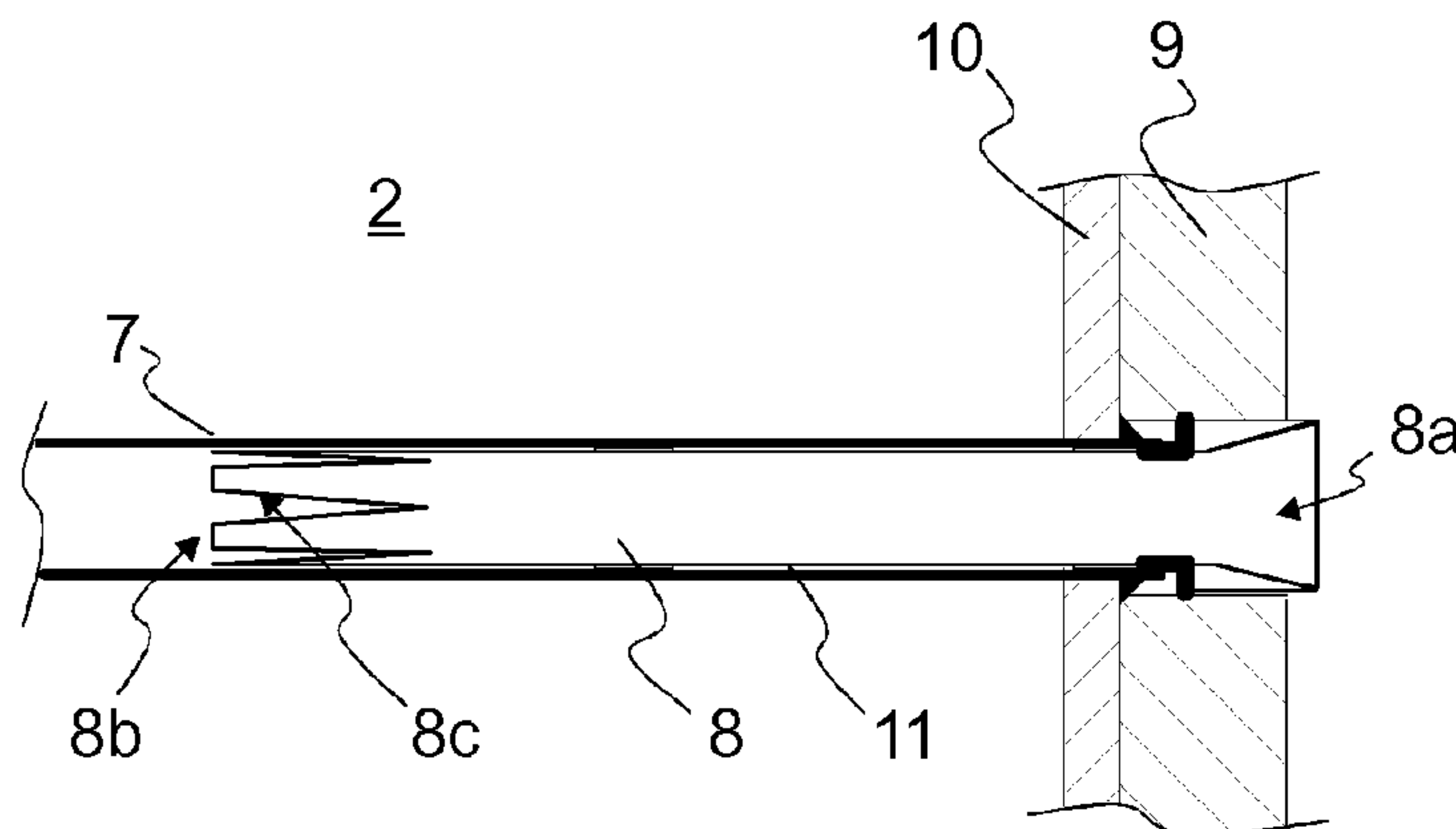




(86) Date de dépôt PCT/PCT Filing Date: 2010/05/21
(87) Date publication PCT/PCT Publication Date: 2010/12/09
(45) Date de délivrance/Issue Date: 2017/07/11
(85) Entrée phase nationale/National Entry: 2011/11/25
(86) N° demande PCT/PCT Application No.: FI 2010/050414
(87) N° publication PCT/PCT Publication No.: 2010/139852
(30) Priorité/Priority: 2009/06/04 (FI20095621)

(51) Cl.Int./Int.Cl. *F23L 15/04* (2006.01),
F28F 19/00 (2006.01)
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(54) Titre : PROCEDE POUR ALIMENTER EN AIR DE COMBUSTION UN PRECHAUFFEUR D'AIR DE GAZ DE CARNEAU, APPAREIL DE PRECHAUFFAGE, ET MANCHON DE GUIDAGE D'AIR
(54) Title: A METHOD FOR SUPPLYING COMBUSTION AIR TO A FLUE GAS AIR PREHEATER, A PREHEATING APPARATUS, AND AN AIR GUIDE SLEEVE



(57) Abrégé/Abstract:

A flue gas air preheating apparatus for combustion air in a boiler of a power plant, comprising an air pipe placed in a flue gas duct. An air guide sleeve is provided at the initial end of the air pipe, at least partly inside the air pipe, the air guide sleeve being made of a poorly heat conductive material and designed to diminish turbulence in the air flow and having an inflow end and a second end placed inside the air pipe. The shaping of the second end is designed to diminish turbulence in the air flow. The air guide sleeve is provided with splits or notches which become wider towards its second end. The invention also relates to a method and a corrosion shield.



