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(54) **IMPROVED MODULAR BURNER**

(57) A modular burner comprising a plurality of mixer modules (10), positioned side by side and parallel to a longitudinal plane (Y), each of which has a length (L) measured parallel to the longitudinal plane (Y), and an emission surface (14) that has a width (D), measured perpendicularly to the longitudinal plane (Y), and wherein two adjacent emission surfaces (14) are separated by a distance (S), measured perpendicularly to the longitudinal plane (Y). The ratio between the distance (S) and the width (D) is comprised between 0.4 and 0.7.

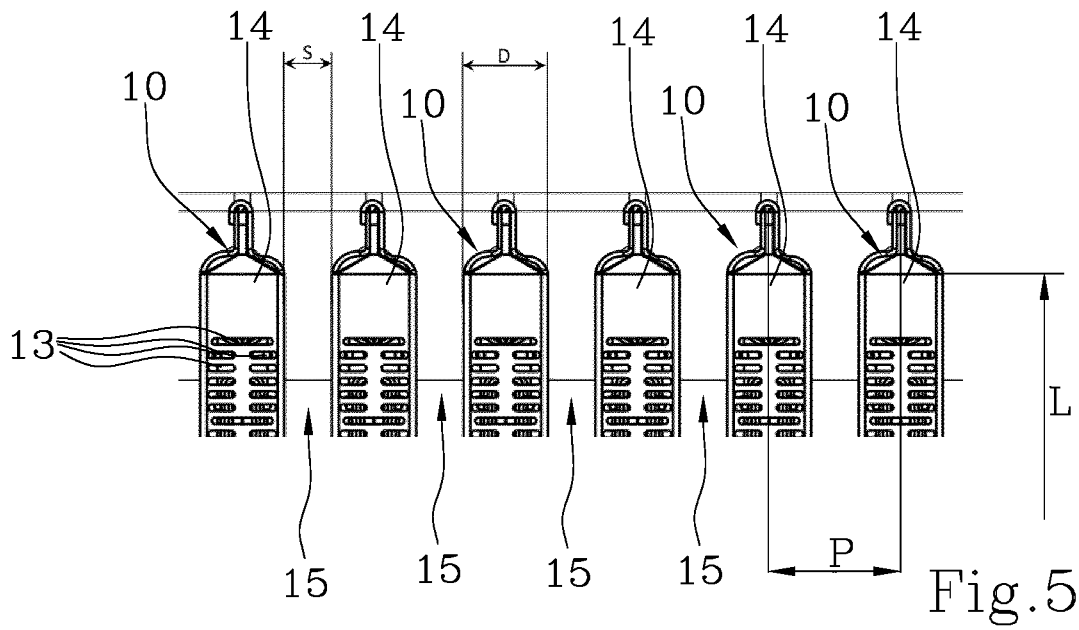

Fig.5

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Description

[0001] The present invention relates to a modular burner which may be used, for example, in a wall-mounted boiler.

[0002] In particular, the invention refers to a modular burner comprising a plurality of mixer modules, also called "ramps", positioned side by side.

[0003] Each mixer module normally comprises a flow conduit for the air-fuel mixture. The flow conduit is bent into a U shape, i.e. it has a configuration comprising two portions that are slightly inclined relative to each other and connected by a curve that defines an angle not much smaller than 180°. The flow conduit lies in a substantially vertical plane. The upper portion of the flow conduit is in communication with a series of outlet openings with an elongate shape, arranged side by side on a substantially flat emission surface, which are intended to emit the mixture of air and combustible gas. The emission surfaces of mixer modules lie in a main emission plane of the burner. The lower portion of the flow conduit of each mixer module faces a nozzle for injecting the combustible gas, at a Venturi disposed substantially perpendicular to an inlet opening of the flow conduit.

[0004] The flow of combustible gas injected into the inlet of the flow conduit produces an entrainment through the Venturi of so-called primary air, which is mixed with the fuel inside the flow conduit. The air-fuel mixture, which flows out of the flow conduit through the outlet openings of the mixer module, feeds a flame that develops above the mixer module, in proximity to the outlet openings themselves. Additional combustion air, called secondary air, is fed to the flame from the surrounding environment, and in particular through the spaces separating the various adjacent mixer modules from one another.

[0005] An important geometric feature of modular burners is the ratio between the total area of the burner, considered as the total area of the emission surfaces of the mixer modules and of the spaces separating the emission surfaces, and the total area of the spaces between the emission surfaces of the mixer modules. Both areas are measured on the main emission plane of the burner.

[0006] In the current modular burners, the aforesaid ratio is about 0.3. This determines a very substantial contribution of secondary air to the completion of combustion. At the outlet the mixer modules, through the outlet openings, the air-fuel mixture thus has a relatively low lambda (typically less than 1, i.e. less than the stochiometric ratio). This means that the flame temperature, in the sections closest to the outlet openings of the mixer modules, is above the critical value for the formation of nitrogen oxides (NOx). This phenomenon is particularly accentuated towards low power regimes of the boiler and is certainly undesirable for obvious reasons tied to the containment of harmful emissions.

[0007] In Italian patent application 102018000005589, the same applicant offered an effective solution to the problem summarised above, describing a modular burner in which the ratio between the areas is less than 0.2, i.e. it is at least 60% lower than the same ratio in traditional burners. In the modular burner of Italian application 102018000005589, the mixer modules are much closer to one another than is provided for in traditional modular burners.

[0008] This reduction in the ratio between the two areas makes it possible to considerably reduce the contribution of secondary air to the combustion that develops at the outlet of the outlet openings, in proximity to the emission surfaces and the emission plane, and thus enables the emission of NOx to be reduced.

[0009] Following extensive research, the applicant has identified a further geometric parameter which enables the morphology of the modular burner to be defined with greater simplicity, while also producing a further decrease in NOx emissions.

[0010] An advantage of the burner according to the present invention is that of not requiring any particular modifications either to the structure of the wall-mounted boiler in which it is installed, or to the burner itself, which has an overall structure that is substantially analogous to that of the currently available burners .

[0011] Another advantage of the burner according to the present invention is that of enabling a more precise adjustment of the power delivered.

