



(11)

EP 4 450 870 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
23.10.2024 Bulletin 2024/43

(51) International Patent Classification (IPC):
F23D 14/02 ^(2006.01)

(21) Application number: **24187758.8**

(52) Cooperative Patent Classification (CPC):
F23D 14/02; F23D 2203/1012; F23D 2203/1023;
F23D 2203/106

(22) Date of filing: **05.02.2021**

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR**

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(30) Priority: **05.02.2020 IT 202000002209**

(62) Document number(s) of the earlier application(s) in
accordance with Art. 76 EPC:
21708745.1 / 4 100 679

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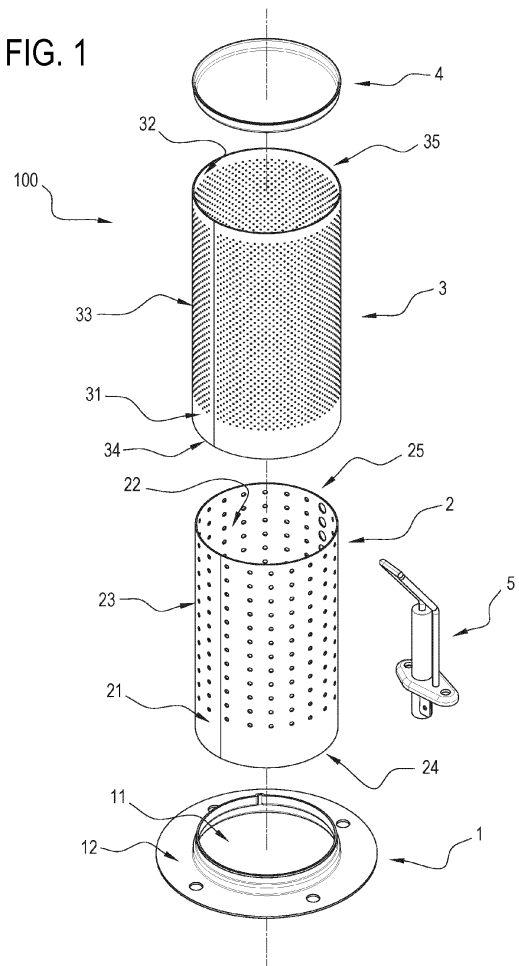
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(54) **PREMIX BURNER**

(57) Premix burner (100) provided with a perforated outer body (3) and with a distributor (2) located inside the body (3) and provided with openings (23, 26) that allow the passage of a mixture of fuel and oxidizer towards the outer surface (31) of the casing (3) on which the flames develop during combustion.

The distributor (2) and the outer casing (3) are separated by an air gap of non-zero thickness; the surface (21) of the distributor (2) has a region (200) in which the openings (26) ensure a greater volumetric flow rate of mixture than on the rest of the distributor. The burner comprises spacing elements disposed in the air gap between the internal distributor (2) and the outer casing (3).

FIG. 1



Description

Technical field

[0001] The present invention relates to a premix burner for burning a mixture of a fuel and an oxidizer.

Prior art

[0002] Burners of this type are frequently used in boilers for domestic heating and have a casing with a typically circular cross-section, on the surface of which flames are generated by burning a mixture generally obtained by mixing air and gas in a predetermined quantity ratio.

[0003] The value of this ratio for which the mass of fuel present in the mixture reacts completely with the mass of oxidizer is defined as stoichiometric; values of the ratio greater than the unit, i.e., values for which the quantity of air is in excess with respect to the stoichiometric ratio, are defined as hyperstoichiometric. The optimal value of the ratio, usually used in domestic boilers, is equal to about 1.3: this value is therefore hyperstoichiometric and allows limiting the level of harmful emissions, with respect to the level obtained at the stoichiometric ratio, and at the same time obtaining a good efficiency.

[0004] In particular, in the case of domestic applications, it is necessary to modulate the thermal power required by the burner according to the needs of the users: consequently, unless arrangements are adopted for dynamically adjusting the ratio between the quantities of air and gas, during the operation of a premix burner the ratio *deviates* from the optimal value according to the variations in the thermal load of the burner.

[0005] To obviate this drawback, which results in an increase in emissions of polluting or harmful unburned residues, the prior art provides for adjusting the quantity of air to be mixed with the gas by means of suitable pneumatic adjustment systems.

[0006] A further development of such adjustment systems is represented by the system described in the European patent EP 1 036 984 B1, in which the air-gas ratio (generally indicated with the Greek letter λ) is electronically adjusted by means of a control circuit which receives a signal, called ionization signal, from an electrode located near the outer surface of the burner on which flames develop during combustion of the mixture. The signal detected by the electrode is proportional to the intensity of the flames and allows estimating the value of the ratio λ ; the value thus estimated can be used to dynamically adjust the quantity of gas and keep the value of λ equal to the optimal nominal value. In order to improve the sensitivity of the detection of the ionization signal, patent EP 1 036 984 B1 proposes to increase the intensity of the flames in the zone of the burner in front of which the ionization electrode is located. A solution similar to that illustrated in patent EP 1 036 984 B1 is proposed in patent application EP 0 339 499 A2 (see in particular Figure 3 of the latter document).

[0007] The increase in the intensity of the flames produces a temperature gradient on the surface of the burners of the prior art; this gradient can cause mechanical breakage and reduce the reliability of the burner itself in general. Thermal gradients are emphasised when a burner is used in modulation regime, i.e., when the required thermal power is dynamically changed.

[0008] In order to reduce the thermal stresses produced by these gradients, it is known to use fibre or metal mesh coatings disposed on the outer surface of the burner. This solution, in addition to involving high costs due to the fact that the material of the coating, having to withstand high temperatures, is made of expensive alloys (for example based on iron and chromium or silicon carbide), also involves the formation of gas pockets between the coating and the support of the coating itself; finally, due to the relative elasticity of the coating, the behaviour of the burner is subject to variations and is therefore not stable.

Object of the invention

[0009] It is an object of the present invention to provide a premix burner which overcomes the aforementioned drawbacks of the prior art.

[0010] In particular, it is an object of the present invention to provide a premix burner capable of allowing the detection of an ionization signal during the operation of the burner in a reliable, stable and economical manner, in particular when the thermal power is dynamically modulated, while avoiding at the same time the formation of gas pockets.

[0011] Said objects are fully achieved by the burner according to claim 1.

[0012] In particular, the burner according to this claim comprises an outer casing on whose surface, called combustion surface, flames develop during combustion of the mixture; the outer casing is provided with openings, called flame openings, disposed in a zone of said surface called flame zone. Therefore, in the present invention, the flame zone indicates the portion of the combustion surface in which flame openings are present and in which, consequently, flames can develop during the operation of the burner: the parts of the combustion surface without flame openings therefore do not belong to the flame zone. The flame zone may consist of a single region or, alternatively, a plurality of regions separated by portions without flame opening.

[0013] The burner further comprises a distributor located inside the outer casing and also provided with openings, called flow openings, disposed on a surface opposite the outer casing, called distribution surface, in a zone also called distribution zone so as to allow the fuel and oxidizer mixture to pass from inside the distributor to the flame openings. Similarly to what has already been indicated for the flame zone, the distribution zone indicates, in the present invention, the portion of the distribution surface in which flow openings are present; the

parts of the distribution surface without flow openings do not belong to the distribution zone. The distribution zone may be made up of a single region or, alternatively, of a plurality of regions separated by portions without flow opening.

[0014] The distribution zone and the flame zone are disposed opposite each other: in other words, the distribution zone and the flame zone face each other.

[0015] The outer casing and the distributor extend at least in a first and a second direction orthogonal to each other. By way of example, it is mentioned that the outer casing and the distributor may have the shape of parallelepipeds or cylinders.

[0016] The flow openings on the distribution surface of the distributor are geometrically configured in a portion of the distribution zone in such a way that the ratio between the specific flow rate of mixture in said portion, called detection portion, is greater than the specific flow rate in the rest of the distribution zone.

[0017] In the context of the present invention, the expression *specific flow rate* (indicated in the following with the symbol q) denotes the volumetric flow of mixture through the unit surface (i.e., through a surface with a surface area of one square meter) per unit time (that is, in a second) and it is therefore measured in $\text{m}^3/(\text{m}^2 \cdot \text{s})$: the specific flow rate thus has the dimensions of a velocity (m/s).

[0018] The burner is characterised in that the distributor is located inside the outer casing and is separated from the outer casing by an air gap of non-zero thickness, through which the mixture flows from the flow openings towards the flame openings. The air gap extends in a third direction orthogonal to the first and the second direction.

[0019] The burner according to the present invention differs from the burners described in the aforementioned documents EP 1 036 984 B1 and EP 0 339 499, in which a flat perforated burner (*Brennerplatte*, in the original German terminology of the two documents) is disposed on top of a mixture duct. The mixture is *not* distributed by means of a distributor located inside the burner but flows directly from the duct through the holes of the flat burner, on the outer surface of which flames are formed during the combustion of the mixture itself.

