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(54) Secondary tube combustion chamber located in the primary combustion chamber of a solid biofuel gasification boiler

(57) The invention concerns boiler for solid biofuels of the interjacent or upper combustion type, see figures 8 and 9 respectively.

A secondary combustion chamber (2) is located within the primary combustion chamber (3) and consists of a temperature resistance tube with sufficient length and cross section. The tube (2) extends in the primary combustion chamber (3) in such a way, that it exposes the maximum outer surface to the hot exhaust gases and flames and being closed to the surface of the combusted biofuel (4), (5) in the primary combustion chamber (3).

Within the tube (2) the primary combustion gases enter forcibly along with the secondary combustion air "S", which enters in the form of a high-speed jet, while the primary combustion air "P" is inserted in the primary combustion chamber (3).

The hot gases are lead from the exit of the secondary chamber (2) to the heat exchangers (1) of the boiler.

The particular this configuration achieves very good combustion efficiency, satisfying the three conditions of combustion, i.e.Temperature, since tube (2) is heated externally by the pyrolized mass and the combustion gases, Turbulence, since passing the exhaust gases within the narrow and long tube (2) are compulsory mixed with the secondary combustion air and finally Time, since the tube has adequate length to ensure enough combustion time.

Measurements carried out on experimental boiler based on the invention, showed values of pollutants CO2 = 16%, CO= 200ppm, 02 = 14.9%, which are within the limits established under more stringent EU, to take effect after 2017.

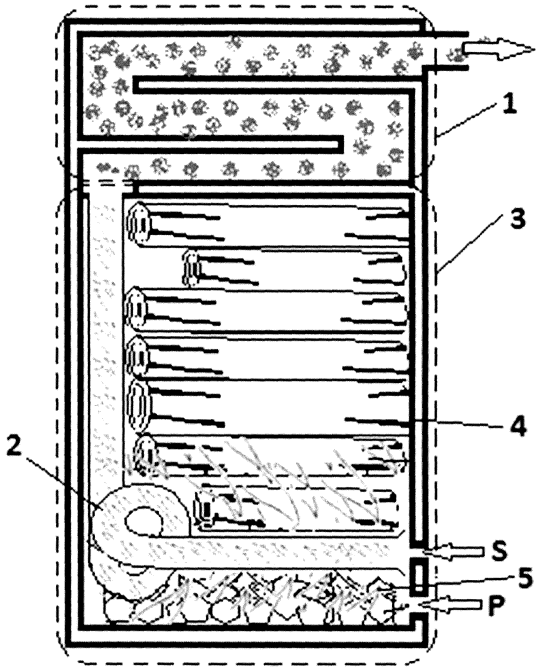

Figure 8

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Description

[0001] According to the science level, the solid biofuels combustion takes place in three basic styles. Firstly at the upper combustion (oberer Abbrand), in accordance with figure 1, the interjacent combustion (Durchbrand), figure 3 and the down or reverse combustion (unterer Abbrand), figure 6.

[0002] All combustion techniques can be implemented with natural or forced air adduction, where in the figures, "P" is the primary (primar) air and "S» is the secondary (sekundar) air. The forced air discharge provides better control and combustion stability and is achieved either through an air supply fan or via a suction exhaust fan at the end of the gas path.

[0003] Generally the combustion of solid biofuels is a heterogeneous process carried out and separated into distinct stages. As to the venue of combustion, this is separated into primary and secondary. The primary combustion takes place on grille and refers directly to the solid biofuel. The rate of the primary combustion shall be determined directly from the primary air supply, i.e. from the imported air in the primary combustion chamber. The entry of the primary air is done either on the grille, cases of upper combustion figure 1 and reverse combustion figure 6, or through the grille, case of interjacent combustion figure 3.

[0004] The exhaust gases produced during the primary combustion mostly contain combustible gases, such as carbon monoxide and hydrocarbons. These exhaust gases need to be burned further in the secondary combustion chamber by using the secondary air. Therefore the secondary combustion refers to the exhaust gases, produced by the primary combustion and not directly to the solid biofuel.

[0005] Generally the necessary and satisfactory conditions for a successful secondary combustion, as defined in the international literature are as follows: Temperature, Turbulence and Time, i.e. a high temperature is required in the secondary combustion chamber (Temperature), sufficient exhaust turbulence for mixing them with the secondary air (Turbulence) and sufficient delay time in the secondary combustion chamber (Time).

[0006] In figures 2, 4 and 7 representative boilers are presented, based on the three basic styles of combustion as follows, in figure 2 a boiler of upper combustion, in figure 4 a boiler of interjacent combustion and in figure 7 a boiler of reverse combustion All boilers, figures 2, 4, 7, are divided into three particular parts, the primary combustion chamber (3), bounded by the space that includes the combusted material along with the flaming exhaust, the secondary combustion chamber (2), bounded by the area that receives the fuel combustion exhaust gases from the primary chamber and running the ignition and combustion and the exhaust gas heat exchanger (1), bounded by the area that receives the exhaust gases from the secondary chamber and which brings them into contact with the surfaces of heat transaction of the boiler. The combusted solid biofuel (4) is located in each case, within the primary combustion chamber, where the already pyrolized biofuel (5) namely incandescent coals is located on the base. The position of entering the primary air is marked with "P" and that of the secondary air with "S." The upper combustion and the interjacent combustion boiler are characterized, as it is obvious in the figures 2 and 4, by the lack of a well framed secondary chamber. In that case the secondary combustion takes place in sequence with the primary one, but at a higher level in the primary combustion chamber. The unclear distinction between the two chambers is a disadvantage indeed, where the three rules of successfully combustion, namely Temperature, Turbulence and Time would be difficult to meet. The burning success considerably depends also on the type and quality of the biofuel. So, biofuel free of moisture and in bulk form will burn more easily and more efficiently than compact firewood. In the case of the use of compact firewood, the reverse combustion style boiler with its independent secondary combustion chamber shows better combustion and performance results, but it is not suitable for burning biofuel in bulk form.

