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(54) **ELECTROSTATIC PRECIPITATOR UNIT WITH HEAT SHIELD PLATE AND MEANS FOR COOLING BY CONVECTION**

(57) The invention relates to an electrostatic precipitator unit (1) for insertion in a flue gas passageway. It comprises a pipe (4) in which a discharge electrode (5) is arranged, a high voltage generator (6) for providing an electric field being generated in a region around the discharge electrode, and a controller (8). A casing (9) extending from the pipe comprises a first compartment (101) adjacent to the pipe, and a second compartment (102) at a distance from the pipe and separated from the first compartment by a heat shield plate (103). The controller and the high voltage generator are arranged in the second compartment or in a third compartment (108). The walls of the casing are provided with ventilation holes (110,111) arranged to cause a flow of air along the second compartment as a result of thermal convection caused by hot flue gas flowing in the flow passage during use of the electrostatic precipitator unit.

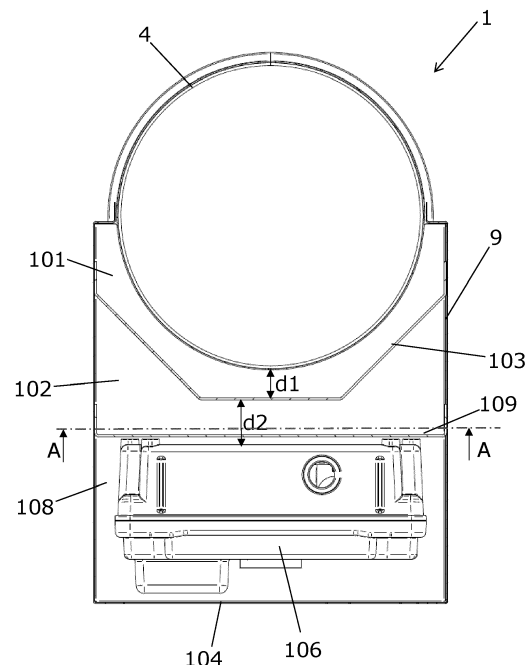


Fig. 3

Description**FIELD OF THE INVENTION**

[0001] The present invention relates to an electrostatic precipitator unit for insertion in a flue gas passageway, such as a chimney. In particular, it relates to an electrostatic precipitator unit having a controller which is protected from the high temperature of the flue gas by the combined effect of a heat shield plate and cooling by convection.

BACKGROUND OF THE INVENTION

[0002] An electrostatic precipitator (ESP) system can be used for reducing the number of fine and ultrafine particles in an aerosol or a flow of flue gas from e.g. a woodburning stove or a pellet boiler. In an ESP, an electric field is generated by a discharge electrode connected to a high voltage generator. The electric field causes the aerosol or flue gas around the discharge electrode to become ionized. Hereby either free electrons or charged gas molecules become trapped on the particles and thereby charge the particles. The charged particles are repulsed from the discharge electrode towards a grounded collection electrode on which they settle and build up and from where they can subsequently be removed in a controlled manner. Hereby the amount of pollution can be significantly lowered.

[0003] The components forming an ESP is arranged close to and partly inside the flow of the flue gas in a chimney, and the temperature in such a flue gas typically reaches up to around 250 degrees Celsius or possibly even higher. Therefore, the controller has to be arranged at a safe distance from the chimney in order not to damage it. The present invention has been developed for an ESP unit designed to be small and compact for use in relation to a pellet boiler. This has caused problems with known systems, since the desired compact size makes it hard or impossible to ensure a sufficient cooling of the heating from the flue gas before it reaches the control unit.

[0004] Hence, an improved electrostatic precipitator unit with a more efficient cooling would be advantageous.

OBJECT OF THE INVENTION

[0005] It is an object of the present invention to provide an electrostatic precipitator unit which is more compact than a corresponding prior art system.

[0006] It is another object of the present invention to provide an electrostatic precipitator unit with which a high safety against over-heating of the controller can be obtained.

[0007] It is a further object of the present invention to provide an alternative to the prior art.

[0008] In particular, it may be seen as an object of the present invention to provide an electrostatic precipitator

unit that solves the above mentioned problems of the prior art.

SUMMARY OF THE INVENTION

[0009] The above described object and several other objects are intended to be obtained in a first aspect of the invention by providing an electrostatic precipitator unit for insertion in a flue gas passageway, such as a chimney, the electrostatic precipitator unit comprising:

- a flue gas inlet for receiving a flow of flue gas,
- a flue gas outlet for venting the flow of flue gas,
- a pipe forming a flow passage extending between the flue gas inlet and the flue gas outlet,
- a discharge electrode arranged in the flow passage,
- a high voltage generator connected to the discharge electrode for providing an electric field being generated in a region around the discharge electrode, when the high voltage generator is turned on,
- an insulator arranged between the high voltage generator and the discharge electrode,
- a controller for controlling the operation of the high voltage generator and the discharge electrode, and
- a casing extending laterally from the pipe, the casing comprising:
 - a first compartment adjacent to the pipe, and
 - a second compartment at a distance from the pipe and separated from the first compartment by a heat shield plate along at least a part of a height of the first compartment,

wherein the controller and the high voltage generator are arranged:

- in the second compartment, or
- in a third compartment adjacent to and at least partly separated from the second compartment by a mounting plate supporting the high voltage generator and the controller, and

wherein walls of the casing are provided with:

- at least one lower hole at a lower region of the second compartment, and
- at least one upper hole at an upper region of the second compartment,

the at least one lower hole being configured to allow air to be drawn into the second compartment from the surroundings and the at least one upper hole being configured to allow air to be vented out of the second compartment thereby causing a flow of air along the second compartment as a result of thermal convection caused by hot flue gas flowing in the flow passage during use of the electrostatic precipitator unit.

[0010] When it is desired to provide an existing chim-

ney with an electrostatic precipitator unit according to the present invention, a part of the chimney is removed and replaced by the electrostatic precipitator unit.

[0011] The feature that the casing extends laterally from the pipe comprises embodiments wherein the casing surrounds the pipe and embodiments wherein the casing is joined with the pipe so that they form one element. An example of a design of the casing will be shown in the figures. The casing will typically be made from stainless steel, but other materials which can withstand the high temperatures can also be used.

[0012] The heat shield plate is used to reduce the thermal radiation from the pipe heated by the hot flue gas flowing therein. Thermal radiation is electromagnetic radiation generated by the thermal motion of particles in matter. It is generated when heat from the movement of the material is converted to electromagnetic radiation. The heat shield plate reflects and possibly also absorbs some of the thermal radiation so that only a reduced amount of heat is transmitted into the second compartment.

[0013] In the second compartment, a large part of the heat is removed by convection, and therefore, the present invention is based on the combined protective effect of the heat shield plate and the convection area in the second compartment.

[0014] Convection can be defined as the transfer of heat from one place to another due to the movement of fluid. When natural buoyancy forces alone are responsible for fluid motion when the fluid is heated, the process is typically called "natural convection". An example of this is the draft in a chimney such as in relation to the present invention. The arrangement of the at least one lower hole and the at least one upper hole at the lower and upper regions, respectively, of the second compartment, results in the main direction of the flow of air in the second compartment being vertically upwards. This flow of air means that hot air in the second compartment is removed by natural convection, and this results in a cooling whereby it can be ensured that the controller and the high voltage generator are not subjected to too high temperatures.