[0020] In the present invention, a distributor is located inside the casing of the burner and is separated from the latter by an air gap: as a result of this arrangement, the mixture leaving the distributor reaches the flame openings only after passing through the internal distributor and the air gap itself. According to the invention, spacing elements are disposed in the air gap between the internal distributor and the outer casing; the spacing elements are preferably integral with the distributor.

[0021] The use of the internal distributor in the present invention allows distributing the mixture more homogeneously on the surface of the burner and significantly reduces the occurrence of thermal gradients, which on the contrary are very pronounced on the combustion sur-

face of the burners of the prior art, in which they often cause breakage and, more generally, a reduction of service life.

[0022] Moreover, the use in the present invention of an air gap between the distributor and the outer casing of the burner, on the surface of which the flames are formed by combustion of the mixture which has passed through the aforesaid air gap, allows reducing the breakage phenomena due to thermal stress also with respect to prior art devices provided with an internal distributor: whilst in such known devices the distributor is typically in contact with the above mentioned metal mesh on which the combustion takes place, with the result that a strong temperature gradient is created between the distributor and the mesh itself, in the burner of the present invention the distributor is never in contact with the surface on which the combustion takes place, thanks to the presence of the air gap. This allows avoiding the formation of sudden thermal gradients between the distributor and the surface on which the high-temperature flames are formed during combustion, with a consequent significant reduction of the phenomena of breakage and degradation of the burner.

[0023] A further advantage of the technical solution adopted in the present invention is that the already mentioned and expensive metal meshes capable of withstanding high temperatures are not used. The absence of such meshes, in addition to allowing a significant reduction in the production costs of the burner, advantageously allows avoiding the formation of gas pockets, typically present between the mesh and the casing of known burners, and also improves the operating stability of the device, the behaviour of which is no longer subject to variations due to the flexibility of the meshes used in the prior art.

[0024] A significant advantage of the technical solution adopted in the present invention is represented by the substantial repeatability of the ionization curve obtainable as the thermal flow rate of the burner varies and for a predefined value of the air-gas ratio λ independently of the type of gas used in the mixture.

[0025] Figures 7A and 7B show the behaviour of the ionization curves measured respectively for a burner according to the invention and for a conventional burner as the thermal flow rate varies, for a mixture of air and gas of the G20 family (methane; curve with diamonds) and a mixture of air and liquid propane gas (LPG; curve with squares). In the case of Figure 7A, relating to a burner according to the present invention, the trend of the ionization current as the thermal flow rate Q varies is qualitatively identical for the two mixtures. On the contrary, in the case of a conventional burner, the ionization curve relating to the air and gas mixture of the G20 family has a behaviour that is very different from that relating to the air and LPG mixture: while the first curve is substantially flat, the second curve has a peak in the region of low flow rates, around 3.5-4 kW, and then falls to significantly lower values than the first curve on the rest of the range of

thermal flow rates.

[0026] The substantial similarity of the ionization curves for mixtures of air with gases of different families allows the operation of a boiler provided with a burner according to the present invention to be controlled in a simple manner also in case, which is frequent in practice, of changes in the composition of the gases available in the gas distribution network.

[0027] The burner according to the present invention is also characterised by a high slope and by the monotony of the sensitivity curve, that is, the function that describes the trend of the ionization current as the air-gas ratio (A) varies, for a predefined value of the number of revolutions per minute of the fan supplying air for the mixture (i.e., for a fixed thermal flow rate value). The high slope of the curve and its substantially monotone descending character over the whole operating range guarantee a one-to-one relationship between the ionization current and the air-gas ratio and allow adjusting the value of said ratio in a precise manner; on the contrary, in conventional burners, the sensitivity may feature the so-called "inversion", i.e., a region where the curve has an inflection point and in which two values of the ratio λ correspond to an ionization current value, which results in the electronic control system for controlling the ratio value having difficulties in properly adjusting the boiler operation.

[0028] In the present invention, the dimensions of the detection portion in the first and the second direction are selected so as to be smaller than the corresponding dimensions of the distributor in the same directions: the detection portion therefore occupies a region of the distribution zone on the surface of the distributor with a surface area smaller than that of the zone itself and limited in two perpendicular directions, respectively coinciding with the first and the second direction.

[0029] The detection portion allows increasing locally the flow of mixture which, through the surface of the distributor, reaches the outer casing. At the circumscribed region in which the flow is thus "amplified", the flames develop with greater intensity than in the rest of the device and generate, in any operating regime of the burner, an ionization signal of such an intensity as to be easily detectable, for example by means of an ionization electrode known per se, thus allowing a reliable adjustment of the air-gas ratio.

[0030] Limiting the spatial extension of the detection portion to a region of limited size in the first and the second developing direction of the distributor and the outer casing allows the amplified flow of mixture to be concentrated in a narrow region, avoiding thermal stresses on the rest of the distributor. The extension limitation also allows the shape of the detection portion to be adapted to the geometry of the ionization electrode, typically of elongated shape, so as to maximize the detected signal. The present invention is not, however, limited to the use of electrodes of elongated shape nor, even less, necessarily requires that the detection portion have an elongated shape: on the contrary, such portion can assume

a square, rhomboidal, oval or circular shape. These shapes are purely exemplary: the detection portion can assume further geometrical shapes, provided that the shape and dimensions of the portion allow the ionization electrode, facing said portion, to detect the ionization signal with the maximum possible sensitivity.

[0031] The location of the detection portion with locally increased flow on the distributor surface inside the casing of the burner, instead of on the surface of said casing, as taught in the prior art, and the presence of an air gap that separates the distributor from the outer casing therefore allow reducing the thermal stresses normally produced by a local increase in the intensity of the flame caused by an increase in the flow rate of mixture. The local increase in the specific flow rate in the detection portion can be advantageously achieved by adjusting the ratio between the sum of the surface areas of the flow openings formed on the surface of the distributor and the total surface area of said portion, so that it is greater than the ratio between the sum of the surface areas of the openings in the rest of the distribution zone and the surface area of said rest. In other words, the local increase in the specific flow rate can be advantageously controlled by adjusting the porosity of the detection portion with respect to the porosity of the rest of the surface of the distributor.

[0032] Since the surface area of the flow openings can be controlled in a precise and repeatable manner and since these openings are formed on the surface of the distributor by means of high precision mechanical processing, with the present invention it is possible to guarantee a reliable and stable adjustment of the ionization signal and, consequently, a stable behaviour of the burner itself.

[0033] Preferably, the surface area of each of the flow openings present in the detection portion on the surface of the distributor is greater than the surface area of each of the flame openings on the combustion surface of the outer casing. Since the zone in which the flame openings are disposed, that is, the so-called flame zone, is disposed in front of the detection portion in which the flow openings are disposed, the increased surface area of the latter with respect to the surface area of each flame opening causes the flow leaving each flow opening to be distributed between several flame openings, instead of reaching a single flame opening. In this way it is possible to create a bed of sealing flames on the surface of the burner and the phenomenon of flame detachment is advantageously avoided.

[0034] In particular, in the case in which the flow openings and the flame openings are chosen with circular shape, it becomes particularly simple to adjust the relative ratio between the surface area of each flow opening and the surface area of each flame opening, because in this case it is sufficient to adjust the diameters of the respective openings when manufacturing the distributor and the outer casing. The use of circular openings therefore allows controlling the operation of the burner in a

particularly reliable, simple and economical way. In the case of circular openings, the diameter of the flame openings is preferably less than 1.5 mm; this value advantageously reduces the phenomenon of backfire.

[0035] The flow openings and the flame openings can advantageously be disposed evenly on the surface of the distributor and on that of the outer casing of the burner, for example, by arranging the flow openings according to a periodic pattern having a first spacing i.e., pitch) P1 and the flame openings according to a periodic pattern having a second spacing i.e., pitch) P2, different from the first spacing and preferably smaller. The arrangement of the openings according to a periodic pattern is particularly advantageous in terms of manufacture, since these openings are formed by repeatedly perforating a metal strip, usually made of steel, from which two perforated portions are then cut which are intended to form the distributor and the outer casing, by means of programmable mechanical machines which perform a stepwise machining of the strip: the manufacture of regular patterns can in fact be obtained by simply setting the advancement pitch of the machine equal to the value of the first or second spacing (i.e., pitch) of the periodic pattern.

[0036] It is understood that the objects of the present invention can be achieved also by means of periodic patterns which have two different spacings in two different directions: for example, the flow openings can be disposed according to a periodic grid with a spacing P1 in a first direction (for example, in the case of a cylindrical burner, in the tangential direction, i.e. along the circumference of the cylinder) and with a spacing (i.e., pitch) P1', different from the spacing (i.e., pitch) P1, in a second direction different from the first one (for example, in the case of a cylindrical burner, in the axial direction). Similarly, the flame openings can be disposed according to a periodic grid with a spacing (i.e., pitch) P2 in a first direction and a spacing P2' (i.e., pitch), different from the spacing P2, in a second direction different from the first one.

