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# (54) INCINERATION PLANT FOR SOLID MATERIAL

(57) The invention relates to an incineration plant for solid material having
- a combustion material inlet through which solid material is to be introduced,
- a combustion chamber in which the solid material is introduced and in which the solid material is combusted, whereby flue gases are produced,
- a vertically aligned empty pass (1) downstream of the combustion chamber, the empty pass (1) having an empty pass width (2) at it its lower section,
- a horizontally aligned boiler pass (3) downstream of the empty pass (1), the boiler pass (3) having a boiler pass width (4), the boiler pass width (4) being smaller than the empty pass width (2) at its lower end,
characterized in that
the empty pass (2) comprises at least one flow guiding means (5, 6, 7, 8) arranged in such a way that the flow of flue gases is narrowed toward the boiler pass (3).

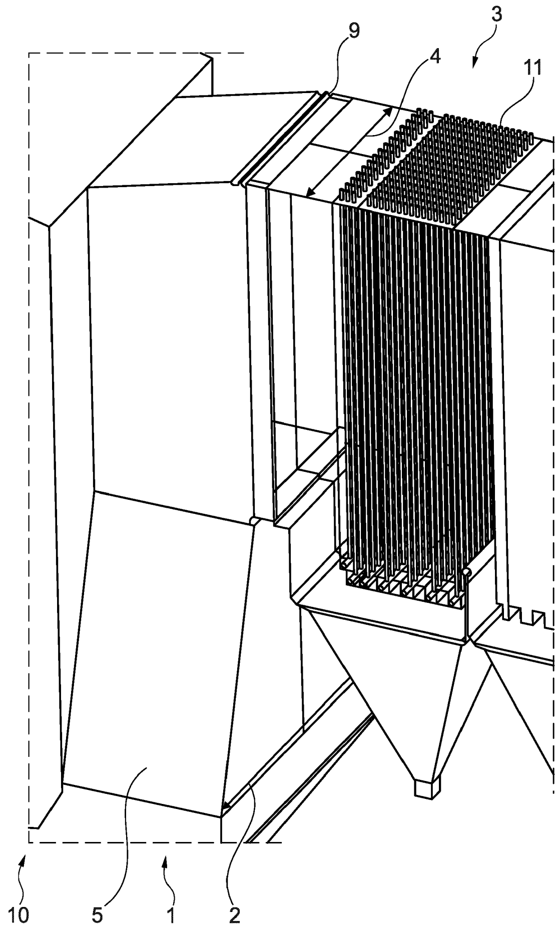

Fig. 1

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## Description

**[0001]** The present invention relates to an incineration plant for solid material such as waste or biomass, the incineration plant having a combustion material inlet through which solid material is to be introduced, a combustion chamber in which the solid material is introduced and in which the solid material is combusted, whereby flue gases are produced, a vertically aligned empty pass downstream of the combustion chamber, the empty pass having an empty pass width at it its lower section, and a horizontally aligned boiler pass downstream of the empty pass, the boiler pass having a boiler pass width, the boiler pass width being smaller than the empty pass width.

**[0002]** The incineration plant usually comprises a combustion grate arranged within a lower section of the combustion chamber with which the solid material and combusted solid material can be conveyed through the combustion chamber from the combustion material inlet to a slag container. Primary air is usually supplied from below the combustion grate to the solid material arranged on the combustion grate, so that the solid material arranged on the combustion grate is combusted with the primary air. Such an incineration plant is for example known from EP 3 763 996 A1.

**[0003]** Additionally, nozzles may be provided above the combustion grate with which secondary air, tertiary air for afterburning and/or an oxygen poor carrier gas can be provided to the flue gases.

**[0004]** Empty passes may be arranged vertically or horizontally, wherein the flue gases flow from the combustion chamber through the at least one empty pass to at least one boiler pass. In particular, two, three or more empty passes may be embodied. The empty pass arranged directly ahead of a first and horizontally aligned boiler pass is aligned vertically, so that the flue gases advance upwardly within the last empty pass. Usually there are arranged three empty passes downstream of the combustion chamber. The flue gases from the combustion chamber advance upwardly in the first empty pass, are redirected downwardly in the second empty pass and then advance upwardly again in the third (and last) empty pass. In some embodiments, there might be only one empty pass and in other embodiments there might be five empty passes. Accordingly, there is usually an uneven number of empty passes aligned vertically. Each empty pass has usually a rectangular cross section with a width and depth. According to the prior art the side walls of the vertically aligned empty passes extend in a vertical plane.

**[0005]** The boiler passes downstream of the empty pass(es) may be arranged (in sections) vertically or horizontally, wherein also an oblique orientation is possible. A first boiler pass arranged directly after the vertically aligned (last) empty pass is aligned horizontally. Downstream of the horizontally aligned boiler pass further (eventually vertically and in the following horizontally aligned) boiler passes may be arranged. The horizontally aligned boiler pass has usually a rectangular cross section with a width and a height. Accordingly, the walls of the horizontally aligned boiler pass extend in a horizontal and vertical plane.

**[0006]** The walls of the combustion chamber and the empty pass(es) are usually equipped with heat exchangers (i.e. tubes). Bundles of heat exchangers (i.e. tubes) are arranged within the boiler passes, so that the flue gases flow around the heat exchangers in the boiler passes. The heat exchange medium of the heat exchangers is in particular provided to one common boiler drum.

**[0007]** A flue gas purification device downstream of the boiler pass(es) may comprise elements for dedusting, scrubbing and desulfurization (such as SCR or SNCR) of the flue gas. A chimney may by arranged downstream of the flue gas purification device.

**[0008]** The heat recovery system of the incineration plant comprises heat exchangers (i.e. tubes), which come into (thermal) contact with the flue gases, wherein a heat exchange medium (i.e. water or steam) provided through the heat exchangers transfers the exchanged heat to a boiler drum or similar. The heat recovery steam system usually comprises a superheater heat exchanger, an evaporator heat exchanger and an economizer heat exchanger.

**[0009]** In such known incineration plants the vertically aligned empty pass directly ahead of the horizontally aligned boiler pass has a greater width than the boiler pass itself. Accordingly, flue gases passing from the empty pass into the boiler pass are impinged with large-scale turbulences so that undesired flow separation at least at the front of horizontally aligned boiler pass occurs, so that the heat recovery steam system is operated inefficiently.

