(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 492 814 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
05.06.2019 Bulletin 2019/23

(51) Int Cl.:
F24B 1/02 *(2006.01)* ***F24B 5/02*** *(2006.01)*
F23B 80/02 *(2006.01)*

(21) Application number: **18209730.3**

(22) Date of filing: **03.12.2018**

(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
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **04.12.2017 IT 201700139805**

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(54) BIOMASS STOVE WITH REDUCED EMISSIONS

(57) The invention concerns a biomass stove, particularly a pellet stove, comprising a combustion chamber, an unburned gas storage chamber, a flue gas extractor fan device for extracting unburned gas from the storage chamber and for sending it to an exhaust flue, at least one air intake for feeding air from the outside to the inside of the combustion chamber. The combustion chamber comprises a brazier area adapted to receive the biomass and to generate combustible gas and a flame area intended for the combustion of combustible gas coming from the brazier area. There are a first series of apertures at the brazier area for supplying primary gas and a second series of apertures at the flame area for supplying secondary gas. The stove further comprises a branch intercepting the flue gases directed to the exhaust flue such to at least partially direct said flue gases to the primary gas inlet apertures.

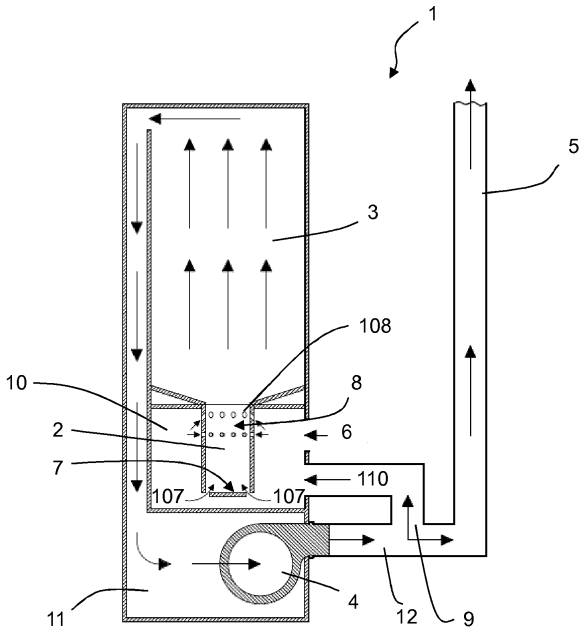

Fig. 1

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Description

[0001] The present invention concerns a biomass stove, particularly a pellet stove.

[0002] This type of stove typically comprises a combustion chamber, an unburned gas storage chamber, a flue gas extractor fan device for extracting unburned gas from the storage chamber and for sending it to an exhaust flue, and at least one air intake for feeding air from the outside to the inside of the combustion chamber. The combustion chamber comprises a brazier area adapted to receive the biomass, typically by means of an auger, and to generate combustible gas and a flame area intended for the combustion of combustible gas coming from the brazier area.

[0003] Furthermore, a first and a second series of apertures are typically present in these stoves. The first series of apertures is placed at the brazier area for supplying primary air, while the second series of apertures is placed at the flame area for supplying secondary air.

[0004] National and international standards require the manufacturers of these stoves to contain the emissions of polluting particles present in flue gases within ever more stringent levels.

[0005] To this end, known solutions provide for the use of a recirculation system which allows to reintroduce flue gases in the flame area of the stove such that to subject them to further combustion before being discharged.

[0006] This ensures that the flue gases released in the environment contain a reduced quantity of polluting particles due to poor combustion.

[0007] However, this only minimally acts on NO_x emissions on which the standard is increasingly focusing. The formation mechanism of these pollutants is in fact inherent in each combustion due to the presence of comburent oxygen which oxidizes the nitrogenous compounds regardless of the refinement process adopted to obtain maximum yield.

[0008] Combustion stoves are known, in particular wood stoves in relatively large numbers, such as for example the one described in EP0268208, in which two supplies of combustion air or other combustion gas with similar effects are provided. An aperture for the primary combustion air is provided in communication with the combustion chamber in which the combustible material load is housed.

[0009] The combustible material rests on a combustion plane in which one or more apertures are provided for the passage of the gases generated in the combustion of the combustible material in an underlying storage chamber of these gases, also named flue gases. This chamber in turn communicates with an exhaust flue.

[0010] In an intermediate position between the combustion chamber and the storage chamber, there is a post-combustion chamber for flue gases coming from the combustion chamber. A supply duct of secondary ambient air flows in this post-combustion chamber and causes any possible unburned residues present in the flue gases coming from the combustion chamber to be burned before these flue gases are transferred into the storage chamber from where they are eliminated by the exhaust flue.

[0011] As is clear, in this case, the flue gases coming from the combustion of the combustible are subjected to the post-combustion step in a separate chamber and the energy produced is not combined with the one generated by the combustion of the combustible material in the combustion chamber. The process is therefore inefficient from a thermal point of view.

[0012] The document DE202006007860U1 shows a particular of a combustion chamber intended to operate in devices of the type described in EP260208. Also in this case, the primary air is directly supplied into a combustion chamber, while the secondary air is supplied into a post-combustion chamber in which the flue gases coming from the combustion of the combustible material are subjected to combustion. The primary air is supplied into the combustion chamber which is at a higher height than the post-combustion chamber of the fuel gases. This chamber has an independent inlet for the supply of secondary combustion air.