Abstract

A flue gas air preheating apparatus for combustion air in a boiler of a power plant, comprising an air pipe placed in a flue gas duct. An air guide sleeve is provided at the initial end of the air pipe, at least partly inside the air pipe, the air guide sleeve being made of a poorly heat conductive material and designed to diminish turbulence in the air flow and having an inflow end and a second end placed inside the air pipe. The shaping of the second end is designed to diminish turbulence in the air flow. The air guide sleeve is provided with splits or notches which become wider towards its second end. The invention also relates to a method and a corrosion shield.

**A METHOD FOR SUPPLYING COMBUSTION AIR TO A FLUE GAS AIR
PREHEATER, A PREHEATING APPARATUS, AND AN AIR GUIDE
SLEEVE**

5 Field of the invention

The invention relates to a flue gas air preheating apparatus for combustion air in a boiler of a power plant, as well as an air guide sleeve in an air pipe of a flue gas air preheater.

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Background of the invention

For preheating combustion air for a solid fuel boiler, flue gas air preheaters (LUVOs) are typically used, in which the heating medium, *i.e.* flue gas, flows
15 outside heat exchanger pipes, and the medium to be heated, *i.e.* air, flows inside the heat exchanger pipes. The heat exchanger pipes (below: air pipes) are placed horizontally in the flue gas duct, and the heat exchanger units on different levels are connected to each other by air channels outside the flue gas duct. There are also configurations, in which the flue gas flows
20 inside the pipes and the pipes are vertical.

In known configurations, the temperature of the air pipe is significantly low on the air inlet side. The considerable cooling effect of air at the inlet end of the pipe is due to the fact that at the point of inflow, the heat transfer
25 coefficient of the flow is multiple compared to the developed flow deeper in the pipe. Furthermore, the air to be supplied has not been substantially warmed yet. Strong cooling induces a relatively low material temperature at the air inlet end of the heat exchanger structure of the preheater, in spite of the relatively high average temperature. Thus, the acid dew point of the flue
30 gases may be reached at the surface of the heat exchanger structure. The acid dew point, in turn, will cause strong corrosion in the cold heat exchanger structure and erosion in a short time, particularly with difficult

fuels. In particular, the joint between the air pipe of the coldest LUVU bundle and the end plate (or the wall of the flue gas duct) may be corroded, if the temperature of the material is too low.

- 5 At the cold end (air inlet) of the LUVU pipe of the coldest LUVU bundles, various insulation sleeves fitted around the outer surface of the air pipe have been used to prevent corrosion of the air pipe.

Brief summary of the invention

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Now, a solution has been found that makes it possible to diminish the problem of corrosion at the joint between the air pipe of the preheating apparatus and the end plate.

- 15 In accordance with the invention, there is provided a flue gas air preheating apparatus for combustion air in a boiler of a power plant, comprising an air pipe placed in a flue gas duct, and an air guide sleeve provided at the initial end of the air pipe, at least partly inside the air pipe, the air guide sleeve being made of a poorly heat conductive material and having an inflow end
20 and a second end placed inside the air pipe, wherein the shaping of the second end is designed to diminish turbulence in the air flow in such a way that the portion of the wall of the air guide sleeve on the surface area limited by the outer circumference of the air pipe decreases towards the second end, wherein in that the second end of the air guide sleeve is provided with
25 splits or notches which become wider towards its second end.

- In accordance with the invention, there is provided an air guide sleeve for an air pipe in a flue gas air preheater for combustion air in a boiler of a power plant, the air guide sleeve being made of a poorly heat conductive material
30 and arranged to be fitted inside an air pipe, having an inflow end and a second end arranged to be placed inside the air pipe, and arranged to guide the combustion air to be heated into the air pipe, at a distance from the wall

of the flue gas duct, wherein the shaping of the second end is designed to diminish turbulence in the air flow in such a way that the portion of the wall of the air guide sleeve on the surface area limited by the outer circumference of the air pipe decreases towards the second end, wherein in that the second
5 end of the air guide sleeve is provided with splits or notches which become wider towards its second end.

The basic idea of the invention is to form a preheating apparatus for combustion air in a boiler by providing an air guide sleeve at the initial end of
10 the air pipe, at least partly inside the air pipe, the air guide sleeve being made of a poorly heat conductive (*i.e.* thermally insulating) material and designed to diminish turbulence in the air flow.

