by the gas premix is transferring its heat to a fluid (mostly water) in a heat exchanger.

[0024] Elements of different embodiments and/or elements of different examples of the invention can be combined within the scope of the invention.

Brief Description of Figures in the Drawings

[0025]

Figure 1 shows a flat gas premix burner according to the invention.

Figure 2 shows a cross section of the flat gas premix burner of figure 1.

Figure 3 shows a cylindrical gas premix burner according to the invention.

Figure 4 shows the ionization current measured as a function of burner load for a burner according to the invention and for a prior art burner.

Mode(s) for Carrying Out the Invention

[0026] As a first example of a burner according to the invention figures 1 and 2 show a flat gas premix burner 100 according to the invention. The gas premix burner 100 has a frame 105 to which a fiber based burner deck 110 is connected, e.g. a knitted fabric made out of yarns spun from stainless steel fibers. The fiber based burner deck 110 is placed on a perforated plate or woven wire mesh (115 in figure 2, figure 2 shows the cross section of the gas premix burner of figure 1 along line I-I'). The perforated plate or the woven wire mesh has a uniform perforation pattern over their full surface. The perforated plate or the woven wire mesh are advantageously made out of stainless steel.

The burner of the example is a flat burner, having a length L_1 of 105 mm and a width L_2 of 30 mm. The burner deck of the flat burner can have a curved shape or can even have an undulated shape.

In at least part of the region of ionization pen 130, the fiber based burner deck is thicker (in the region indicated with reference number 140) than in the remainder of the fiber based burner deck 110. As an example the region at the ionization pen 130 where the fiber based burner deck is thicker 140 is having a length L_3 of 40 mm and a width L_4 of 24 mm. The ionisation pen 130 has e.g. a length L_5 of 30 mm.

[0027] In the example a fabric knitted from yarns made out of stainless steel fibers using an alloy according to DIN 1.4767 was used as fiber based burner deck. The knitted fabric has a surface weight of 1.4 kg/m².

In the region 140 of the ionization pen 130, the knitted fabric has a thickness of 1.7 mm with a porosity of 89.7%. Outside this region, the thickness of the knitted fabric is 1.07 mm with a porosity of 82.5%. The difference in thickness can be obtained by compressing the knitted fabric in the region outside the ionization pen. The thickness of the fabric at the ionization pen is 60% higher than outside this region. The ionization current at minimum load of the burner is 43 microampere.

In another example, in the region 140 of the ionization pen 130, the knitted fabric has a thickness of 2.7 mm with a porosity of 93.5%. Outside this region, the thickness of the knitted fabric is 1.07 mm with a porosity of 82.5%. The thickness of the knitted fabric in the region of the ionization pen is 150% higher than outside this region. The ionization current at the same minimum load of the burner is 58 microampere.

The results have been compared with a prior art burner with uniform fabric thickness for which the ionization current at the same minimum load was measured as being only 25 microampere.

[0028] As a second example of a burner according to the invention figure 3 shows a cylindrical gas premix burner 300 according to the invention. The burner has a length L_1 (e.g. between 50 and 2000 mm), e.g. 400 mm and a diameter D_1 (e.g. between 30 and 300 mm), e.g. 98 mm. The gas premix burner 300 has a flange 305, an inlet 308

for gas premix, a cylindrical fiber based burner deck 310 on a cylindrical perforated plate (not shown in the figure) and an end cap 315. In region 340 at ionization pen 330, which is mounted in a holder 332, the fiber based burner deck is thicker than in the remainder of the fiber based burner deck 310. As an example the region at the ionization pen 330 where the fiber based burner deck is thicker 340 is having a length L_3 of 50 mm and a width L_4 of 24 mm. The ionization pen 130 has a length L_5 of 40 mm. In the example a fabric knitted from yarns made out of stainless steel fibers of an alloy according to DIN 1.4767 was used as fiber based burner deck. The knitted fabric has a surface weight of 1.4 kg/m². In the region 340 of the ionization pen 330, the knitted fabric has a thickness of 1.7 mm with a porosity of 89.7%. Outside this region, the thickness of the knitted fabric is 1 mm with a porosity of 82.5%. The difference in thickness can be obtained by compressing the knitted fabric in the region outside the ionization pen. In another example, in the region 340 of the ionization pen 330, the knitted fabric has a thickness of 2.7 mm with a porosity of 93.5%. Outside this region, the thickness of the knitted fabric is 1 mm with a porosity of 82.5%.