[0037] In the case of double-pitch periodic lattices, it is understood that the relationship discussed above between the spacing (i.e., pitch) of the lattice of the flow openings and the spacing of the lattice of the flame openings must be satisfied in both directions in which the lattices have different periodicity: in other words, if the periodic lattice of the flow openings has a first spacing (pitch) P1 and a second spacing ((i.e., pitch)) P1' in two different directions and the periodic lattice of the flame openings has a third spacing (pitch) P2 and a fourth spacing (pitch) P2' in the same two directions, the condition according to which the lattice of the flow openings must have a period greater (or shorter, if required) than the period of the grid of the flame openings is satisfied only if $P1 > P2$ and $P1' > P2'$ are simultaneously valid (or $P1 < P2$ and $P1' < P2'$, if the condition is that the lattice of the flow openings has a shorter period).

[0038] It is understood that the objects of the present invention can also be achieved by non-regular and non-

periodic distribution of the flow and/or flame openings, provided that the distributor and the outer casing are kept spaced apart by means of an air gap and provided that an increased specific flow rate detection portion is formed on the surface of the distributor, as explained above.

[0039] The thickness of the air gap must be different from zero; preferably, the thickness of the air gap is less than 4 mm and, even more preferably, this thickness is chosen equal to 0.6 mm. The presence of an air gap of non-zero thickness improves the distribution effect of the mixture leaving each flow opening on several flame openings and thus reduces the phenomenon of flame detachment; the value of 0.6 mm has proved experimentally optimal in reducing this phenomenon.

[0040] The burner subject matter of the present invention is advantageously used in boilers provided with a combustion chamber, preferably in combination with a detection electrode for detecting the ionization signal generated by the flames that develop on the surface of the burner, when the mixture is burned.

[0041] The present invention also relates to a method for adjusting the flow intake of a mixture of oxidizer and fuel in a premix burner as described above. The method comprises the following steps:

- 1) feeding the mixture into the distributor through the head of the burner;
- 2) spreading the mixture from the distribution zone on the distribution surface of the distributor to the flame zone on the combustion surface of the outer casing through the air gap of non-zero thickness;
- 3) burning the mixture in the flame zone;
- 4) detecting an ionization signal, produced by the burning of the mixture, by means of a detection electrode disposed outside the flame zone of the outer casing at the detection portion of the distributor;
- 5) sending the ionization signal to a control device for adjusting the ratio between the quantity of oxidizer and the quantity of fuel in the mixture;
- 6) adjusting said ratio through the control device in such a way that the ratio is equal to a predetermined value.

Brief description of the drawings

[0042] The above-mentioned characteristics will be better understood from the following description of a preferred embodiment, illustrated purely by way of non-limiting example in the accompanying drawings, in which:

- Figure 1 shows the parts of a premix burner according to the present invention;
- Figure 2 shows a side view of the burner of figure 1 in the state in which the parts are assembled together;
- Figure 3 shows the burner of figure 2 with the outer casing partially raised with respect to the internal distributor;

- Figure 4 shows the internal distributor of the burner of figure 2;
- Figure 5 shows another side view of the burner of figure 2 with the outer casing partially raised with respect to the internal distributor, together with an enlargement showing the air gap between the outer casing and the internal distributor;
- Figure 6 shows a perforated flat strip usable for manufacturing the outer casing of a burner according to the invention, with an alternative distribution of the flame openings with respect to that illustrated in figures 2;
- Figures 7A and 7B show the trend of the ionization current as the thermal flow rate varies for a predefined value of the air-gas ratio, respectively in a burner according to the patent and in a conventional burner, for two different mixtures of air with gases of different families (methane and LPG).

Detailed description of preferred embodiments of the invention

[0043] Figure 1 shows an exploded view, purely by way of example, of a premix burner (100) according to a preferred embodiment of the present invention. The burner comprises an outer casing (3) provided on its surface (31), called combustion surface, with openings (33) called flame openings; the combustion surface (31) represents the surface on which, during the operation of the burner (100), flames develop, in particular at the flame openings (33). The region of the combustion surface (31) on which the flame openings (33) are present substantially constitutes the so-called flame zone.

[0044] In the example, the outer casing (3) has a cylindrical shape and is provided with circular openings (33); it is understood that the objects of the present invention can also be achieved by means of outer casings of different shape, for example in the form of a parallelepiped, and by using flame openings (33) with a shape different from the circular one, for example elongated slits; such slits may be combined with circular openings and may be distributed on the combustion surface according to periodic or uneven geometric patterns, depending on the desired flame distribution.

[0045] Purely by way of example, it is recalled that the flame openings (33) can be distributed on the combustion surface (31) along the axial direction of the cylindrical casing (3) in zones having different geometrical patterns: for example, the diameter of the openings (33) and/or the distance between them within each zone may be different from the diameter and distance in each - or even in some - of the other zones. The criteria for selecting the dimensions (diameter of the openings and/or distance between them in each zone, width of each zone in the axial direction, number of zones) are known to those skilled in the art and will not be repeated here. In the example of the embodiment illustrated in the figures, the flame openings (33) are circular holes with a diameter of

0.6 mm, repeated periodically both in the tangential direction and in the axial direction of the cylindrical casing (3). The holes (33) are disposed periodically in sequence along the tangential direction at a mutual distance (pitch or spacing) equal to 1.4 mm; sequences of adjacent holes (33) in the axial direction are staggered along the tangential direction; the periodic distance in the axial direction between adjacent hole sequences (33) is 1.2 mm. In general, it is preferable to keep the diameter of the holes below 1.5 mm in order to avoid flame lift-off (i.e., detachment) phenomena.

[0046] The outer casing (3) of the burner (100) is disposed around a distributor (2), located inside the outer casing (3) itself; in the example of Figure 1 the distributor (2) (to which reference will also be made with the expression *internal distributor*) also has a cylindrical shape and is disposed coaxially with the outer casing (3), as can be appreciated from Figure 3, in which the outer casing (3) is partially raised with respect to the distributor (2) and allows the lower part of the latter to be seen. As already indicated for the outer casing (3), the distributor (2) can also have other geometrical shapes: for example, in the aforementioned case of a parallelepiped-shaped outer casing (flat burner), the internal distributor (2) also preferably has the shape of a parallelepiped, contained inside the largest parallelepiped that forms the outer casing.

[0047] The outer casing (3) is manufactured from a flat strip which is perforated by means of a punching machine, so as to provide the desired spatial distribution of flame openings (33); in the case of a cylindrical outer casing, the flat strip, once perforated, is folded onto itself to form the cylindrical casing (3). Although the outer casing (3) shown in Figure 1 has a homogeneous spatial distribution of flame openings (33), other distributions can be applied. By way of example, Figure 6 shows a flat strip, usable for manufacturing a cylindrical outer casing, characterised by a distribution of flame openings (33) that is gradually less dense in the axial direction running from the base (34) of the casing (3) towards the top (32) of the casing (3) itself. As can be seen from Figures 1 and 2, the base (34) of the casing (3) is close, in the mounted burner, to a flange (12), while the top (32) is adjacent to a cap (4) which closes the cylindrical casing (3). Thanks to the gradual reduction in the density of openings (33) along the surface (31) of the outer casing (3), it is possible to reduce the deformations of the outer casing (3) due to the abrupt passage from a perforated region, i.e., the flame zone provided with flame openings (33), to a region without perforations. As a matter of fact, an abrupt transition between the flame zone and the zone without perforations creates a sudden thermal gradient, due to the fact that the flames essentially develop only in the flame zone, and can therefore cause deformations. In a further variant, not shown, the gradual reduction in the densities of openings (33) along the surface (31) of the outer casing (3) can be obtained in the opposite direction to that illustrated in Figure 6, i.e., going from the top (32) towards the base (34).

[0048] As can be better appreciated from Figure 4, in which the internal distributor (2) is shown without the outer casing (3) surrounding it, the distributor (2) has on its surface (21) (called distribution surface) a plurality of openings (23, 26), called flow openings; in the example of Figure 4, these openings have a circular shape. The region of the distribution surface (21) on which the flow openings (23, 26) are present substantially makes up the so-called distribution zone.

[0049] The main function of the distributor (2) is to allow the passage and the spreading of a fluid mixture fed into the burner (100) towards the combustion surface of the burner, coinciding with the combustion surface (31) of the aforementioned outer casing (3). The mixture, typically consisting of air and gas, is fed through one or more openings (11) disposed on the surface of a head (1) located at the base of the burner (100), as can be seen from the exploded view of Figure 1, and fixed to the latter by means of a flange (12), shown in perspective view in Figure 1 and in side view in Figure 4. Although not explicitly shown in the figures, both the internal distributor (2) and the outer casing (3) of the burner (100) are fixed to the head (1). The number, shape and dimensions of the feeding openings (11) present on the head (1) and their spatial distribution can be determined by the person skilled in the art on the basis of commonly known design principles.