By means of the air guide sleeve, the air flow to be supplied into the air pipe
15 is kept off the inner surface of the air pipe until the air flow has developed sufficiently, that is, the turbulence in the air flow has been sufficiently levelled out. The heat transfer coefficient of the developed air flow is significantly lower than that of a turbulent air flow, so that the air flow to be supplied from the air guide sleeve does not cause excessive cooling of the air pipe.

20 In the method according to the basic idea, turbulence in the combustion air flow to be supplied to the flue gas air preheater is levelled out by means of a structure keeping the air flow off the inner surface of the air pipe, after which the substantially turbulence-free combustion air flow is brought in contact
25 with the inner surface of the air pipe, to heat the air.

The corrosion shield or air guide sleeve according to the basic idea is made of a poorly heat conductive material, and it can be fitted inside the air pipe to diminish turbulence in the air flow and to guide the combustion air to be
30 heated into the air pipe at a distance from the wall of the flue gas duct.

In one embodiment, the air guide sleeve is fitted to guide the combustion air to be heated into contact with the inner surface of the air pipe at a distance from the initial end of the air pipe, the distance being at least three times the diameter of the air pipe. In this way, the cooling of the outer surface of the
5 initial end of the air pipe and the warming of air at the inlet point are minimized.

In one embodiment, the air guide sleeve is made at least partly of a polymer material, preferably heat-resistant plastic. In an advantageous embodiment,
10 the air guide sleeve is made of polyphenyl sulphide (PPS).

In an embodiment, the apparatus comprises a protective sleeve surrounding the air pipe at the initial end of the air pipe.

15 In an embodiment, the apparatus comprises a thermal insulation layer surrounding the flue gas duct, and the air guide sleeve extends through the insulation layer and the air pipe does not extend through the insulation layer.

The different embodiments of the above-described configuration, taken
20 separately and in various combinations, provide various advantages. A single embodiment may comprise one or more of the following advantages depending on its implementation:

- the material temperature of the air pipe of the preheating apparatus can be raised at the air inflow point;
- 25 - the temperature at the joint between the air pipe of the preheating apparatus and the end plate becomes higher and the problem of corrosion is eliminated;
- the distortion of the temperature of the flue gases can be levelled out;
- the structure becomes simpler and the manufacture is faster.

Description of the drawings

In the following, the invention will be described in more detail with reference to the appended principle drawings, in which

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Fig. 1 shows a power plant in a principle view;

Fig. 2 shows an embodiment of the flue gas air preheater in a principle view;

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Fig. 3 shows one inlet of the flue gas air preheater in a cross-sectional view;

Fig. 4 shows another inlet of the flue gas air preheater;

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Fig. 5 shows an embodiment of the air guide sleeve.

For the sake of clarity, the drawings only show the details necessary for understanding the invention. The structures and details that are not necessary for understanding the invention but are obvious for anyone skilled in the art have been omitted from the figures in order to emphasize the characteristics of the invention.

20

Detailed description of the invention

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Figure 1 shows a power plant in a principle view. The power plant comprises a furnace 1, a flue gas duct 2, a flue gas air preheater 3, and a stack 4. The flue gas air preheater 3 is placed in the flue gas duct 2. As can be seen from the figure, the flue gas air preheater 3 is placed at the terminal end of the flue gas duct 2 in the flow direction F of the flue gases.

30

Figure 2 shows an embodiment of the flue gas air preheater 3 in more detail. In this example, the air flows S, P to be heated are guided into the preheater 3 from air supply areas 5, 6 in the lower part. The heated air is discharged from the upper part of the preheater. In the example, the preheater 3 comprises two air circulations, *i.e.* a primary air circulation P and a secondary air circulation S. Both air circulations P, S comprise air pipes 7 which are placed horizontally in the flue gas duct 2, and the heat exchanger units on different levels are connected to each other by channels outside the flue gas duct.

10

Figure 3 shows one inlet of the flue gas air preheater 3 in a cross-sectional view. A unit in a typical vertical flue gas duct 2 comprises 20 to 30 pipes 7 on top of each other and about a hundred pipes adjacent to each other. The figure shows an air pipe 7 and an air guide sleeve 8 installed in the same. In the example, the air pipe 7 extends a short distance (about 1/3 of the length) into an insulation layer 9 that surrounds the flue gas duct 2. The air pipe 7 is preferably welded in a gas-tight manner to the end plate (or inner wall) 10 of the flue gas duct 2. In the example, the air guide sleeve 8 extends through the insulation layer 9, and the outer surface of the air guide sleeve is connected tightly to the end of the air pipe 7. For example, silicone can be used for sealing. The inflow end 8a of the air guide sleeve 8, *i.e.* the inlet of the air flow, is preferably shaped as a funnel.

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The length of the air guide sleeve 8 is advantageously more than three times the diameter of the air pipe 7, preferably about 4 to 8 times the diameter of the air pipe or the air guide sleeve. For example, if the diameter of the air pipe 7 is about 50 mm, the length of the air guide sleeve 8 is preferably about 20 to 40 cm.