[0029] Figure 4 shows the ionization current (Y, in microampere) measured by the ionization pen as a function of burner load (X, expressed in kW) for a prior art burner (indicated with curve A in figure 4) and for the burner according to the invention as described the example in figures 1 and 2 (indicated with curve B in figure 4) for a burner where the knitted fabric has a thickness of 2.7 mm in the region of the ionization pen and a thickness of 1 mm outside this region. The effect of the invention that a higher ionization current is measured at low burner loads is clearly demonstrated in figure 4 and leads to a broader load range over which the ionization current as measured by the ionization pen can be used to modulate the burner, e.g. to control air to gas ratio of the premix supplied to the burner.

[0030] Comparative experiments have been performed with the burner of the first example, shown in figure 1. For a length L_3 equal to 40 mm of the region 140 at the ionization pen 130 where the fiber based burner deck is thicker, and with an ionization pen 130 with length L_5 equal to 40 mm, a normative ionization current of 100 was measured at a low burner load.

For a length L_3 equal to 35 mm of the region 140 at the ionization pen 130 where the fiber based burner deck is thicker, and with an ionization pen 130 with length L_5 equal to 40 mm, a normative ionization current of 95 was measured at a same low burner load.

For a length L_3 equal to 25 mm of the region 140 at the ionization pen 130 where the fiber based burner deck is thicker, the ionization pen 130 with length L_5 equal to 40 mm, a normative ionization current of 75 was measured at a same low burner load.

Claims

1. Gas premix burner (100, 300) comprising

- a perforated plate (115), a woven wire mesh or expanded metal sheet;
- a fiber based burner deck (110, 310) placed on said perforated plate (115), woven wire mesh or expanded metal sheet;
- an ionization pen (130, 330) to measure the ionization current over the flame of the gas premix burner (100, 300),

characterized in that said fiber based burner deck (110, 310) is thicker in at least part of the region (140, 340) where the ionization pen (130, 330) is located compared to other regions of the fiber based burner deck (110, 310).

2. Gas premix burner as in any of the preceding claims, wherein said fiber based burner deck is thicker in a region of at least 5 mm at both sides of at least 50% of the length of the perpendicular projection of the ionization pen onto the burner deck.

3. Gas premix burner as in any of the preceding claims, wherein the fiber based burner deck has a same mass per surface area over the full surface of the burner deck, and is less compressed in the at least part of the region where the ionization pen is located compared to other regions of the fiber based burner deck, resulting in it that said fiber based burner deck is thicker in the at least part of the region where the ionization pen is located compared to other regions of the fiber based burner deck.

4. Gas premix burner as in any of the preceding claims, wherein the thickness of the fiber based burner deck in at least part of the region where the ionization pen is located is at least 40% higher than the average of the thickness outside said at least part of said region where the ionization pen is located.

5. Gas premix burner as in any of the preceding claims, wherein the porosity of the fiber based burner deck where it is thicker in at least part of the region where the ionization pen is located is less than 92 %.

6. Gas premix burner as in any of the preceding claims, wherein the average porosity of the fiber based burner deck outside said at least part of the region where the ionization pen is located, is higher than 75 %.

7. Gas premix burner as in any of the preceding claims, wherein the fiber based burner deck comprises metal fibers.

8. Gas premix burner as in any of the preceding claims,

wherein the fiber based burner deck comprises a woven, knitted, braided or nonwoven fabric.

9. Gas premix burner as in any of the preceding claims, further comprising a control system using the ionization current measured by said ionization pen as input value and controlling the air to gas ratio in the premix supply to the burner. 5
10. Method to control the air to gas ratio of a gas premix burner, wherein a gas premix burner is used as in any of the claims 1 - 10 and wherein the ionization current measured by said ionization pen is used in a control system to modulate the air to gas ratio in the premix supply to the burner. 10
11. Method to control the air to gas ratio of a gas premix burner as in claim 10, wherein the burner is installed in a boiler and wherein the ratio of the ionization current at maximum load of the burner in the boiler is less than 50% higher than the ionization current at minimum load of the burner in the boiler. 20
12. Boiler or instantaneous water heater comprising a gas premix burner as in any of the claims 1 to 9. 25