[0007] One form of an interjacent high powered biofuel boiler is shown in Figure 5, which features also a separate secondary combustion chamber (2) and presents better combustion results. Reference for the particular boiler is taken from the publication "Emissionsminderung Maßnahmen zur feuerungsseitigen bei der gewerblichen Holzverbrennung in Feuerungsanlagen, Bericht Nr. 50-2002, Universität Stuttgart, Institut fur Verfahrenstechnik und Dampfkesselwesen Reinhaltung der Luft - '.The possibility of recirculation of the exhaust gases, which potentially exists in the boiler of the figure 5, is not considered nor evaluated in the context of this science level descriptor.

[0008] According to the invention, a solid biofuel boiler of upper or interjacent combustion type is used, with a secondary combustion chamber located in the primary combustion chamber, consisting of a temperature resistance non insulated tube, in which the primary combustion gases are compulsory entering, as well as the secondary air, so ultimately takes place in the tube the secondary combustion. Figure 8 shows a representative upper combustion type boiler in accordance with the invention; while in figure 9 respectively an interjacent combustion type boiler is presented, according again to the invention. In correspondence with all boilers of this technical description, the parts of the boiler according to the invention, are the same, namely the primary combustion chamber (3), bounded by the space that includes the combusted material along with the flaming exhaust, the secondary combustion chamber (2), bounded by the tube according to the invention, that receives the fuel combustion exhaust gases from the primary chamber and running the ignition and combustion, the exhaust gas heat exchanger (1), bounded by the area that receives the exhaust gases from the secondary chamber and brings them into contact with the surfaces of heat transaction of the boiler,

the combusted solid biofuel material (4) which is already within the primary combustion chamber and the already pyrolized biofuel (5), namely incandescent coals.

[0009] The position of entry of the primary air is marked with "P" and that of the secondary air with "S." The secondary tube combustion chamber is dimensioned in cross-section and length according to the heat power and the solid biofuel type of each boiler. The use of the secondary tube combustion chamber (2) rapidly improves the combustion performance of an interjacent or upper brand boiler type, while simultaneously satisfies the conditions of successful combustion, i.e.Temperature, since it's heated externally by the pyrolized mass and the combustion gases, Turbulence, since passing the exhaust gases within the narrow and long tube are compulsory mixed with the secondary combustion air and finally Time, since the tube has adequate length to offer to the combustion enough time. The secondary air should enter the tube as a jet at a high speed, or as multiple jets, in order to achieve good mixing with the exhaust gases. The entry of the secondary tube chamber (2), as shown in the figures 8 and 9, is close to the walls of the primary combustion chamber and at a short distance from them so the incoming secondary air "S" enters immediately and without losses in the tube. The exhaust gases, after burning secondary in the tube chamber (2), are driven to the heat exchanger of the boiler (1).

[0010] The secondary tube combustion chamber (2), within the primary combustion chamber (3), must show the maximum outer surface, free and coming into contact with the hot exhaust gas, the flames and the combusted biofuel (4) and (5) of the primary combustion. Usually the required length of the tube (2) is greater than the length of the primary combustion chamber (3), so it is extended within the primary combustion chamber in every possible way and always under the criterion of maximum external surface for heat transaction. According to figure 10, there is the possibility of placing part of the tube on its finished edge, in an independent place within the primary combustion chamber, point (6) of figure (10), servicing purposes of planning and mechanical protection of the tube. The other parts of the boiler in figure (10) follow the same labels as all other boilers of this description, i.e. position (1) exhaust gas exchanger, position (2) secondary combustion chamber - tube according the invention, location (3) primary combustion chamber, position (4) combusted solid biofuel, position (5) incandescent coals.

[0011] The secondary tube combustion chamber which can bring internal layout to improve exhaust turbulence is profiled to circular, rectangular or ellipsoid, orthogonal, diamond or even can alter its cross-section in terms of shape and surface.

[0012] In a sufficiently large primary combustion chamber (3) many independent secondary tube combustion chambers (2) could be supported, where many secondary combustions would be held at the same time within the primary combustion chamber. Also, within the primary combustion chamber (3), the secondary tube combustion chamber (2) could be dichotomized, broke in parts and multi divaricated into smaller tubes, where each one is located and is extended within the primary combustion chamber.

[0013] In each case, all placement conditions, in accordance with the preceding paragraphs, are applying.

[0014] To get an idea about the size and position of a secondary tube combustion chamber, and on the basis of preliminary research and experiments conducted on a solid fuel boiler of upper combustion type, powered with 25 KW and length of primary combustion chamber of 500 mm, a secondary tube combustion chamber of 100 mm diameter and 1500 mm length was needed. The tube initially came through the entire length of the primary chamber and subsequently was placed spiraling at the end of this.