[0012] Additional features and advantages of the present invention will become more apparent from the detailed description that follows of an embodiment of the invention in question, illustrated by way of non-limiting example in the appended figures, in which:

- figure 1 shows a schematic view of a mixer module which may be used in a burner according to the present invention;
- figure 2 schematically shows a boiler in which a burner according to the present invention may be used;
- figure 3 shows an exploded isometric view of the burner according to the present invention;
- figure 4 shows a top view of a modular burner according to the present invention;
- figure 5 shows an enlargement of figure 4;
- figures 6 and 7 respectively show a rear and front view of the burner according to the present invention;
- figure 8 shows a top view in which some significant areas of the burner are highlighted;
- figure 9 shows a graph representing the lambda of the air-fuel mixture as a function of the power delivered by the burner in a currently available burner;
- figure 10 shows a graph representing the lambda of the air-fuel mixture as a function of the power delivered by the burner according to the present invention.

[0013] The modular burner (1) according to the present invention can be used in a boiler of the type schematically illustrated in figure 2. The burner (1) produces a flame that heats an overlying heat exchanger (3), in which a carrier fluid is circulated, the carrier fluid transporting the heat received towards the destinations provided for. The fumes produced by combustion are sucked up by a fan (4) so as to be sent to an exhaust.

[0014] The modular burner according to the present invention comprises a plurality of mixer modules (10) positioned side by side. The mixer modules have an overall flattened conformation and are arranged parallel, connected to one another by means of supporting brackets (20,30) which enable the burner (1) to be constrained to a support structure. The mixer modules (10) are separated from one another by free spaces allowing the passage of air.

[0015] Each mixer module (10) comprises a flow conduit (11), i.e. a conduit for the passage of an air-fuel mixture. In the illustrated embodiment, the flow conduit (11) has a curved U configuration, in which a lower portion (11a) is connected to an upper portion (11b) by means of a curve (11c). The upper portion (11b) can be inclined slightly upwards from the curve (11c).

[0016] The flow conduit (11) is provided with an inlet opening (12). The inlet opening (12) is located at the end of the lower portion (11a). The inlet opening (12) is intended to receive a predetermined flow of fuel emitted by a nozzle (2), which can be located in a frontal position relative to the inlet opening (12). The flow conduit (11) is further provided with a Venturi (12a) located downstream of the inlet opening (12). In a known manner, the flow of fuel produced by the nozzle (2), by passing through the Venturi (12a), generates a negative pressure that produces suction of a certain flow of air through the inlet opening (12).

[0017] The flow conduit (11) is further provided with a plurality of outlet openings (13) arranged on an emission surface (14). The outlet openings (13) are obtained through a plate with an elongate shape, substantially strip-like, which defines the emission surface (14). In the illustrated embodiment, as may be seen particularly in figures 4 and 5, the outlet openings (13) are elongate in shape and parallel to one another.

[0018] The mixer modules (10) are arranged in such a way that the emission surfaces (14) lie in an emission plane (100) of the burner. The emission plane (100) is substantially a plane containing the emission surfaces (14), except in the event of misalignments due to the assembly of the mixer modules (10) and the effective geometry of the emission surfaces (14). In any case, the emission plane (100) contains the geometric projections of the emission surfaces (14).

[0019] On the emission plane (100), the emission surfaces (14) are separated from one another by free surfaces (15). The free surfaces (15), indicated by cross-hatching in figure 8, are substantially defined by the geometric projection, on the emission plane (100), of the spaces separating the mixer modules (10). The emission surfaces (14) are instead indicated by slanting lines.

[0020] Each emission surface (14) has a width (D), measured perpendicularly to the longitudinal plane (Y) and understood as the distance separating two longitudinal edges of the emission surface itself, parallel to the longitudinal plane (Y).

[0021] Furthermore, two adjacent emission surfaces (14) are separated by a distance (S), measured perpendicularly to the longitudinal plane (Y) and understood as the distance separating the adjacent longitudinal edges of the two emission surfaces (14).

[0022] In the current modular burners, the ratio between the distance (S) separating two adjacent emission surfaces (14) and the width (D) of each emission surface (14) is comprised between 0.9 and 1.6. There further exists a particular category of water-cooled modular burners in which the S/D ratio is lower than 0.1.

[0023] In the modular burner according to the present invention, the ratio between the distance (S) separating two adjacent emission surfaces (14) and the width (D) of each emission surface (14) is comprised between 0.4 and 0.7.

[0024] Essentially, in the modular burner according to the present invention, the mixer modules (10) are much closer to one another compared to what is provided for in the current modular burners. This reduces the space separating the mixer modules (10) from one another and thus reduces the free surfaces (15).

[0025] Such a reduction in the operating ratio makes it possible to considerably reduce the contribution of secondary air to the combustion that develops at the outlet of the outlet openings (13), in proximity to the emission surfaces (14) and the emission plane (100). In fact, as previously underscored, the mixer modules (10) are separated by spaces that are greatly reduced compared to the current burners, so the free sections (15) available for the flow of secondary air are likewise reduced.

[0026] As a result of the substantial reduction in the contribution of secondary air, the flow of primary air that is drawn into the flow conduit (11) through the inlet opening (12) becomes preponderant. The flow of primary air drawn into the flow conduit (11) through the inlet opening (12) substantially and mainly depends in turn on the negative pressure created by the fan (4) inside the boiler, whereas the effect of the negative pressure created by the flow of fuel passing through the Venturi (12a) becomes substantially negligible. In other words, the flow of primary air and the flow of secondary air remain substantially constant with variations in the power regime of the boiler. Once an operating regime of the fan (4) is fixed, the power of the burner is adjusted by varying solely the flow of gas sent to the flow conduit, i.e. by varying the feed pressure of the gas to the nozzle (2). Furthermore, the flow of primary air remains substantially constant with variations in the flow of fuel sent to the Venturi (12a).

[0027] Thanks to the features of the modular burner according to the invention, and in particular thanks to the reduction in the flow of secondary air, it is possible to set the flow of primary air that is drawn into the flow conduit (11) of each mixer module (10) so that the primary lambda of the air-fuel mixture is relatively high, about 1.3, at the low operating powers of the burner (figure 9), and decreases with increases in power until reaching a value of about 0.9 at the maximum of the burner power. The lambda is equal to 1 at about 85% of the operating power of the burner.