Patentansprüche

1. Gasvormischungsbrenner (100, 300), umfassend 30
 - eine perforierte Platte (115), ein Drahtgeflecht oder Streckmetallblech;
 - ein auf Fasern basierendes Brennerdeck (110, 310), das auf die perforierte Platte (115), das Drahtgeflecht oder das Streckmetallblech platziert ist; 35
 - eine Ionisierungssonde (130, 330), um den Ionisierungsstrom über der Flamme des Gasvormischungsbrenners (100, 300) zu messen, 40

dadurch gekennzeichnet, dass das auf Fasern basierende Brennerdeck (110, 310) in mindestens einem Teil des Bereiches (140, 340), in welchem sich die Ionisierungssonde (130, 330) befindet, im Verhältnis zu anderen Bereichen des auf Fasern basierenden Brennerdecks (110, 310) dicker ist. 45
2. Gasvormischungsbrenner nach einem der vorhergehenden Ansprüche, wobei das auf Fasern basierende Brennerdeck in einem Bereich von mindestens 5 mm auf beiden Seiten von mindestens 50 % der Länge der senkrechten Projektion der Ionisierungssonde auf das Brennerdeck dicker ist. 50
3. Gasvormischungsbrenner nach einem der vorhergehenden Ansprüche, wobei das auf Fasern basierende Brennerdeck dieselbe Masse pro Oberfläche 55

über die gesamte Oberfläche des Brennerdecks aufweist, und in dem mindestens einen Teil des Bereiches, in welchem sich die Ionisierungssonde befindet, im Verhältnis zu anderen Bereichen des auf Fasern basierenden Brennerdecks weniger komprimiert ist, wodurch das auf Fasern basierende Brennerdeck in dem mindestens einen Teil des Bereiches, in welchem sich die Ionisierungssonde befindet, im Verhältnis zu anderen Bereichen des auf Fasern basierenden Brennerdecks dicker ist.

4. Gasvormischungsbrenner nach einem der vorhergehenden Ansprüche, wobei die Dicke des auf Fasern basierenden Brennerdecks in mindestens einem Teil des Bereiches, in welchem sich die Ionisierungssonde befindet, mindestens 40 % höher als der Durchschnitt der Dicke außerhalb des mindestens einen Teils des Bereiches ist, in welchem sich die Ionisierungssonde befindet.
5. Gasvormischungsbrenner nach einem der vorhergehenden Ansprüche, wobei die Porosität des auf Fasern basierenden Brennerdecks, an der Stelle, an der es in mindestens einen Teil des Bereiches, in welchem sich die Ionisierungssonde befindet, dicker ist, weniger als 92 % beträgt.
6. Gasvormischungsbrenner nach einem der vorhergehenden Ansprüche, wobei die durchschnittliche Porosität des auf Fasern basierenden Brennerdecks außerhalb des mindestens einen Teils des Bereiches, in welchem sich die Ionisierungssonde befindet, höher als 75 % ist.
7. Gasvormischungsbrenner nach einem der vorhergehenden Ansprüche, wobei das auf Fasern basierende Brennerdeck Metallfasern umfasst.
8. Gasvormischungsbrenner nach einem der vorhergehenden Ansprüche, wobei das auf Fasern basierende Brennerdeck einen gewebten, gewirkten, geflochtenen oder einen Vliesstoff umfasst.
9. Gasvormischungsbrenner nach einem der vorhergehenden Ansprüche, des Weiteren ein Steuersystem umfassend, welches den Ionisierungsstrom, der durch die Ionisierungssonde gemessen wird, als Eingangswert verwendet, und das Luft-/Gasverhältnis in der Vormischungszufuhr zu dem Brenner regelt.
10. Verfahren zum Regeln des Luft-/Gasverhältnisses eines Gasvormischungsbrenners, wobei ein Gasvormischungsbrenner nach einem der Ansprüche 1 bis 10 verwendet wird, und wobei der Ionisierungsstrom, der durch die Ionisierungssonde gemessen wird, in einem Steuersystem verwendet wird, um das Luft-/Gasverhältnis in der Vormischungszufuhr zu

dem Brenner zu modulieren.

11. Verfahren zum Regeln des Luft-/Gasverhältnisses eines Gasvormischungsbrenners nach Anspruch 10, wobei der Brenner in einem Kessel installiert ist, und wobei das Verhältnis des Ionisierungsstroms bei maximaler Last des Brenners in dem Kessel weniger als 50 % höher als der Ionisierungsstrom bei minimaler Last des Brenners in dem Kessel beträgt.
12. Kessel oder Durchlaufwassererhitzer, umfassend einen Gasvormischungsbrenner nach einem der Ansprüche 1 bis 9.