[0015] When the electrostatic precipitator unit is arranged in a chimney of a 25 kW pellet burner for which the invention was developed, the temperature of the flue gas is typically in the order of up to 250 degrees Celsius. Tests have shown that by use of the present invention, it is possible to keep the temperature at the location of the controller and the high voltage generator below 50 degrees Celsius. However, the scope of protection also covers embodiments configured for use with other temperatures.

[0016] The casing may be provided with more holes than those mentioned above. It may e.g. be provided with holes in the part of the walls forming the first compartment in order to obtain additional cooling thereof. The at least one lower hole and the at least one upper hole are preferably arranged with as large vertical distance from each

other as possible for a given size of the casing in order to provide venting of most of the second compartment. Typically there will be a plurality of lower holes and a plurality of upper holes; an example of such an embodiment will be shown in the figures.

[0017] In presently preferred embodiments of the invention, both the at least one lower hole and the at least one upper hole are provided in two opposing walls of the casing. Hereby a widespread flow of air is obtained whereby it can be ensured that substantially all of the second compartment is efficiently cooled by the natural convection.

[0018] The insulator may be arranged in a fourth compartment of the casing, the fourth compartment being above and at least partly separated from the second or third compartment in which the controller and the high voltage generator are arranged. The insulator is connected to the discharge electrode via an opening in the pipe, and hot flue gas and ash may exit the pipe via the same opening. Therefore, by arranging the insulator in such a fourth compartment, it can be obtained that this flue gas and ash does not reach and possibly cause damage to the controller or the high voltage generator.

[0019] The controller and the high voltage generator may be arranged in a control box forming a unitary enclosure. Such a control box can provide protection against heat, moisture and dirt. Furthermore, it can facilitate the installation and possible subsequent maintenance, because the control box can be handled as a separate unit.

[0020] A shortest horizontal distance between the pipe and the heat shield plate may be at least 10 mm, such as at least 13 mm, such as at least 15 mm. A shortest horizontal distance between the heat shield plate and both the controller and the high voltage generator may be at least 15 mm, such as at least 18 mm, such as at least 20 mm. These two measures have been found suitable at least for an electrostatic precipitator unit designed for use in a chimney with a flue pipe having a diameter of around 150 mm. However, similar distances may also be used for larger or smaller units.

[0021] In some embodiments of the invention, the electrostatic precipitator unit comprises adapters configured to form connections between the unit and the flue gas passageway, such as a chimney, in which the unit is inserted during use. Hereby it will be possible to mount one size of electrostatic precipitator unit to different sizes of flue gas passageways by using different sizes and designs of the adapters.

[0022] In some embodiments of the invention, the electrostatic precipitator unit further comprises a discharge electrode assembly, the discharge electrode assembly comprising:

- the discharge electrode,
- the insulator, and
- a connector pin connected to the discharge electrode at a first end, and

- an insulator connector connecting the insulator and a second end of the connector pin,

wherein:

- the connector pin comprises a first locking surface at the first end and a second locking surface at the second end,
- the discharge electrode comprises a third locking surface at an upper end,
- the insulator connector comprises a fourth locking surface, and

wherein:

- the first and the third locking surfaces are configured to form a fixed mutual engagement preventing translational and rotational movement of the discharge electrode in relation to the connector pin,
- the second and the fourth locking surfaces are configured to form a fixed mutual engagement preventing translational and rotational movement of the connector pin in relation to the insulator connector.

[0023] The design of the different components of the discharge electrode assembly and the way they are connected provide a number of advantages. The various locking surfaces and the engagement between them ensure that all the components are in the correct location and thereby that the discharge electrode assembly works as intended. The efficiency of such an electrostatic precipitator is dependent on the discharge electrode being arranged centrally in the flow passage and aligned therewith. Therefore, the discharge electrode assembly has been designed so that it is easy and efficient to ensure such correct positioning in the flow passage which forms part of the flue gas passageway.

[0024] The mutual engagement between the first and the third locking surfaces may be releasable, and/or the mutual engagement between the second and the fourth locking surfaces may be releasable. Hereby it is obtained that it is easy and efficient to ensure a correct positioning of the discharge electrode after a temporary removal of the discharge electrode for cleaning of the discharge electrode itself as well as the flow passage in which it is arranged during use.

[0025] In some embodiments of the invention, the first locking surface is a protrusion extending from the first end of the connector pin, and the third locking surface is a locking hole matching the shape and dimensions of the protrusion. The two parts are then preferably connected, e.g. by use of a matching screw, to ensure that they remain connected. Other means of connecting are also covered by the scope of protection. The first and third locking surfaces may e.g. be kept in place by a press fit, a pin or a clamp.

[0026] In some embodiments of the invention,

- the second locking surface is a recess in the connector pin, and
- the fourth locking surface is a combination of:

- a guiding hole in the insulator connector configured to receive the second end of the connector pin, and
- a set screw configured to fixedly engage with the recess when the connector pin is at a pre-defined position in the guiding hole.

In such embodiments, the insulator connector may comprise the guiding hole, and the connector pin may be configured to slide along the guiding hole in the insulator connector to allow for movement the discharge electrode relative to the insulator. Hereby it is possible and easy to move the discharge electrode sideways away from the normal central position in a flow passage in a guided manner. This movement will be relevant for regular cleaning of the discharge electrode and/or the flow passage. An example of such an embodiment will be shown in the figures.

[0027] In some embodiments of the invention, the insulator connector comprises a fifth locking surface, the insulator comprises a sixth locking surface, and the fifth and the sixth locking surfaces are configured to form a fixed mutual engagement preventing translational and rotational movement of the insulator connector in relation to the insulator.

[0028] The discharge electrode may comprise a first discharge electrode part and a second discharge electrode part, which first and second discharge electrode parts are aligned and releasably and fixedly connected to each other during use of the discharge electrode. Hereby a higher freedom is obtained with respect to the shape of the discharge electrode than if it had been made as a unitary element. An example of such a presently preferred design will be shown in the figures. Such a design allows for an efficient establishment of the third locking surface and the associated engagement with the first locking surface; this will be seen from the figures. Furthermore, it is an efficient way of increasing the stiffness and thereby a lowering the risk of damage and misalignment of the discharge electrode. The first and second discharge electrode parts may e.g. be assembled by rivets, screws or bolts.

[0029] This and other aspects of the invention will be apparent from and elucidated with reference to the embodiments described hereinafter.

BRIEF DESCRIPTION OF THE FIGURES

[0030] The electrostatic precipitator unit according to the invention will now be described in more detail with regard to the accompanying figures. The figures show one way of implementing the present invention and is not to be construed as being limiting to other possible embodiments falling within the scope of the attached claim

set.

Figure 1 schematically shows the different parts of an electrostatic precipitator unit according to the present invention.

Figure 2 schematically shows a three-dimensional view of an embodiment of the invention.

Figure 3 is a cross-sectional top view of the embodiment in figure 2 with the horizontal section being made just above the control box.

Figure 4 is a three-dimensional sectional view with the section being along line A-A in figure 3.