[0028] By virtue of the features of the burner according to the present invention, the primary lambda of the air-fuel mixture is thus relatively high starting from low operating powers of the burner, thus also in proximity to the outlet openings (13) and the emission plane (100). This feature makes it possible to maintain, from the early phases of combustion, the flame temperature below the typical values that cause the formation of nitrogen oxides (NOx). In the current burners, by contrast, cooling of the flame below critical temperatures for the formation of NOx does not take place until after the contribution of secondary air, when nitrogen oxides have already formed in proximity to the emission plane (14).

[0029] The modular burner according to the present invention comprises a rear bracket (20) and a front bracket (30). By means of the brackets (20,30), the mixer modules (10) are maintained parallel to one another, in the above-described position. Furthermore, the brackets (20,30) enable the burner (1) to be constrained to a support structure.

[0030] The rear bracket (20) comprises a main portion (21), positioned substantially perpendicular to the longitudinal plane (Y) and to the emission plane (100). The main portion (21) is structured so as to be positioned facing a rear zone of the mixer modules (10), thus closing off the burner (1) from the rear. The main portion (21) is provided with a plurality of through openings (22). The through openings (22), being located in the rear zone of the burner, ensure an optimal flow of secondary air.

[0031] Each through opening has a defined area. The overall area A of the through openings (22) is thus an area available for the flow of secondary air. Where N is the total number of mixer modules (10) forming the burner (1), S is the distance (S) separating two adjacent emission surfaces (14), it is possible to define the nondimensional parameter K in the following manner:

$$K = \frac{A}{(N-1)S^2}$$

[0032] In the burner according to the present invention, the nondimensional parameter K is greater than 4. This enables the features of the burner to be further improved in terms of efficiency and reduction of NOx emissions. The through openings (22) preferably have a circular shape and are arranged along two parallel rows, spaced apart at regular pitches. Preferably, two through openings (22) are aligned with each space separating two adjacent mixer modules (10).

[0033] The rear bracket (20) comprises a plurality of housings (23), each of the which is shaped so as to receive a respective rear coupling portion of a mixer module (10). The housings (23) are in the form of slots fashioned in two wings (23a,23b) of the rear bracket (20) which project transversely to the main portion (21) towards the mixer modules (10).

[0034] The front bracket (30) comprises a main portion (31), positioned substantially perpendicular to the longitudinal plane (Y) and to the emission plane (100), i.e. parallel to the main portion (21) of the rear bracket (20). The main portion (31) is structured so as to be positioned facing a front zone of the mixer modules (10), thus closing off the burner (1) from the front.

[0035] The main portion (31) of the front bracket (30) is provided with a through opening (32). The through opening (32) has an elongate slot shape and is positioned facing the inlet openings (12) of the conduits (11) of the mixer modules (10). An elongate slot shape, that is, without any bridges or transverse partitions, enables a free flow, without any substantial turbulence, towards the inlet openings (12) through the through opening (32).

[0036] The front bracket (30) comprises a plurality of housings (33), each of which is shaped so as to receive a respective rear coupling portion of a mixer module (10). The housings (33) are in the form of slots fashioned half in an upper wing (33a), which projects transversely to the main portion (31) towards the mixer modules (10), and half on a lower rib (33b), located below the main portion (31) and turned towards the mixer modules (10). The front bracket (30) further has a support foot (35), located below the main portion (31). The foot (35) is defined by an edge of the front bracket (30) that is folded substantially perpendicular to the main portion (31), i.e. substantially parallel to the emission plane (100). In the illustrated embodiment, the foot (35) is facing back towards the mixer modules (10), but it could be facing forwards on the opposite side. In addition to facilitating the support of the burner (1) and the constraint thereof to a support structure, the foot (35) contributes to considerably stiffening the front bracket (30), partially weakened by the presence of the through opening (32).

[0037] The following further geometric parameters, either taken individually or adopted in any combination, make it possible to further improve the combustion characteristics of the modular burner according to the present invention.

[0038] Preferably, but not necessarily, in the burner according to the present invention, the operating ratio between the total free area, given by the sum of the free surfaces (15) projected onto the emission plane (100), and the total area of the burner, given by the sum of the emission surfaces (14) and the free surfaces (15) projected onto the emission plane (100), is less than or equal to 0.2.

[0039] In the currently available modular burners, by contrast, the above-described operating ratio is about 0.3. In the modular burner according to the present invention, the operating ratio is thus about 60% lower than the operating ratio provided for in the currently available burners.

[0040] In the burner according to the present invention, the ratio between the total area of the outlet openings (13) and the area of the emission surface (14) is greater than 0.20 for each mixer module. For example, the aforesaid ratio is comprised between 0.20 and 0.30 for each mixer module (10). Considering that the mixer modules (10) have standard dimensions that provide for a length (L) of the emission surface (14) of 160 mm, in the burner according to the present invention the mixer modules (10) are separated by a mounting pitch (P) of about 13 mm, measured as the distance between the average longitudinal planes of two adjacent modules (10), whereas in the current burners this pitch is comprised between 17 and 20.5mm. In the burner according to the present invention, the ratio between the length of the mixer modules (10) and the mounting pitch (P) is greater than 11, whereas in the current burners it at most 9.41. In a particularly advantageous embodiment, the ratio is about 12.3.

Claims

1. A modular burner comprising a plurality of mixer modules (10) positioned side by side and parallel to a longitudinal plane (Y), each of which has a length (L) measured parallel to the longitudinal plane (Y), wherein each mixer module (10) comprises:

    a flow conduit (11) provided with an inlet opening (12) and a plurality of outlet openings (13) arranged on an emission surface (14);
    wherein the emission surfaces (14) lie in an emission plane (100) of the burner;
    wherein each emission surface (14) has a width (D), measured perpendicularly to the longitudinal plane (Y), and wherein two adjacent emission surfaces (14) are separated by a distance (S), measured perpendicularly to the longitudinal plane (Y);
    characterised in that the ratio between the distance (S) and the width (D) is comprised between 0.4 and 0.7.