[0050] The passage of the mixture, fed through the aforesaid head (1), from the inside of the distributor (2) to the combustion surface (31) of the outer casing (3) is ensured by the aforementioned flow openings (23), the shape, dimensions and spatial distribution of which - except for the openings (26) in the region, called detection portion (200), described below with reference to Figure 4 - may in general be determined by the person skilled in the art on the basis of known principles, in order to ensure a predetermined fluid-dynamic distribution of the mixture inside the burner. By way of example, the distribution of the openings (23) on the surface of the distributor (2) can be determined - except for the openings (26) in the detection portion (200) - according to the teachings of the European patent EP 1 914 476 B1 of which the Applicant of the present application is the owner. In the example of the embodiment shown in Figure 4, the flow openings (23) have a circular shape and, except for the aforesaid detection portion (200), partially hidden in the figure by an electrode (5) described below and used to detect an ionization signal, these openings are distributed evenly on the distribution surface (21) with constant spacing and diameter.

[0051] In the latter, as can be clearly seen from Figure 4, the flow openings (26) are geometrically configured in such a way that the specific flow rate of mixture flowing through the detection portion (200) is greater than in the remaining parts (201, 202) of the distribution zone, that is, in the rest of the distribution surface (21), in which flow openings (23) are present, which is formed in the example shown in the figure by two regions denoted by the

numerals 201 and 202. As already indicated, *specific flow rate* q is the volumetric flow of mixture passing through the unit of surface (i.e., a surface with an area of one square meter) in the unit time (i.e., in one second).

[0052] In the example of Figure 4, the detection portion (200) is a region of narrow and elongated shape along the axial direction of the distributor (2) and within which the flow openings (26), with circular shape in the example, have a greater diameter than the flow openings (23) in the rest (201, 202) of the distribution zone. The increased dimension of the flow openings (26) in the detection portion (200) facilitates the passage of the mixture in this portion and therefore increases the specific volume of mixture which reaches, in the unit time, the combustion surface (31) of the outer casing (3) (not visible in Figure 4), where it is burned on the flame openings (33) during the combustion process. The increased dimension of the flow openings (26) in the detection portion (200) thus produces locally more intense flames on the part of the combustion surface (31) overlying the underlying detection portion (200).

[0053] In general, the local increase in the mixture flow in the detection portion (200) is achieved if the ratio between the sum of the surface areas of the flow openings (26) present in the aforesaid detection portion (200) and the total surface area of that portion (200) is greater than the ratio of the sum of the surface areas of the openings (23) in the rest (201, 202) of the distribution zone and the total surface area of the remaining distribution zone. In other words, the local increase in the mixture flow is ensured if the local porosity ρ_R in the detection portion (200) is greater than on the rest (201, 202) of the distribution surface (21). The term *porosity* is used in accordance with its usual meaning in the technical field of burners and generally indicates, with reference to a surface with openings or "voids", the ratio between the sum of the empty surface areas and the total surface area of the surface.

[0054] The porosity can be increased in different ways by acting on the geometric configuration of the flow openings: it is possible, in the case of circular openings disposed evenly, to increase the diameter of each flow opening (26) in the detection portion (200) with respect to the diameter of the openings (23) in the rest (201, 202) of the distribution zone, as shown in Figure 4; again in the case of circular openings disposed evenly, it is possible alternatively to maintain unchanged the diameter of the flow openings (26), increasing instead the density thereof (i.e. reducing the pitch) in the detection portion (200) with respect to the rest of the distribution zone. In fact, it is easy to show how, in the case of flow openings disposed evenly with a spacing p_R in the detection portion (200) and with a spacing p_0 in the rest (201, 202) of the distribution zone, called d_1 and d_2 , the respective diameters of the openings (26) and (23), the ratio between the porosity ρ_R of the detection portion (200) and the porosity ρ_D of the rest (201, 202) of the distribution zone is equal to $(d_1/d_2) \cdot (p_D/p_R)$ and can be made greater than the unit,

so as to guarantee the increased flow condition required by the present invention, by acting on the diameters and/or the spacings.

[0055] The objects of the present invention can also be achieved by disposing the flow openings in the detection portion (200) and/or on the rest (201, 202) of the distribution surface (21) in an uneven manner, provided that the condition that the specific flow rate of mixture in the detection portion (200) is greater than on the rest (201, 202) of the distribution zone is ensured. Thanks to the increased local flow of mixture at the detection portion (200), the intensity of the flames that develop on the part of the flame surface (31) of the outer casing (3) covering the aforesaid portion (200) is always greater than on the rest of the flame surface (31); as a result, the intensity of the ionization signal detectable near this part of the flame surface (31) by means of the detection electrode (5) is greater than at the rest of the flame surface, since the intensity of the ionization signal is directly proportional to the intensity of the flames. By appropriately selecting the geometrical parameters of the flow openings (26) in the portion (200) according to the principles illustrated above, it is therefore possible to guarantee, over the whole operating range of the burner, an ionization signal of sufficient intensity to dynamically adjust, by means of a feedback circuit, the ratio between the quantity of air and the quantity of gas of the mixture fed into the burner. The present invention therefore allows adjusting in a dynamic and optimal manner the value of the so-called ratio λ as the thermal power required by the burner varies, i.e., as a function of the modulation regime. Adjustment circuits are known per se and will not be described; an example of such a circuit is illustrated in the aforementioned European patent EP 1 036 984 B1.

[0056] By using a conventional adjustment circuit in combination with a premix burner according to the present invention and with a detection electrode, disposed outside the flame zone of the outer casing at the detection portion, it is possible to adjust the flow intake of mixture of oxidizer (for example, air) and fuel (for example gas) in an optimal manner during the operation of the burner, even in the case where the thermal power required by the burner is modulated.

[0057] The method for adjusting the flow intake of mixture according to the present invention comprises the following steps:

- 1) feeding the mixture into the distributor (2) through the head (1) of the burner (100);
- 2) spreading the mixture from the distribution zone (200, 201, 202) on the distribution surface (21) of the distributor (2) to the flame zone on the combustion surface (31) of the outer casing (3) through the air gap (300) of non-zero thickness G;
- 3) burning the mixture in the flame zone on the combustion surface (31);
- 4) detecting the ionization signal produced by the burning of the mixture by means of the detection

electrode (5), disposed outside the flame zone located at the detection portion (200) of the distributor (2);

5) sending the ionization signal to a control device, placed in the adjustment circuit, for adjusting the ratio (λ) between the quantity of oxidizer and the quantity of fuel of the mixture;

6) adjusting said ratio through the control device in such a way that the ratio (λ) is equal to a predetermined value.

[0058] The control device can be, for example, a valve that regulates the inflow of gas into the chamber in which the air is premixed with the gas, before being fed into the burner (100) through the head (1). The predetermined value of the ratio λ depends on the type of oxidizer and fuel used: in general words, this value is chosen equal to the so-called stoichiometric value, i.e., the value for which the combustion reaction of the fuel is complete and does not produce residues, such as carbon monoxide, in the case of a fossil-gas fuel.

[0059] Preferably, the dimensions of the detection portion (200) are chosen according to the dimensions of the detection electrode (5), so as to concentrate the increased flow of mixture in a region disposed in front of the electrode (5) and thus increase the sensitivity of the measurement of the ionization signal detected by the electrode itself. Since the ionization electrode (5) usually has an elongated shape, as can be seen from Figures 1, 4 and 5, the detection portion (200) typically also has an elongated shape in a first direction, essentially parallel to the projection of the electrode (5) on the outer surface (31) of the burner. As already explained above, the shape of the detection portion (200) is not limited to an elongated shape and may, by way of example, be square. In the example shown in the figure, the dimension of the detection portion (200) in the first direction is smaller than the dimension of the distributor (2) in the same direction; the dimension of the detection portion (200) in a second direction perpendicular to the first dimension is also limited and is smaller than the corresponding dimension of the distributor in the same direction. In the case of a cylindrical ionization electrode (5) of length L and diameter D disposed parallel to the axis of the burner, as in the example of Figure 4, the detection portion (200) can extend, for example, in a direction parallel to the length of the electrode (5) - hence parallel to the axis of the burner (100) - over a section of height L of the distribution surface (21), while the dimension of the portion in the direction perpendicular to the electrode, that is, the width W of the distribution portion (200), may be equal to 3D. In any case, the length and width of the distribution portion (200) are smaller than the corresponding dimensions of the distributor (2).

[0060] The detection portion (200) is limited to a region with smaller dimensions than the corresponding dimensions of the distributor (2) in the two directions mentioned above. In the case shown in Figure 4, the detection por-

tion (200) extends in height (i.e., in the direction of the axis of the burner along which the mixture spreads) along a shorter section than the total height of the distributor (2): as can be seen from the figure, the internal distributor (2) also extends in a lower zone located below the regions 200, 201 and 202 and without, in the example, flow openings (23) and (26). Figure 4 also shows that the detection portion 200 is also limited in width, i.e., in the circumferential direction of the cylinder (2). It is understood that the objects of the present invention can also be achieved by using a detection portion whose height is different from that of the remaining parts (201, 202) of the distribution zone. As indicated above, the distribution zone is defined as the part of the distribution surface (21) provided with flow openings (23, 26): therefore, in the example of Figure 4, the distribution zone corresponds substantially to the regions 200, 201, 202 disposed above the lower part of the surface (21) without openings (the so-called blind zone).

