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(54) HEAT EXCHANGER BODY, HEAT EXCHANGER AND CONDENSING BOILER

(57) A heat exchanger body for transfer of heat from a flue gas to an operating fluid, in particular of a condensing boiler, wherein the heat exchanger body comprises an integral casting from aluminium or an aluminium alloy and comprises: one or more flue gas drafts each configured to guide a flow of flue gas in a flue gas flow direction;

and an operating fluid channel configured to guide a flow of operating fluid in an operating fluid flow direction along an operating fluid flow path. Viewed in the flue gas flow direction, the operating fluid flow path loops around and thereby encloses each of the one or more flue gas drafts.

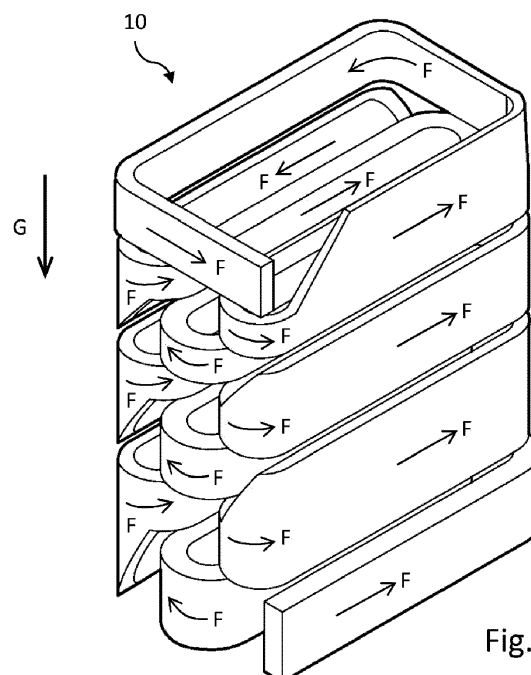


Fig. 3a

EP 4 030 113 A1

Description

FIELD

[0001] The invention relates to a heat exchanger body, a heat exchanger and a condensing boiler. The invention also relates to a pattern assembly for producing a part of a mold for casting the heat exchanger body and to a method of producing the heat exchanger body with the part of the mold.

BACKGROUND

[0002] Heat exchanger bodies are known from practice. As part of a heat exchanger, a heat exchanger body can enable exchange of heat between fluidly separate flows of fluids, e.g. from a flow of flue gas to a flow of operating fluid. Such heat exchangers are applied for example in heating appliances, e.g. boilers, e.g. for heating interior spaces of buildings or vehicles or for using the heated operating fluid otherwise, e.g. as heated tap water. Typically, in a heat exchanger, the separate flows of fluids are passed close to each other, preferably in opposite directions, while being fluidly separated by a heat conductive, e.g. metallic, material. Where the fluids contact the heat conductive material, they can exchange heat with the heat conductive material, so that they can indirectly exchange heat with each other via the heat conductive material.

[0003] It is generally desired to have a high efficiency of heat exchange in heating appliances, in particular to enable exchange of a relatively large amount of heat in a relatively short amount of time and/or in a relatively small space. In this respect, for example, condensing boilers are known to provide increased efficiency compared to conventional boilers by extracting additional heat from a flue gas through water vapor condensation in the flue gas.

[0004] However, there has long been, and still is, an ongoing desire for further improving heat exchanger efficiency, in particular in condensing boilers. This desire is due to various factors such as energy scarcity, environmental concerns, space limitations for heating appliances and high demand for comfort in interior environments.

SUMMARY

[0005] An objective of the present invention is to provide an improved heat exchanger body, an improved heat exchanger and an improved condensing boiler. A particular objective is to provide increased heat exchanger efficiency, for example a higher amount of heat exchange in the same or a smaller amount of time and/or space, or the same amount of heat exchange in a smaller amount of time and/or space. A further particular objective is to provide a heat exchanger with a reduced operating fluid flow resistance and/or an increased operating

fluid flow contact surface area.

[0006] To that end, an aspect of the invention provides a heat exchanger body for transfer of heat from a flue gas to an operating fluid. The heat exchanger body comprises an integral casting from aluminium or an aluminium alloy and comprises: one or more flue gas drafts each configured to guide a flow of flue gas in a flue gas flow direction; and an operating fluid channel configured to guide a flow of operating fluid in an operating fluid flow direction along an operating fluid flow path. Viewed in the flue gas flow direction, the operating fluid flow path loops around and thereby encloses each of the one or more flue gas drafts.