2. The burner according to claim 1, comprising a rear bracket (20) provided with a main portion (21) having a plurality of through openings (22), wherein the through openings have an overall area A, **characterised in that** a nondimensional parameter K:

$$K = \frac{A}{(N-1)S^2}$$

is greater than 4, where N is the overall number of mixer modules (10) and s is the distance (S) separating two adjacent emission surfaces (14).

3. The burner according to claim 2, wherein the through openings (22) have a circular shape and are arranged along two parallel rows, and wherein each space separating two adjacent mixer modules is faced by two through openings (22).

4. The burner according to claim 2, wherein the rear bracket (20) comprises a plurality of housings (23), each of which is shaped so as to receive a respective rear coupling portion of a mixer module (10).

5. The burner according to claim 1, comprising a front bracket (30) provided with a main portion (31) having a through opening (32) in an elongate slot shape, wherein the through opening (32) is facing the inlet openings (12) of the flow conduits (11).

6. The burner according to claim 5, wherein the front bracket (30) comprises a foot (35) defined by a folded lower edge of the front bracket (30) that is substantially perpendicular to the main portion (31), i.e. parallel to the emission plane (100).

7. The modular burner according to claim 1, comprising a plurality of mixer modules (10), positioned side by side and parallel to a longitudinal plane (Y), each of which has a length (L) measured parallel to the longitudinal plane (Y), wherein the mixer modules are separated from one another by a mounting pitch (P), measured as the distance between the median longitudinal planes of two adjacent modules (10), **characterised in that** the ratio between the length of the mixer modules (10) and the mounting pitch (P) is greater than 11.

8. The modular burner according to claim 7, wherein the ratio between the length of the mixer modules (10) and the mounting pitch (P) is about 12.3.

9. The modular burner according to claim 1, wherein each mixer module (10) comprises: a flow conduit (11) provided with an inlet opening (12) and a plurality of outlet openings (13), arranged on an emission surface (14); wherein the emission surfaces (14) lie in an emission plane (100) of the burner and, in the emission plane (100), they are separated from one another by free surfaces (15); **characterised in that** the ratio between the total area of the free surfaces (15) and the total area of the emission surfaces (14) and the free surfaces (15) is less than 0.2.

10. The burner according to claim 1, wherein each mixer module (10) comprises: a flow conduit (11) provided with an inlet opening (12) and a plurality of outlet openings (13), arranged on an emission surface (14); wherein the emission surfaces (14) lie in an

emission plane (100) of the burner and, in the emission plane (100), they are separated from one another by free surfaces (15); **characterised in that**, in each mixer module (10), the ratio between the overall area of the outlet openings (13) and the area of the emission surface (14) is comprised between 0.20 and 0.30.