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The end 8b of the air guide sleeve 8 that is placed inside the air pipe 7 is shaped so as to induce no significant turbulence in the air flow discharging from the air guide sleeve. In the example, the end of the air guide sleeve 8b

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is shaped so that the portion of the wall of the surface area limited by the outer circumference of the pipe decreases towards the end. In the configuration shown in the figure, this has been achieved by means of notches 8c and thinning. The air guide sleeve 8 is provided with notches 8c
5 that become broader towards the end 8b. The thickness of the wall of the air guide sleeve 8, in turn, has been reduced towards the end 8b. In the example, the shaping that diminishes turbulence in the air flow is provided particularly at the end 8b of the air guide sleeve within a length that constitutes about 1/6 to 1/3 of the length of the air guide sleeve.

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In the embodiment shown in Fig. 3, a clearance 11 is provided between the air guide sleeve 8 and the air pipe 7. By means of the clearance 11 and the air guide sleeve 8, the conduction of heat from the outer surface of the air pipe 7 to the inside of the air guide sleeve is efficiently prevented, thereby
15 preventing the cooling of the initial end of the air pipe.

Figure 4, in turn, shows one inlet of a flue gas air preheater according to another embodiment, in a cross-sectional view. In this embodiment, a protective sleeve 12 is provided outside the air pipe 7. The configuration
20 according to Fig. 4 is particularly advantageous in structures to be retrofitted, already comprising the air pipe 7 and the protective sleeve 12. In such a case, the air guide sleeve 8 is fitted in the air inlet pipe 7. The air pipe 7 and the protective sleeve 12 are cut out in such a way that they end inside the insulation material layer 9. In this way, no heat will be conducted along the
25 air pipe 7 and the protective sleeve 12 to the outside of the flue gas duct 2. It is also advantageous to connect the ends of the protective sleeve 12 to the air pipe 7, for example by welding. The air guide pipe 8, in turn, is connected to the end of the air pipe 7 in a gas-tight manner, for example with silicone or by another solution.

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Figure 5 shows an advantageous embodiment of the air guide sleeve 8, that is, the corrosion shield. The air guide sleeve 8 and particularly its outflow

end 8b are designed to diminish turbulence in the air flow. Advantageously, the end 8b of the air guide sleeve is formed so that the portion of the wall of the surface area limited by the outer circumference of the pipe reduces towards the outflow end 8b of the air guide sleeve 8. In other words, the cross-sectional area available for the air flow increases towards the outflow end 8b. This can be achieved, for example, by means of various notches 8c and/or by thinning of the wall. In the example, the air guide sleeve 8 is provided with splits 8c that become wider towards the end 8b, and the thickness of the wall is reduced towards the end. In the example, the shaping that reduces turbulence in the air flow is provided particularly at the outflow end 8b of the air guide sleeve 8 within a length that is about 1 to 3 three times the diameter of the air guide sleeve.

On the outer surface of the air guide sleeve 8, elements 8d are provided for controlling the clearance 11 between the outer surface of the air guide sleeve and the inner surface of the air pipe 7. In the example, the elements 8d are protrusions on the outer surface of the air guide sleeve 8. In the example, protrusions 8d are provided in two locations in the longitudinal direction of the air guide sleeve 8 and in four locations on the circumference. The shape and the number of the elements 8d may vary according to the embodiment so that the desired clearance 11 between the outer surface of the air guide sleeve 8 and the inner surface of the air pipe 7 can be formed and maintained in use. The thickness and the material properties of the wall of the air guide sleeve 8 as well as the size of the clearance 11 are factors affecting the conduction of heat between the outer surface of the air pipe 7 and the inner surface of the air guide sleeve 8.

The air guide sleeve 8 can be made of a material having sufficient heat resistance and heat insulation properties. The heat resistance should be advantageously higher than 200°C, preferably higher than 250°C. The thermal conductivity should be advantageously lower than 0.3 W/(K*m) (23°C). The materials used may be, for example, suitable polymers

reinforced with glass fibre, such as PPS (polyphenyl sulphide, one commercial trademark being Fortron 1140 L6) or PPA (polyphthalamide).

5 By combining, in various ways, the modes and structures disclosed in connection with the different embodiments of the invention presented above, it is possible to produce various embodiments of the invention. Therefore, the above-presented examples must not be interpreted as restrictive to the invention, but the embodiments of the invention may be freely varied within the scope of the inventive features presented in the claims hereinbelow.

Claims:

1. A flue gas air preheating apparatus for combustion air in a boiler of a power plant, comprising an air pipe placed in a flue gas duct, and an air
5 guide sleeve provided at an initial end of the air pipe, at least partly inside the air pipe, the air guide sleeve being made of a material, having a heat resistance higher than 200°C and a thermal conductivity lower than $0.3 \text{ W}/(\text{K}\cdot\text{m})$ at 23°C , the air guide sleeve having an inflow end and a second end placed inside the air pipe, wherein the shaping of the second end is
10 configured to diminish turbulence in an air flow in such a way that a thickness of a wall of the inflow end of the air guide sleeve reduces towards the second end and wherein the second end of the air guide sleeve is provided with splits or notches which become wider towards the second end of the air guide sleeve.
- 15 2. The flue gas air preheating apparatus according to claim 1, wherein the shaping of the second end that diminishes turbulence in the air flow is provided within a length less than $1/3$ of the length of the air guide sleeve.
- 20 3. The flue gas air preheating apparatus according to claim 1 or 2, wherein the air guide sleeve is fitted to guide the combustion air to be heated in contact with the inner surface of the air pipe at a distance from the initial end of the air pipe, the distance being at least three times the diameter of the air pipe.
- 25 4. The flue gas air preheating apparatus according to any one of claims 1 to 3, wherein the air guide sleeve is made at least partly of a polymeric material.