[0007] It has been found that such a configuration of an operating fluid flow path in a heat exchanger body can enable reduced operating fluid flow resistance. Without wishing to be bound by theory, it is believed that this can be due to the operating fluid flow path being smoother, e.g. having fewer relatively sharp curves or corners, and/or having more gentle curves or corners, compared to known heat exchanger bodies.

[0008] As an alternative or additional advantage, such a configuration can enable an increased operating fluid flow contact surface area: a narrower channel can yield an increased contact surface area, and since the path configuration can enable reduced resistance, the operating fluid flow channel can thus be designed to be more narrow without a net flow resistance increase.

[0009] Further, by looping around and enclosing each of the one or more flue gas drafts, a relatively high rate of heat exchange between flue gas and operating fluid can be realized within a relatively small space, with a relatively low amount of heat exchanger material (e.g. metal) and/or relatively quickly. In particular, heat can thus be exchanged more homogeneously in the heat exchanger.

[0010] Heat exchanger efficiency of a heat exchanger can thus be increased by a heat exchanger body according to the present disclosure.

[0011] In a further aspect the invention provides: a heat exchanger for transfer of heat from a flue gas to an operating fluid, wherein the heat exchanger comprises the heat exchanger body according to the above-described aspect, wherein the integral casting of the heat exchanger body comprises one or more core holes, wherein the heat exchanger comprises one or more core plugs arranged in at least one of the one or more core holes for closing off said at least one of the one or more core holes.

[0012] The invention also provides a condensing boiler comprising said heat exchanger.

[0013] Such a heat exchanger and such a condensing boiler can provide above-mentioned advantages, wherein the invention finds particular advantage in combination with such a condensing type boiler.

[0014] Further aspects of the invention provide a pattern assembly and a method of producing an integral casting of a heat exchanger body. The method comprises: providing the pattern assembly, using the pattern as-

sembly to produce a part of a mold for casting an integral casting; and casting an integral casting using the produced part of the mold.

[0015] The pattern assembly is configured for producing a part of a mold for casting an integral casting of a heat exchanger body according to the above-described aspect. The pattern assembly comprises: one or more flue gas draft core sections which each extend along a respective flue gas draft core main axis; and at least one operating fluid channel core section, wherein the operating fluid channel core section defines an operating fluid channel core path which loops around and thereby encloses the respective flue gas draft core main axis of each of the one or more flue gas draft core sections.

[0016] With such a method and/or with such a pattern assembly, a heat exchanger body according to the present disclosure can be provided.

[0017] Further advantageous elaborations of the invention are provided by the features of the dependent claims, as explained in the detailed description.

DETAILED DESCRIPTION

[0018] In the following, the invention will be further explained using exemplary embodiments and drawings. In the drawings:

Fig. 1a shows an isometric view of an operating fluid flow channel of a heat exchanger body according to a first embodiment;

Fig. 1b shows a top view of the heat exchanger body according to the first embodiment;

Fig. 1c shows a side view of the heat exchanger body according to the first embodiment;

Fig. 1d shows the operating fluid flow path of the operating fluid flow channel of Fig. 1a in an isometric view corresponding to the view of Fig. 1a;

Fig. 2a shows an isometric view of an operating fluid flow channel of a heat exchanger body according to a second embodiment;

Fig. 2b shows a top view of the heat exchanger body according to the second embodiment;

Fig. 2c shows a side view of the heat exchanger body according to the second embodiment;

Fig. 3a shows an isometric view of an operating fluid flow channel of a heat exchanger body according to a third embodiment;

Fig. 3b shows a top view of the heat exchanger body according to the third embodiment;

Fig. 3c shows a side view of the heat exchanger body according to the third embodiment;

Fig. 4 shows a partially opened isometric view of an exemplary condensing boiler comprising an exemplary heat exchanger;

Fig. 5a shows an exploded isometric view of a heat exchanger according to an embodiment;

Fig. 5b shows a partly transparent side view of an operating fluid channel of the heat exchanger of Fig.

5a;

Fig. 6a shows an exploded isometric view of a heat exchanger according to a further embodiment; and Fig. 6b shows a partly transparent side view of an operating fluid channel of the heat exchanger of Fig. 6a.