[0061] As can be appreciated from Figure 5, the internal distributor (2) is separated from the outer casing (3) of the burner (100) by an air gap (300) of non-zero thickness G. The thickness G is preferably less than 4 mm: in the example shown in the figure, G is equal to 0.6 mm. The air gap (300) is empty and contains air.

[0062] The experiments carried out have indicated that the presence of an air gap of non-zero thickness G and preferably not greater than 4 mm improves the effect of distribution of the mixture leaving each flow opening (23, 26) towards the flame openings (31): the mixture leaving each flow opening (23, 26) in a direction substantially perpendicular to the surface area of the opening, i.e. in a radial direction, in the case of the cylindrical burner shown in the figures, passing through the air gap of non-zero thickness is distributed also in directions that are different from the aforesaid direction perpendicular to the surface area of each opening (23, 26). In particular, the passage through the air gap allows the mixture leaving each single flow opening to spread also in the axial direction and consequently to reach more than one flame opening (33). A flame bed of non-zero thickness is created on the combustion surface (31) thanks to the distribution of the mixture leaving each flow opening (23, 26) over several flame openings (33), which flame bed contributes to the reduction of the phenomenon of flame detachment. The value of the thickness G equal to 0.6 mm has proved experimentally optimal in reducing this phenomenon. According to the invention, spacing elements (not shown) are disposed in the air gap that separates the internal distributor (2) from the outer casing (3) of the burner (100).

[0063] The phenomenon of flame lift-off (detachment), the effects of which are generally negative on the operation of the burner, has particularly detrimental consequences if it occurs on the region of the combustion surface (31) onto which the detection electrode (5) faces, since in this case the ionization signal necessary to optimally adjust the air-gas ratio may be lost. To avoid flame

lift-off in the aforesaid region of the combustion surface (31), it is preferable to select the surface area of each of the flow openings (26) present in the detection portion (200) so that it is greater than the surface area of each of the flame openings (31) present on the combustion surface (31) of the outer casing (3). In this way, the effect of distributing the mixture leaving each flow opening (26) over several flame openings (33) is further strengthened.

[0064] This effect can also be achieved by acting on the periodicity of the distributions of the flow openings and of those of the flame openings, by disposing the flame openings on the combustion surface uniformly with a periodic spacing (i.e., a pitch) greater than the spacing with which the flow openings are uniformly distributed at least in the detection portion. If the flame openings and/or the flow openings are disposed according to double-period lattices, it is necessary that in both directions of the lattices the flame openings be disposed with greater spacings (pitches) than the corresponding spacings of the flow openings.

Claims

1. A premix burner (100) comprising:

an outer casing (3) having a combustion surface (31) provided with flame openings (33) located in a first zone, called flame zone,
a distributor (2) having a distribution surface (21) provided with flow openings (23, 26) located in a second zone, called distribution zone,
and a head (1) connected to the outer casing and to the distributor and provided with at least one opening (11) to feed a mixture of fuel and oxidizer into the distributor (2),
wherein the outer casing (3) and the distributor (2) of the burner (100) extend at least in a first and a second direction
and the flow openings (26), in a portion (200) of the distribution zone called detection portion, are geometrically configured in such a way that the specific flow rate (q) of mixture, defined as the flow of mixture through a unit surface per unit time, is greater in the detection portion (200) than in the rest (201, 202) of the distribution zone,
the surface area of the detection portion (200) being smaller than the surface area of the distribution zone,
wherein the distributor (2) is located inside the outer casing (3) and the outer casing (3) and the distributor (2) are separated along a third direction, orthogonal to the first and second directions, by an air gap (300) of non-zero thickness (G) through which the mixture directed outwards from the flow openings (23, 26) flows towards the flame openings (33),

characterised in that

the burner comprises spacing elements disposed in the air gap and preferably integral with the distributor.

2. The burner according to claim 1, wherein the non-zero thickness of the air gap is less than 4 mm and preferably equal to 0.6 mm.
3. The burner according to claim 1, wherein the non-zero thickness of the air gap is less than 0.5 mm and preferably equal to 0.3 mm.
4. The burner according to any one of the preceding claims, wherein the flow openings in the detection portion are geometrically configured in such a way that the ratio between the sum of the surface areas of the flow openings and the total surface area of said portion is greater than the ratio between the sum of the surface areas of the openings in the rest of the distribution zone and the surface area of the rest of the distribution zone.
5. The burner according to any one of the preceding claims, wherein the surface area of each of the flow openings in the detection portion is greater than the surface area of each of the flame openings.
6. The burner according to any one of the preceding claims, wherein the flow openings are circular in shape and have a first diameter (D1) and the flame openings are circular in shape and have a second diameter (D2), smaller than the first diameter (D1), wherein the second diameter is preferably less than or equal to 1.5 mm.
7. The burner according to any one of the preceding claims, wherein the outer casing and the distributor are shaped like coaxial cylinders, closed at one end by a cap, at the position opposite the head of the burner, and the burner does not comprise any metal meshes.
8. The burner according to claim 7, wherein the flame zone is made up of a plurality of longitudinal sectors which extend in a direction parallel to the axis of the coaxial cylinders and are mutually separated in the circumferential direction by non-perforated sectors.
9. The burner according to claim 8, wherein the number (N) of non-perforated sectors is greater than or equal to 18 and the width (x) of each of these sectors in the circumferential direction is less than or equal to 1.8 mm.
10. The burner according to claim 8, wherein the number (N) of non-perforated sectors is less than 18 and greater than or equal to 8 and the width (x) in milli-

metres of each of these sectors in the circumferential direction is less than or equal to $1.8 \cdot 18/N$, where N is the number of non-perforated sectors.

- 5 11. The burner according to claim 8, wherein the number (N) of non-perforated sectors is less than 8 and the width (x) of each of these sectors in the circumferential direction is less than 10 mm.
- 10 12. The burner according to claim 7, wherein the flame zone is made up of a plurality of circumferential sectors which extend in parallel with the direction of the circumference of the coaxial cylinders and are contiguous in the axial direction.
- 15 13. The burner according to claim 12, wherein:

if the number (M) of circumferential sectors is greater than or equal to 3, the width (y) of each of these sectors in the axial direction is less than 5 mm;

if the number (M) of circumferential sectors is less than 3, the width (y) of each of these sectors in the axial direction is less than 30 mm.
- 20 14. The burner according to any one of the preceding claims, comprising a detection electrode disposed outside the flame zone of the outer casing at the detection portion of the distributor.
- 25 15. A boiler comprising a combustion chamber and a burner according to any one of the preceding claims.
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FIG. 1