**[0010]** Accordingly, it is an object of the present invention to provide an incineration plant, in which the heat recovery steam system is operated more efficiently. One solution to this object is given with the features of the independent claim. Further solutions and preferred embodiments are described in the dependent claims and in the foregoing and following description. Single features of the embodiments may be combined with each other in a technically meaningful manner.

**[0011]** It is suggested that the empty pass comprises at least one flow guiding means arranged in such a way that the flow of flue gases is narrowed from the lower section of the empty pass towards the boiler pass. With other words, structural elements are arranged within the empty pass or are part of the wall of the empty pass, which structural elements individually or in combination force the flow of flue gases within the empty pass (leading towards the boiler pass) to have a smaller width. With such reduction of the width of the flue gas flow towards the boiler pass turbulences at the beginning of the boiler pass are avoided, so that the heat recovery steam system can be operated more efficiently, as the first heat exchanger bundle in the horizontally aligned boiler pass is impinged more uniformly by the flue gases.

**[0012]** According to one embodiment the flow guiding means is embodied by at least one section of at least one side wall of the empty pass, which section is inclined towards the boiler pass. In particular, two oppositely arranged side walls of the empty pass are inclined towards each other and towards the boiler pass. Accordingly, the width of the flow of flue gases along the flow direction is reduced by the inclined side walls of the empty pass towards the boiler pass. With such inclined side walls of the empty pass it is avoided that there is an abrupt reduction of the width of the flow cross section in the transition (the through flown plane between the empty pass and the boiler pass) from the empty pass to the boiler pass.

**[0013]** For example, a section of the side wall of the empty pass may be inclined horizontally. With other words, a section of the empty pass is arranged like a slanted roof so that the upwardly advancing flue gases are forced towards the central axis of the empty pass. For example, the side wall of the empty pass immediately below the transition to the boiler pass has a horizontally inclined wall section, so that the width of the flue gas flow is already reduced when arriving at an height of the transition towards the boiler pass. In such an embodiment, the width at the end of the empty pass is (almost) as small as the width of the boiler pass.

**[0014]** Additionally or alternatively, a section of the side wall of the empty pass may be inclined vertically. With such a vertically inclined side wall of the empty pass the width of the empty pass decreases along a horizontal direction.

**[0015]** In a further embodiment a flow guiding means is embodied by multiple (in particular at least three, preferably at least five, more preferably at least ten) heat exchange tubes which are arranged within the empty pass and therefore spaced (at least in sections) from a wall of the empty pass. Such heat exchange tubes, if arranged within the boiler pass(es) or within the transition from the empty pass to the boiler pass, are also known as evaporator harps (German: Verdampfer-Harfen). Multiple (three or more or five or more parallel) heat exchange tubes are arranged as group within the empty pass. Two or more groups of heat exchange tubes may be arranged in the empty pass.

**[0016]** The heat exchange tubes (of one group) are arranged within the empty pass with such a distance to each other (for example the gap between adjacent heat exchange tubes is no more than 400 mm, preferably no more than 250 mm and most preferably no more than 150 mm) so that flue gases flowing within the empty pass along the heat exchange tubes are forced towards the center of the empty pass, whereby the effective width of the flue gas flow is reduced. Preferably, the heat exchange tubes of a group are arranged parallel to each other. Accordingly, the flue gas flow is narrowed by the heat exchange tubes. Such heat exchange tubes may be easily retrofitted to already existing incineration plants. Furthermore, such heat exchange tubes may easily be integrated in new incineration plants without changing the design of well-known empty passes. Furthermore, the heat exchange tubes as flow guiding means have the advantage, that in case of a sudden pressure increase of the flue gases the space between the heat exchange tubes and the wall of the empty pass may be used as a compensation region of the flue gas flow within the empty pass, so that the raise of pressure is not that steep and high within the boiler pass as it is at the beginning of the empty pass.

**[0017]** Principally, the multiple heat exchange tubes may be aligned horizontally and arranged above each other. It might also be possible, that the multiple heat exchange tubes are aligned diagonally or transversely with regard to the flow direction of the flue gases. In a preferred embodiment, the heat exchange tubes are aligned vertically and are arranged beside each other, in particular in a parallel manner.

**[0018]** Principally, the heat exchange tubes may be arranged with a respective alignment at any desired place within the empty pass, as long as the desired reduction of the effective width of the flue gas flow is achieved. For example, the heat exchange tubes might be arranged below the transition from the empty pass to the boiler pass. In a preferred embodiment, a group of heat exchange tubes is arranged adjacent to the transition from the empty pass to the boiler pass. Preferably, one group of heat exchange tubes is arranged on each side of the transition. In particular, the heat exchange tubes may only be arranged in the height of the transition from the empty pass to the boiler pass. In a further embodiment, the heat exchange tube may further extend downwards.

**[0019]** The heat exchange tubes extend with an oblique section (preferably with its beginning and end sections) from the wall of the empty pass, so that the main section of the heat exchange tubes is arranged with a distance to the wall of the empty pass.

**[0020]** A group (at least three or at least five) of the multiple heat exchange tubes may be arranged, at least with their main sections, beside each other in a plane, which plane is inclined towards the boiler pass. Accordingly, the plane may be inclined horizontally and/or vertically as already described with reference to the inclined sections of the side wall above.

**[0021]** The heat exchange tubes are preferably part of an evaporator heat exchanger.

**[0022]** The invention and the technical background will now be described with reference to the figures. The figures schematically depict

Figure 1: a perspective view of a first embodiment of an incineration plant with a vertical extending empty pass and a horizontally extending boiler pass,

Figure 2: a top view of the embodiment of figure 1,

Figure 3: a perspective view of a second embodiment of an incineration plant with a vertical extending empty pass and a horizontally extending boiler pass,

Figure 4: a top view of the embodiment of figure 3,

Figure 5: a perspective view of a third embodiment of an incineration plant with a vertical extending empty pass and a horizontally extending boiler pass,

Figure 6: a top view of the embodiment of figure 5,

Figure 7: a perspective and partially transparent view of a fourth embodiment of an incineration plant with a vertically extending empty pass and a horizontally extending boiler pass,

Figure 8: a top and partially transparent view of the embodiment of figure 7 and

Figure 9: a side and partially transparent view of the embodiment of figures 7 and 8.