[0019] The drawings are schematic. In the drawings, similar or corresponding elements have been provided with similar or corresponding reference signs.

[0020] Figs. 1b, 1c, 2b, 2c, 3b and 3c show embodiments of a heat exchanger body 2 for transfer of heat from a flue gas to an operating fluid, in particular of a condensing boiler 4. The heat exchanger body 2 comprises an integral casting 6 from aluminium or an aluminium alloy.

[0021] The heat exchanger body comprises: one or more flue gas drafts 8, 8', 8" each configured to guide a flow of flue gas in a flue gas flow direction G; and an operating fluid channel 10 (see also Figs. 1a, 2a and 3a) configured to guide a flow of operating fluid in an operating fluid flow direction F along an operating fluid flow path P (see also Fig. 1d).

[0022] Viewed in the flue gas flow direction G, the operating fluid flow path P loops around and thereby encloses each of the one or more flue gas drafts 8, 8', 8".

[0023] In Figs. 1b, 1c, 2b, 2c, 3b and 3c boundaries of the heat exchanger body 2 have been indicated schematically by dotted lines, while respective operating fluid flow channels 10 extending inside the body 2 have been indicated with solid lines and, for obscured sections, with thin dashed lines.

[0024] In Fig. 1b an exemplary section of an operating fluid flow path P is shown with a dashed line. It will be appreciated that in the embodiments shown, respective operating fluid flow paths P extend throughout the operating fluid flow channels 10 which define the respective paths P.

[0025] In the drawings, the operating fluid flow direction F has been indicated intermittently by arrows F. It will be appreciated that the operating fluid flow direction F is tied to and follows the subsequent directions of the operating fluid flow path P along said path P. Hence, in the drawings, the trajectory of the operating fluid flow path P can be related to the shown indications of the operating fluid flow direction F.

[0026] Figs. 1a-1d relate to a first embodiment, wherein the heat exchanger body 2 comprises one flue gas draft 8. Figs. 2a-2c relate to a second embodiment, wherein the heat exchanger body 2 comprises two flue gas drafts 8, 8'. Figs. 3a-3c relate to a third embodiment, wherein the heat exchanger body 2 comprises three flue gas drafts 8, 8', 8". It will be appreciated that the invention is not limited to any maximum number of flue gas drafts.

[0027] It will also be appreciated that various configurations of the operating fluid flow path are possible within the scope of the invention and that the configurations shown are not necessarily limitative with respect to the

number of flue gas drafts shown. For example, in the first embodiment (see Figs. 1a-d), the heat exchanger body 2 has a single flue gas draft 8 and the operating fluid flow path P is a substantially helical path.

[0028] In Fig. 1d, with respect to the first embodiment, a trajectory of the flue gas draft 8 has been indicated schematically by the flue gas flow direction arrow G relative to the operating fluid flow path P. In the isometric view of Fig. 1d, which corresponds to the view of Fig. 1a, the operating fluid flow path P can be seen to pass alternately in front of and behind the arrow G, thus looping around and thereby enclosing the arrow G, hence the operating fluid flow path P loops around and encloses the flue gas draft 8. This information can also be deduced from the combination of Figs. 1a, 1b and 1c. For the second and third embodiments, the information on their respective operating fluid flow paths P can similarly be deduced from the relevant drawings.

[0029] Thus, it is clear from the respective drawings how in the various embodiments, the operating fluid flow path P loops around and thereby encloses each of the one or more flue gas drafts 8, 8', 8".

[0030] For example, in the second embodiment, shown in Figs. 2a-2c, the operating fluid flow path P extends subsequently along a first outer section P_O bounding a second flue gas draft 8', a first end section P_E bounding a first end of the second flue gas draft 8', a first intermediate section P_I between the second flue gas draft 8' and a first flue gas draft 8, a second end section P_E bounding a second end of the first flue gas draft 8, a second outer section P_O bounding the first flue gas draft 8, a third end section P_E bounding a first end of the first flue gas draft 8, a second intermediate section P_I along the first intermediate section P_I, a fourth end section P_E bounding a second end of the second flue gas draft 8', a third outer section P_O along the first outer section, a fifth end section along the first end section, and so on.