[0013] Moreover, the flue gases deriving from the post-combustion process can be recovered and mixed with the fuel gases coming from the combustion chamber so that to be subjected to the post-combustion step together. As is clear, the post-combustion step is carried out directly on the flue gases in a post-combustion chamber that is separate from the brazier, and the flue gases deriving from the post-combustion process are at least partially reintroduced in the post-combustion chamber where they are mixed with the flue gases combing from the combustion chamber and that still have to be subjected to the post-combustion.

[0014] Also in this case, from an energy point of view, the post-combustion of the flue gases does not participate directly in the combustion of the combustible.

[0015] Moreover, in both of the aforesaid cases, it is difficult to achieve an easy, extremely efficient and also inexpensive retrofitting on existing stoves.

[0016] Object of the present invention is therefore to achieve a biomass stove, particularly a pellet stove, with reduced NO_x emissions compared to traditional stoves.

[0017] The invention achieves the object with a stove as described in the beginning, in which there is a branch intercepting the flue gas directed to the exhaust flue such to at least partially direct said flue gases to the primary gas inlet apertures.

[0018] Thanks to this, the unburned gases are sent to the primary air inlet, i.e. in the brazier area, instead of being directed on the flame area in order to face a further combustion. The primary air therefore results poorer in oxygen and at a higher temperature compared to traditional stoves. This favors the pyrolytic step, i.e. the generation of combustible gases intended to be burned with secondary comburent air.

[0019] Pyrolysis is a reaction of transformation of a sol-

id combustible into gas, which occurs at high temperatures without a flame and, therefore, without oxidation. The inventors have surprisingly discovered how such reaction can be facilitated by using the same flue gases intended to be reclaimed in a very original way and with a drastic reduction of the pollutants released in the environment as the final result.

[0020] Flue gases can be channeled directly to the primary air intake, both pure and mixed with the external air, or they can also be sent both to the primary inlet and to the secondary inlet so that to also achieve the beneficial effect of the secondary combustion of unburned gases in order to further improve the quality of the flue gases released in the environment.

[0021] Constructive variations provide the use of a mixing chamber in fluid dynamic communication either only with the primary inlets or with the primary and secondary inlets, by arranging the external air intake at the primary inlets so that to achieve different flue gases/air mixing ratios for the primary and secondary inlets with a simple geometric arrangement. More complex solutions, in which the stoichiometric ratio of the primary and secondary gases can be finely varied by acting on the flows of flue gases and external air, can obviously be provided, for example with fans and separate mixing chambers.

[0022] According to an embodiment, the bypass created for the recirculation of exhausted flue gases is advantageously provided inside the stove structure downstream the fan acting as the extractor device of flue gas so that to achieve a very compact solution. It is however also possible to provide an external deviation to be applied to traditional stoves so that to intercept part of the flue gases directed to the chimney flue and to direct them to the primary air inlet. This allows to achieve a kit to be used to retrofit existing systems with clear benefits for users in terms of direct costs and installation fees.

[0023] To this end, according to an aspect, the invention concerns kits for biomass stoves, particularly pellet stoves, equipped with a flue gas outlet for the connection to an exhaust flue, a primary air inlet and a secondary air inlet in fluid dynamic communication respectively with a brazier area and a flame area of a combustion chamber, characterized in that it comprises a fitting intended for the connection of flue gas outlet with the exhaust flue and with primary air inlet to make a stove according to one or more of the preceding claims.

[0024] The fitting can advantageously comprise a choke, a grid, a labyrinth or the like to adjust the ratio of the flue gases reintroduced in the combustion chamber through the primary air inlet of the stove in a simple and effective way.

[0025] It is clear that for all different previously described variations or embodiments, the storage chamber is directly provided under the combustion chamber and the brazier also significantly juts out inside the storage chamber.

[0026] The brazier is well-like, cup-like or bowl-like, the latter being open on the side facing the combustion chamber and jutting out inside the storage chamber under the combustion chamber and which storage chamber constitutes a flue gases and air mixing chamber.

[0027] The flame is generated in this well that has apertures for the primary combustion air intake on the bottom and apertures for the secondary air intake at the end of said brazier, the end facing the combustion chamber and being open towards it, which are essentially coinciding or interfering with the area of said brazier 7 in which the flame is formed.

[0028] An embodiment provides that the storage or mixing chamber of the flue gases with ambient air is separated in two parts of which one directly communicates with the secondary air passage apertures and the other directly with the passage apertures of the primary air and recirculated flue gases.

[0029] In particular, the brazier is a body with a vertical axial extension that ends in a diametrical bottom wall of the combustion chamber and with its upper side open, while the bottom wall, at or immediately near which the inlet apertures of the primary combustion air and recirculation flue gases are provided, ends in the storage or mixing chamber which is under the combustion chamber.

[0030] The primary air supply, together with the unburned flue gases, is supplied to these lower apertures, while the secondary air is supplied through the holes in the upper part of the brazier, which are rather spaced from the bottom wall.

[0031] The figures show different possible variations from which a user can choose.

[0032] The further characteristics and improvements are object of the sub-claims.

[0033] The characteristics of the invention and the advantages deriving therefrom will be much clearer from the following detailed description of the accompanying figures, wherein:

Figure 1 shows a simplified scheme of a stove according to a first embodiment of the invention.
Figure 2 shows an exemplified scheme of a stove according to a second embodiment of the invention.
Figure 3 shows an exemplified scheme of a stove according to a third embodiment of the invention.
Figure 4 shows an exemplified scheme of an embodiment variation of the stove shown in figure 2.
Figure 5 shows an exemplified scheme of an embodiment variation of the stove shown in figure 3.
Figure 6 shows a further embodiment variation that combines the characteristics of the embodiment of figure 1 with those of figures 4 and 5.