**[0023]** In the figures the last vertically extending empty pass 1 and the first part of the subsequent horizontally extending boiler pass 3 are depicted. Upstream of the empty pass 1 a preceding empty pass 10 is arranged, which is also shown in figure 1. The empty passes 10, 1 and the boiler pass 3 are part of a heat recovering system of an incineration plant, such as an incineration plant for waste. An incineration plant for waste is for example disclosed in EP 3 763 996 A1.

**[0024]** The flue gases of the incineration plant flow downwardly within the preceding empty pass 10 and are deflected into an upwardly flow within the empty pass 1, whereas the flue gases enter the horizontally extending empty pass 3 through a transition 9. Accordingly, flue gases within the empty pass advance upwardly, wherein the flue gases within the boiler pass advance horizontally.

**[0025]** Boiler pass heat exchange bundles 11 are arranged within the boiler pass 3. The boiler pass heat exchange bundle 11 consist of heat exchange tubes, which are flown by by the flue gas and which are connected to a common boiler drum.

**[0026]** All of the depicted embodiments of the figures have an empty pass width 2 at the lower end of the empty pass 1. Furthermore, all of the horizontally extending boiler passes 3 have a boiler pass width 4, which is smaller than the empty pass width 2 at the lower end of the empty pass 1.

**[0027]** According to (not depicted) prior art incineration plants, there is a sudden decrease of width in the transition 9 from the empty pass 1 to the boiler pass 3.

**[0028]** The present invention suggests to provide flow guiding means in order to narrow the flue gas stream towards the transition 9.

**[0029]** According to the embodiment depicted in figures 1 and 2 a section 5 of the side wall of the empty pass 1 is inclined horizontally, so that the width of the empty pass 1 decreases along the vertical direction with the upwardly flowing flue gases. Accordingly, the width of the empty pass 1 directly upstream of the transition 9 is about the same as the width 4 of the boiler pass 3. Accordingly, the width of the flue gas stream is not suddenly narrowed, so that the boiler pass heat exchange bundle 11 is impinged with a more even flue gas flow.

**[0030]** According to the embodiment depicted in figures 3 and 4 the flow guiding means is embodied by side wall sections 6, which are inclined vertically, so that the width of the empty pass 1 decreases along the horizontal direction towards the boiler pass 3.

**[0031]** According the embodiment depicted in figures 5 and 6 a section 7 of the side walls of the empty pass is inclined horizontally and vertically and a further section 6 of the side walls of the free pass 1 is inclined vertically. This way the flue gas flow towards the transition 9 is narrowed down.

**[0032]** The embodiment for the flow guiding means depicted in figures 7 to 9 can be retrofitted to existing incineration plants without changing the geometry of the outer walls of the empty pass 1. According to this embodiment multiple heat exchange tubes 8, which extend mainly in a vertical direction, are arranged on both sides of the transition 9 within the empty pass 1. Each heat exchange tube 8 comprises a beginning section and an end section, with which the heat exchange tubes 8 are connected to collecting tubes of the heat recovery system. The strictly vertically extending main sections of the heat exchange tubes 8 are arranged in a plane, which is inclined vertically towards the transition 9. The heat exchange tubes 8 have a relatively small distance (gap) to each other so that the effective width of the flue gas flow is narrowed down towards the transition 9.

1 empty pass
2 empty pass width at lower section
3 boiler pass
4 boiler pass width
5 horizontally inclined wall section
6 vertically inclined wall section
7 horizontally and vertically inclined wall section
8 heat exchange tubes
9 transition
10 preceding empty pass
11 boiler pass heat exchange bundle

## Claims

**1.** Incineration plant for solid material having

- a combustion material inlet through which solid material is to be introduced,
- a combustion chamber in which the solid ma-

terial is introduced and in which the solid material is combusted, whereby flue gases are produced,

- a vertically aligned empty pass (1) downstream of the combustion chamber, the empty pass (1) having an empty pass width (2) at it its lower section,
- a horizontally aligned boiler pass (3) downstream of the empty pass (1), the boiler pass (3) having a boiler pass width (4), the boiler pass width (4) being smaller than the empty pass width (2) at its lower end,

**characterized in that**
the empty pass (2) comprises at least one flow guiding means (5, 6, 7, 8) arranged in such a way that the flow of flue gases is narrowed toward the boiler pass (3).

**2.** Incineration plant according to claim 1, wherein the flow guiding means (5, 6, 7, 8) is embodied by at least one section of at least one side wall of the empty pass, which is inclined towards the boiler pass.

**3.** Incineration plant according to claim 2, wherein the at least one section (5, 7) of the side wall of the empty pass is inclined horizontally.

**4.** Incineration plant according to claim 2 or 3, wherein the at least one section of (6, 7) the side wall of the empty pass is inclined vertically.

**5.** Incineration plant according to one of claims 2 to 4, wherein oppositely arranged side walls are inclined towards each other and towards the boiler pass (3).

**6.** Incineration plant according to claim 1, wherein the flow guiding means is embodied by multiple heat exchange tubes (8) arranged within the empty pass (1).

**7.** Incineration plant according to claim 6, wherein the heat exchange tubes (8) are aligned vertically.

**8.** Incineration plant according to claim 6 or 7, wherein a group of heat exchange tubes (8) are arranged adjacent to the transition (9) from the empty pass (1) to the boiler pass (3).

**9.** Incineration plant according to one of claim 6 to 8, wherein at least sections of the heat exchange tubes (8) are arranged in a plane, which plane is inclined towards the boiler pass (3).

**10.** Incineration plant according to one of claim 6 to 9, wherein a gap between adjacent heat exchange tubes (8) is no more than 400 mm.

**11.** Incineration plant according to one of claim 6 to 10, wherein the heat exchange tubes (8) are part of an evaporator heat exchanger.

**12.** Incineration plant according to one of the preceding claims, wherein the horizontally aligned boiler pass (3) and/or a subsequent boiler pass comprises a superheater heat exchanger, an evaporator heat exchanger and an economizer heat exchanger.

**13.** Incineration plant according to one of the preceding claims, wherein the incineration plant comprises a flue gas purification device downstream of the boiler pass (3).