[0031] As another example, in the third embodiment, shown in Figs. 3a-3c, the operating fluid flow path P extends subsequently along a first outer section P_O bounding a third flue gas draft 8", a first end section P_E bounding a first end of the third flue gas draft 8", a first intermediate section P_I between the third flue gas draft 8" and a second flue gas draft 8', a second end section P_E bounding a second end of the second flue gas draft 8', a second intermediate section P_I between the second flue gas draft 8' and a first flue gas draft 8, a third end section P_E bounding a first end of the first flue gas draft 8, a second outer section P_O bounding the first flue gas draft 8, a fourth end section P_E bounding a second end of the first flue gas draft 8, a third intermediate section P_I along the second intermediate section P_I, a fifth end section P_E bounding a first end of the second flue gas draft 8', a fourth intermediate section P_I along the first intermediate section P_I, a sixth end section P_E bounding a second end of the third flue gas draft 8", a third outer section P_O along the first outer section P_O, a seventh end section P_E along the first end section P_E, and so on.

[0032] As explained in the summary section, heat exchanger efficiency of a heat exchanger can be increased by such a heat exchanger body 2.

[0033] In an embodiment, viewed perpendicular to the flue gas flow direction G, the operating fluid flow path P ascends or descends substantially monotonically along the flue gas flow direction G.

[0034] In the context of the present disclosure, the expression "ascends or descends substantially monotonically along a direction" is to be interpreted as ascending without descending or, alternatively descending without ascending.

[0035] As shown, when the flue gas flow direction G is a downward direction, the operating fluid flow path P preferably ascends substantially monotonically, i.e. during use the operating fluid preferably flows in a substantially opposite overall direction compared to the flue gas.

[0036] In this way, a relatively smooth flow of operating fluid can be realized, in particular with respect to the flue gas flow direction G, thus promoting efficient heat transfer.

[0037] In an embodiment, the operating fluid flow path P forms a substantially singular operating fluid flow path P.

[0038] Such a substantially singular path can enable particular robust operation, wherein for example any blockage (e.g. due to debris) in the operating fluid flow channel 10 can be detected using temperature sensors arranged at both ends of the flow path P. Local overheating can thus be prevented. For example, the operating fluid flow path P may thus be a substantially undivided path which may be free from path junctions such as path splits and path mergers.

[0039] In an embodiment, viewed in the flue gas flow direction G, the operating fluid flow path P loops around each of the one or more flue gas drafts 8, 8', 8" at least two times, preferably at least three times, preferably at least four times, preferably at least five times.

[0040] Such a configuration can enable that operating fluid is heated up more gradually along the operating fluid flow path P and/or that flue gas is cooled down more gradually along the flue gas flow direction G, thus promoting heat exchanger efficiency.

[0041] In an embodiment, the one or more flue gas drafts 8, 8', 8" comprise at least two flue gas drafts 8, 8', 8", wherein the at least two flue gas drafts 8, 8', 8" comprise at least one pair of neighboring flue gas drafts (one pair 8, 8'; another pair 8', 8").

[0042] Viewed in the flue gas flow direction G, between each pair of neighboring flue gas drafts 8, 8', 8" one or more intermediate sections P_I of the operating fluid flow path P may extend, such that the operating fluid flow path P loops around and thereby encloses each flue gas draft 8, 8', 8" individually.

[0043] The at least two flue gas drafts 8, 8', 8" can promote heat exchanger efficiency by a higher total functional contact surface area of the flue gas drafts, in particular as a ratio to the total flue gas draft volume. The

intermediate sections P_I of the operating fluid flow path P can thereby enable that above-described features are realized and that respective advantages are maintained or enhanced, e.g. a smooth operating fluid flow and gradual heating and/or cooling.

[0044] While the third embodiment is shown in Figs. 3a-3c as comprising three flue gas drafts 8, 8', 8" arranged to form two pairs of neighboring flue gas drafts (one pair 8 and 8', another pair 8' and 8"), it will be appreciated that an embodiment with three flue gas draft can also comprise a third pair of neighboring flue gas drafts, e.g. when the flue gas drafts are arranged with respect to each other in a triangular configuration. It will also be appreciated that an embodiment with more than three flue gas drafts is possible and that such an embodiment can comprise e.g. three or more than three pairs of neighboring flue gas drafts.