Figures 5.a and 5.b schematically show an assembled and an exploded view, respectively, of a discharge electrode assembly which may form part of an electrostatic precipitator unit according to the present invention.

Figure 6.a-6.c schematically show the region around the connection between the connector pin and the discharge electrode in figures 5.a and 5.b.

Figures 7.a to 7.c schematically show the connection between the connector pin and the isolator in figures 5.a and 5.b.

DETAILED DESCRIPTION OF AN EMBODIMENT

[0031] Figure 1 schematically shows the different parts of an electrostatic precipitator unit 1 according to the present invention as well as their mutual locations. The electrostatic precipitator unit 1 comprises a flue gas inlet 2 for receiving a flow of flue gas, a flue gas outlet 3 for venting the flow of flue gas, and a pipe 4 forming a flow passage extending between the flue gas inlet 2 and the flue gas outlet 3. A discharge electrode 5 is arranged in the flow passage, preferably centrally arranged as that improves the efficiency thereof. A high voltage generator 6 is connected to the discharge electrode 5 for providing an electric field being generated in a region around the discharge electrode 5, when the high voltage generator 6 is turned on. An insulator 7 is arranged between the high voltage generator 6 and the discharge electrode 5. The electrostatic precipitator unit 1 comprises a controller 8 for controlling the operation of the high voltage generator 6 and the discharge electrode 5. A casing 9 extends laterally from the pipe 4. The casing 9 comprises a first compartment 101 adjacent to the pipe 4, and a second compartment 102 at a distance from the pipe 4 and separated from the first compartment 101 by a heat shield plate 103 along at least a part of a height of the first compartment 101. In figure 1, the controller 8 and the high voltage generator 6 are arranged in a third compartment 108 located next to the second compartment 102.

However, at mentioned above, they could also be arranged in the second compartment.

[0032] Figure 2 schematically shows a three-dimensional view of an embodiment of an electrostatic precipitator unit 1 according to the invention. The cover plate 104 (see figure 3) and the upper lid (not shown) have been removed to reveal the location of the control box 106 forming a unitary enclosure in which the controller 8 and the high voltage generator 6 are arranged. In this embodiment, the insulator 7 is arranged in a separate fourth compartment 107 above the compartment housing the control box 106. The upper lid can e.g. be removed for inspection of the system or when it is necessary to clean the discharge electrode 5.

[0033] Figure 3 is a cross-sectional top view of the embodiment in figure 2 with the horizontal section being made just above the control box 106. The discharge electrode 5 and the connection between the discharge electrode 5 and the high voltage generator 6 via the insulator 7 cannot be seen in this view. This figure clearly shows how the casing 9 extends laterally from the pipe 4. The figure further shows the first compartment 101 adjacent to the pipe 4 and the second compartment 102 at a distance from the pipe 4 and separated from the first compartment 101 by the heat shield plate 103. In this embodiment, the controller 8 and the high voltage generator 6 are arranged in a control box 106 in a third compartment 108 adjacent to and at least partly separated from the second compartment 102 by a mounting plate 109 supporting the high voltage generator 6 and the controller 8. In some embodiments of the invention, a shortest horizontal distance d_1 between the pipe 4 and the heat shield plate 103 is at least 10 mm, such as at least 13 mm, such as at least 15 mm. Furthermore, in some embodiments of the invention, a shortest horizontal distance d_2 between the heat shield plate 103 and both the controller 8 and the high voltage generator 6 is at least 15 mm, such as at least 18 mm, such as at least 20 mm.

[0034] In the embodiment illustrated in figure 3, the control box 106, housing the controller 8 and the high voltage generator 6, is arranged the third compartment 108 adjacent to and at least partly separated from the second compartment 102 by a mounting plate 109 for carrying the control box 106. The control box 106 of this embodiment forms a unitary enclosure which is mounted to the mounting plate 109 by bolts, but other ways of mounting, such as clamps or brackets, are also covered by the scope of protection.

[0035] Figure 4 is a three-dimensional sectional view with the section being made along line A-A in figure 3. The figure shows that the walls of the casing are provided with lower holes 110 at a lower region of the second compartment 102 and upper holes 111 at an upper region of the second compartment 102. The lower holes 110 and upper holes 111 are provided in two opposing walls of the casing 9. The lower holes 110 are configured to allow air to be drawn into the second compartment 102 from the surroundings, and upper holes 111 are configured to

allow air to be vented out of the second compartment 102. As described above, the lower and upper holes 110,111 thereby cause a flow of air along the second compartment 102 as a result of thermal convection caused by hot flue gas flowing in the flow passage during use of the electrostatic precipitator unit. The flow of air is illustrated with arrows in figure 4.

[0036] Figures 5a. and 5.b schematically show an assembled and an exploded view, respectively, of a discharge electrode assembly which may form part of an electrostatic precipitator unit according to the present invention. The discharge electrode assembly 201 comprises a discharge electrode 5 configured to be electrically connected to an associated high voltage generator 6 for providing an electric field being generated in a region around the discharge electrode 5 during use, as explained in relation to figure 1. It further comprises an insulator 7 which is configured to be arranged between the high voltage generator 6 and the discharge electrode 5 during use. A connector pin 202 is connected to the discharge electrode 5 at a first end 203, and an insulator connector 204 connects the insulator 7 and a second end 205 of the connector pin 202. The connector pin 202 comprises a first locking surface LS1 at the first end 203 and a second locking surface LS2 at the second end 205. Details of all the locking surfaces will be given in relation to the following figures. The discharge electrode 5 comprises a third locking surface LS3 at an upper end 206, and the insulator connector 204 comprises a fourth locking surface LS4. As explained above, the first and the third locking surfaces LS1,LS3 are configured to form a fixed mutual engagement preventing translational and rotational movement of the discharge electrode 5 in relation to the connector pin 202, and the second and the fourth locking surfaces LS2,LS4 are configured to form a fixed mutual engagement preventing translational and rotational movement of the connector pin 202 in relation to the insulator connector 204. In the illustrated embodiment, the discharge electrode 5 comprises a first discharge electrode part 5a and a second discharge electrode part 5b, which first and second discharge electrode parts 5a,5b are aligned and releasably and fixedly connected to each other during use of the discharge electrode 5. In this embodiment, the connection between the first and second discharge electrode parts 5a,5b are performed by use of rivets 207; the number of these may differ from what is shown in the figure.

[0037] Figures 6.a-6.c schematically show the region around the connection between the connector pin 202 and the discharge electrode 5 in figures 5.a and 5.b; i.e. the design of the first and third locking surfaces LS1,LS3. In these figures, the angle of view is different from the one in figures 5.a and 5.b to more clearly show the relevant details. Figures 6.a and 6.b show exploded three-dimensional views, and figure 6.c shows an end view after assembly of the first and third locking surfaces LS1,LS3. In the illustrated embodiment, the first locking surface LS1 is a protrusion 208 extending from the first

end 203 of the connector pin 202, and the third locking surface LS3 is a locking hole 209 in the first discharge electrode part 5a, the locking hole 209 matching the shape and dimensions of the protrusion 208. In this embodiment, the mutual connection between the first and third locking surfaces LS1,LS3 is releasably established by use of a button head screw 210 inserted through a hole 211 in the second discharge electrode part 5b and axially into a threaded hole 212 in the connector pin 202 as shown in the figure.