[0034] A biomass stove, particularly a pellet stove, typically comprises a compartment or tank, generally loaded from above, that contains the biomass to be burned. It can have a capacity ranging from fifteen and up to sixty or more kilograms depending on the stove model. Inside it, there is an endless screw or auger that drags the pellet from the tank to the inside of the brazier, where the com-

bustible material is burned thanks to the presence of an electric resistance that, becoming incandescent in the start-up step, triggers the flame in the presence of oxygen coming from an external air inlet. The brazier can, for example, be made according to the teachings of the patent IT1428942 of the same Proprietor to be considered an integral part of the present description.

[0035] The flue gases deriving from combustion are channeled in an exhaust flue by an extractor fan.

[0036] The heat produced is diffused in the environment either by natural convection, by forced air with one or more fans that help distribute the hot hair in the adjacent environments and by a heat-transfer fluid that is circulated in an exchanger of the stove to distribute the heat through the exchangers of a heating system.

[0037] The present invention aims to achieve an improvement that allows to reduce the polluting emissions, in particular NO_x, of traditional stoves by acting on the mechanism that adjusts their combustion. The following description will therefore mainly focus on such improvement, leaving out the details concerning the shared operations of these types of stoves, which are well known to the operators.

[0038] With reference to the figures, the biomass stove comprises a combustion chamber 2, an unburned gas storage chamber 3, a flue gas extractor fan device 4 for extracting unburned gas from the storage chamber 3 and for sending it to an exhaust flue 5, and at least one air intake 6 for feeding air from the outside to the inside of the combustion chamber 2.

[0039] The combustion chamber 2 in turn comprises a brazier area 7 adapted to receive the biomass and to generate combustible gas and a flame area 8 intended for the combustion of combustible gas coming from the brazier area 7.

[0040] There is a first series of apertures 107 at the brazier area 7 for supplying primary gas and a second series of apertures 108 at the flame area 8 for supplying secondary gas.

[0041] Purpose of the primary gas is to transform the biomass into gases intended to be burned in the flame area thanks to the comburent action exerted by the oxygen present in the secondary gas, typically air.

[0042] As shown in the figures, in the exhaust circuit there is a branch 9 intercepting the flue gases directed to the exhaust flue 5 such to at least partially direct said flue gases to the primary gas inlet apertures 107.

[0043] Thanks to this, it is possible to control the reaction of the transformation of the biomass into combustible gas, i.e. the pyrolytic step of the combustion.

[0044] A mixing chamber 10 containing, at least partially, a combustion chamber 2, as shown in the figures, is advantageously present. In alternative, the mixing chamber can be a compartment separate from the combustion chamber and communicating therewith.

[0045] The mixing chamber 10 is in fluid dynamic communication with at least the primary gas inlet apertures 107 and the flue gas intercepting branch 9 to introduce unburned gas, pure or mixed with air coming from outside, into the brazier area 7.

[0046] In the embodiment shown in figure 1, the mixing chamber 10 has an inlet 110 for flue gases coming from the branch 9 and an inlet for the external air 6. The inlet for the flue gases 110 is advantageously provided at the apertures 107 of the brazier area 7 while the air inlet 6 is provided at the apertures 108 of the flame area 8 such that the fuel gases/air mixture reaching the apertures 107 of brazier area 7 has a stoichiometric content different from that of the flue gases/air mixture reaching the apertures 108 of the flame area 8.

[0047] This way, with a simple geometrical arrangement, it is possible to adjust the quantity of flue gas reaching the primary gas inlet apertures 107. More complex solutions are obviously possible. For example, it is possible to include electronically controlled on/off valves able to set with precision the air/flue gases ratio to be sent to the brazier area and/or to the flame area.

[0048] According to the variation shown in figure 2, the mixing chamber 10 is divided in two parts 210, 310 not in communication, for example through a septum. The first part of the mixing chamber 201 is in fluid dynamic communication with the apertures 107 of the brazier area 7 and the intercepting branch 9 of the flue gas while the second part of the mixing chamber 310 is in fluid dynamic communication with the apertures 108 of the flame part 8 and the external air 6.

[0049] This way, the flue gases directed into the mixing chamber 10 only reach the primary gas inlets without acting on the secondary gas inlets. This allows to act with even more precision on the pyrolytic step of the combustion.

[0050] In the variation shown in figure 3, the flue gas intercepting branch 9 has an inlet 109 for the external air such that intercepted flue gases are mixed with the external air before entering the first part of the mixing chamber 210 without altering the oxygen content present in the primary gas.

[0051] In the configurations shown in figures 1 to 3, the flue gas intercepting branch 9 is placed outside of the stove on a duct 12 that puts in communication the extractor fan device 4 with the exhaust flue 5. This is particularly advantageous in case of the retrofit of existing stoves.

[0052] In more compact solutions, the flue gas intercepting branch 9 is placed inside the stove body downstream the extractor fan device 4.

[0053] In the example shown in figures 4 and 5, the extractor fan device 4 and the flue gas intercepting branch 9 are housed within a compartment 11 inside the stove adjacent to the mixing chamber 210.

[0054] In specifics, the first part of the mixing chamber 210 is adjacent to the compartment 11 housing the extractor fan device 4 and has an aperture for the inflow of flue gases coming from the branch 9.

[0055] The first part 210 of the mixing chamber 10 can be closed as shown in figure 4, or have an aperture 110

towards the outside for the inflow of air as shown in figure 5.

[0056] These two last figures show the configuration with the mixing chamber divided in two parts, but obviously the solution with the internal branch can also be applied in the single mixing chamber configuration as shown in figure 6, in which equal parts or with functions identical to those of the embodiments of the preceding figures are denoted by the same reference numbers.