[0045] In an embodiment, as shown in Figs. 2a-2c, the at least two flue gas drafts 8, 8' comprise two flue gas drafts 8, 8', wherein, viewed in the flue gas flow direction G, the operating fluid flow path P extends substantially along a lemniscate and loops around and thereby encloses each of the two flue gas drafts 8, 8' individually.

[0046] A lemniscate is also known as and can be interpreted as a figure-of-eight shape, i.e. an 8-shape or ∞ -shape. Such a shape of the operating fluid flow path P can enable above-described features and advantages, in particular in case of two flue gas drafts.

[0047] It will be appreciated that in the context of the present disclosure, the terms lemniscate, 8-shape and ∞ -shape are to be interpreted as including e.g. the shape shown in Fig. 2b. Thus, the terms indicate a general trajectory and not necessarily any exact curvature, ratio or symmetry. For various practical reasons, e.g. related to manufacturing or connections to other parts, a path extending substantially along such a shape may partly extend otherwise. For example, such a path may partly extend along a convex hull of said shape, as shown for example in Fig. 2b, see path sections indicated with reference sign P_H .

[0048] In an embodiment, the operating fluid flow path P alternately loops around each one of the at least two flue gas drafts 8, 8', 8", preferably changing over to a different respective one of the at least two flue gas drafts 8, 8', 8" at least four times, for example ten times.

[0049] In this way, a gradual heating of operating fluid and/or cooling of flue gas can be realized with multiple flue gas drafts, in particular with a singular operating fluid flow path P which extends substantially monotonically along the flue gas flow direction G. For example, Figs. 2a and 2c show that the operating fluid flow path P thus changes over to a different flue gas draft 8, 8' about ten times. Figs. 3a and 3c show a different embodiment wherein the operating fluid flow path P thus changes over to a different flue gas draft 8, 8', 8" about ten times. It has been found that efficient heat exchange can be realized with such configurations.

[0050] In an embodiment, the operating fluid flow path

P comprises outer sections P_O which bound two opposite sides of the heat exchanger body 2, end sections P_E which bound two opposite end sides of the heat exchanger body 2, and said intermediate sections P_I .

[0051] The height h, measured in the flue gas flow direction G, of the operating fluid channel 10 may be substantially variable along the operating fluid flow path P, wherein said height h is substantially reduced along at least one, preferably each, of the intermediate sections P_I of the operating fluid flow path P, compared to said height h along said outer sections P_O of the operating fluid flow path P.

[0052] As an example of measurement, double arrow h in Fig. 1c indicates how said height h can be measured at one point along the operating fluid flow path P in a side view of a heat exchanger body 2. It will be appreciated that said height can thus be measured along the operating fluid flow path P throughout the operating fluid channel 10 of any embodiment. While the embodiment shown in Fig. 1c does not comprise such intermediate sections, Figs. 2c and 3c thus show how, in respective embodiments, said height can be variable and reduced as described above.

[0053] Such variation and reduction of operating fluid channel height can enable a compact configuration of the operating fluid channel 10, in particular while enabling above-described features and respective advantages such as smooth flow and efficient heat exchange.

[0054] In particular, in this way, viewed in a top view (e.g. Figs 2b and 3b) a number of overlapping intermediate sections P_I of the operating fluid flow path P can thus be larger than respective number of overlapping outer sections P_O , substantially without reducing heat exchanger efficiency at said outer sections P_O . For example, Fig. 2c shows that about eleven intermediate sections P_I thus overlap, while on both outer sides about six respective outer sections P_O thus overlap.

[0055] In an embodiment, a cross sectional area A of the operating fluid channel 10, viewed in the operating fluid flow direction F, along an outer section P_O and an intermediate section P_I which are at substantially the same level along the flue gas flow direction G, is substantially constant, wherein a cross sectional area A of the operating fluid channel 10, viewed in the operating fluid flow direction F, substantially increases along the flue gas flow direction G.

[0056] As an example of measurement, such a cross sectional area A has been indicated at an end of the operating fluid flow path P in Figs. 1a and 1c as a hatched area. It will be appreciated that such a cross sectional area A can thus be measured along the operating fluid flow path throughout the operating fluid channel 10 in various embodiments, in particular as an area which extends perpendicular to the local fluid flow direction F. Figs. 2c and 3c show how in respective embodiments the cross sectional area A can thus be as described above. In particular, for example, it can be seen in Figs. 2c and 3c that where a height h of the operating fluid

channel 10 increases, a respective width of said channel may thus decrease approximately proportionally, thus providing a substantially constant cross sectional area A.