[0038] Figures 7.a to 7.c schematically show the connection between the connector pin 202 and the insulator 7 in figures 5.a and 5.b. Figure 7.a shows the whole discharge electrode assembly 201, and figure 7.b shows the region around the second and fourth locking surfaces LS2,LS4. The second locking surface LS2 is a recess 213 in the connector pin 202; see also figure 6.a. The fourth locking surface LS4 is a combination of a guiding hole 214 in the insulator connector 204 configured to receive the second end 205 of the connector pin 202 and a set screw 215 configured to fixedly engage with the recess 213 when the connector pin 202 is at a predefined position in the guiding hole 214. The mutual engagement between the second and the fourth locking surfaces LS2,LS4 is releasable by loosening the set screw 215 again. As seen in the figures, the insulator connector 204 comprises the guiding hole 214, and the connector pin 202 is configured to slide along the guiding hole 214 in the insulator connector 204 to allow for movement the discharge electrode 5 relative to the insulator 7.

[0039] Figure 7.a also illustrates that the insulator connector 204 comprises a fifth locking surface LS5, the insulator 7 comprises a sixth locking surface LS6, and the fifth and the sixth locking surfaces LS5,LS6 are configured to form a fixed mutual engagement preventing translational and rotational movement of the insulator connector 204 in relation to the insulator 7.

[0040] Figure 7.c schematically shows the possible sliding of the discharge electrode 5 relative to the insulator 7. Loosening of the set screw 215 therefore allows for easy disassembling for cleaning of the discharge electrode 5 as well as for chimney sweeping. The discharge electrode 5 can either be removed completely or retracted so that it is positioned along the wall of the pipe 4 forming the flow passage in which the discharge electrode 5 is arranged during use.

[0041] Although the present invention has been described in connection with the specified embodiments, it should not be construed as being in any way limited to the presented examples. The scope of the present invention is set out by the accompanying claim set. In the context of the claims, the terms "comprising" or "comprises" do not exclude other possible elements or steps. Also, the mentioning of references such as "a" or "an" etc. should not be construed as excluding a plurality. The use of reference signs in the claims with respect to elements indicated in the figures shall also not be construed as limiting the scope of the invention. Furthermore, indi-

vidual features mentioned in different claims, may possibly be advantageously combined, and the mentioning of these features in different claims does not exclude that a combination of features is not possible and advantageous.

Claims

1. Electrostatic precipitator unit (1) for insertion in a flue gas passageway, such as a chimney, the electrostatic precipitator unit (1) comprising:

- a flue gas inlet (2) for receiving a flow of flue gas,
- a flue gas outlet (3) for venting the flow of flue gas,
- a pipe (4) forming a flow passage extending between the flue gas inlet (2) and the flue gas outlet (3),
- a discharge electrode (5) arranged in the flow passage,
- a high voltage generator (6) connected to the discharge electrode (5) for providing an electric field being generated in a region around the discharge electrode (5), when the high voltage generator (6) is turned on,
- an insulator (7) arranged between the high voltage generator (6) and the discharge electrode (5),
- a controller (8) for controlling the operation of the high voltage generator (6) and the discharge electrode (5), and
- a casing (9) extending laterally from the pipe (4), the casing (9) comprising:

- a first compartment (101) adjacent to the pipe (4), and
- a second compartment (102) at a distance from the pipe (4) and separated from the first compartment (101) by a heat shield plate (103) along at least a part of a height of the first compartment (101),

wherein the controller (8) and the high voltage generator (6) are arranged:

- in the second compartment (102), or
- in a third compartment (108) adjacent to and at least partly separated from the second compartment (102) by a mounting plate (109) supporting the high voltage generator (6) and the controller (8), and

wherein walls of the casing (9) are provided with:

- at least one lower hole (110) at a lower region of the second compartment (102), and

- at least one upper hole (111) at an upper region of the second compartment (102),

the at least one lower hole (110) being configured to allow air to be drawn into the second compartment (102) from the surroundings and the at least one upper hole (111) being configured to allow air to be vented out of the second compartment (102) thereby causing a flow of air along the second compartment (102) as a result of thermal convection caused by hot flue gas flowing in the flow passage during use of the electrostatic precipitator unit (1).

2. Electrostatic precipitator unit (1) according to claim 1, wherein both the at least one lower hole (110) and the at least one upper hole (11) are provided in two opposing walls of the casing (9).

3. Electrostatic precipitator unit (1) according to claim 1 or 2, wherein the insulator (7) is arranged in a fourth compartment (107) of the casing (9), the fourth compartment (107) being above and at least partly separated from the second or third compartment (102, 108) in which the controller (8) and the high voltage generator (6) are arranged.

4. Electrostatic precipitator unit (1) according to any of the preceding claims, wherein the controller (8) and the high voltage generator (6) are arranged in a control box (106) forming a unitary enclosure.

5. Electrostatic precipitator unit (1) according to any of the preceding claims, wherein a shortest horizontal distance (d1) between the pipe (4) and the heat shield plate (103) is at least 10 mm, such as at least 13 mm, such as at least 15 mm.

6. Electrostatic precipitator unit (1) according to any of the preceding claims, wherein a shortest horizontal distance (d2) between the heat shield plate (103) and both the controller (8) and the high voltage generator (6) is at least 15 mm, such as at least 18 mm, such as at least 20 mm.

7. Electrostatic precipitator unit (1) according to any of the preceding claims, further comprising a discharge electrode assembly (201), the discharge electrode assembly (201) comprising:

- the discharge electrode (5),
- the insulator (7), and
- a connector pin (202) connected to the discharge electrode (5) at a first end (203), and
- an insulator connector (204) connecting the insulator (7) and a second end (205) of the connector pin (202),

wherein:

- the connector pin (202) comprises a first locking surface (LS1) at the first end (203) and a second locking surface (LS2) at the second end (205),
- the discharge electrode (5) comprises a third locking surface (LS3) at an upper end (206),
- the insulator connector (204) comprises a fourth locking surface (LS4), and

wherein:

- the first and the third locking surfaces (LS1,LS3) are configured to form a fixed mutual engagement preventing translational and rotational movement of the discharge electrode (5) in relation to the connector pin (202),
- the second and the fourth locking surfaces (LS2,LS4) are configured to form a fixed mutual engagement preventing translational and rotational movement of the connector pin (202) in relation to the insulator connector (7).

8. Electrostatic precipitator unit (1) according to claim 7, wherein:

- the mutual engagement between the first and the third locking surfaces (LS1,LS3) is releasable, and/or
- the mutual engagement between the second and the fourth locking surfaces (LS2,LS4) is releasable.

9. Electrostatic precipitator unit (1) according to claim 7 or 8, wherein:

- the first locking surface (LS1) is a protrusion (208) extending from the first end (203) of the connector pin (202), and
- the third locking surface (LS3) is a locking hole (209) matching the shape and dimensions of the protrusion (208).