**14.** Incineration plant according to one of the preceding claims, wherein the plant comprises a combustion grate with which the solid material and combusted solid material can be conveyed through the combustion chamber from the combustion material inlet to a slag outlet, wherein a primary air supply is arranged below the top of the combustion grate and wherein at least one nozzle is arranged above the combustion grate with which secondary air and/or an oxygen poor carrier gas can be provided.

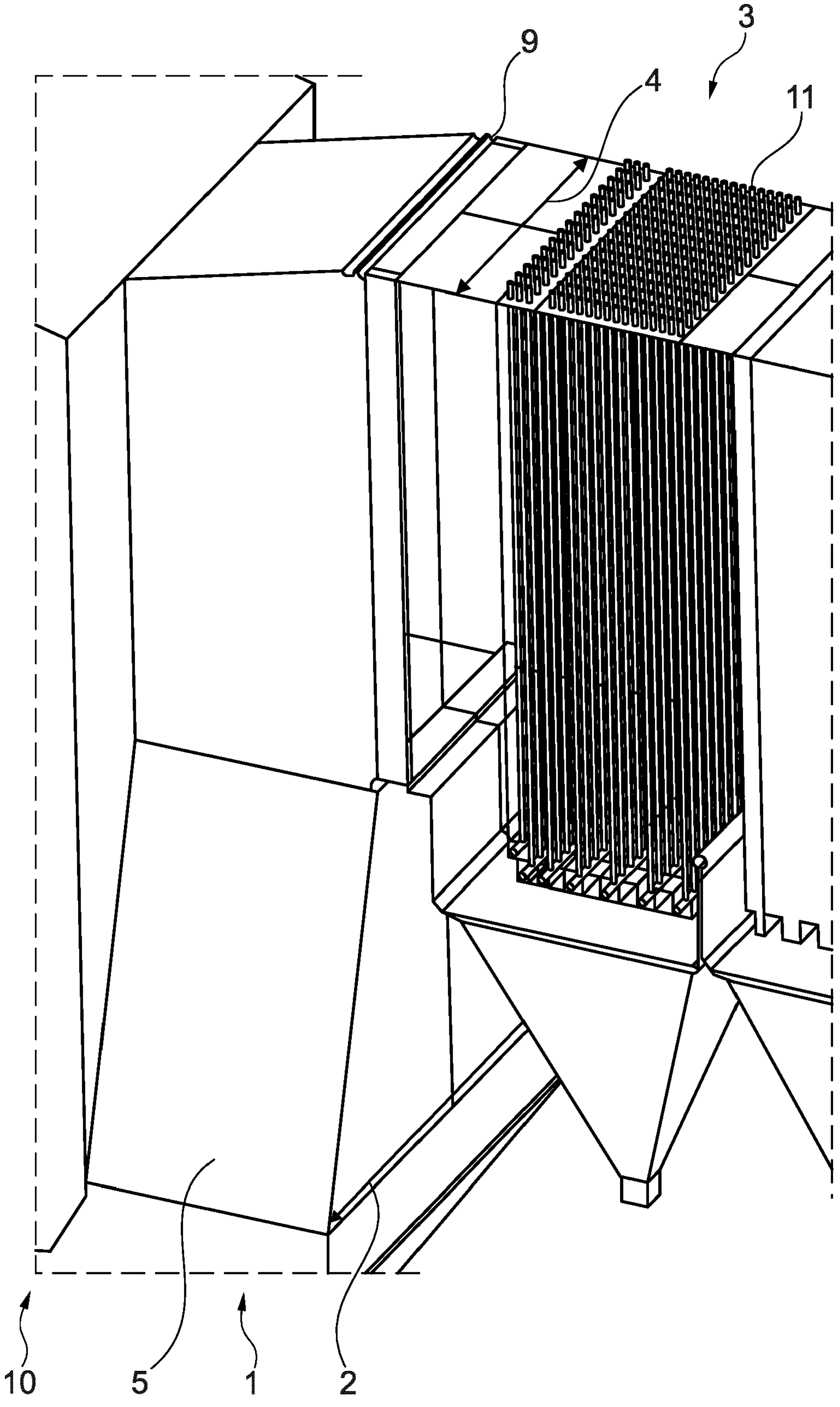


Fig. 1

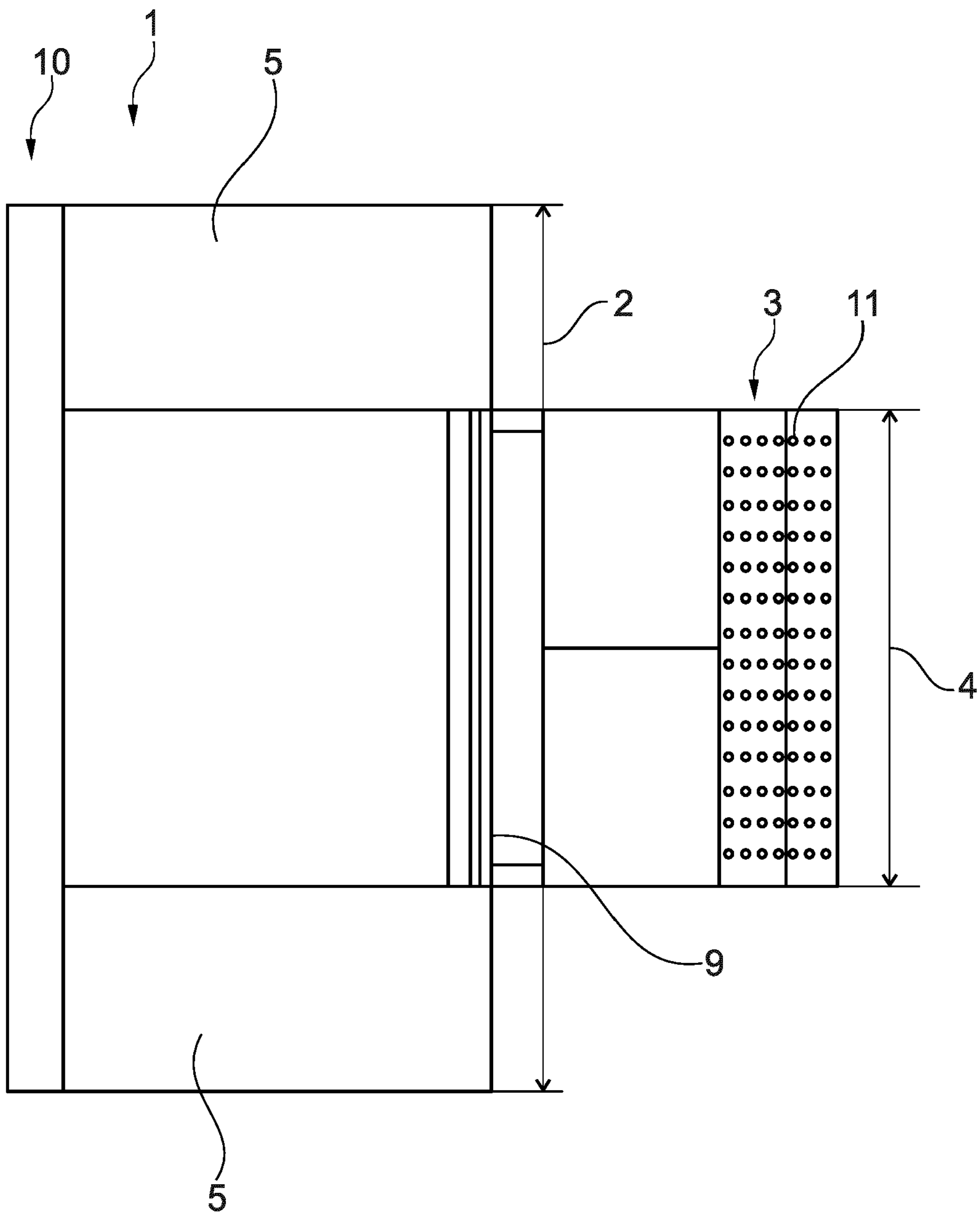