5. The flue gas air preheating apparatus according claim 4, wherein the air guide sleeve is made of polyphenyl sulphide.
6. The flue gas air preheating apparatus according to any one of claims 1 to 5, wherein the apparatus comprises a protective sleeve surrounding the air pipe at the initial end of the air pipe.
7. The flue gas air preheating apparatus according to any one of claims 1 to 6, wherein the apparatus comprises a thermal insulation layer surrounding the flue gas duct, and the air guide sleeve extends through the insulation layer and the air pipe extends only on one side of a surface of the insulation layer.
8. An air guide sleeve for an air pipe in a flue gas air preheater for combustion air in a boiler of a power plant, the air guide sleeve being made of a material, having a heat resistance higher than 200°C and a thermal conductivity lower than $0.3 \text{ W}/(\text{K}\cdot\text{m})$ at 23°C , the air guide sleeve arranged to be fitted inside an air pipe, having an inflow end and a second end arranged to be placed inside the air pipe, and arranged to guide the combustion air to be heated into the air pipe, at a distance from a wall of a flue gas duct, wherein the shaping of the second end is configured to diminish turbulence in the air flow in such a way that a thickness of a wall of the inflow end of the air guide sleeve reduces towards the second end and wherein the second end of the air guide sleeve is provided with splits or notches which become wider towards the second end of the air guide sleeve.
9. The air guide sleeve according to claim 8, wherein the shaping of the second end that diminishes turbulence in the air flow is provided within a length less than $1/3$ of the length of the air guide sleeve.

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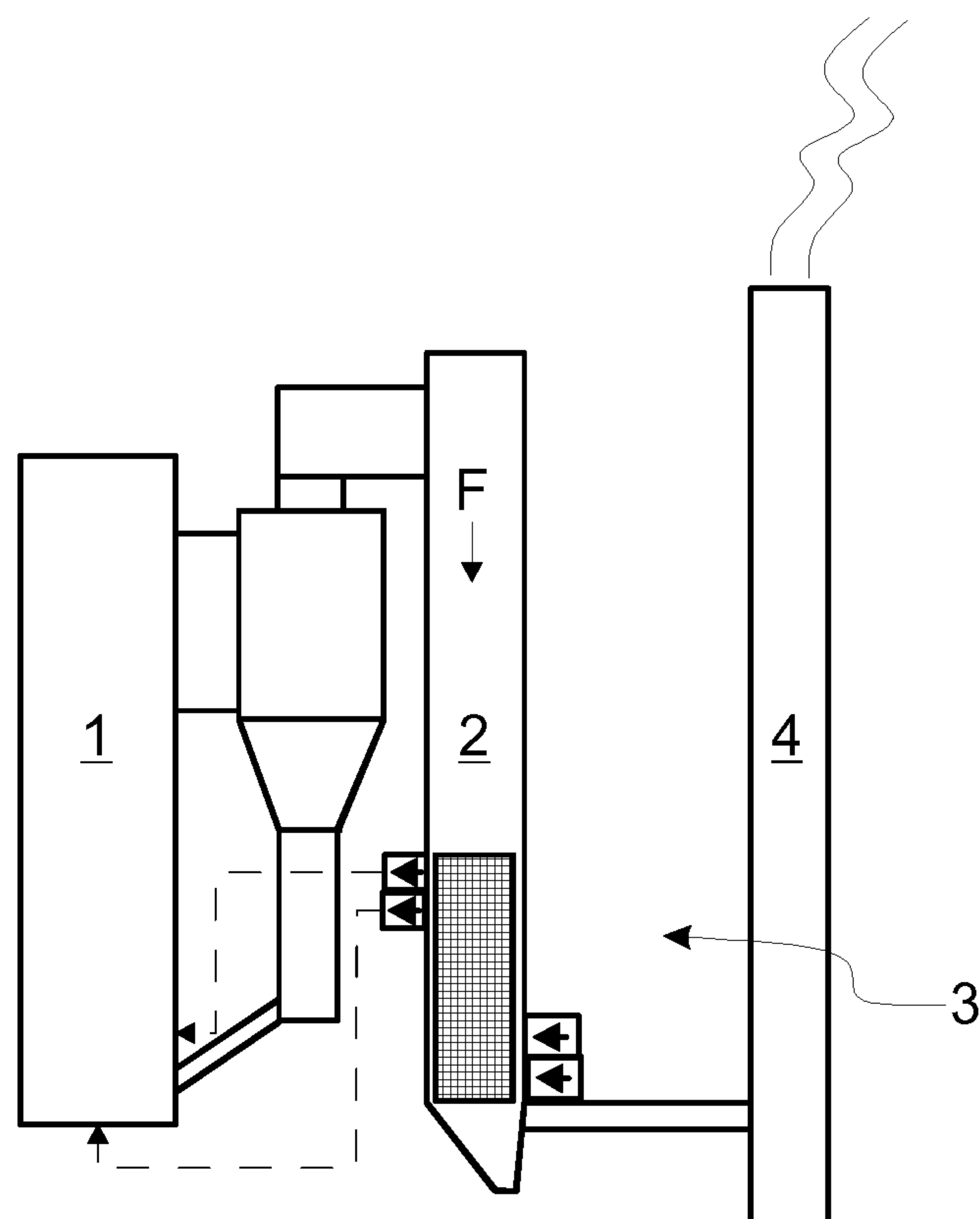