Revendications

1. Brûleur (100, 300) à gaz à pré-mélange, comprenant :

une plaque perforée (115), un treillis de fils tissés ou une tôle de métal déployé, un plafond (110, 310) de brûleur à base de fibres placé sur ladite plaque perforée (115), ledit treillis de fils tissés ou ladite tôle de métal déployé, une tige d'ionisation (130, 330) qui mesure le courant d'ionisation à travers la flamme du brûleur (100, 300) à gaz à pré-mélange, **caractérisé en ce que** dans au moins une partie de la zone (140, 340) dans laquelle la tige d'ionisation (130, 330) est située, ledit plafond (110, 310) de brûleur à base de fibres est plus épais que dans d'autres zones du plafond (110, 310) de brûleur à base de fibres.

2. Brûleur à gaz à pré-mélange selon la revendication précédente, dans lequel ledit plafond de brûleur à base de fibres est plus épais dans une zone d'au moins 5 mm sur les deux côtés d'au moins 50 % de la longueur de la projection perpendiculaire de la tige d'ionisation sur le plafond du brûleur.
3. Brûleur à gaz à pré-mélange selon l'une quelconque des revendications précédentes, dans lequel le plafond de brûleur à base de fibres présente une même masse par unité de surface sur la totalité de la surface du plafond de brûleur ou est moins comprimé dans au moins une partie de la zone dans laquelle la tige d'ionisation est située que dans d'autres zones du plafond de brûleur à base de fibres, de telle sorte que dans la ou les parties de la zone dans laquelle la tige d'ionisation est située, ledit plafond de brûleur à base de fibres est plus épais que dans d'autres zones du plafond de brûleur à base de fibres.

4. Brûleur à gaz à pré-mélange selon l'une quelconque des revendications précédentes, dans lequel dans au moins une partie de la zone dans laquelle la tige d'ionisation est située, l'épaisseur du plafond de brûleur à base de fibres est supérieure d'au moins 40 % à la moyenne de l'épaisseur à l'extérieur de ladite partie de ladite zone dans laquelle la tige d'ionisation est située.

5. Brûleur à gaz à pré-mélange selon l'une quelconque des revendications précédentes, dans lequel dans au moins une partie de la zone dans laquelle la tige d'ionisation est située, la porosité du plafond de brûleur à base de fibres là où il est plus épais est inférieure à 92 %.

6. Brûleur à gaz à pré-mélange selon l'une quelconque des revendications précédentes, dans lequel à l'extérieur de ladite partie de la zone dans laquelle la tige d'ionisation est située, la porosité moyenne du plafond de brûleur à base de fibres est supérieure à 75 %.

7. Brûleur à gaz à pré-mélange selon l'une quelconque des revendications précédentes, dans lequel le plafond de brûleur à base de fibres comprend des fibres métalliques.

8. Brûleur à gaz à pré-mélange selon l'une quelconque des revendications précédentes, dans lequel le plafond de brûleur à base de fibres comprend un tissu tissé, tricoté, tressé ou non-tissé.

9. Brûleur à gaz à pré-mélange selon l'une quelconque des revendications précédentes, comprenant en outre un système de contrôle qui utilise le courant d'ionisation mesuré par ladite tige d'ionisation comme valeur d'entrée pour le contrôle du rapport air-gaz dans l'alimentation en pré-mélange du brûleur.

10. Procédé de contrôle du rapport air-gaz d'un brûleur à gaz à pré-mélange, qui utilise un brûleur à gaz à pré-mélange selon l'une quelconque des revendications 1 à 10 et dans lequel le courant d'ionisation mesuré par ladite tige d'ionisation est utilisé dans un système de contrôle qui module le rapport air-gaz dans l'alimentation en pré-mélange du brûleur.

11. Procédé de contrôle du rapport air-gaz d'un brûleur à gaz à pré-mélange selon la revendication 10, dans lequel le brûleur est installé dans une chaudière et dans lequel le rapport entre le courant d'ionisation à la charge maximale du brûleur de la chaudière est supérieur de moins que 50 % au courant d'ionisation à la charge minimale du brûleur de la chaudière.

12. Chaudière ou préparateur d'eau chaude instantané comprenant un brûleur à gaz à pré-mélange selon

l'une quelconque des revendications 1 à 9.