[0015] Alternatively you may enter only the secondary air "S» via a blower and the primary "P" is sucked out naturally from the environment, due to the negative pressure (phenomenon Injector) developed in the primary combustion chamber.

[0016] In this case, due to the negative pressure within the primary combustion chamber (3), a controlled exhaust gas recirculation out of the secondary tube chamber to the primary combustion chamber (3) may be created, a recirculation that under specific terms and conditions may be desired.

[0017] Measurements taken from an experimental upper combustion boiler, according to the invention, was CO2 = 16%, CO= 200ppm, 02 = 14.9%, which satisfy all the established emissions in EU to take effect after 2017.

Claims

1. Solid biofuel boiler of upper type combustion (figure 8), or interjacent type combustion (figure 9), with generally mechanical air intake, where "P" is the primary combustion air and "S" the secondary, (1) the exhaust gas heat exchanger, (2) the secondary combustion chamber, (3) the primary combustion chamber, (4) the combusted solid biofuel material and (5) the active charcoal of the combusted material, aforesaid boiler is **characterized by** the placement within the primary combustion chamber (3), of a temperature resistance tube (2), located throughout the length of the chamber (3), thus in order to achieve the maximum transaction surface between the external surface of the located tube (2) and the flame, exhaust gases and combusted biofuel (4), (5) of the primary combustion, i.e. to show the tube (2) throughout its extended length within the primary combustion chamber (3), the maximum free outer surface exposed and supplied from the hot exhaust gases, the flames and the combusted biofuel mass (4), (5), where into the aforesaid tube (2) the secondary combustion air "S" enters in the form of a high-speed jet, while the primary combustion air "P"

is inserted in the primary combustion chamber (3) and where into the aforesaid tube (2) the combustion gases from the primary combustion forcibly enter, so that ultimately the secondary combustion is conducted in the tube (2) and further the tube (2) establishes an independent secondary combustion chamber (2) within the primary combustion chamber (3), leading with its exit the produced hot exhaust gases to the heat exchangers (1) of the boiler.

2. Solid biofuel boiler, according to claim 1, (figure 10) **characterized by** placing part of the secondary tube combustion chamber (2) within an independent space (6) within the primary combustion chamber (3).

3. Solid biofuel boiler, according to claim 1, **characterized by** the natural unforced entry of the primary combustion air "P", due the negative pressure created in the primary combustion chamber (3) by the injector (high speed air jet) entry of the secondary combustion air "S" within the tube (2).

4. Solid biofuel boiler, according to claim 1, **characterized by** the entry of the secondary combustion air "S" through more than one air jets.

5. Solid biofuel boiler, according to claim 1, **characterized by** the change in the cross-section of the secondary tube combustion chamber (2) over its length.

6. Solid biofuel boiler, according to claim 1, **characterized by** internal configuration in the secondary tube combustion chamber (2), for the augmentation of the turbulence created.

7. Solid biofuel boiler, according to claim 1, **characterized by** a secondary tube combustion chamber (2) from a cross section of any geometrical shape.

8. Solid biofuel boiler, according to claim 1, **characterized by** the existence of more than one secondary tube combustion chambers (2).

9. Solid biofuel boiler, according to claim 1, **characterized by** the exhaust gases recirculation from the secondary tube combustion chamber (2) to the primary combustion chamber (3), through appropriate openings in the tube (2), provided that the primary combustion chamber (3) is in vacuum.

10. Solid biofuel boiler, according to claim 1, **characterized by** fragmentation and divarication of the secondary tube combustion chamber (2) in smaller cross-section tubes within always the primary combustion chamber (3).