Fig. 1

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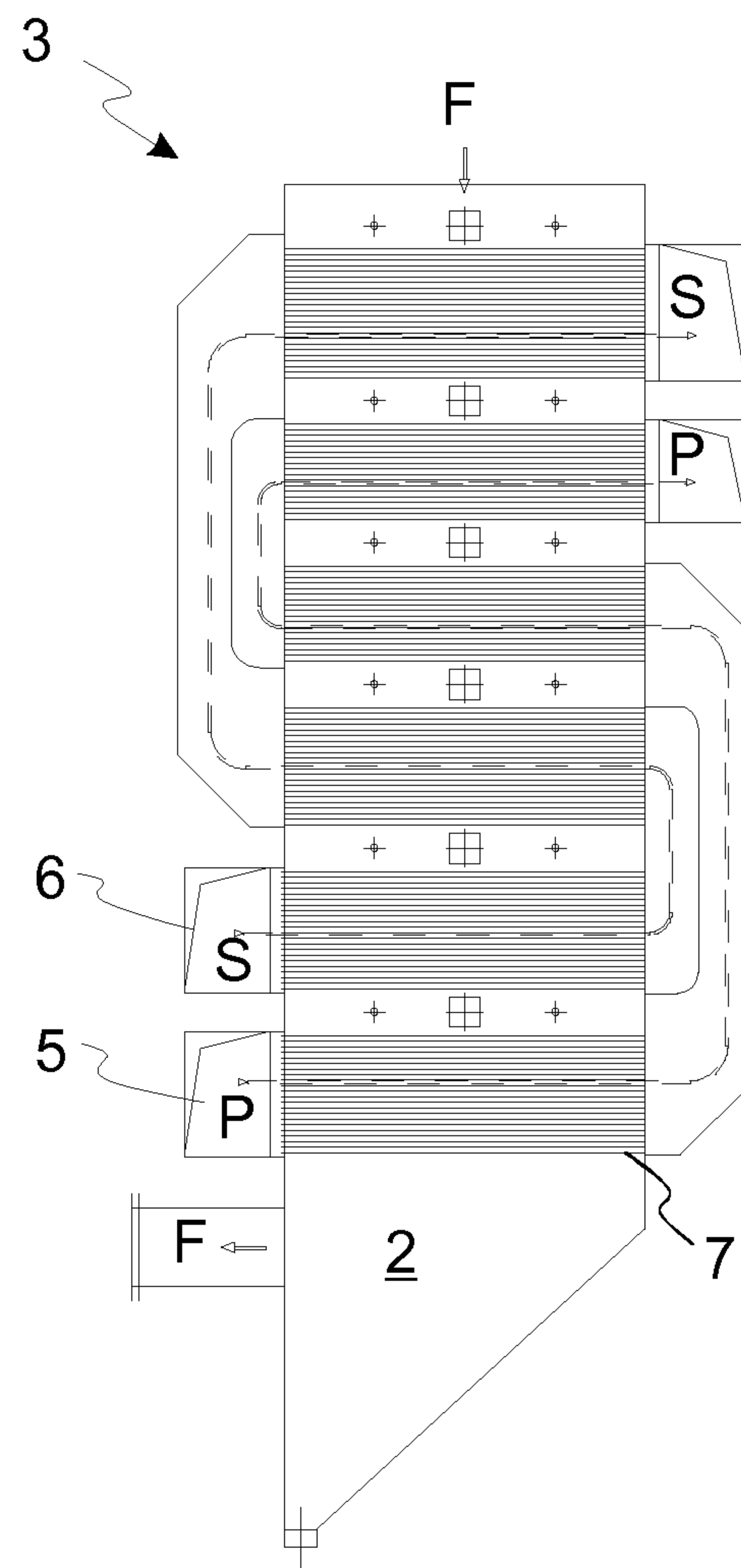