[0057] The flue gas intercepting branch 9 can advantageously comprise a choke, a grid, a labyrinth or the like that in a fixed or variable geometrical manner defines the percentage of flue gases to be directed into the mixing chamber 10.

[0058] Still according to a characteristic of improvement, the inlet of the branch 9 for the flue gas recirculation flow is advantageously provided at a point of the flue gas path in which there is an overpressure compared to the existing pressure inside the flue gas path in the stove. In particular, in the stoves described, generally, the flue gas path from the combustion chamber to the chimney flue itself is in depression, while in the volute of the extractor fan 4 and in the immediate vicinity of the delivery mouth thereof, an overpressure condition is generated, therefore according to a further embodiment of the invention that can be provided in combination with any one of the preceding variations described, the inlet of said branch 9 is provided at said volute of the extractor fan or immediately downstream the delivery mouth thereof. An embodiment provides that said inlet of the branch 9 for the collection of the recirculation flue gases is provided approximately in the maximum overpressure area generated by the extractor fan and, in particular, at a distance not greater than 10-15 mm from the delivery mouth.

[0059] Thanks to this arrangement, the further advantage of making the recirculation system independent of the contingent installation conditions of the chimney flue and of the specific draft of the chimney flue is obtained. This characteristic varies a lot from installation to installation and would therefore require a fine and dedicated setting for each recirculation system.

[0060] The extractor fan device 4 can advantageously be driven by a control unit able to set the flow rate of the flue gases intercepted by the branch 9, for example to adjust the air and recirculation flue gas supply with respect to the combustion process conditions.

[0061] With regard to the aforesaid possibility to adjust the comburent air supply, it was possible to detect that the ideal conditions for obtaining an Nox reduction effect consist in adjusting the mixing ratio of the comburent air to recirculation flue gases so that to determine an oxygen content of the air and recirculation flue gas mixture present in the mixing chamber between 9 and 18% by volume. Better effects are achieved in the narrower range of oxygen content that is preferably between 11 and 16% by volume. The maximum efficiency of Nox content reduction in flue gases is obtained by setting the mixing between comburent air and recirculation flue gases so that to cause an oxygen content of the mixture in the mixing chamber between 13 and 14% by volume.

Claims

1. Biomass stove (1) comprising a combustion chamber (2), an unburned gas storage chamber (3), a flue gas extractor fan device (4) for extracting unburned gas from the storage chamber (3) and for sending it to an exhaust flue (5), at least one air intake (6) for feeding air from the outside to the inside of the combustion chamber (2), wherein the combustion chamber (2) comprises a cup-like or bowl-like brazier area (7) adapted to receive the biomass and to generate combustible gas and a flame area (8) intended for the combustion of the combustible gas coming from the brazier area (7), wherein the combustion chamber (2) comprises a first series of apertures (107) at the bottom area of said brazier (7), optionally in the bottom wall or in the side walls directly adjacent to said bottom wall, for supplying primary gas, in particular ambient air, and a second series of apertures (108) at said flame area (8), i.e. of the upper end of said brazier (7), which is open towards an upper part of the combustion chamber, for supplying secondary gas, **characterized in that** it comprises a branch (9) intercepting the flue gases directed to the exhaust flue (5) such to at least partially direct said flue gases to the primary gas inlet apertures (107).

2. Stove (1) according to claim 1, wherein there is a mixing chamber (10), which mixing chamber (10) is in fluid dynamic communication with at least the primary gas inlet apertures (107) of the bottom area of the brazier (7) and the flue gas intercepting branch (9) to introduce unburned gas, pure or mixed with ambient air coming from outside in the brazier area (7) .

3. Stove (1) according to claim 1 or 2, wherein the mixing chamber (10) has an inlet (110) for flue gases coming from the branch (9) and an external air inlet (6), the flue gas inlet (110) being provided at the apertures (107) of the brazier area (7) and the air inlet (6) being provided at the apertures (108) of the flame area (8) such that the flue gases/air mixture reaching the apertures (107) of the brazier area (7) has a stoichiometric content different from that of the flue gases/air mixture reaching the apertures (108) of the flame area (8).

4. Stove (1) according to one or more of the preceding claims, wherein the mixing chamber (10) is divided in two parts (210, 310) not in direct communication with each other, i.e. whose shared separation walls do not have apertures flowing directly into one or the other chamber, wherein the first part of the mixing

chamber (210) is in direct fluid dynamic communication with the apertures (107) of the brazier area (7) and the flue gas branch (9) and the second part of the mixing chamber (310) is in direct fluid dynamic communication with the apertures (108) of the flame part (8) and the external ambient air (6).

5. Stove (1) according to claim 4, wherein the flue gas branch (9) has an external air inlet (109) such that the intercepted flue gases are mixed with the external air before entering the first part of the mixing chamber (210).

6. Stove (1) according to one or more of the preceding claims, wherein the flue gas intercepting branch (9) is placed outside of the stove on a duct (12) that puts in communication the extractor fan device (4) with the exhaust flue (5).

7. Stove (1) according to one or more of the preceding claims, wherein the flue gas intercepting branch (9) is placed inside the stove body downstream the extractor fan device (4).

8. Stove (1) according to claim 7, wherein the extractor fan device (4) and the flue gas intercepting branch (9) are housed within a compartment (11) inside the stove adjacent to the mixing chamber (210).

9. Stove (1) according to claim 7 or 8, wherein the first part of the mixing chamber (210) is adjacent to the compartment (11) housing the extractor fan device (4) and has an aperture for the inflow of flue gases coming from the branch (9).