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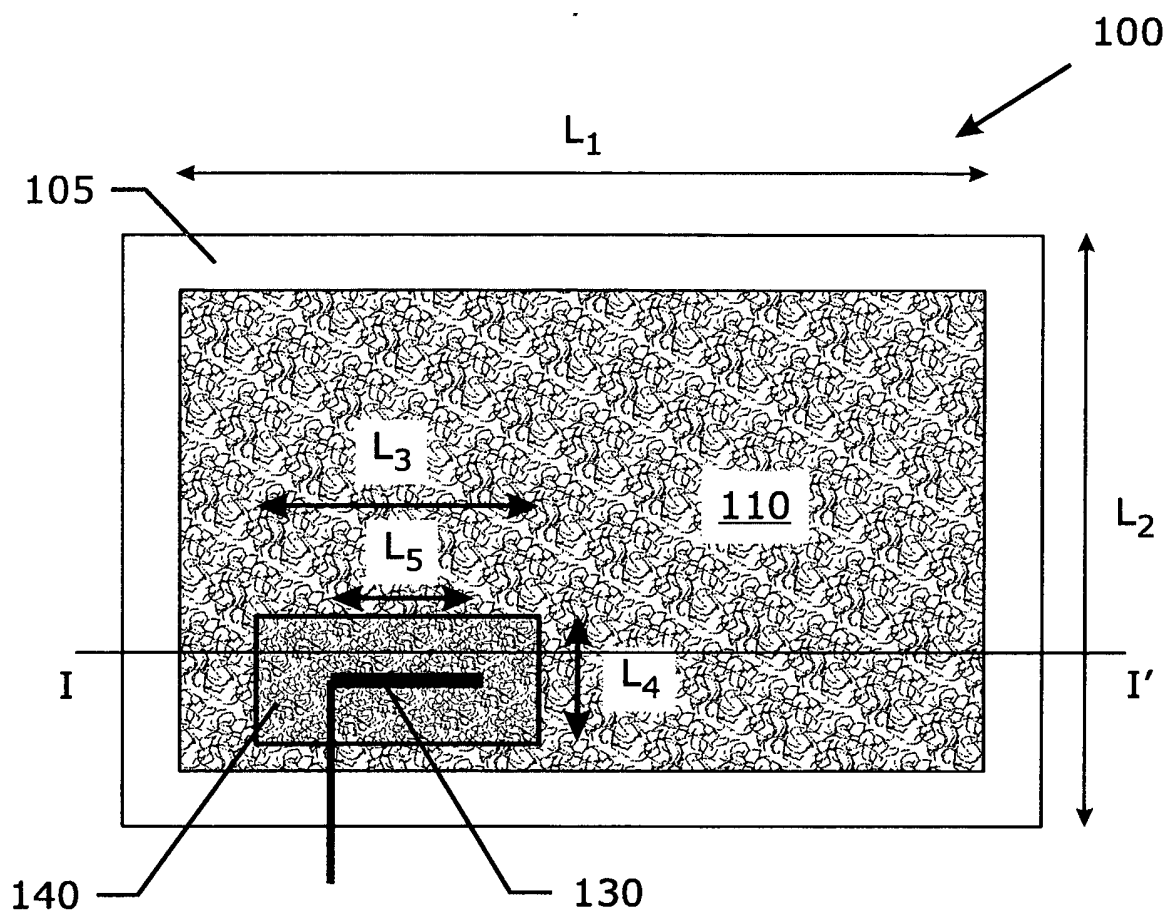