Fig.2

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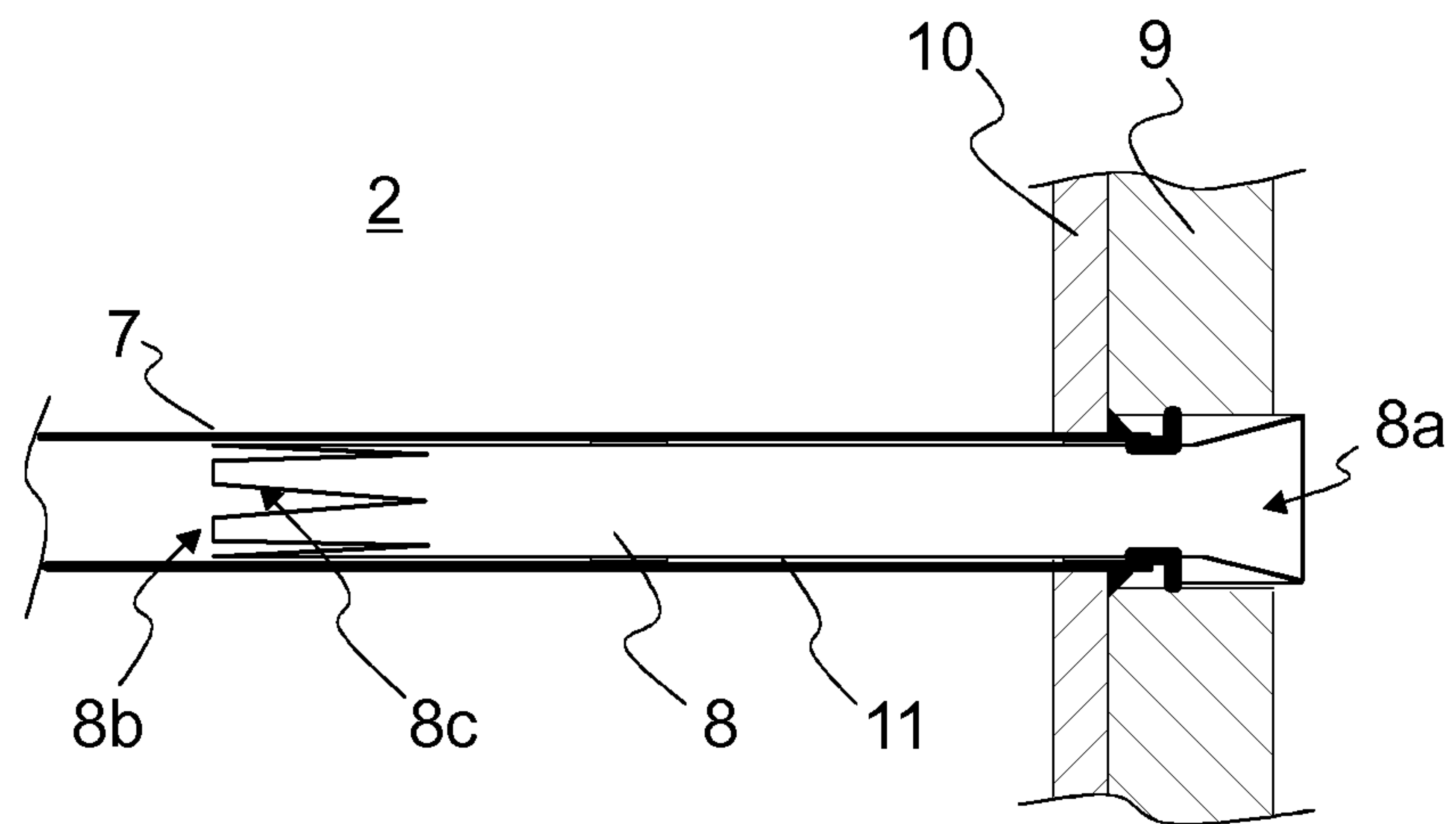