10. Electrostatic precipitator unit (1) according to any of claims 7 to 9, wherein:

- the second locking surface (LS2) is a recess (213) in the connector pin (202), and
- the fourth locking surface (LS4) is a combination of:

- a guiding hole (214) in the insulator connector (204) configured to receive the second end (205) of the connector pin (202), and
- a set screw (215) configured to fixedly engage with the recess (213) when the connector pin (202) is at a predefined position in the guiding hole (214).

11. Electrostatic precipitator unit (1) according to any of claims 7 to 10, wherein:

- the insulator connector (204) comprises the guiding hole (214), and
- the connector pin (202) is configured to slide along the guiding hole (214) in the insulator connector (204) to allow for movement the discharge electrode (5) relative to the insulator (7).

12. Electrostatic precipitator unit (1) according to any of claims 7 to 11, wherein:

- the insulator connector (204) comprises a fifth locking surface (LS5),
- the insulator (7) comprises a sixth locking surface (LS6), and
- the fifth and the sixth locking surfaces (LS5,LS6) are configured to form a fixed mutual engagement preventing translational and rotational movement of the insulator connector (204) in relation to the insulator (7).

13. Electrostatic precipitator unit (1) according to any of the preceding claims, wherein the discharge electrode (5) comprises a first discharge electrode part (5a) and a second discharge electrode part (5b), which first and second discharge electrode parts (5a,5b) are aligned and releasably and fixedly connected to each other during use of the discharge electrode (5).