Fig. 1

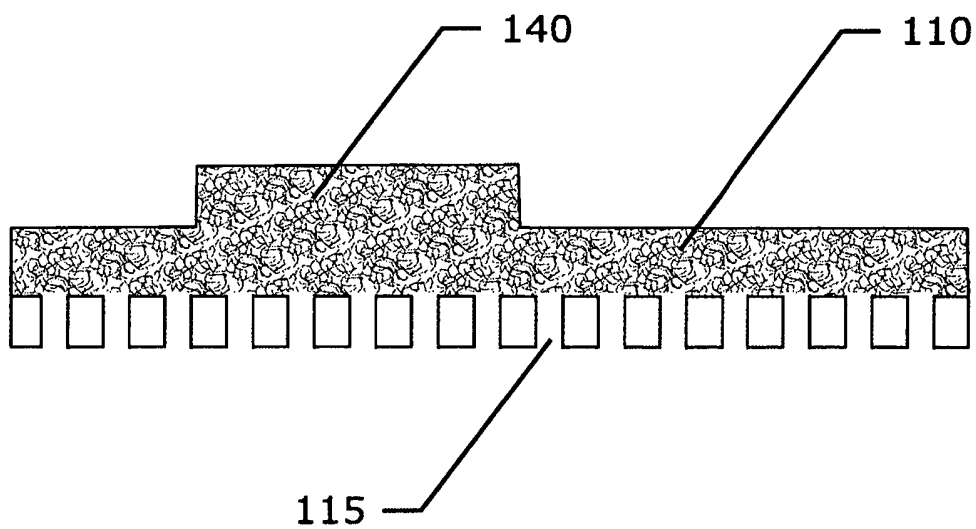


Fig. 2

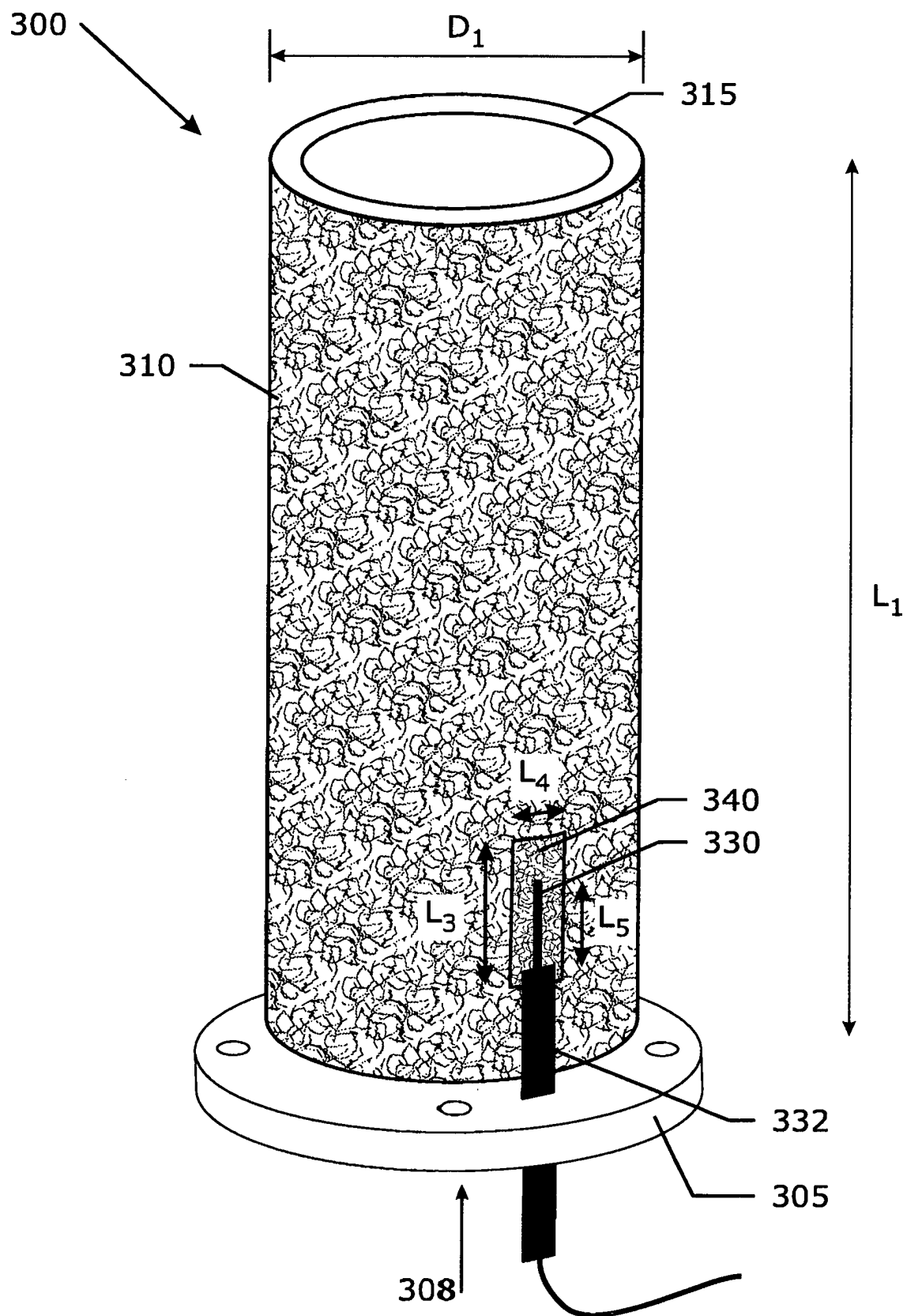


Fig. 3