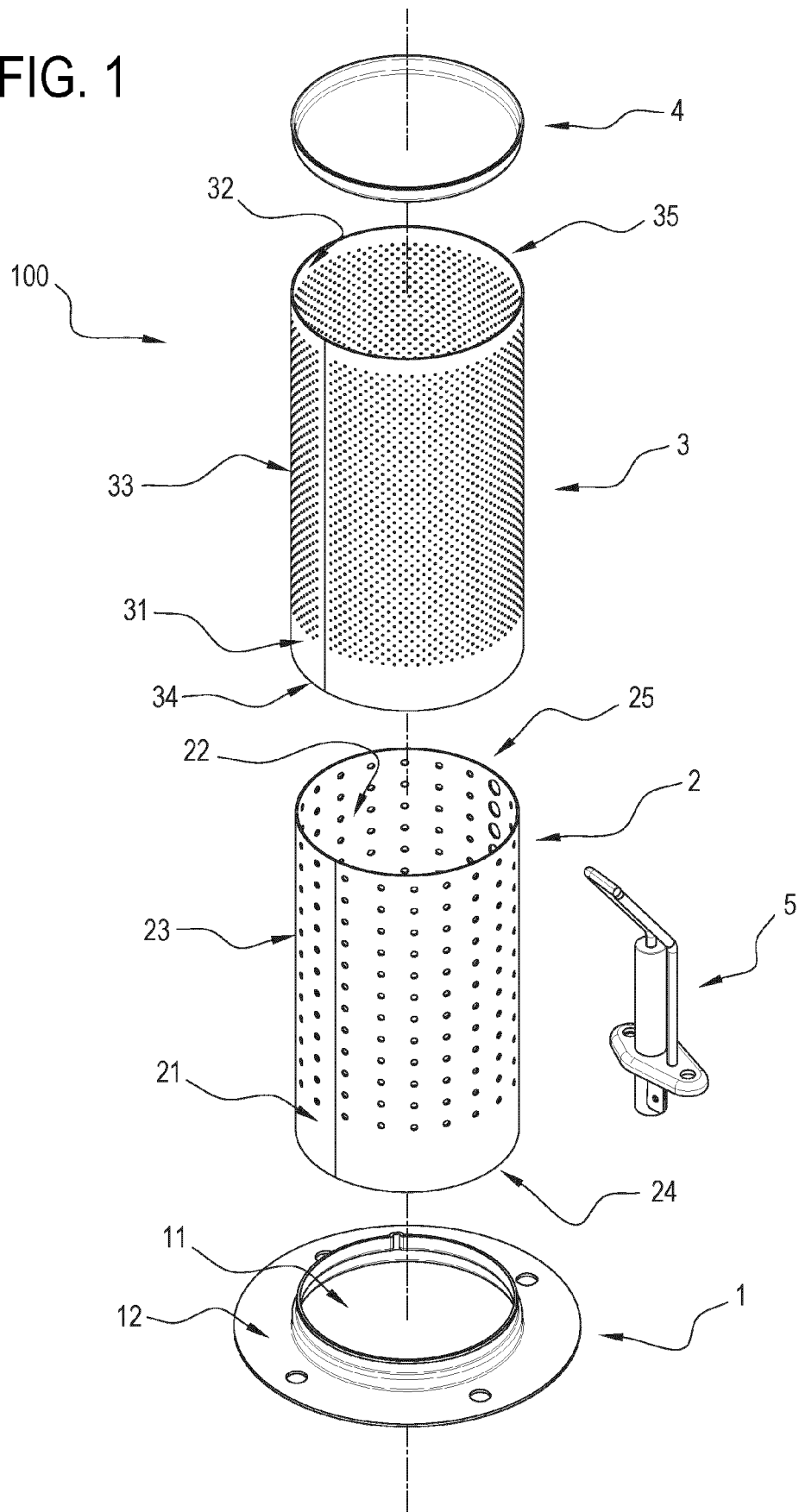


FIG. 2

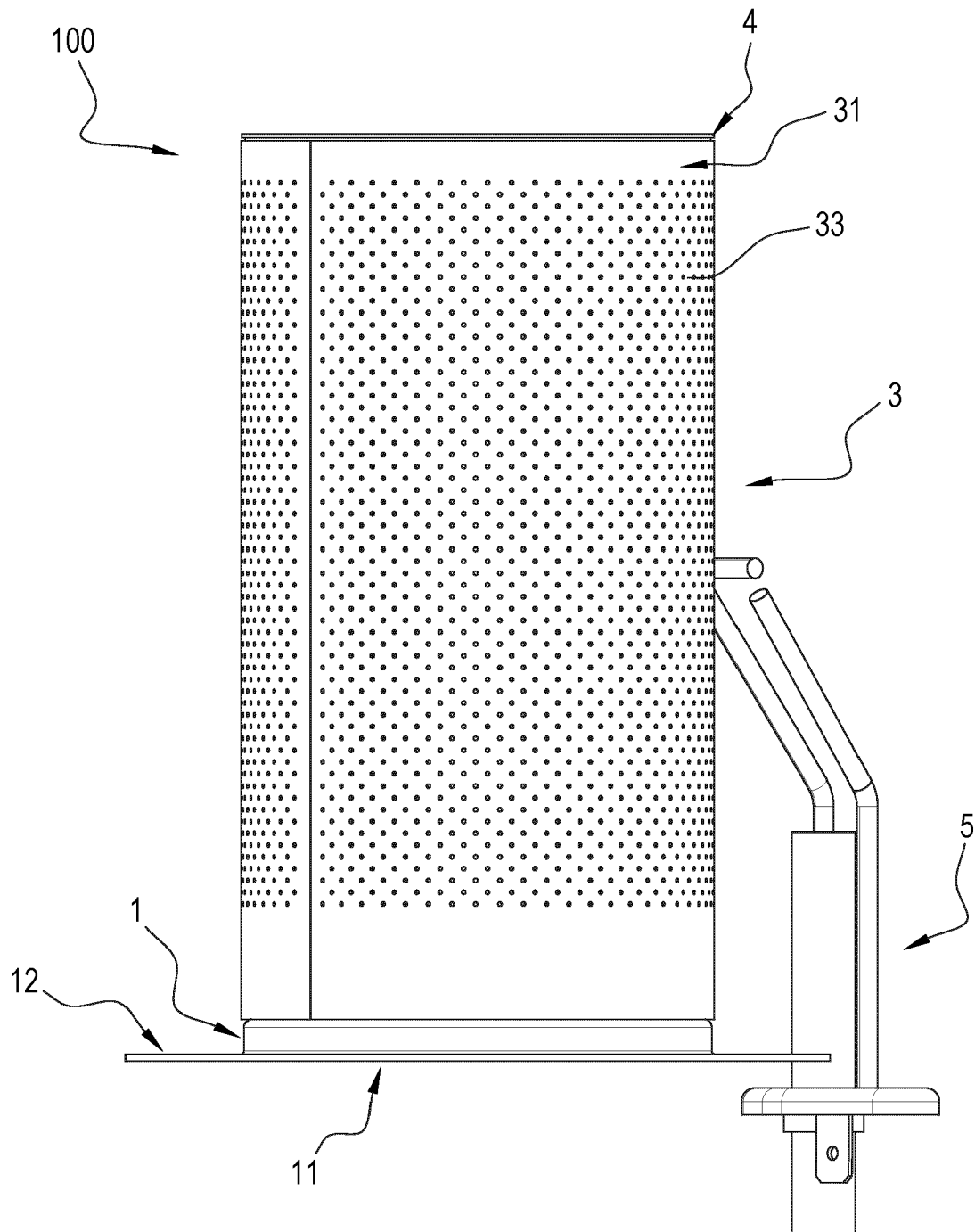


FIG. 3

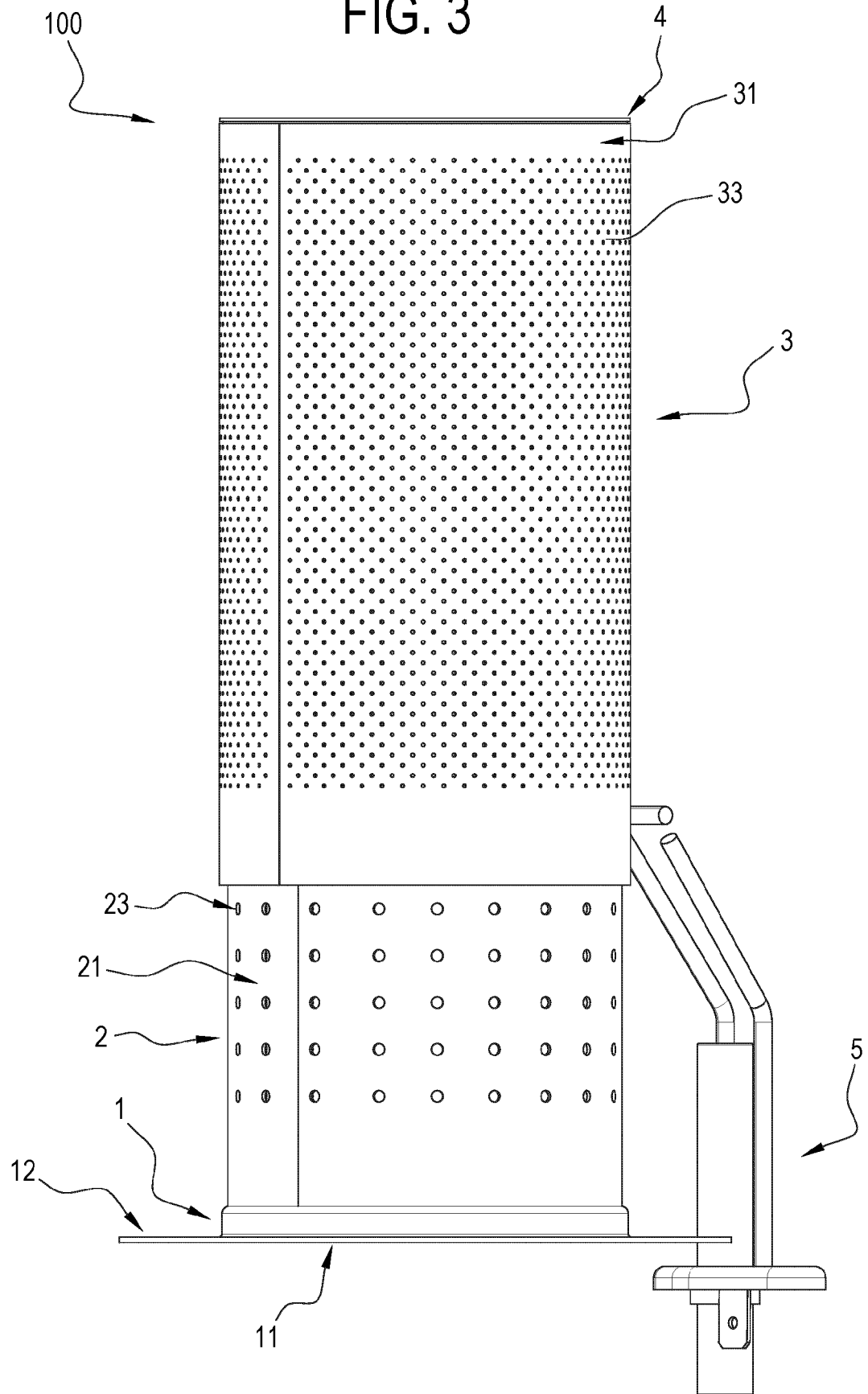