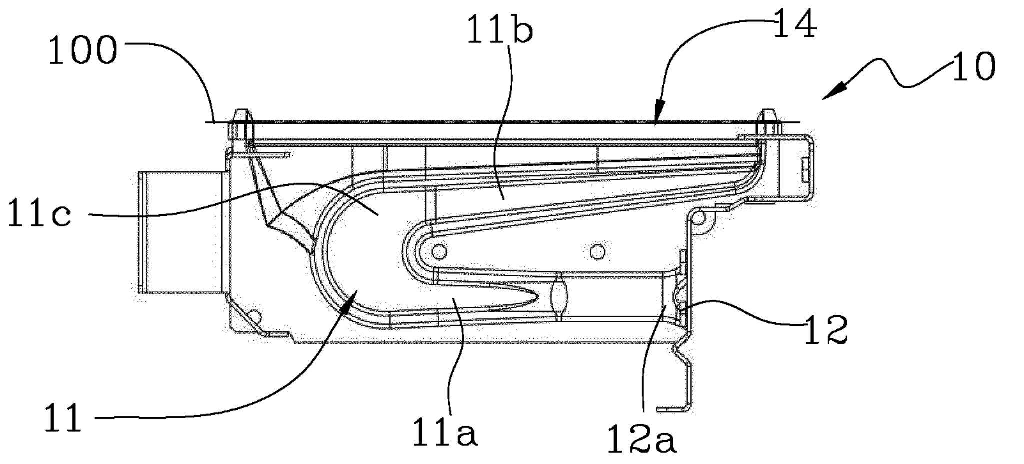

Fig.1

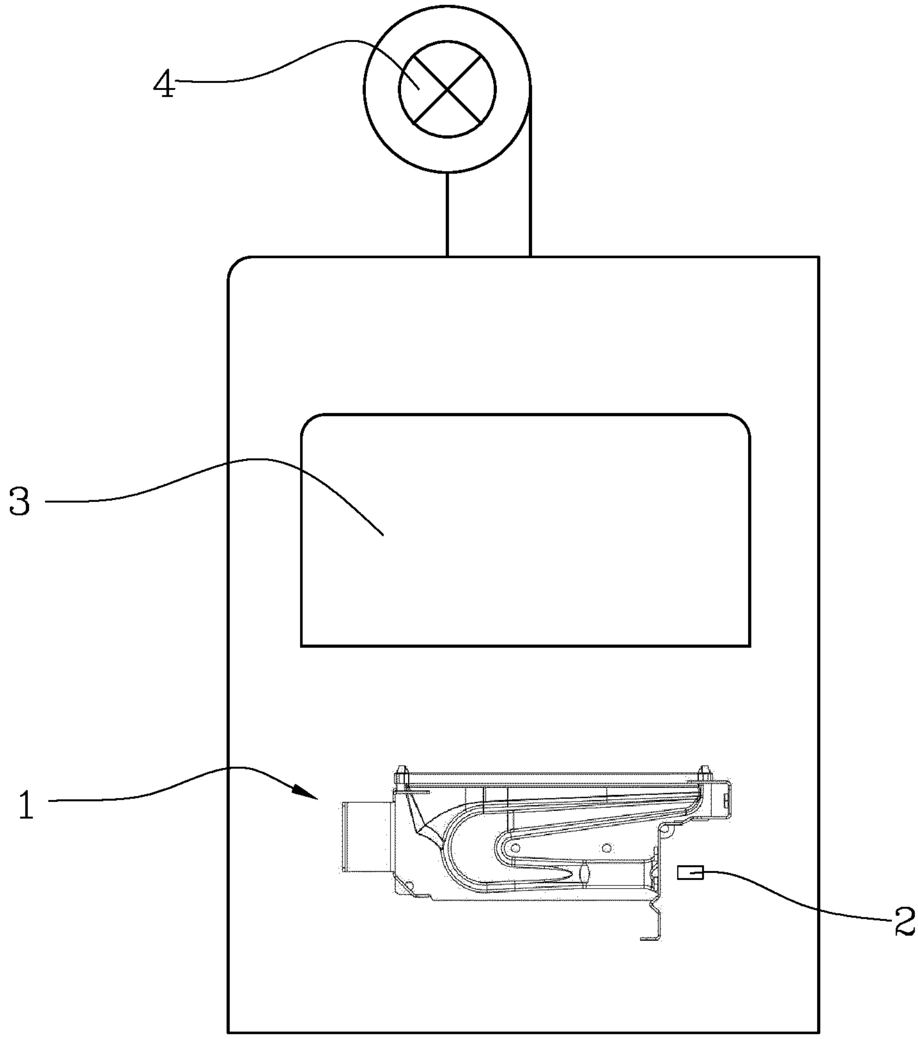

Fig.2

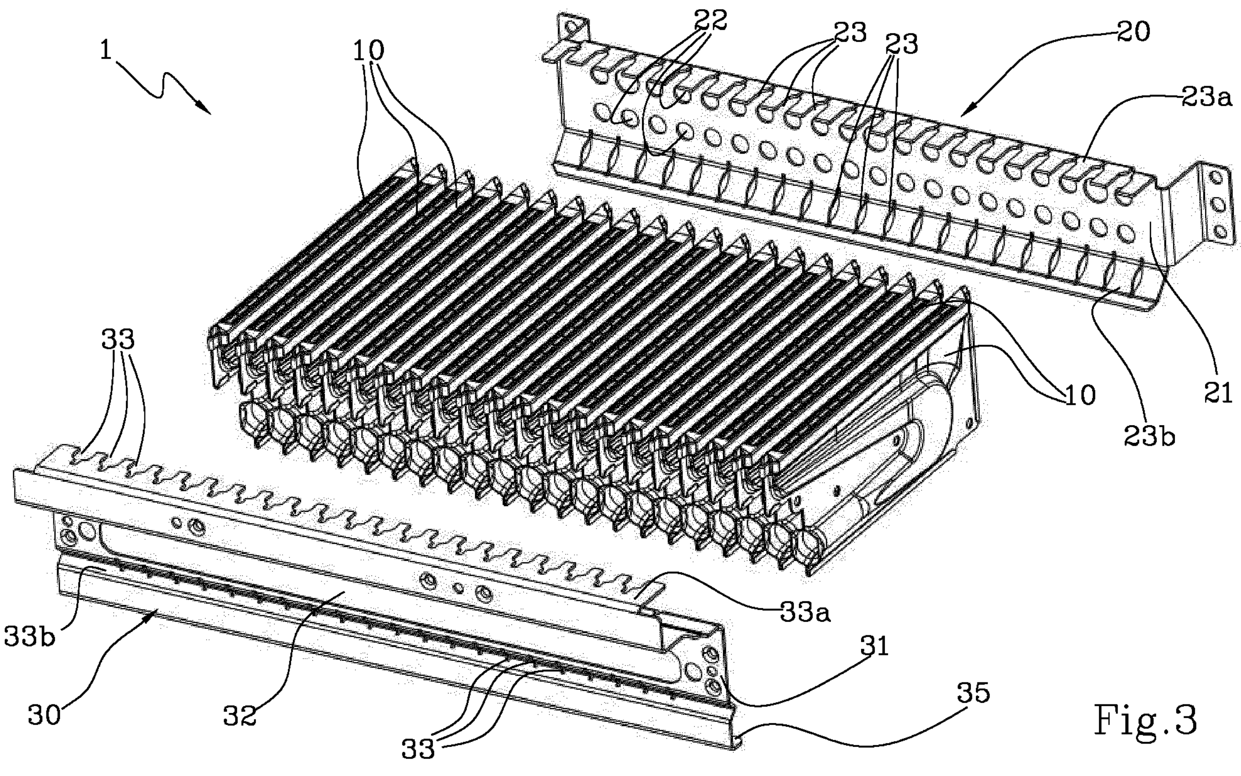

Fig.3

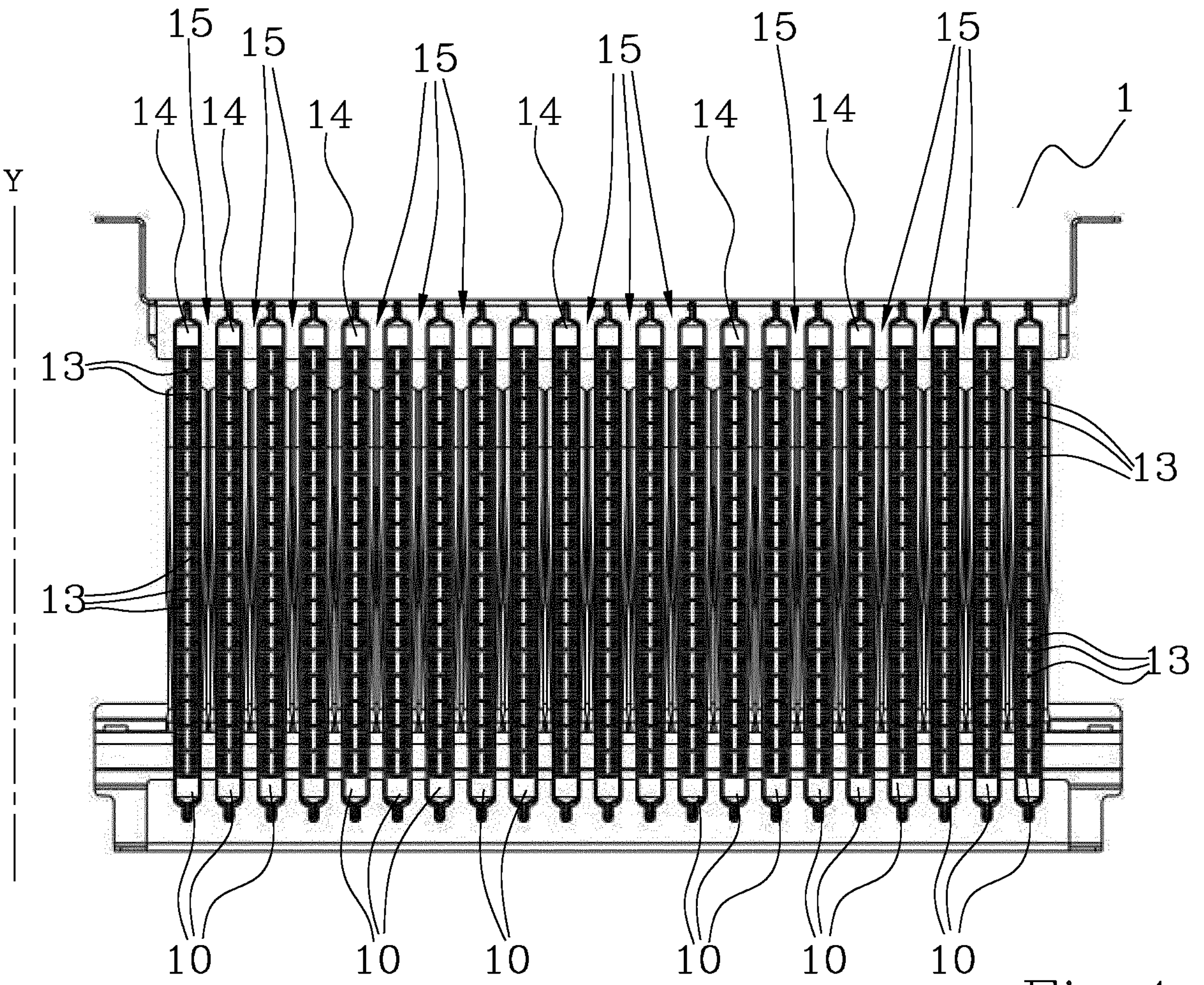
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Fig.4