10. Stove (1) according to claim 9, wherein the first part of the mixing chamber (210) has an aperture (110) to the outside for letting air in.

11. Stove (1) according to one or more of the preceding claims, wherein the flue gas intercepting branch (9) comprises a choke, a grid, a labyrinth or the like that, in a fixed or variable geometrical manner, defines the percentage of flue gases to be directed into the mixing chamber (10).

12. Stove (1) according to one or more of the preceding claims, wherein the extractor fan device (4) is driven by a control unit able to set the flow rate of flue gases intercepted by the branch (9).

13. Stove according to one or more of the preceding claims, comprising adjusting means to adjust the oxygen content of the air and recirculation flue gas mixture ranging from 9 to 18% by volume, preferably from 11 to 16% by volume, and especially from 13 to 14% by volume.

14. Stove according to one or more of the preceding claims, wherein the inlet of the recirculation flue gas branch (9) is provided on the volute of the extractor fan or at the delivery outlet thereof, and anyway in a flue gas flow area wherein there is overpressure due to the action of the extractor fan (4).

15. Kit for biomass stoves, particularly pellet stoves, equipped with a flue gas outlet for the connection to an exhaust flue, a primary air inlet and a secondary air inlet in fluid dynamic communication with a brazier area and a flame area of a combustion chamber respectively, **characterized in that** it comprises a fitting intended for the connection of the flue gas outlet with the exhaust flue and with the primary air inlet to make a stove according to one or more of the preceding claims.

16. Kit according to claim 15, wherein the fitting comprises a choke, a grid, a labyrinth or the like to adjust the ratio of flue gases reintroduced in the combustion chamber through the primary air inlet of the stove.