Fig. 2

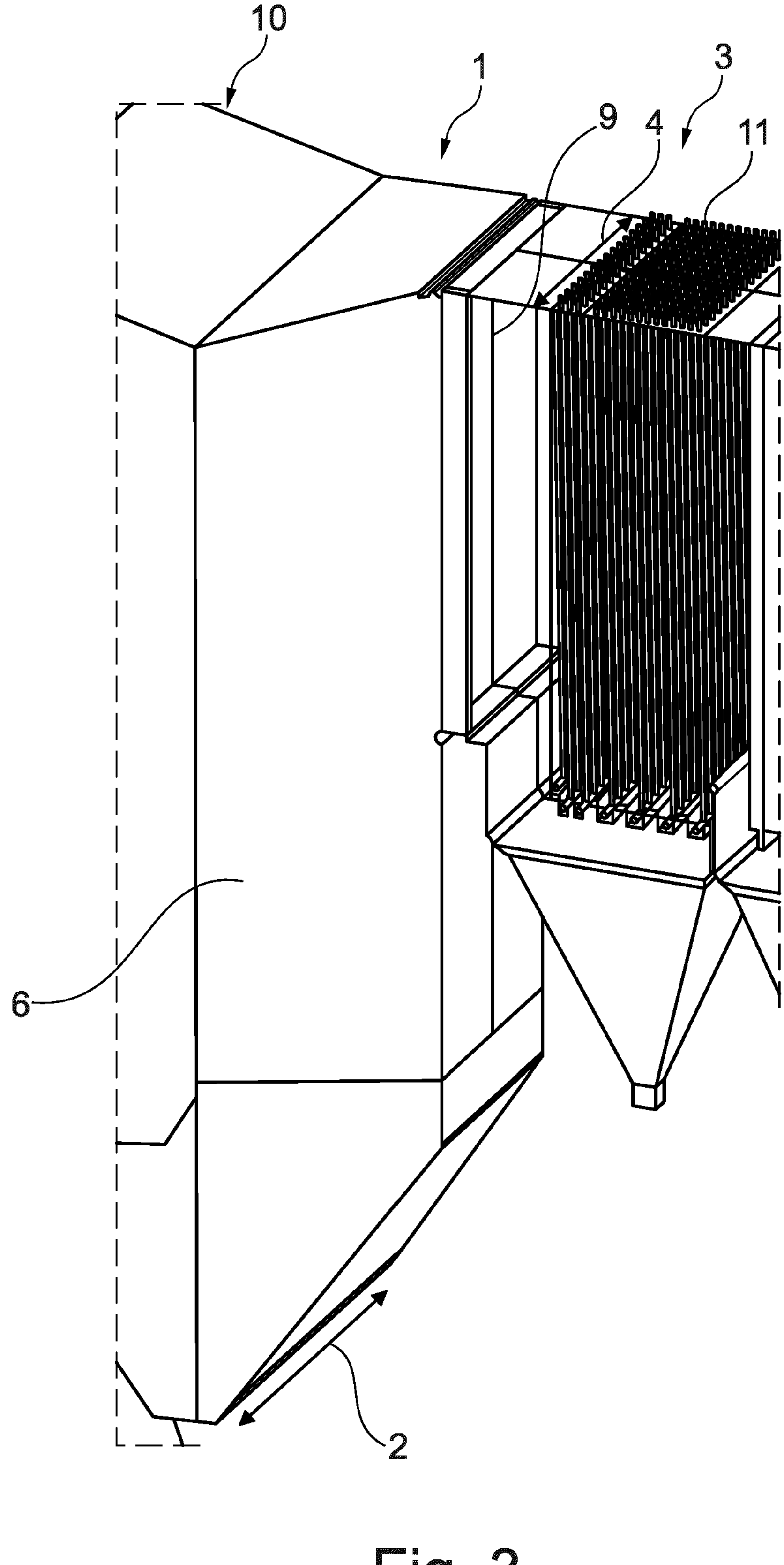


Fig. 3

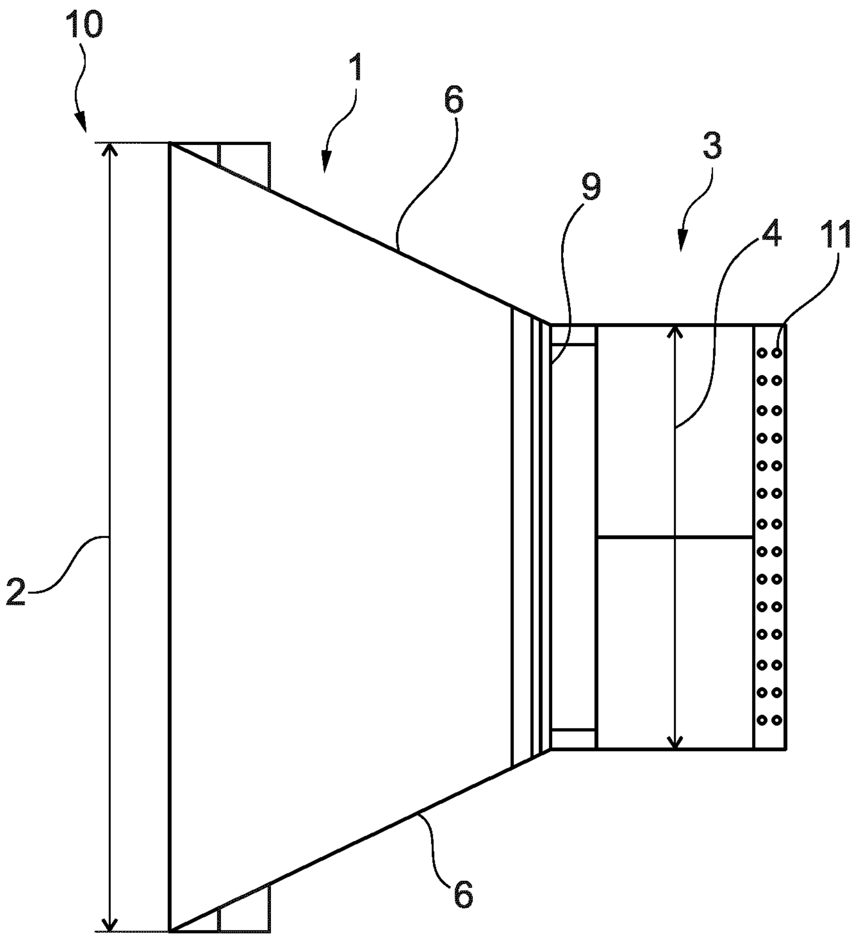


Fig. 4

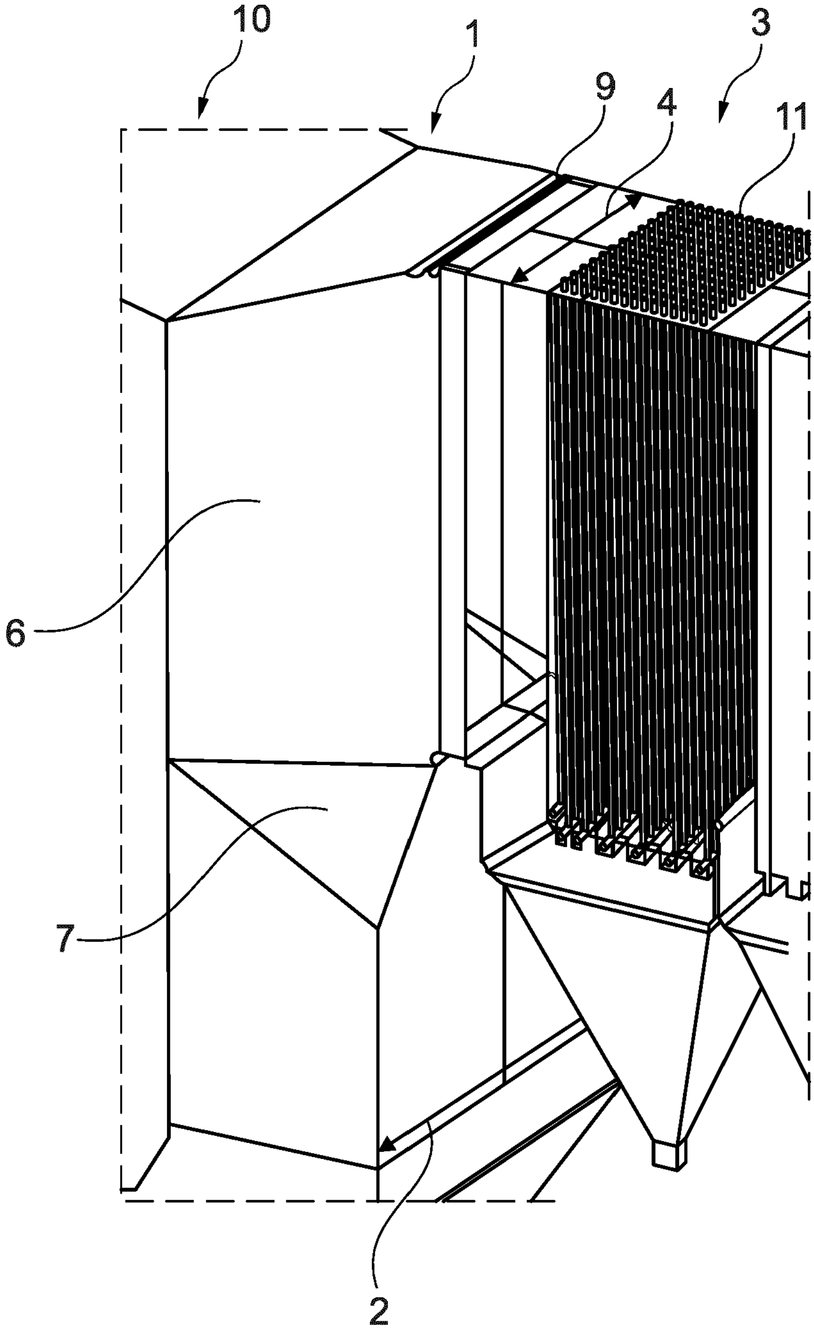


Fig. 5

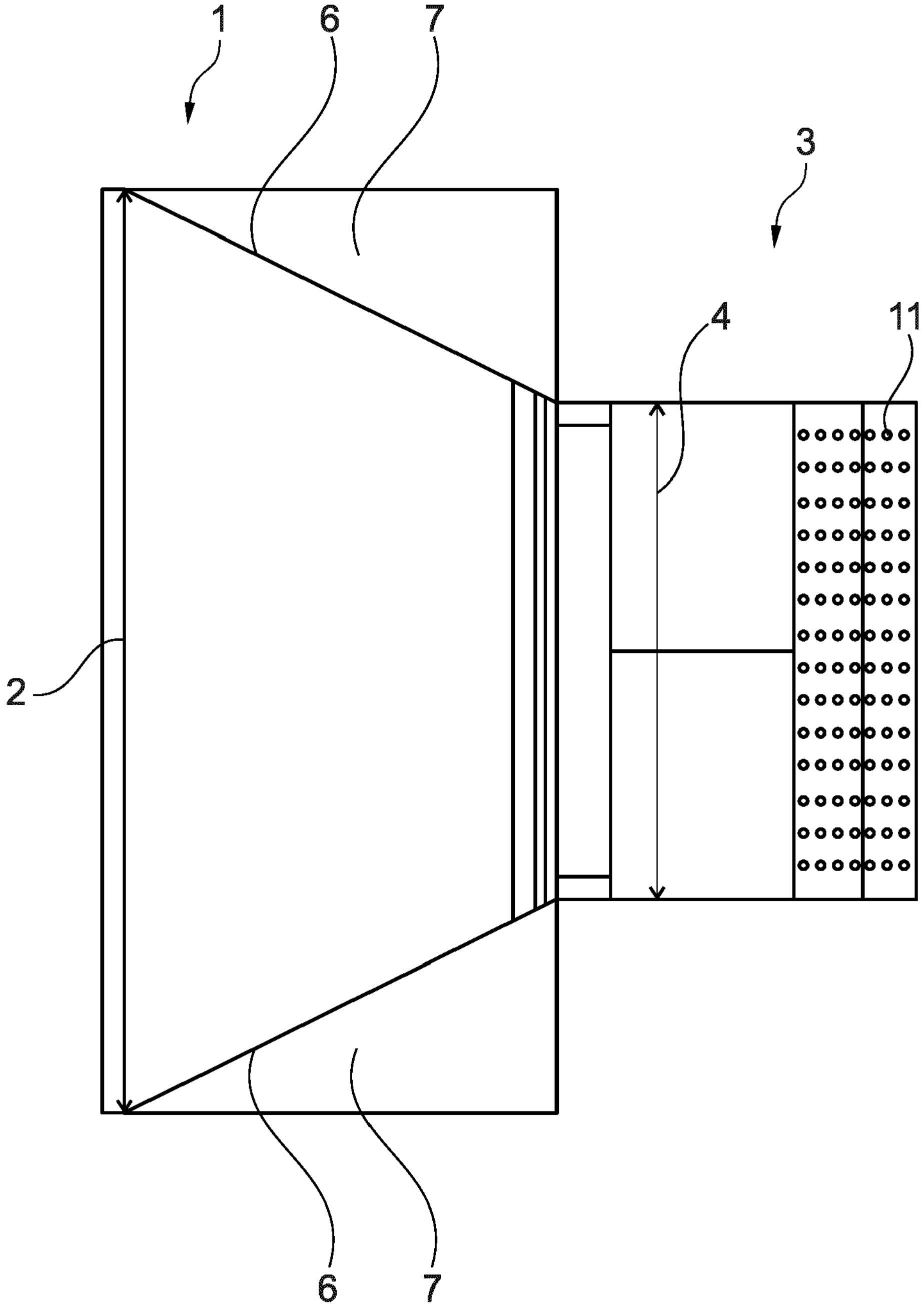


Fig. 6

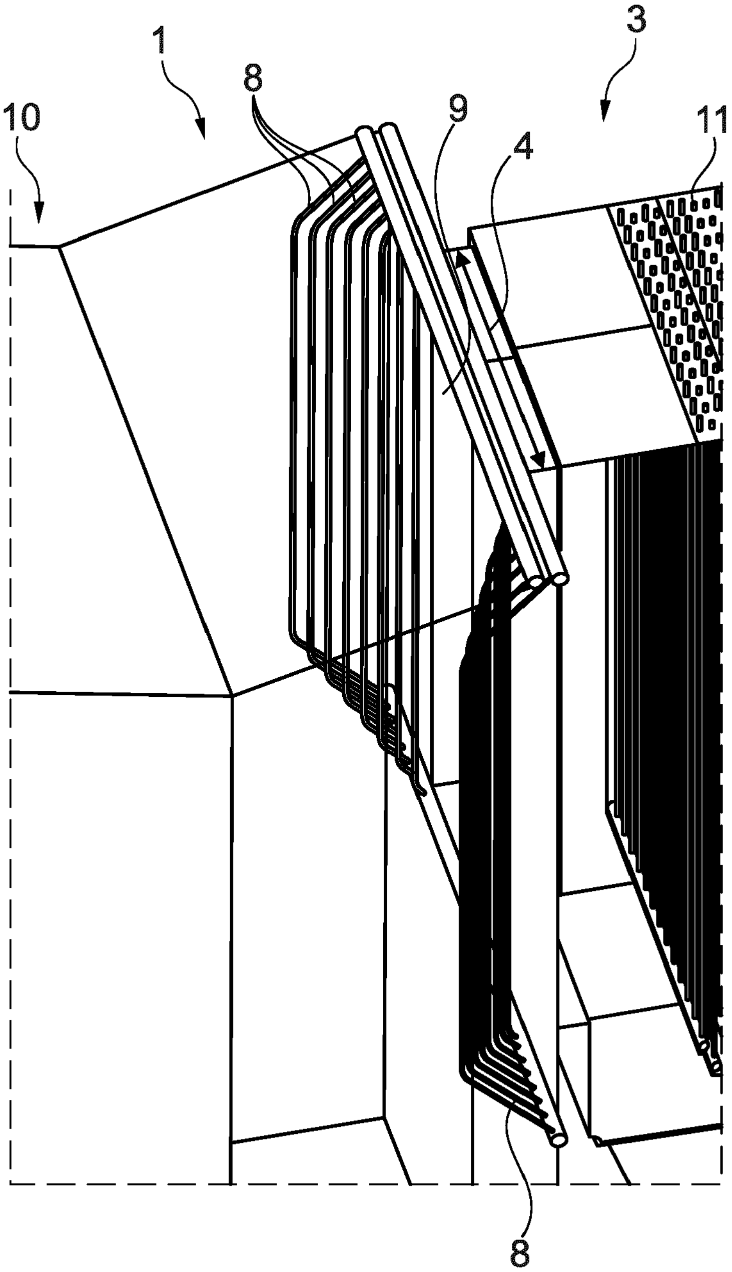


Fig. 7

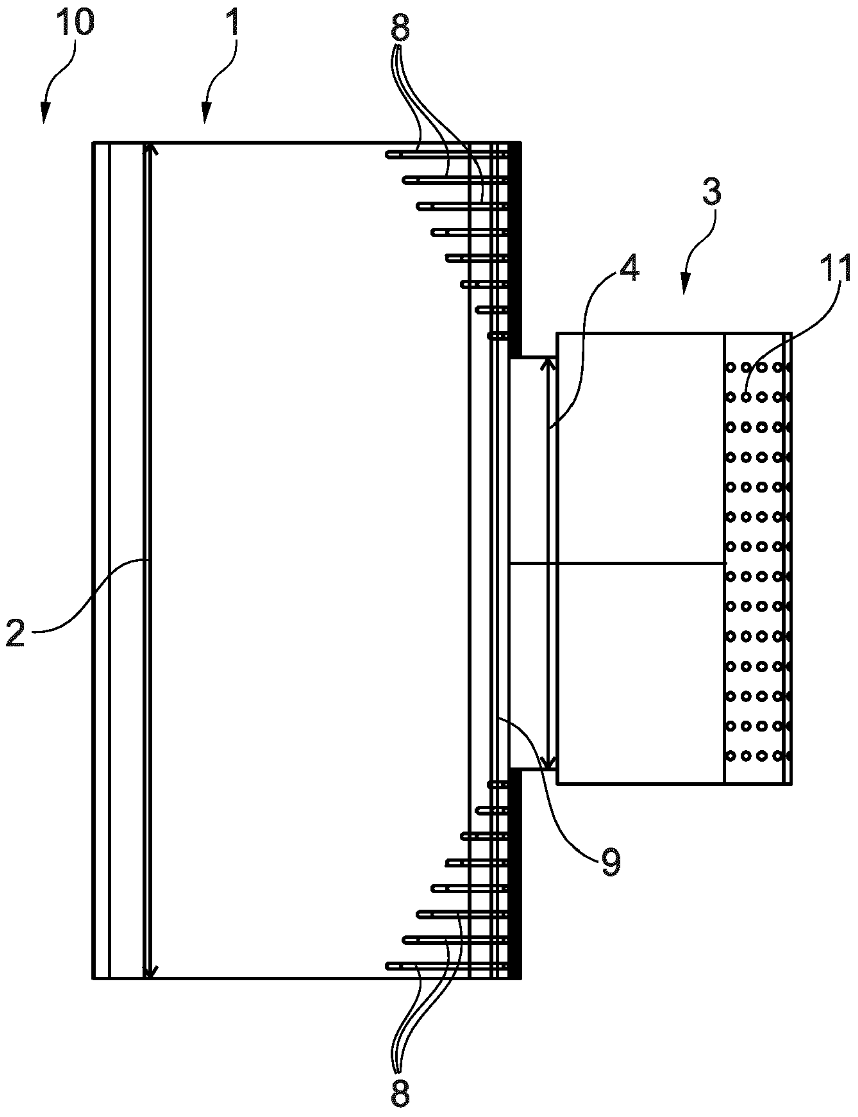