Fig. 3

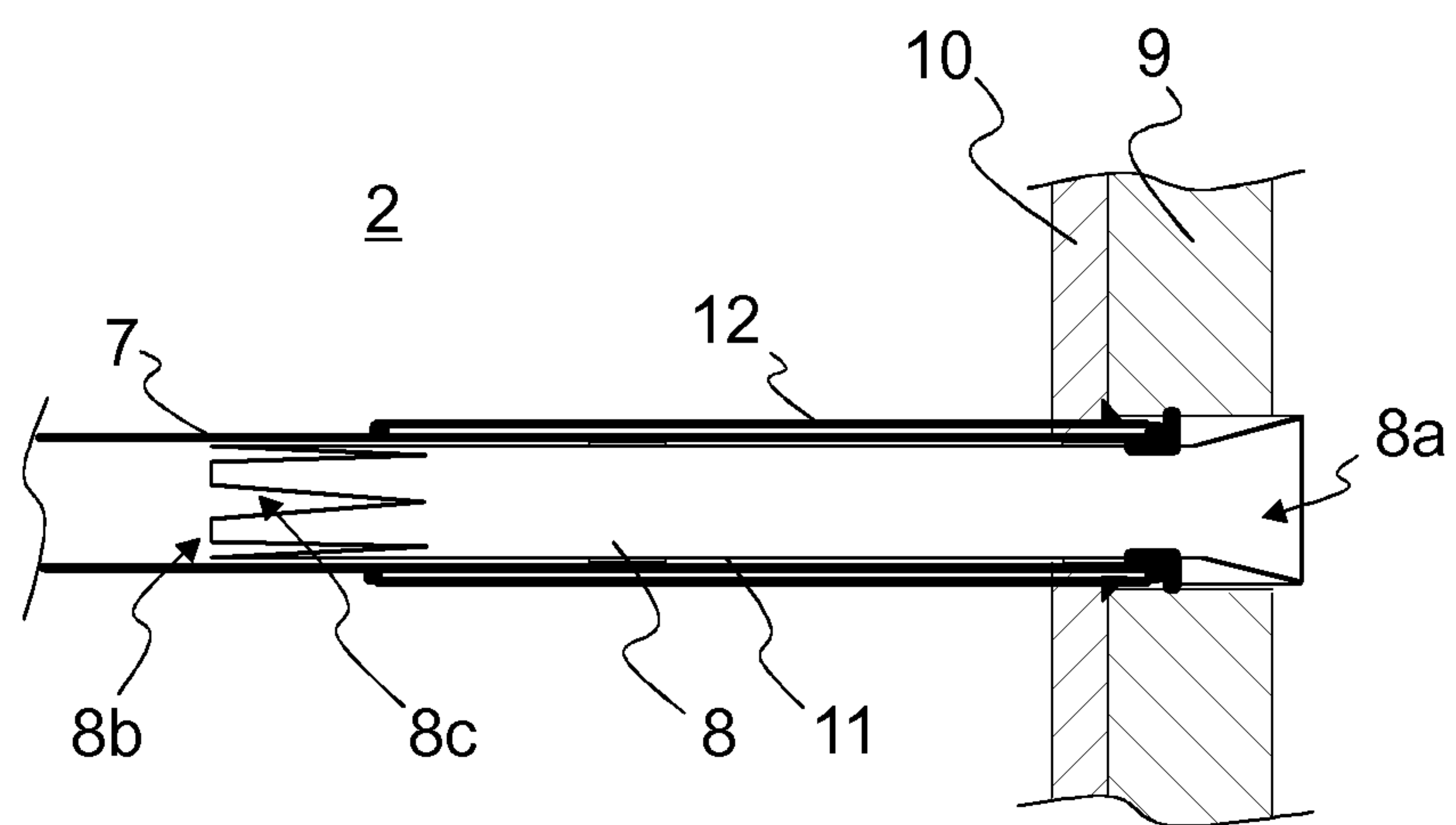


Fig. 4

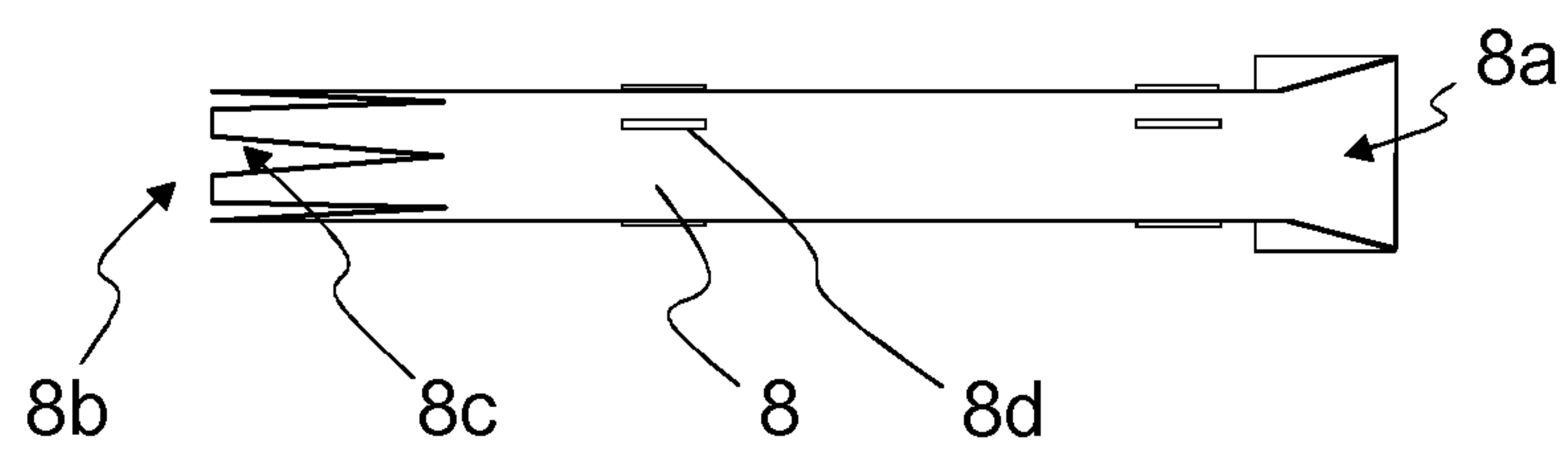


Fig. 5