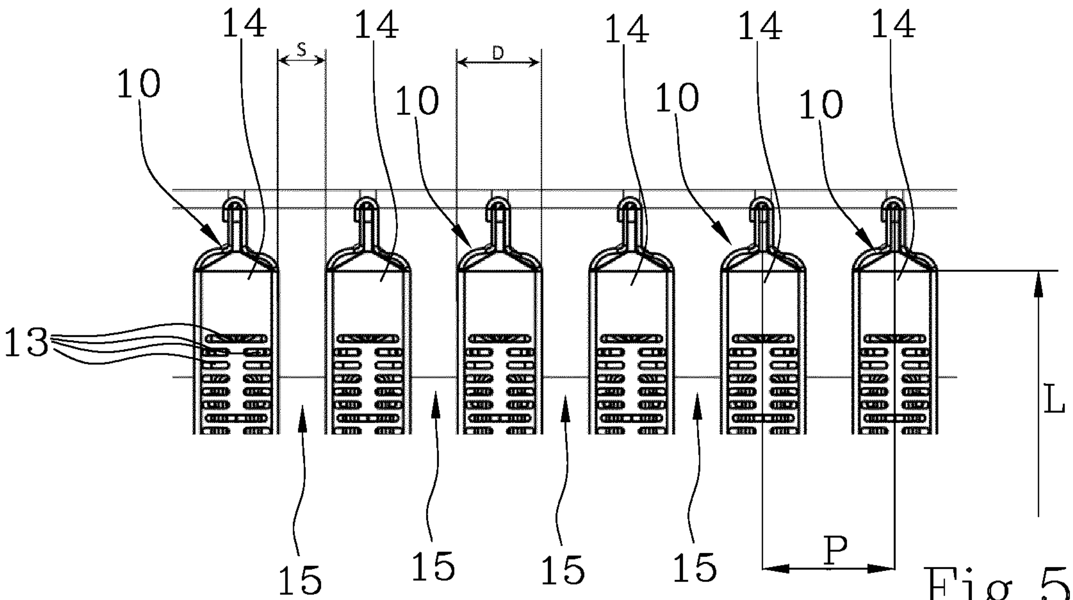
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Fig.5

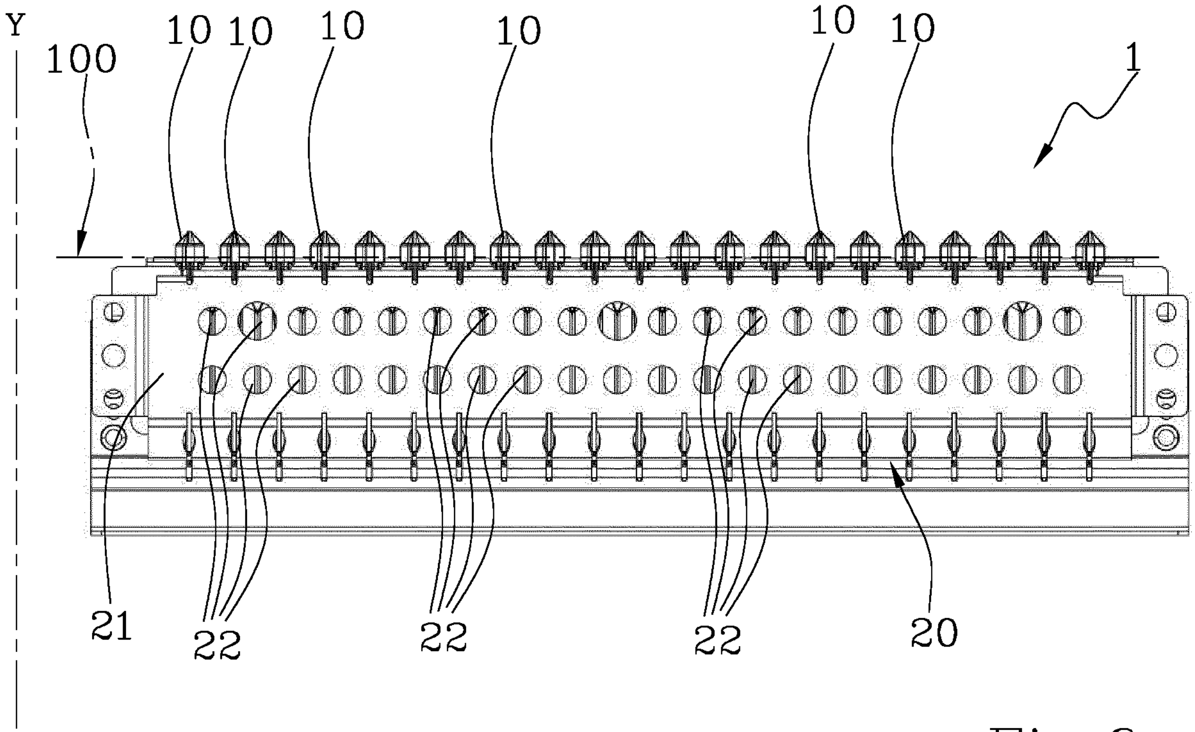
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Fig.6