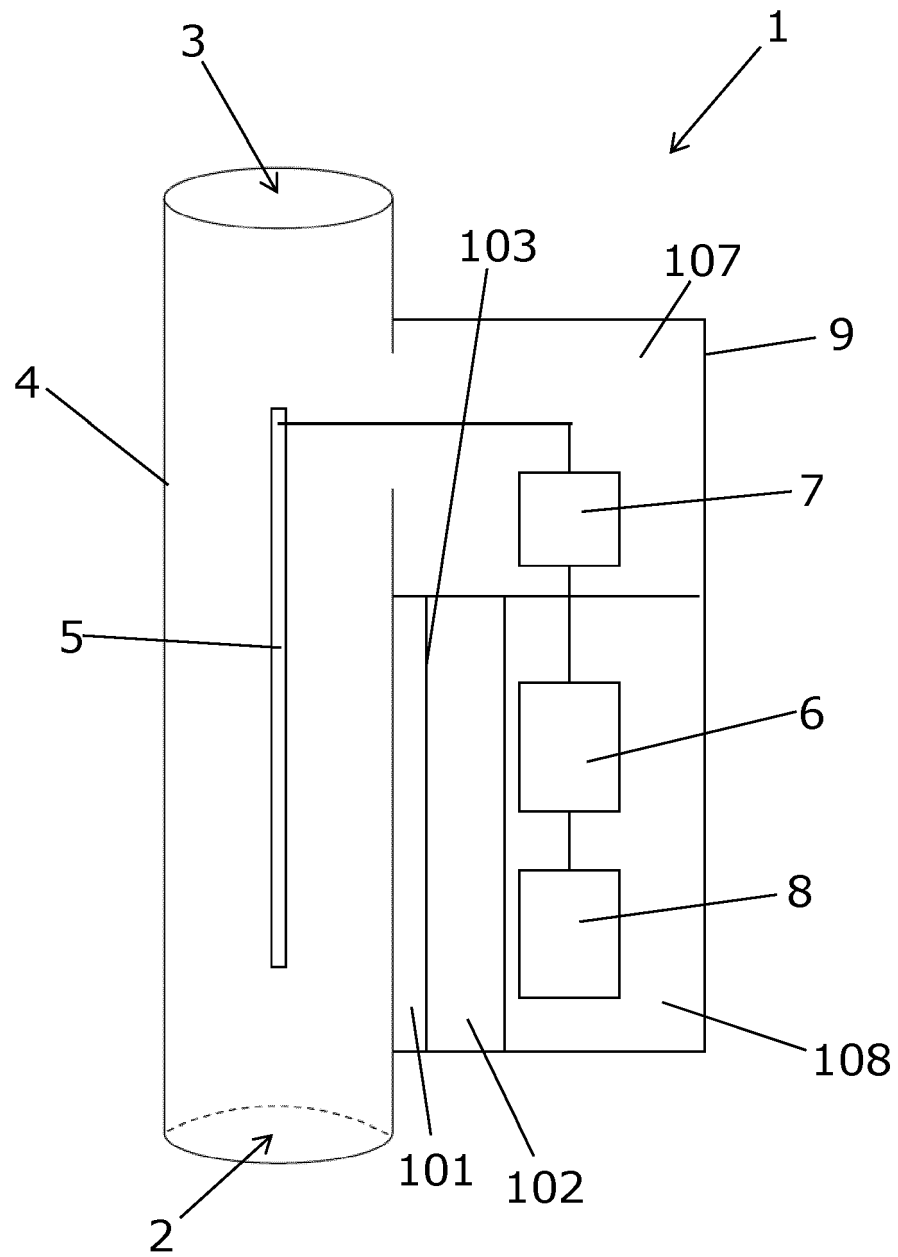


Fig. 1

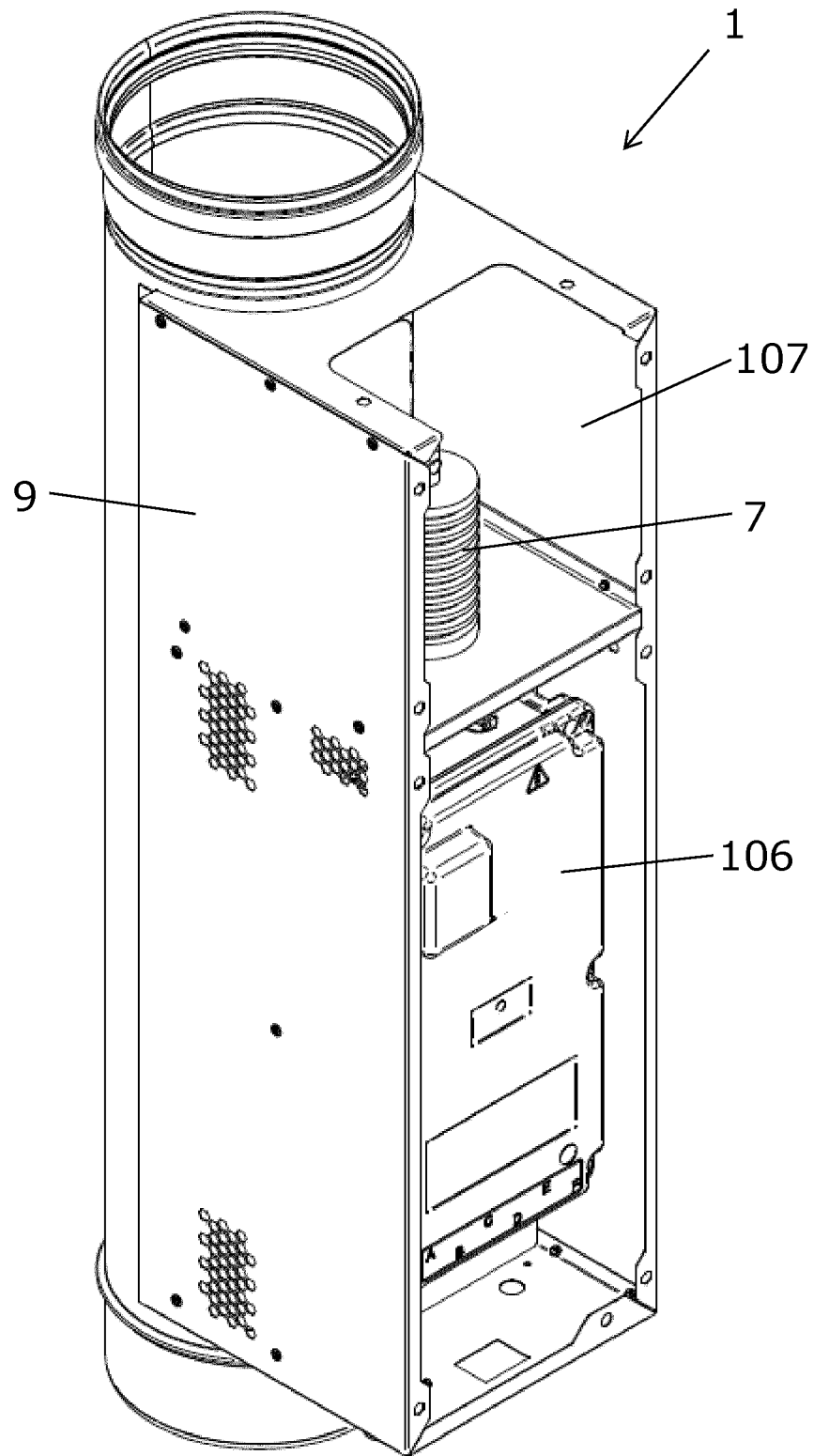


Fig. 2

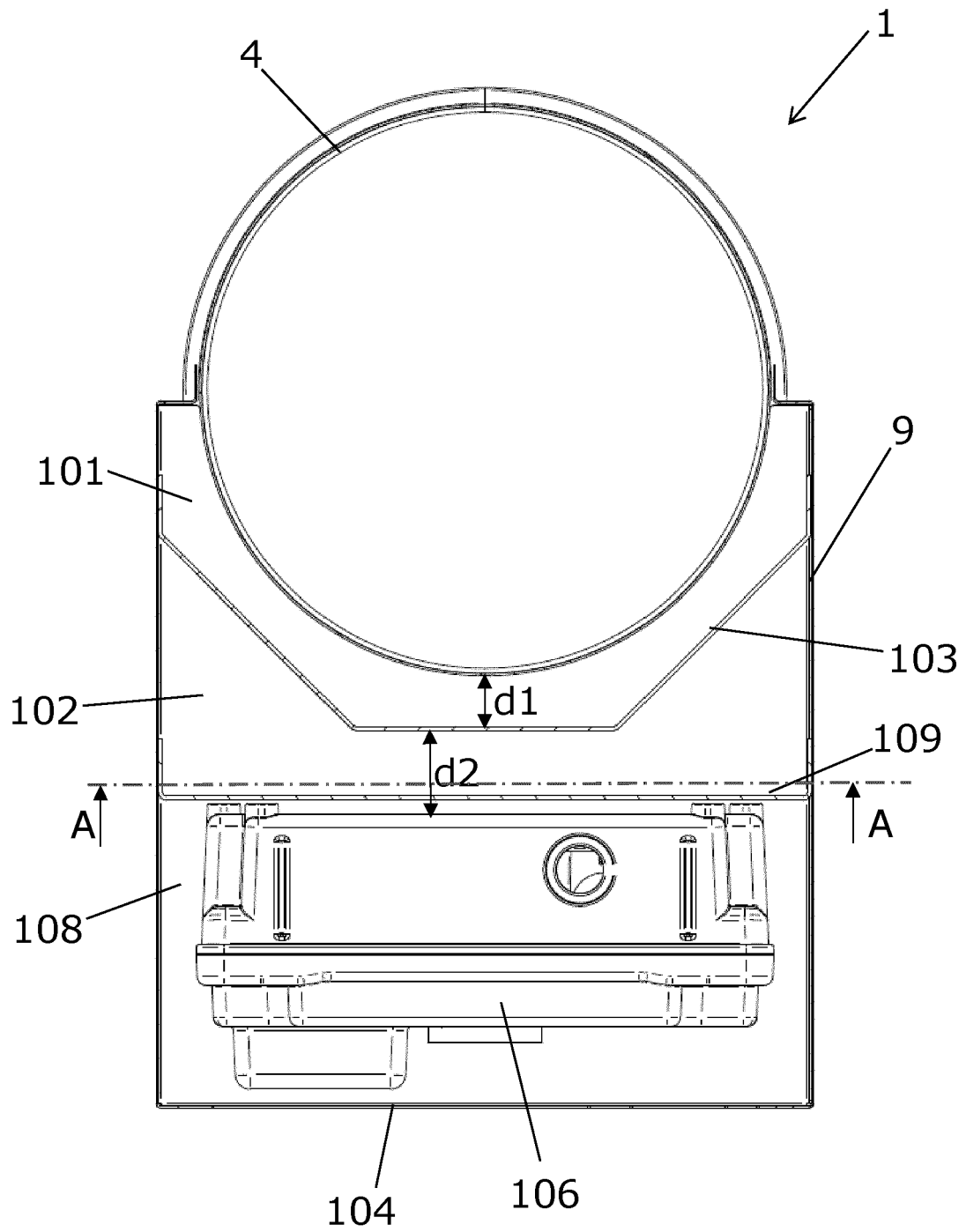


Fig. 3

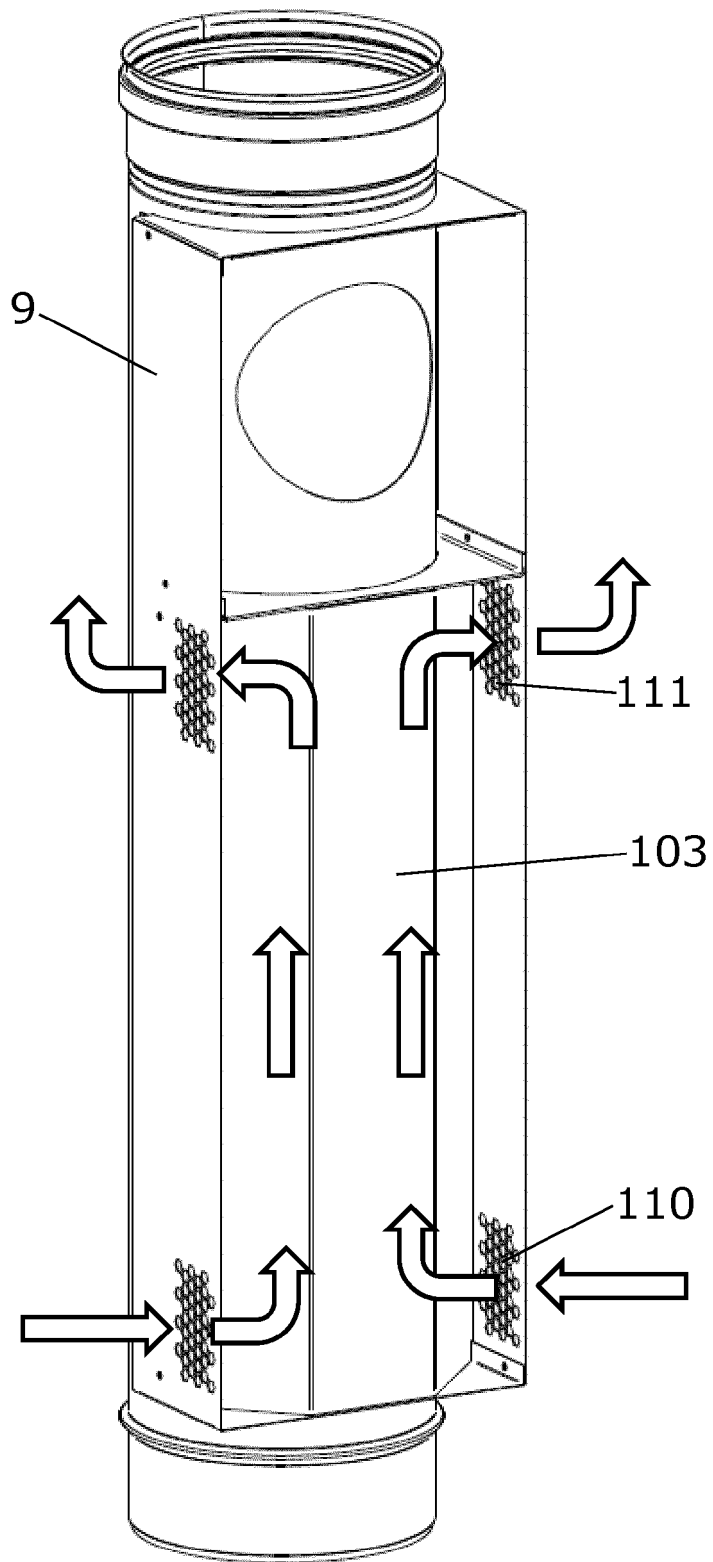


Fig. 4

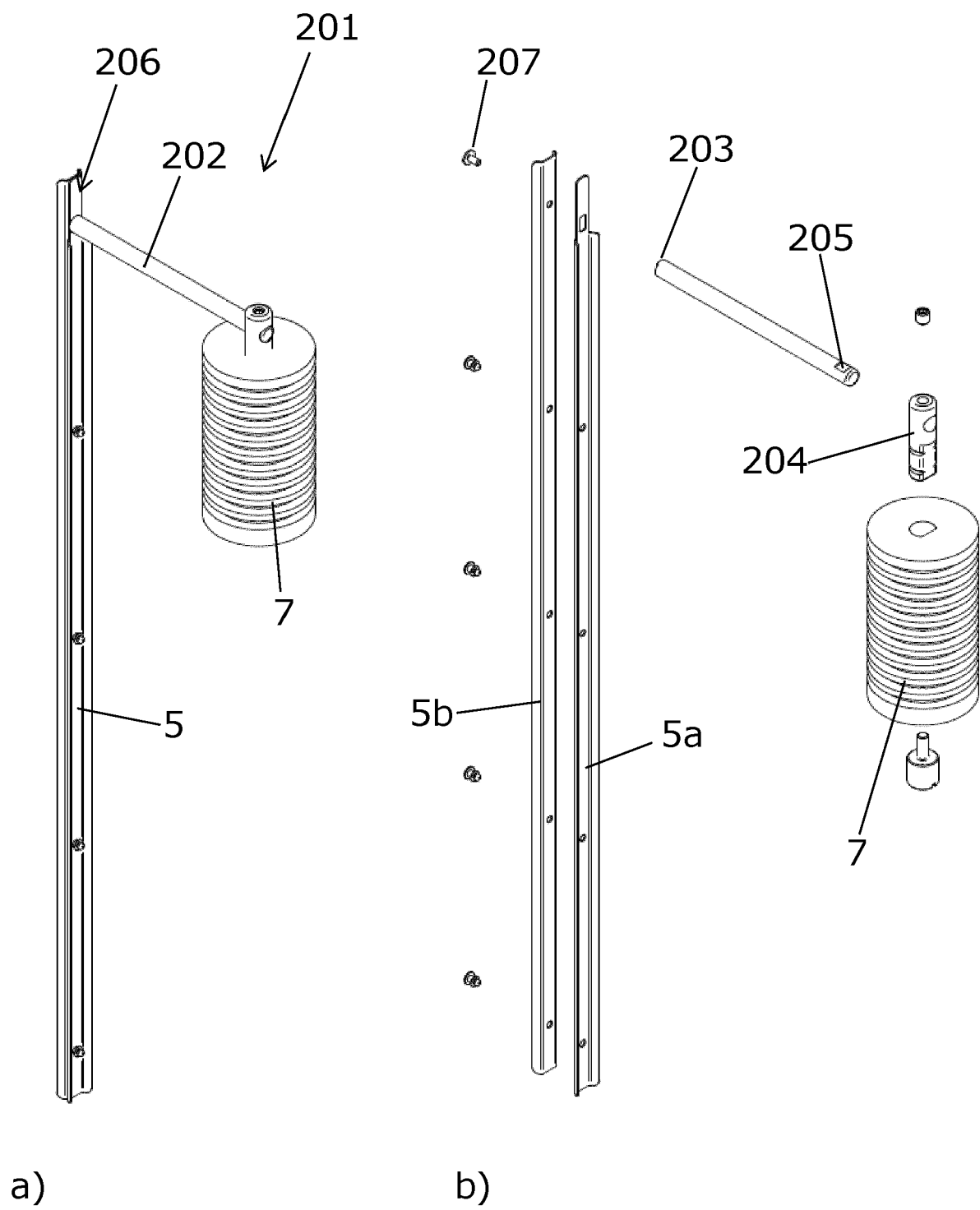


Fig. 5

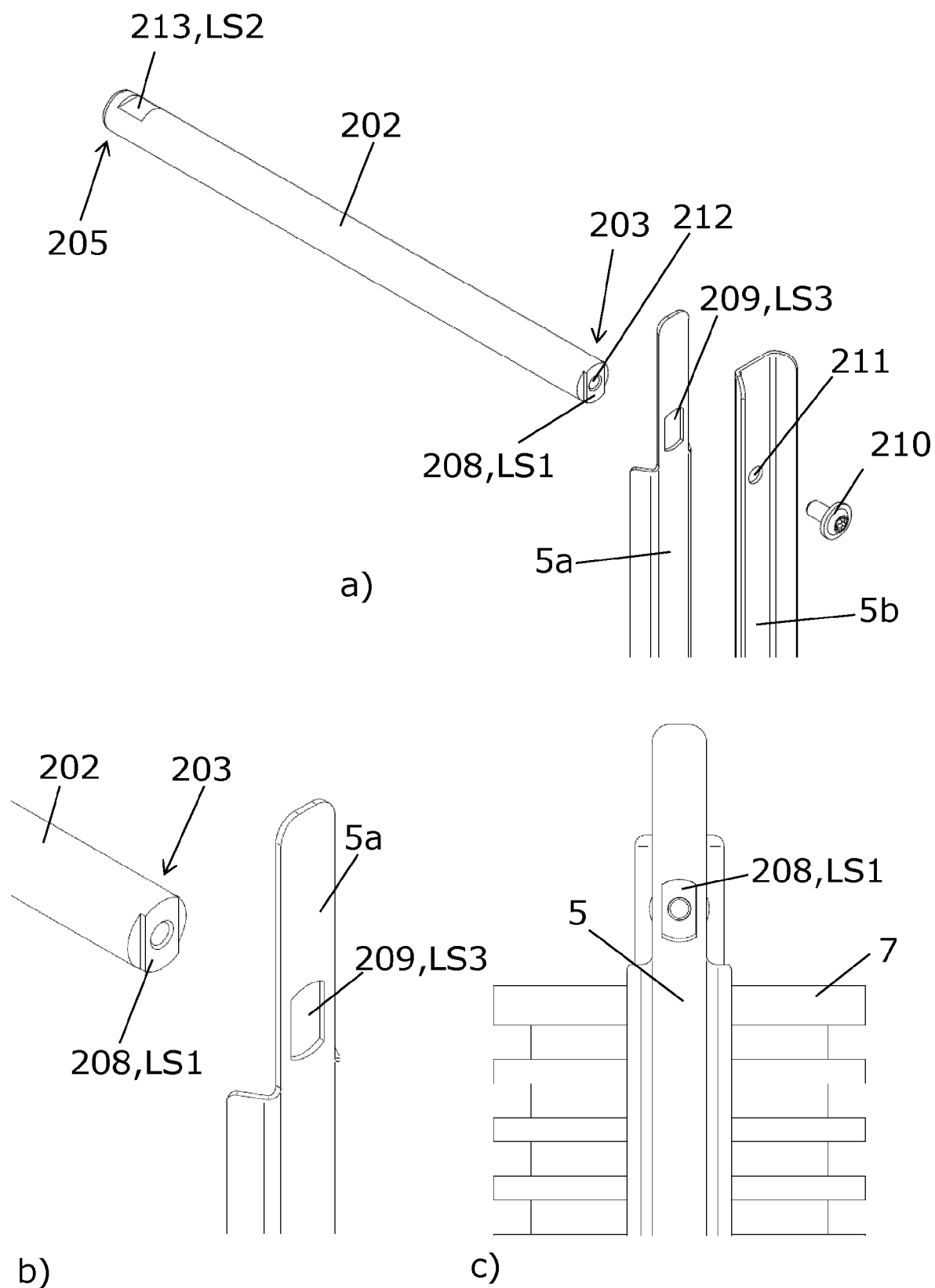


Fig. 6

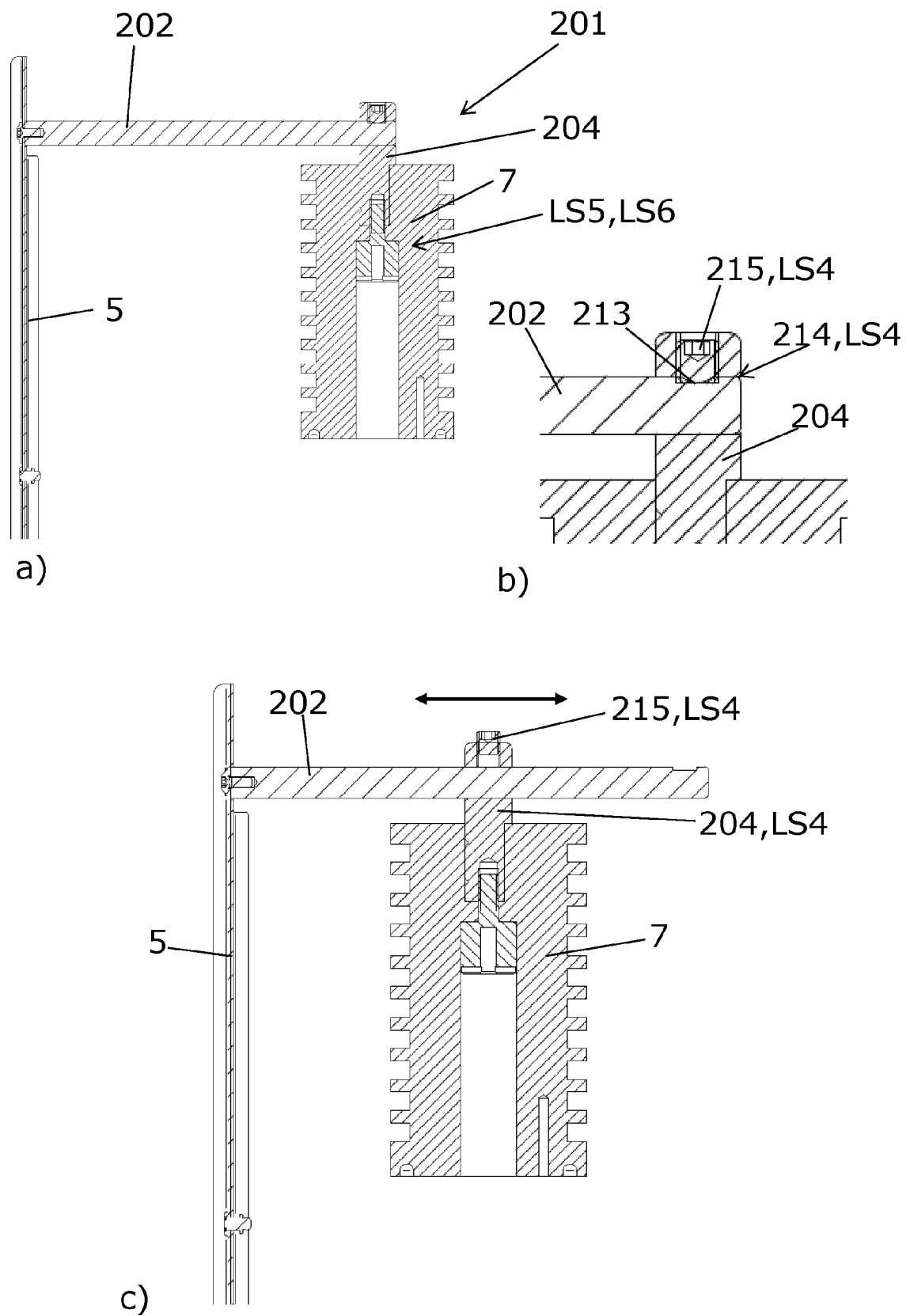


Fig. 7



EUROPEAN SEARCH REPORT

Application Number

EP 23 15 6073

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Y	* figures 3,5-9 * * paragraphs [0057], [0058], [0068], [0073] * * paragraph [0051] - paragraph [0072] * -----	7-13	B03C3/66 B03C3/82 B03C3/86 B03C3/68 B03C3/70
Y	EP 2 551 018 A2 (MUELLER BEAT [CH]; JUD DANIEL [CH]) 30 January 2013 (2013-01-30) * figures 1-2 * * paragraphs [0057], [0058], [0068], [0073] * -----	7-13	
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Place of search The Hague		Date of completion of the search 14 July 2023	Examiner Menck, Anja
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

**ANNEX TO THE EUROPEAN SEARCH REPORT
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