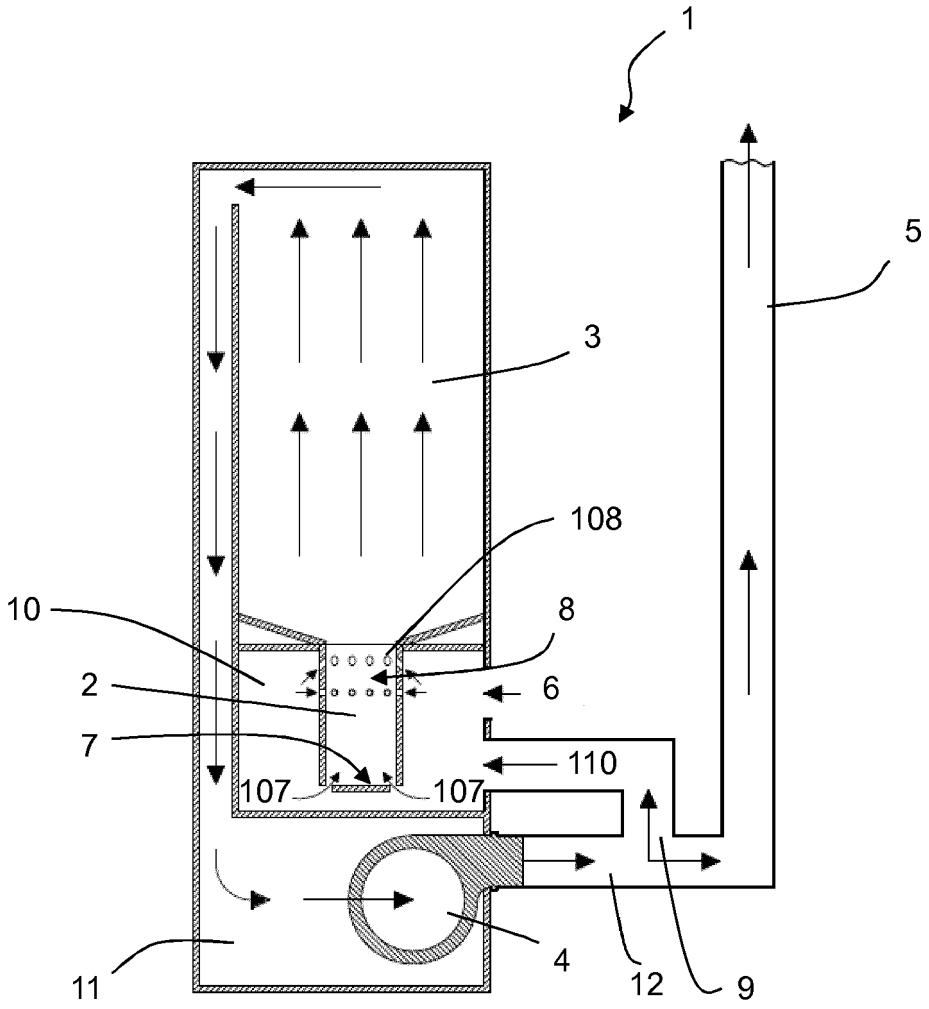

Fig. 1

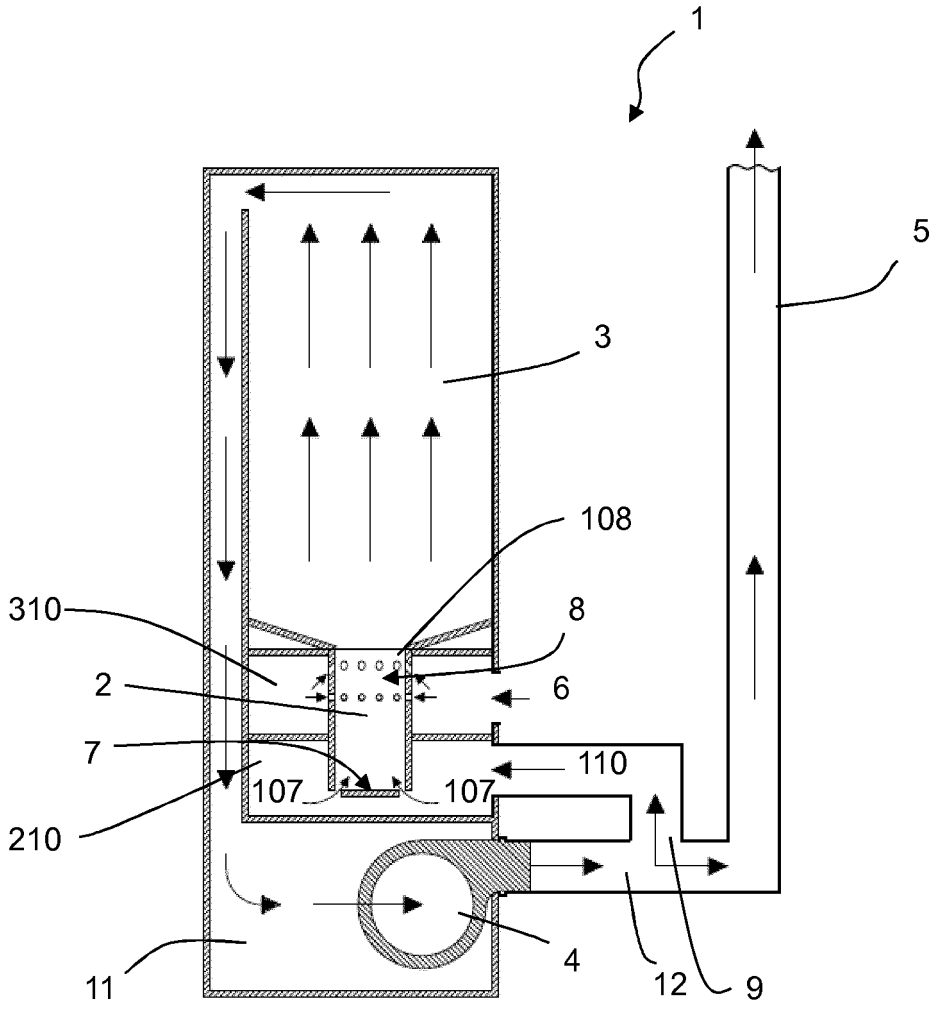

Fig. 2

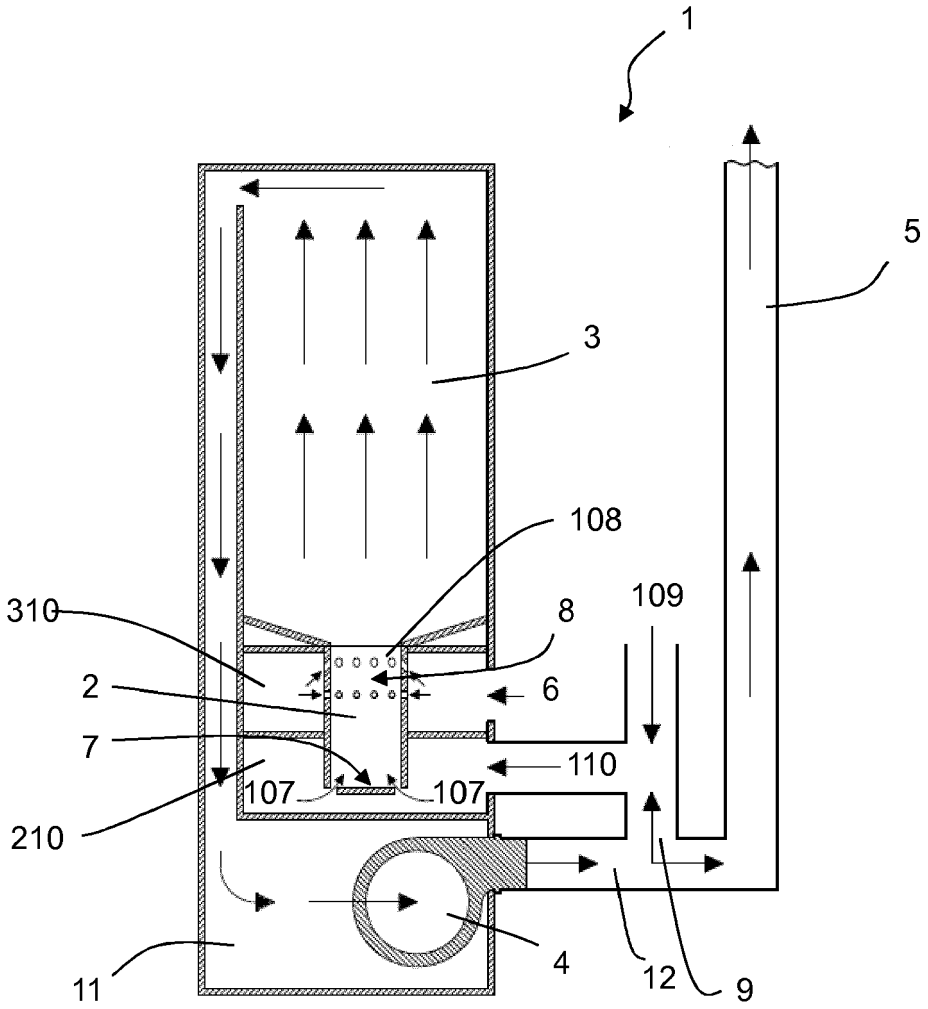

Fig. 3

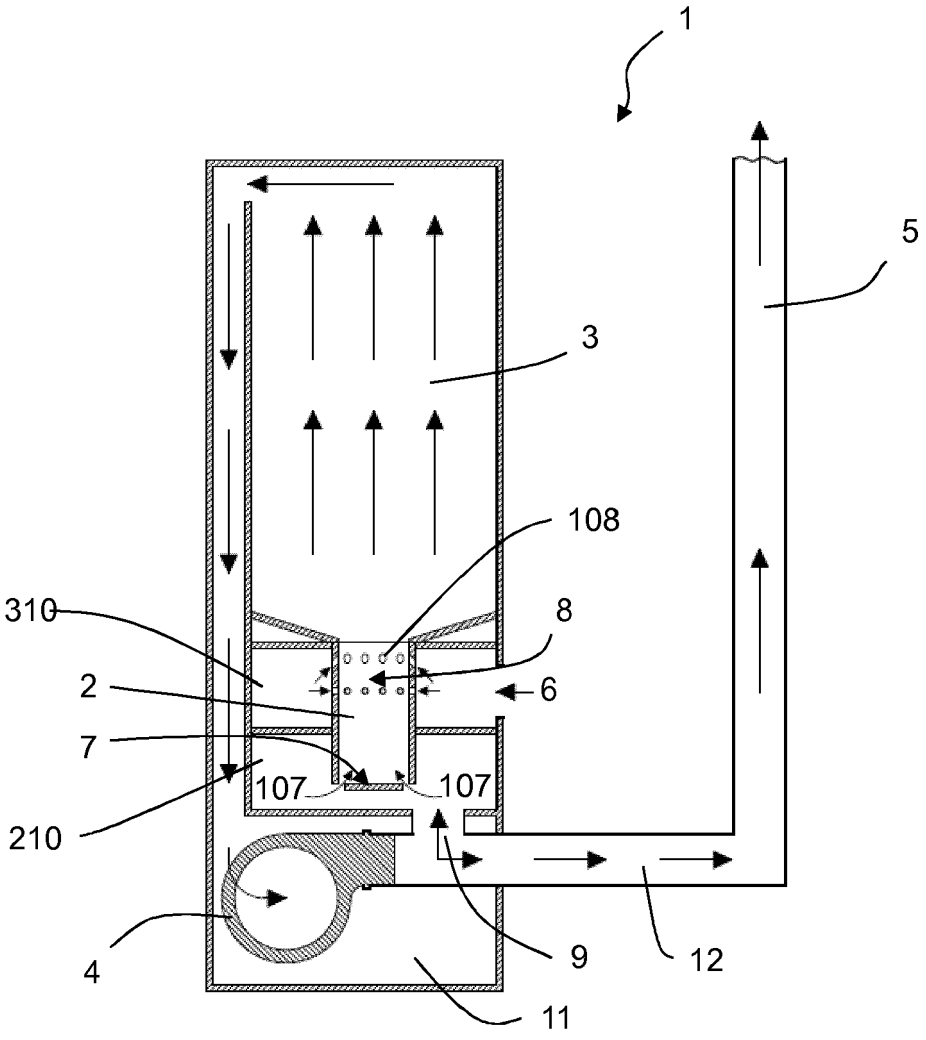

Fig. 4

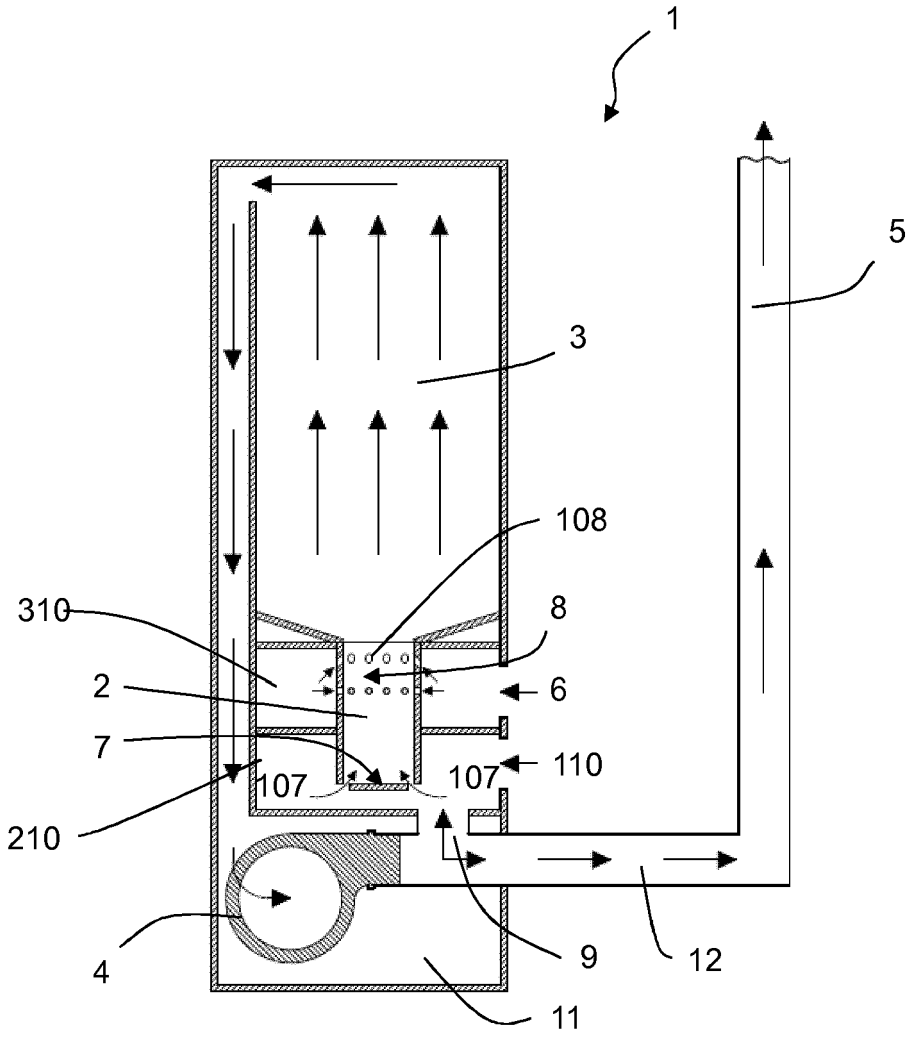

Fig. 5

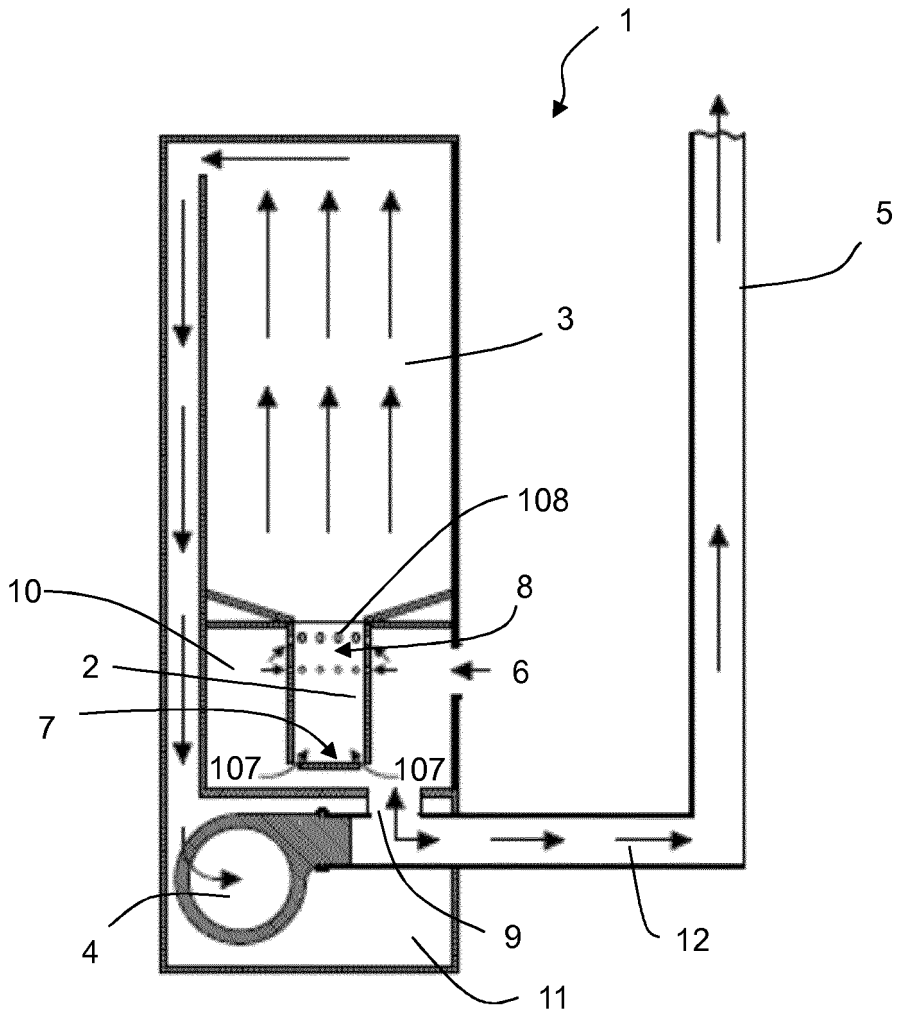

Fig. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 18 20 9730

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	DE 20 2006 007860 U1 (PAUL KUENZEL GMBH & CO [DE]) 21 September 2006 (2006-09-21) * paragraph [0035]; figure 1 *	1-14	INV. F24B1/02 F24B5/02 F23B80/02