Fig. 8

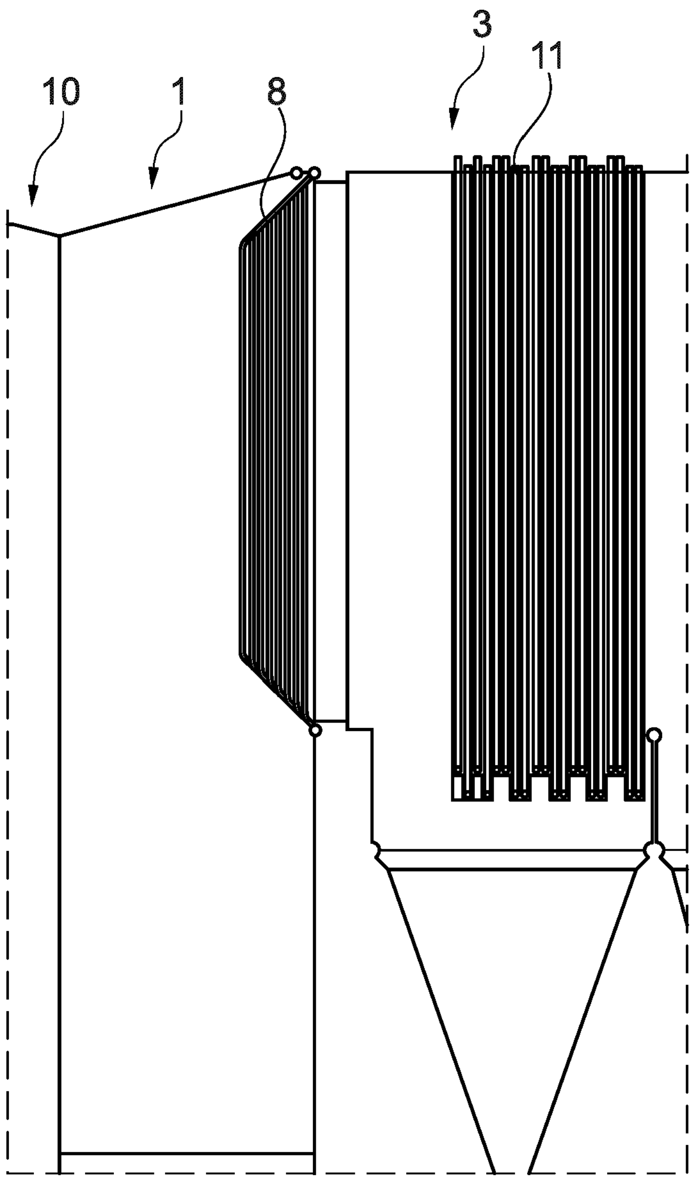


Fig. 9

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# EUROPEAN SEARCH REPORT

Application Number
EP 21 15 8826

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The present search report has been drawn up for all claims

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| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| Munich | 24 August 2021 | Zerf, Georges |

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## REFERENCES CITED IN THE DESCRIPTION

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