FIG. 4

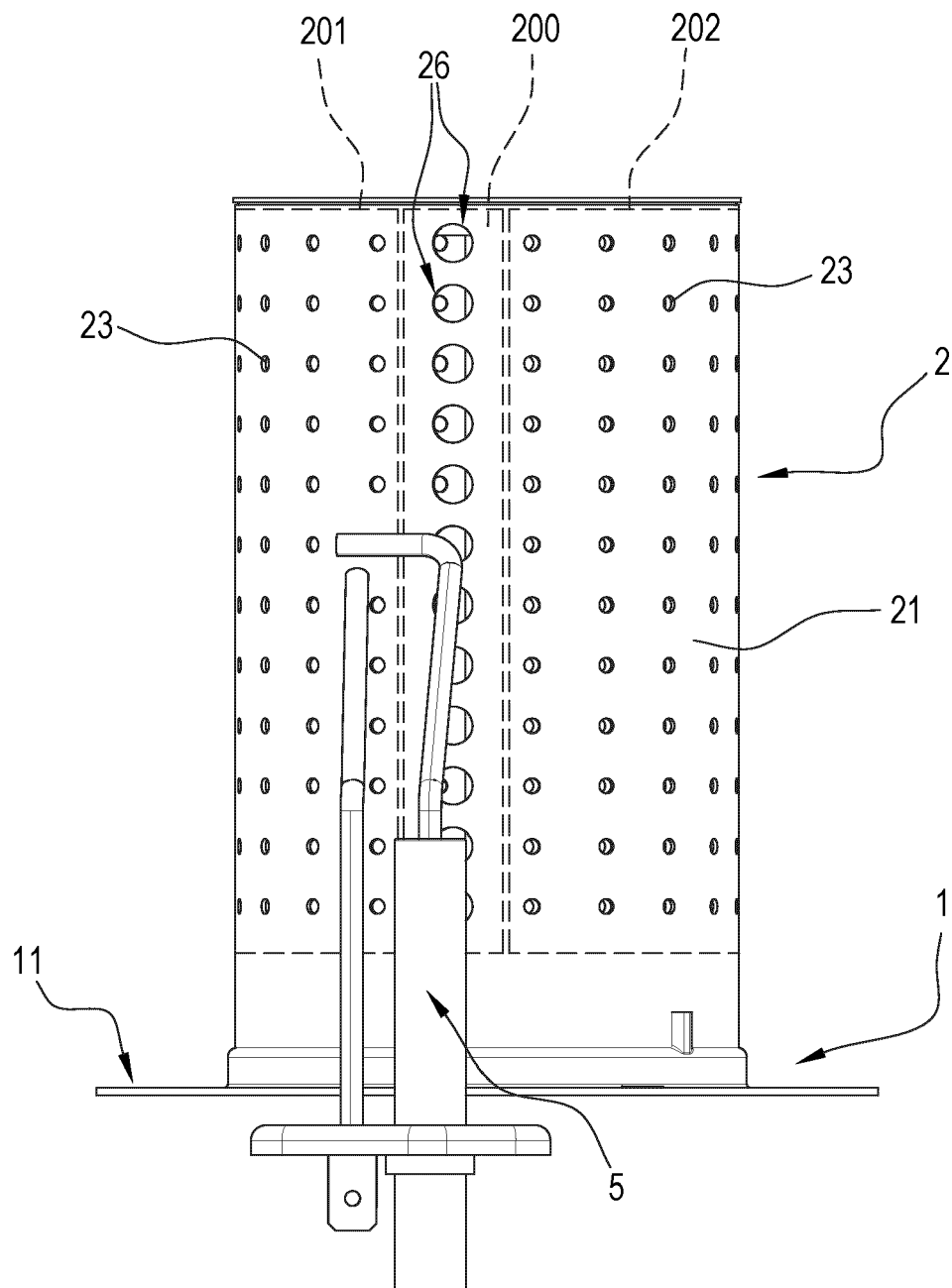


FIG. 5

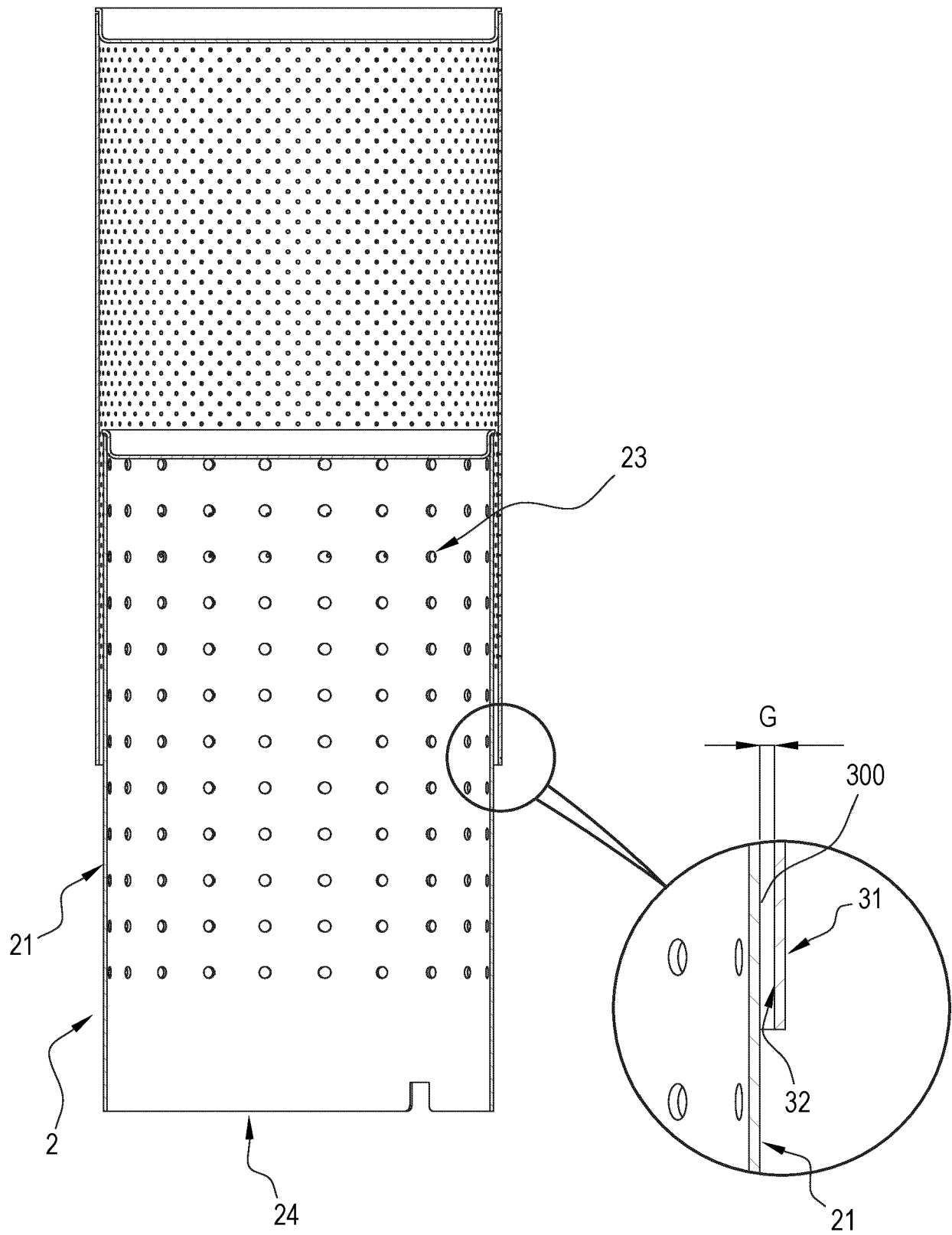
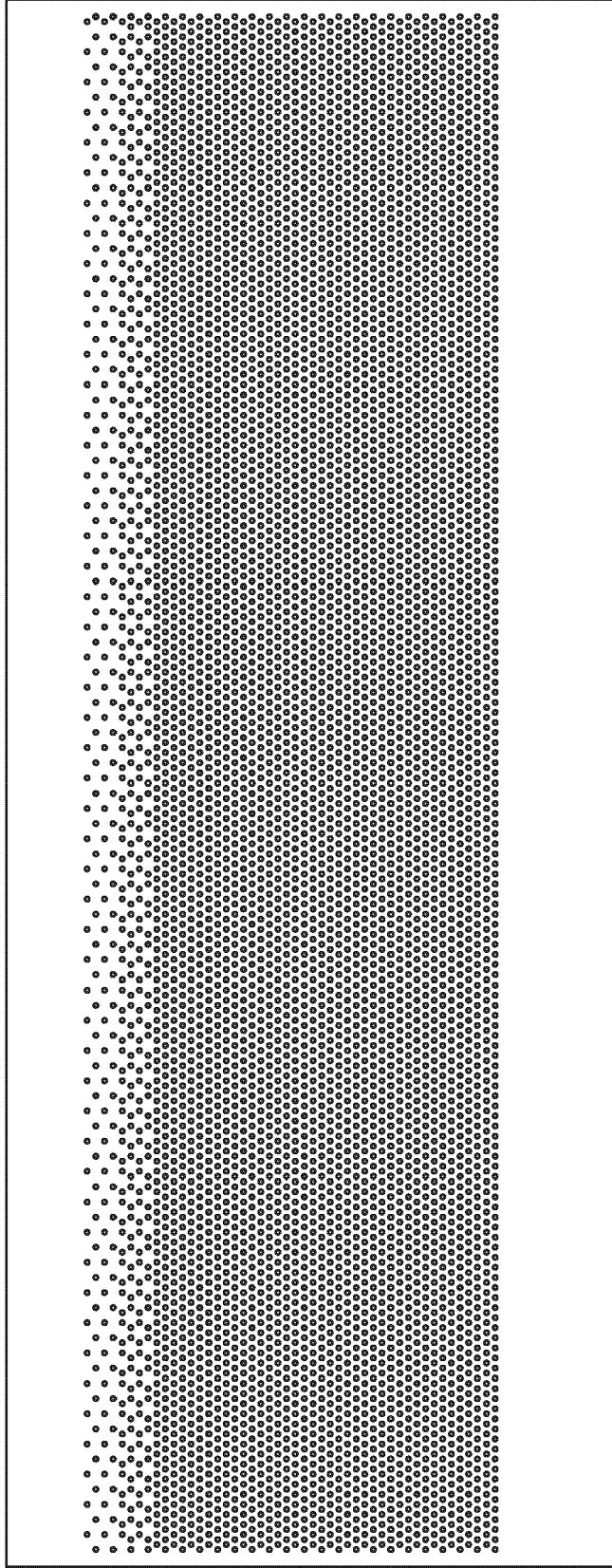