X	WO 83/00373 A1 (HULTGREN KARL S H) 3 February 1983 (1983-02-03)	15,16	
A	* page 8, paragraph 2; figure 1 *	1-14	
X	KR 101 658 559 B1 (KIM JONG RACK [KR]) 21 September 2016 (2016-09-21) * figures 2,4 *	15,16	
Y	CN 205 102 178 U (WANG LIJUN) 23 March 2016 (2016-03-23) * figure 1 *	3	
A	WO 98/19108 A1 (HERLT CHRISTIAN [DE]) 7 May 1998 (1998-05-07) * the whole document *	1	
A	DE 10 2011 109780 B3 (B & 0 SAATINVEST HEIZHAUS OHG [DE]) 31 January 2013 (2013-01-31) * the whole document *	1	TECHNICAL FIELDS SEARCHED (IPC) F24B F23B
A	FR 2 752 915 A1 (MIQUEE MAX [FR]) 6 March 1998 (1998-03-06) * the whole document *	1	
Y	US 4 438 756 A (CHAMBERLAIN JOSEPH G [US] ET AL) 27 March 1984 (1984-03-27) * column 2, lines 10-13; figure 7 *	1-14	
Y	KR 2014 0001316 A (KOREA ENERGY RESEARCH INST [KR]) 7 January 2014 (2014-01-07) * paragraphs [0027], [0028]; figure 4 *	1-14	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	4 April 2019	Rodriguez, Alexander

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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