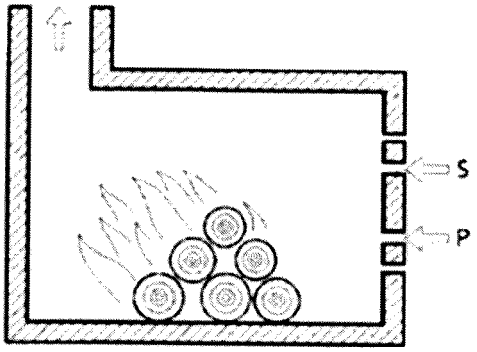

Figure 1

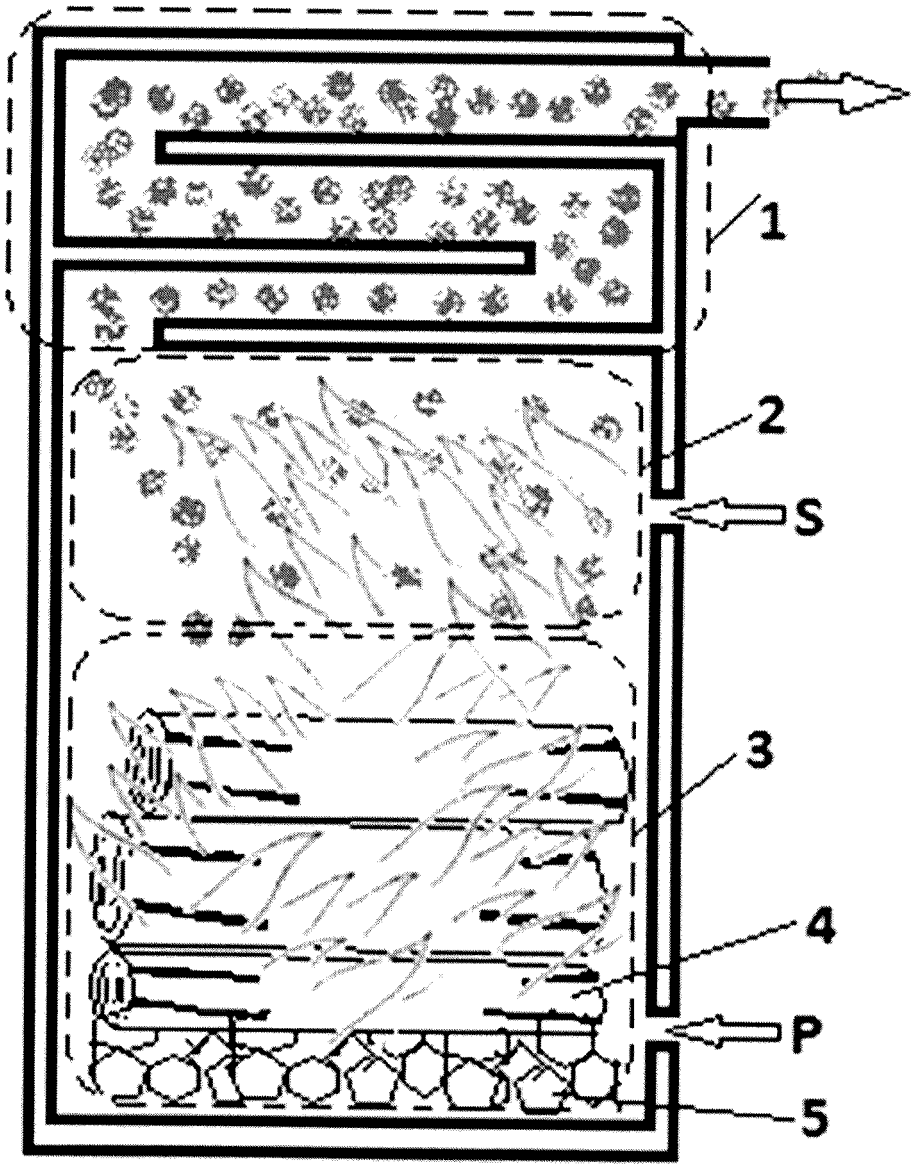

Figure 2

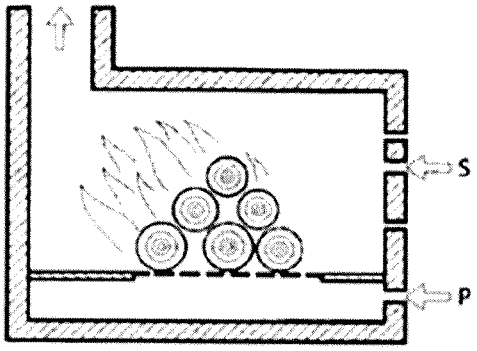

Figure 3

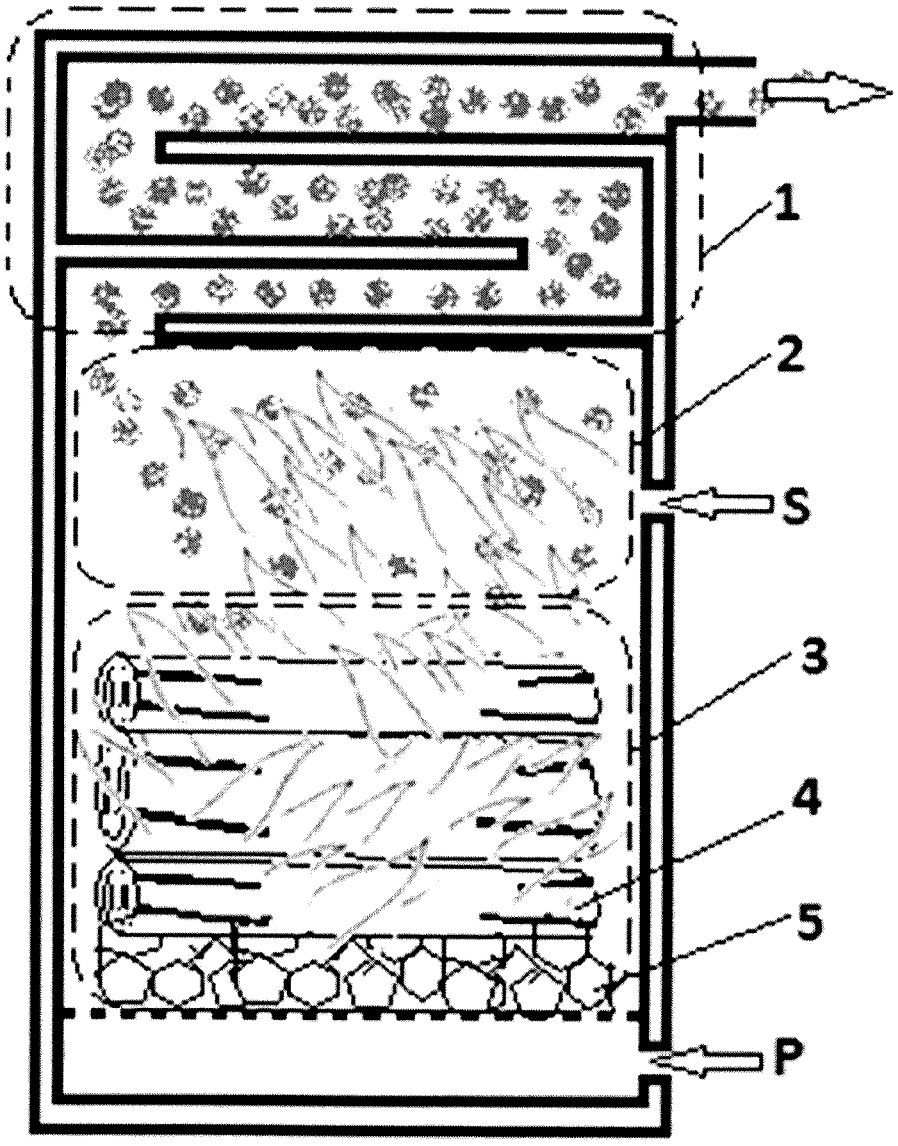

Figure 4

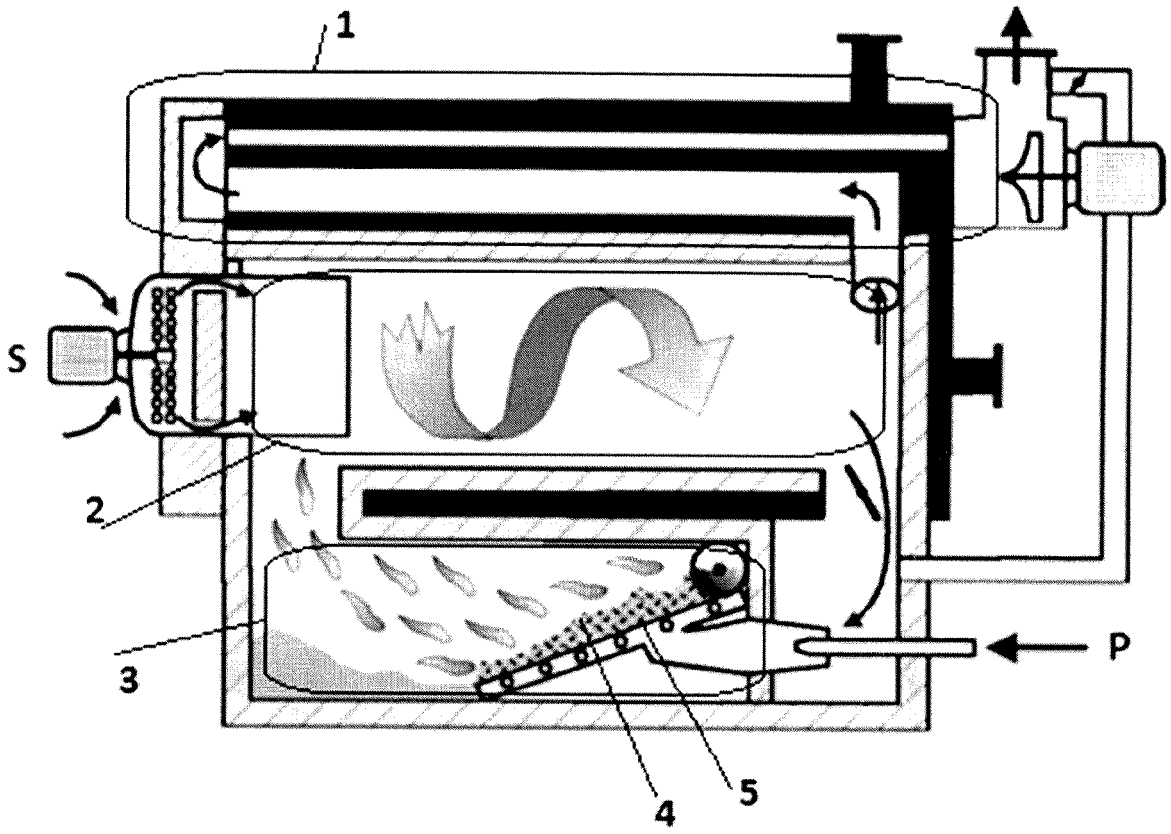

Figure 5

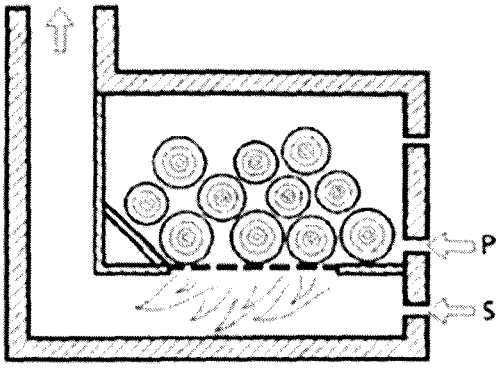

Figure 6