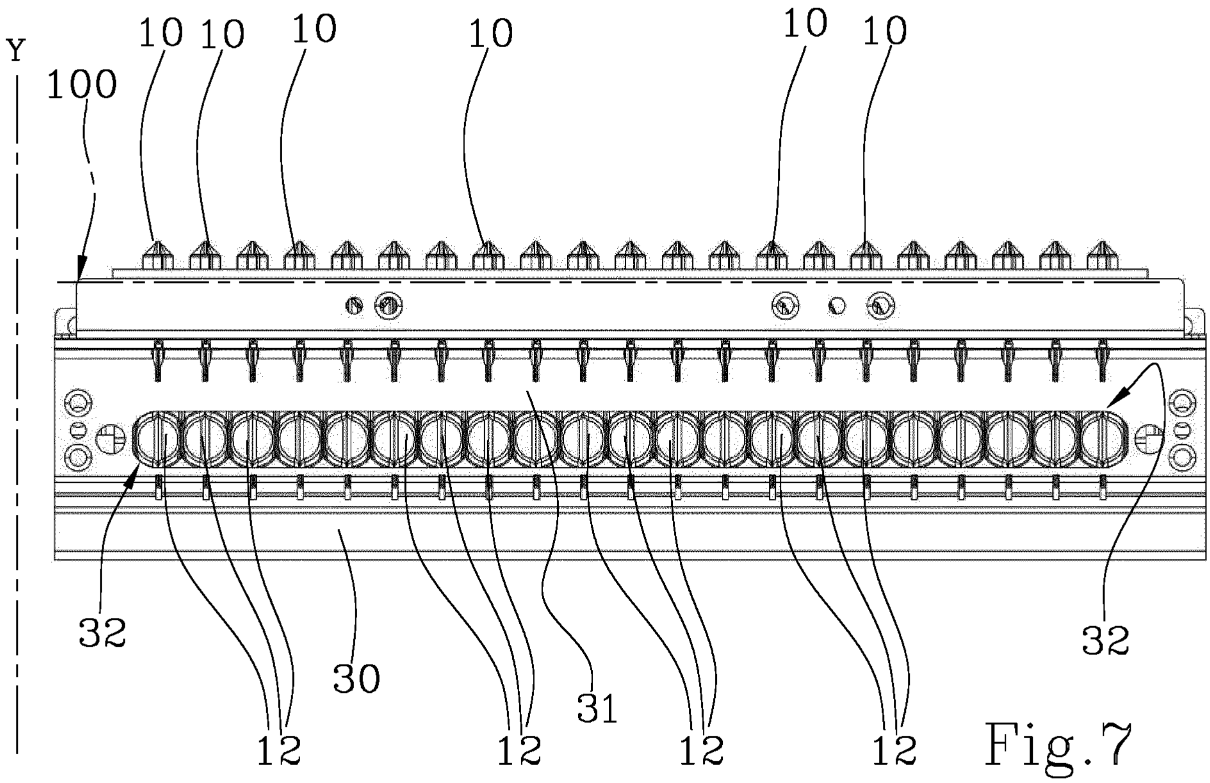
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Fig.7