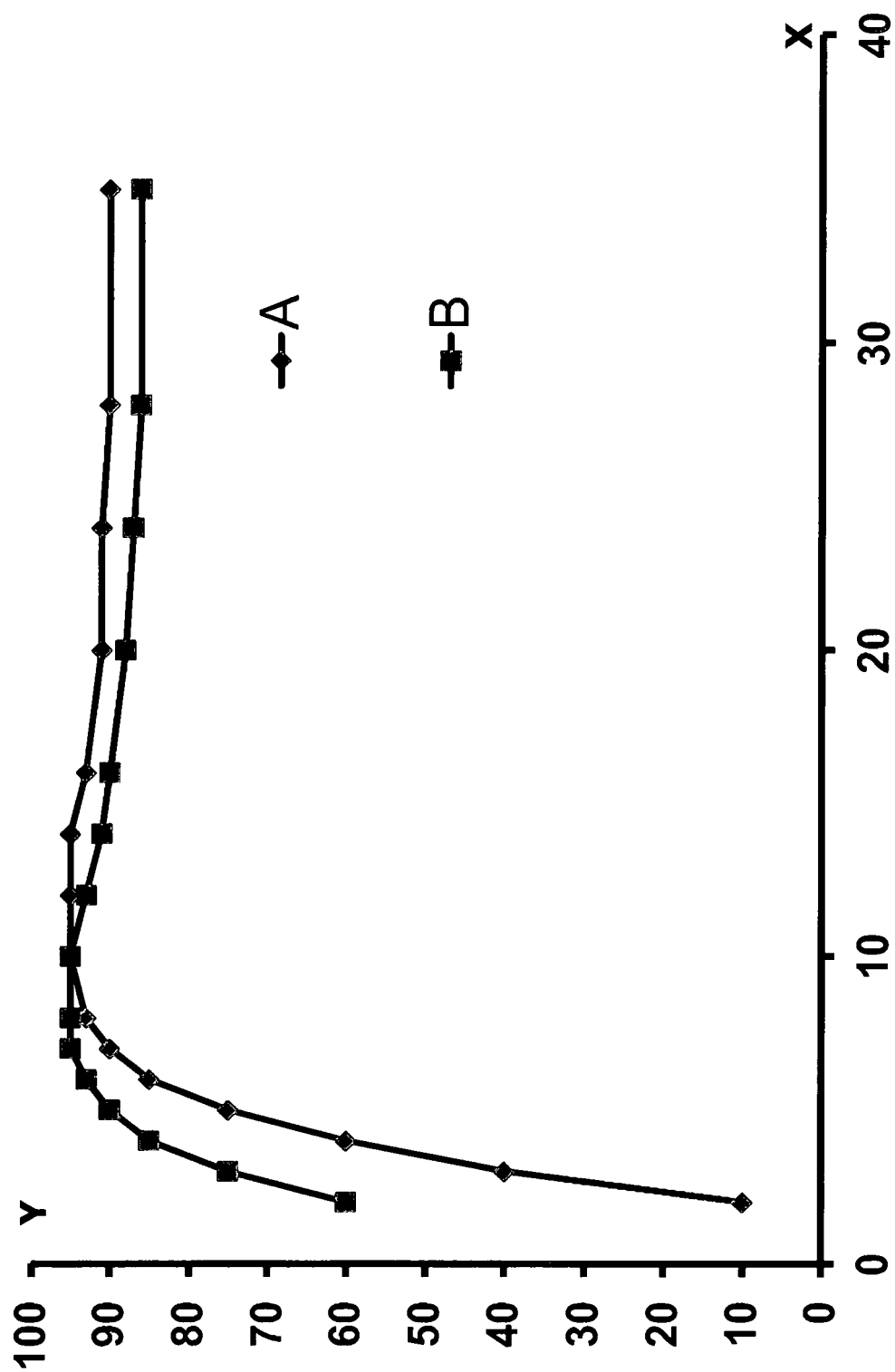


Fig. 4

REFERENCES CITED IN THE DESCRIPTION

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