FIG. 6

CAP



FLANGE

FIG. 7A

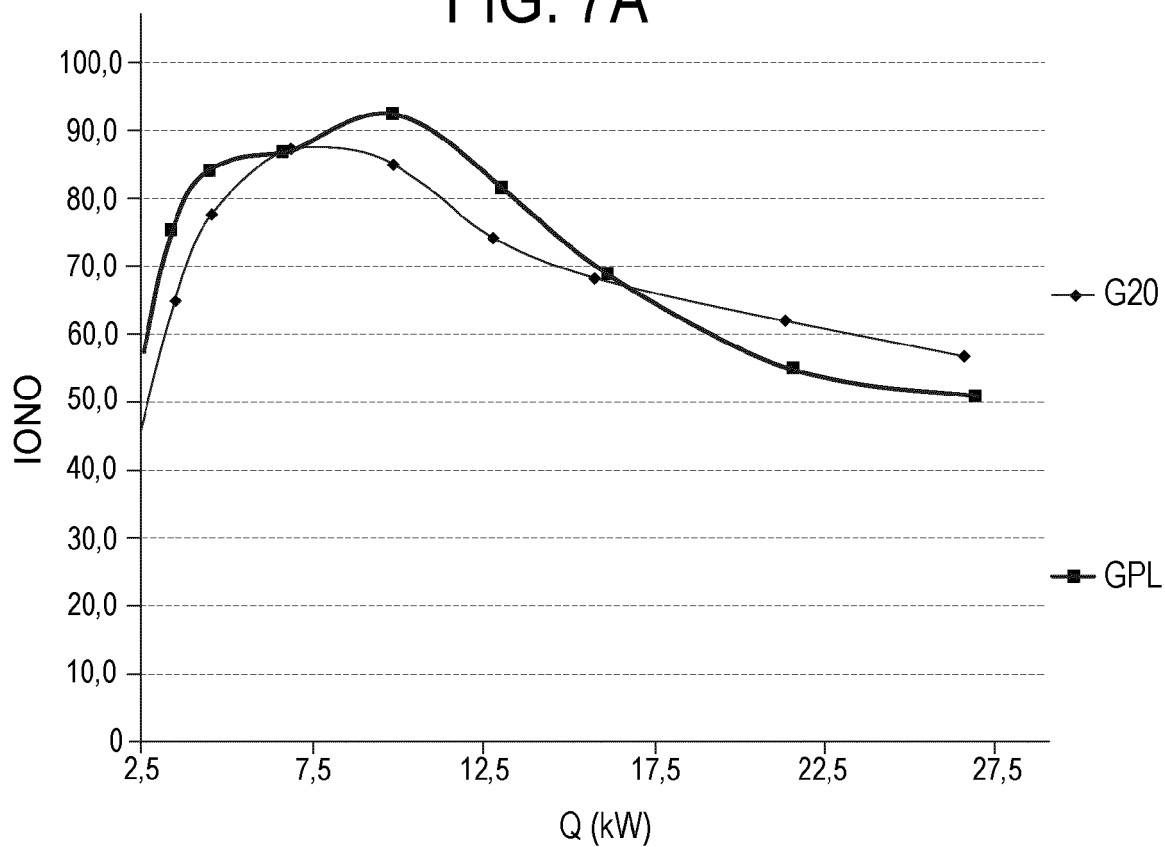
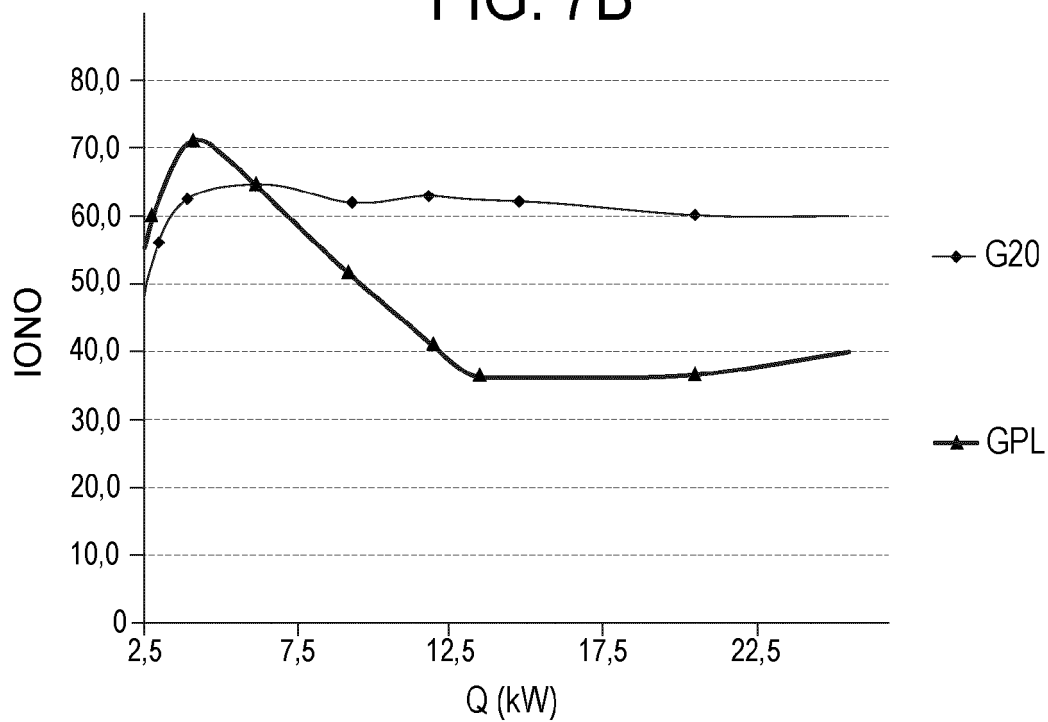


FIG. 7B





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Application Number

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X	EP 0 774 623 A1 (DEJATECH BV [NL]) 21 May 1997 (1997-05-21)	1-6, 15	INV. F23D14/02
Y	* column 1, line 3 - line 20; figures 1-4, 5E * * column 3, line 3 - line 18 * * column 3, line 28 - line 39 * * column 4, line 51 - column 5, line 22 * * column 6, line 11 - column 7, line 15 * * column 7, line 43 - line 55 * * column 9, line 21 - line 53 * * column 10, line 7 - line 9 * -----	14	
Y	EP 2 167 876 B1 (WORGAS BRUCIATORI SRL [IT]) 10 July 2013 (2013-07-10)	14	
A	* paragraph [0001] - paragraph [0001]; figures 1-4 * * paragraph [0010] - paragraph [0013] * * paragraph [0015] - paragraph [0027] * * paragraph [0038] - paragraph [0041] * -----	7-13	
			TECHNICAL FIELDS SEARCHED (IPC)
			F23D
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 12 September 2024	Examiner Hauck, Gunther
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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