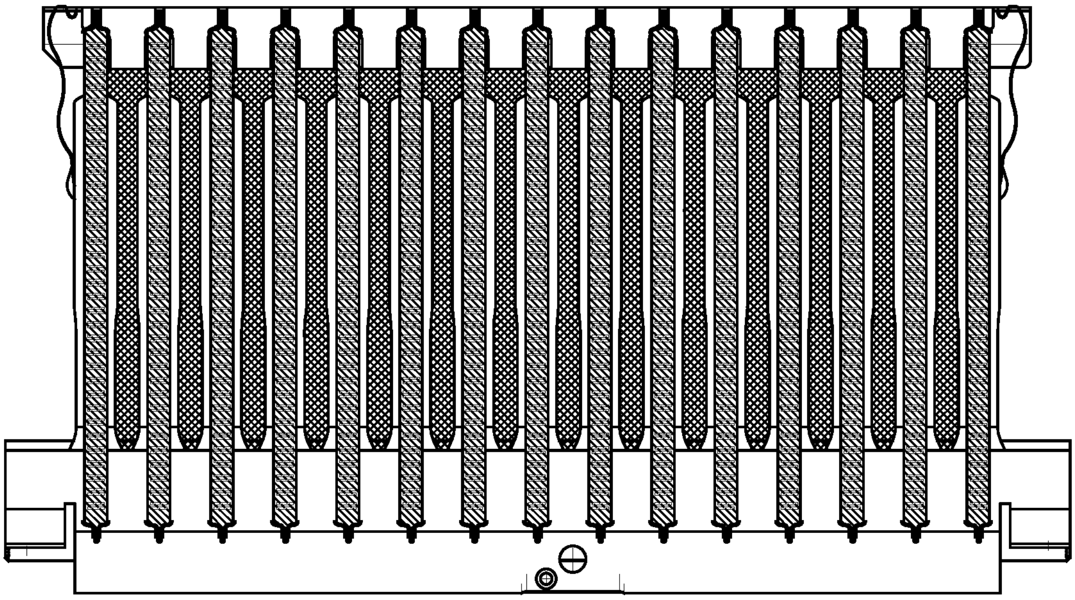
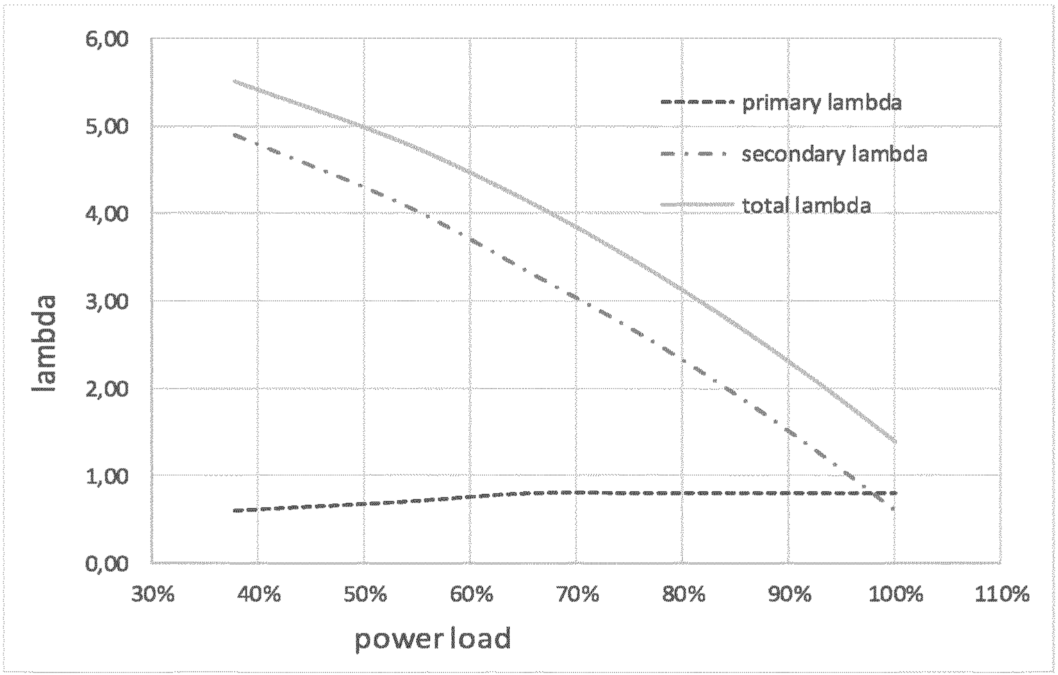


Fig.8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primary lambda
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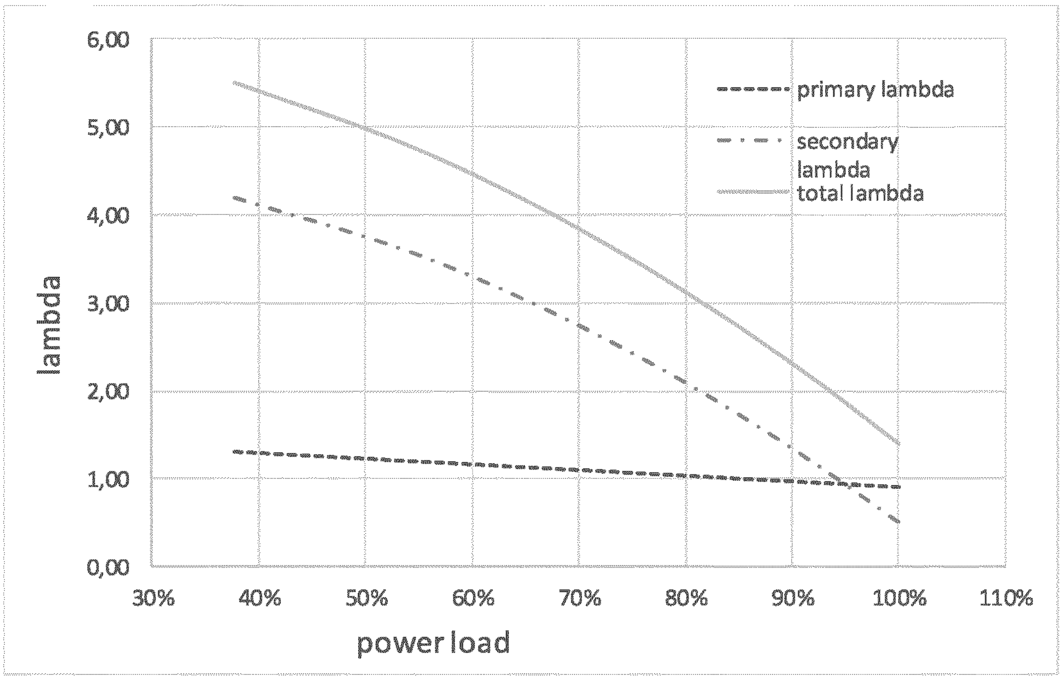
total lambda

Fig.9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secondary lambda
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Fig.10

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EUROPEAN SEARCH REPORT

Application Number
EP 21 17 0052

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	EP 1 130 315 A2 (BOSCH GMBH ROBERT [DE]) 5 September 2001 (2001-09-05) * column 2, paragraph 8 - column 3, paragraph 15 * * claim 5 * * figures 1,2,4 * -----	1,3,4, 6-10 2,5	INV. F23D14/04 F23D14/08 F23D14/46
Y	WO 2005/059437 A1 (WORGAS BRUCIATORI SRL [IT]; FOGLIANI GIUSEPPE [IT] ET AL.) 30 June 2005 (2005-06-30) * page 4, line 25 - page 5, line 3 * * figure 11 * -----	2,5	
A	DE 91 12 869 U1 (J. VAILLANT GMBH [DE]) 19 December 1991 (1991-12-19) * page 5, last paragraph * * page 7, paragraph 1 - paragraph 3 * * figures 1,7 * -----	1	

TECHNICAL FIELDS SEARCHED (IPC)

F23D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	13 August 2021	Gavriliu, Costin

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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13-08-2021

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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