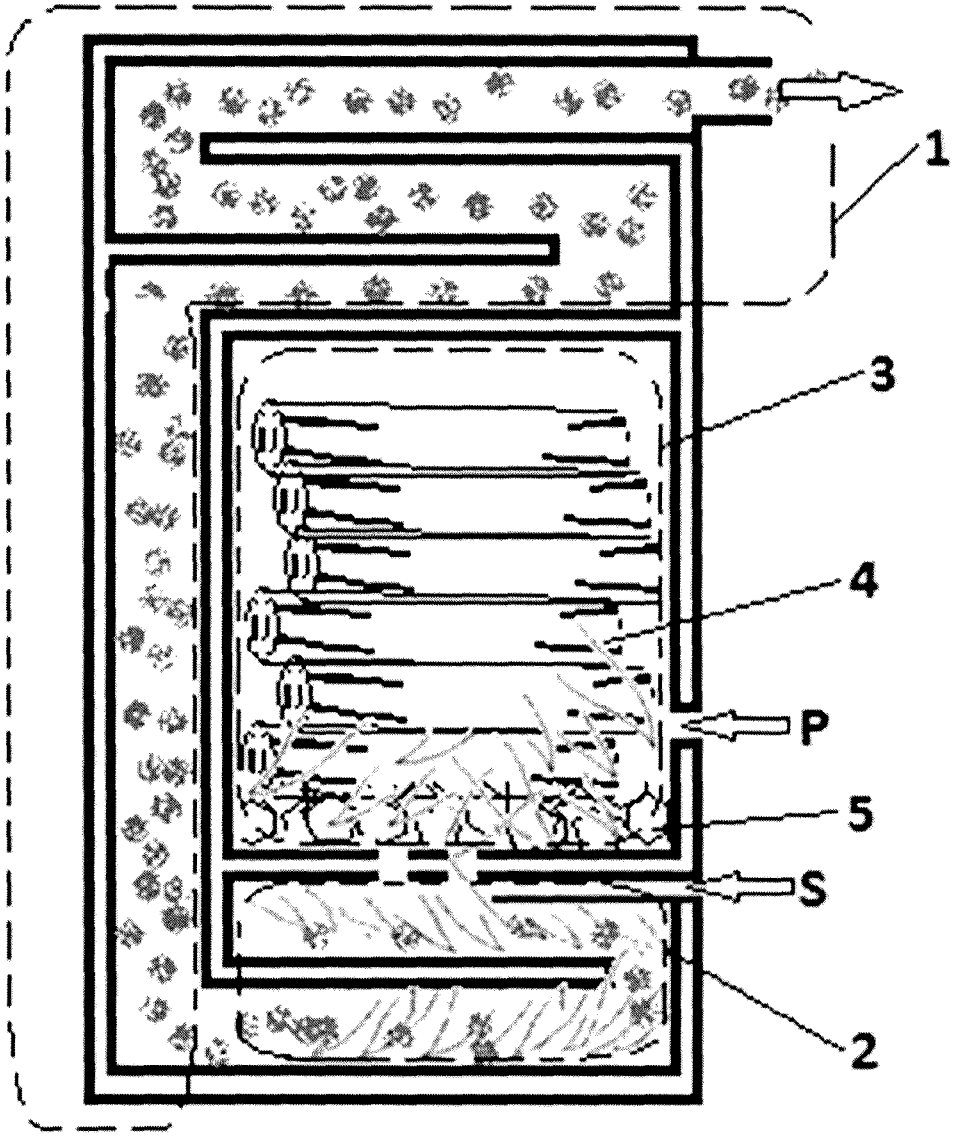

Figure 7

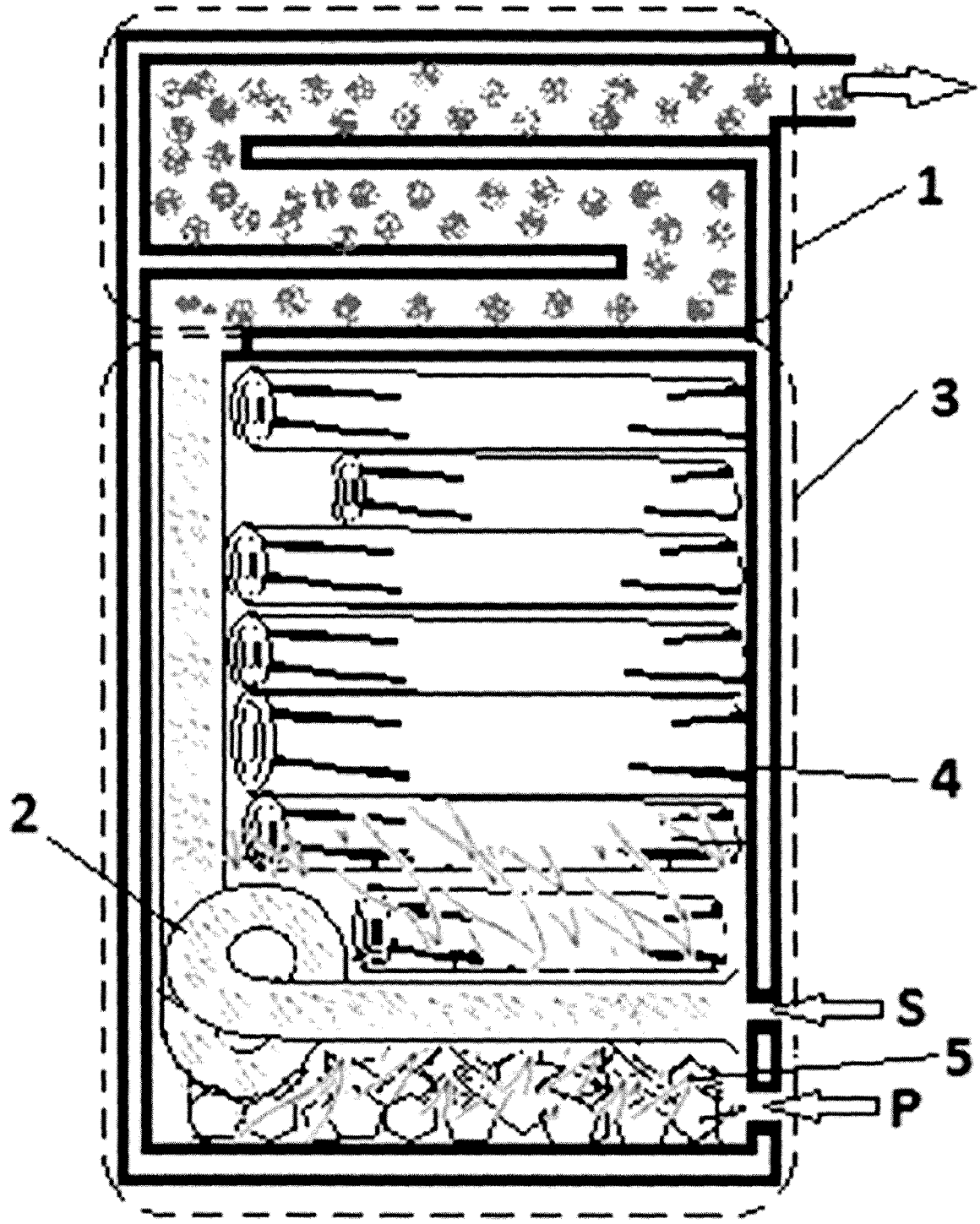

Figure 8

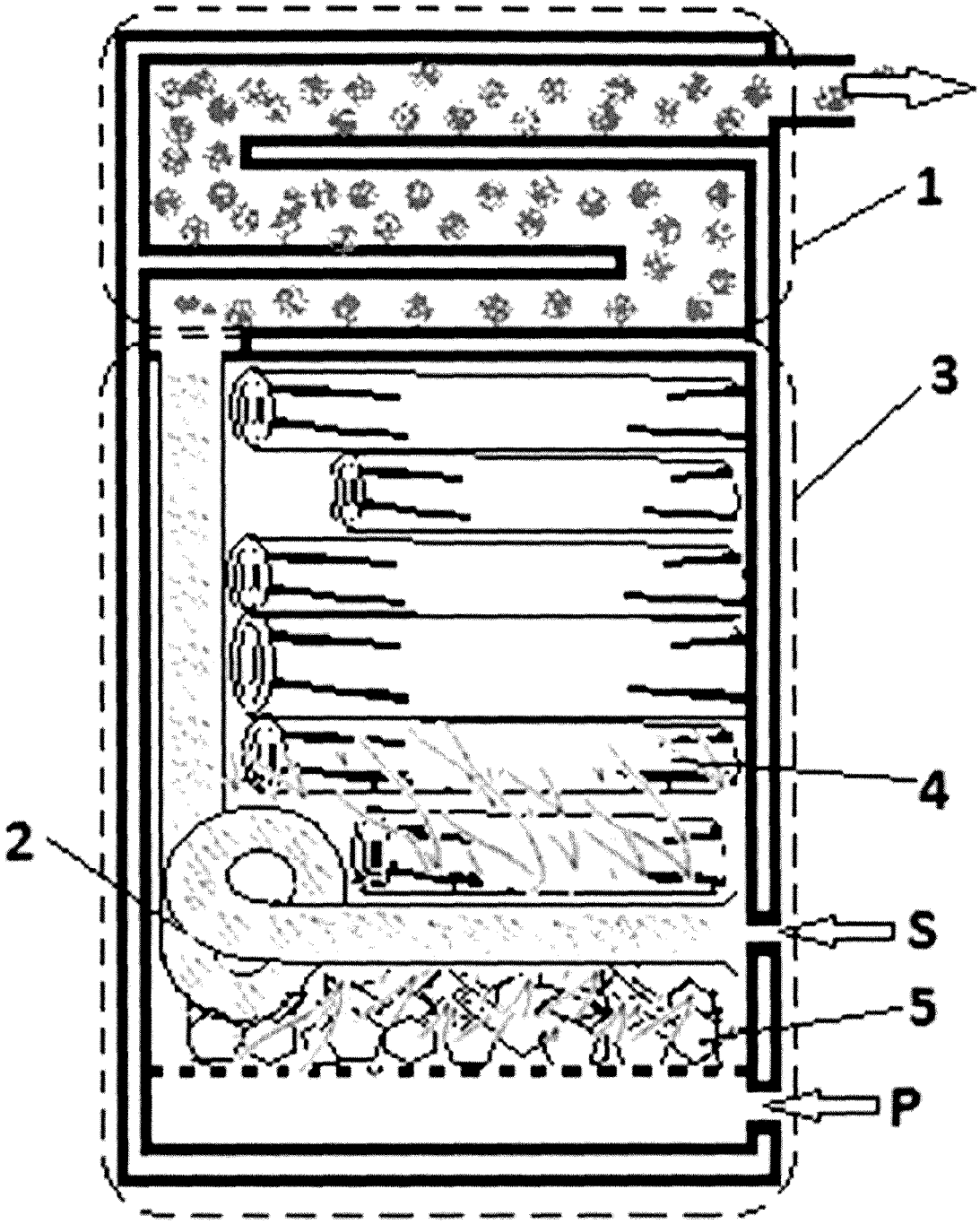

Figure 9

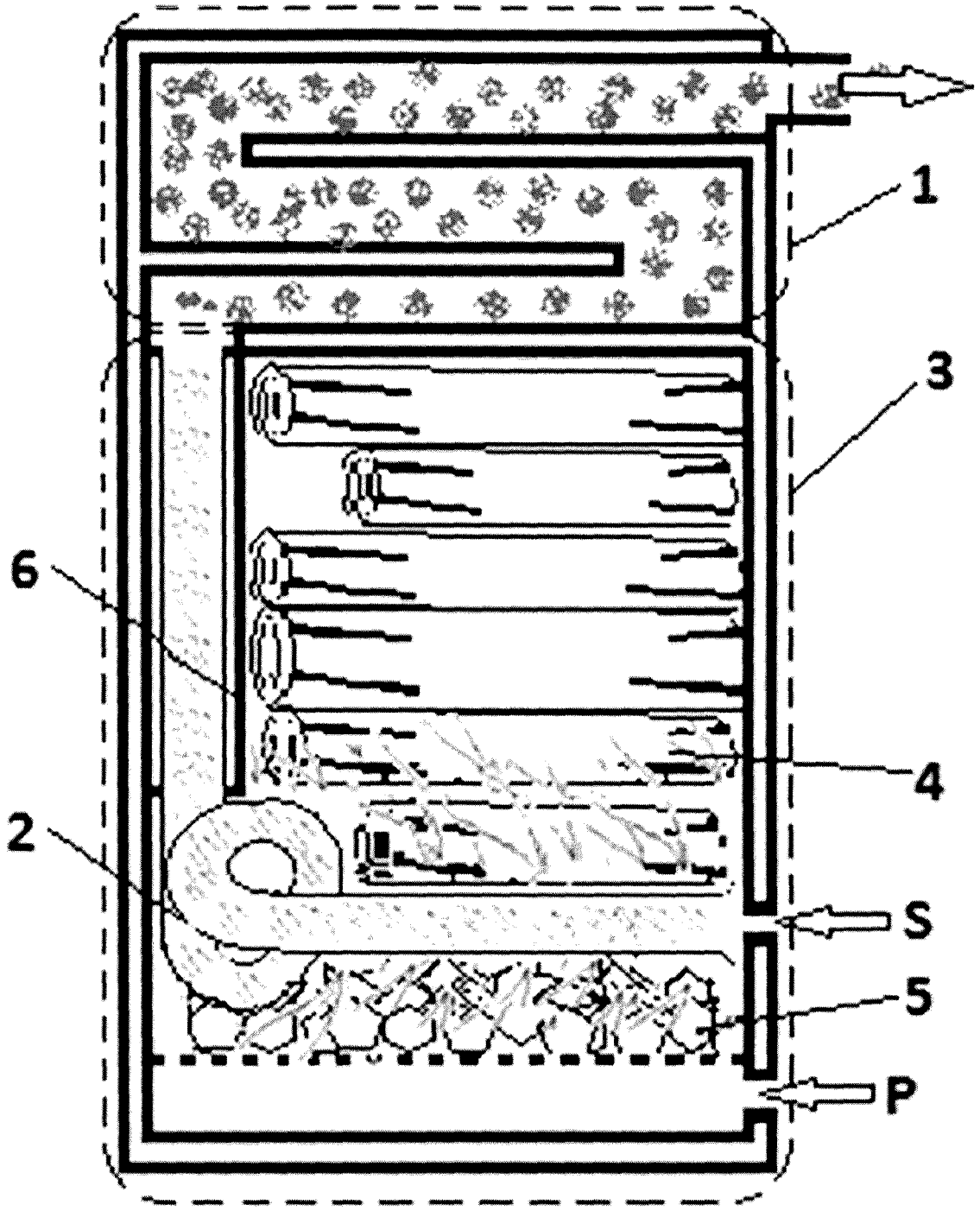

Figure 10

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EUROPEAN SEARCH REPORT

Application Number
EP 14 38 6010

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	FR 2 503 835 A1 (MENIERS MICHAEL [FR]) 15 October 1982 (1982-10-15) * page 1, line 1 - line 3; figures 1-3 * * page 1, line 15 - line 33 * * page 2, line 26 - page 4, line 5 * -----	1-10	INV. F23B10/02 F23B80/00
A	DE 10 2009 038242 A1 (HET HEIZ & ENERGIETECHNIK ENTWICKLUNGS GMBH [AT]) 24 February 2011 (2011-02-24) * paragraphs [0001], [0006], [0011], [0014]; figure 1 * * paragraph [0026] - paragraph [0033] * * paragraph [0036] * * paragraph [0047] - paragraph [0051] * -----	1-10	

TECHNICAL FIELDS SEARCHED (IPC)

F23B
F23L
F24B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	1 December 2014	Hauck, Gunther

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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01-12-2014

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
FR 2503835 A1	15-10-1982	NONE	
DE 102009038242 A1	24-02-2011	NONE	

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