[0057] A dual advantage can be realized in this way. On the one hand, a substantially constant cross sectional area A at substantially the same level along the flue gas flow direction G enables a substantially constant flow rate of the operating fluid at said level, thus promoting a smooth flow. On the other hand, a substantially increasing cross sectional area A along the flue gas flow direction G can enable a higher flow rate of the operating fluid near an upstream section of a flue gas draft compared to a downstream section, wherein the flue gas is typically hotter in said upstream section compared to said downstream section. In this way, efficient heat exchange can be promoted throughout the heat exchanger body 2, wherein in particular the flue gas can be cooled efficiently along the flue gas flow direction G such that an end temperature of the flue gas, i.e. where it leaves the heat exchanger, can be advantageously low, e.g. about 60 degrees Celsius.

[0058] In an embodiment, the operating fluid flow path P is curved, wherein the one or more flue gas drafts 8, 8', 8" each have a respective smallest width w measured in a plane perpendicular to the flue gas flow direction G, wherein, along the operating fluid flow path P, the radius of curvature r of the operating fluid flow path P is larger than a quarter of the respective smallest width w of the nearest of the one or more flue gas drafts 8, 8', 8", said width w being measured at the same level along the flue gas flow direction G compared to said radius of curvature r.

[0059] Measurement examples of smallest width w and radius of curvature r are shown in Fig. 1b. It will be appreciated that these quantities can thus be measured throughout a heat exchanger body and in various embodiments.

[0060] Such a radius of curvature r can enable that operating fluid flow through the curved path P is substantially smooth and in particular experiences less drag compared to alternatives. Moreover, efficient heat exchange is thus promoted since heat from flue gas in the respective flue gas draft can more easily reach into the curves of the operating fluid flow path P.

[0061] In an embodiment, the operating fluid channel 10 is substantially formed by one or more fluid channel walls 12 which extend substantially along the operating fluid flow path P, wherein the walls 12 have a continuous inner surface so as to be free from forming cavities in which air may collect.

[0062] An exemplary indication of the one or more fluid channel walls 12 is provided in Figs. 1b and 1c. It will be appreciated that such walls 12 can be seen substantially throughout respective operating fluid channels 10 in the various embodiments e.g. as shown in Figs. 1a, 2a and 3a.

[0063] Such a continuous inner surface can thus prevent that air collects in the operating fluid channel 10,

thus preventing that collection of air could otherwise negatively affect heat exchanger efficiency.

[0064] In an embodiment, at least one of the one or more flue gas drafts 8, 8', 8" comprises an array of fins 14 extending into the respective flue gas draft 8, 8', 8" from one or more walls of said flue gas draft 8, 8', 8", wherein the fins 14 are configured to increase a flue gas contact surface area of said flue gas draft 8, 8', 8".

[0065] Fins 14 can for example comprise blades and/or pins and may be part of the integral casting 6. Such fins 14 are as such known as a means for increasing contact surface area in a heat exchanger. Application of such fins 14 is particularly advantageous in the context of the present invention as the fins can further enhance heat exchanger efficiency. For simplicity of the drawings, only eight exemplary fins 14 are shown in Fig. 1b, of which only two have been provided with a reference sign 14. It will be appreciated that many fins 14 can be applied throughout each flue gas draft, in the various embodiments. Dimensions of fins 14 and/or spatial fin density can vary, e.g. within a flue gas draft, e.g. along the flue gas flow direction G. In particular, flue gas contact surface area of a flue gas draft may thus be increased along the flue gas flow direction G, in order to promote heat exchanger efficiency.

[0066] Fig. 4 shows an exemplary heat exchanger 16 for transfer of heat from a flue gas to an operating fluid, in particular of a condensing boiler 4, wherein the heat exchanger 16 comprises the heat exchanger body 2 as described herein for transfer of heat from the flue gas to the operating fluid. Fig. 4 also shows an exemplary condensing boiler 4 for heating an operating fluid, the condensing boiler 4 comprising an exemplary heat exchanger 16.

[0067] It will be appreciated that merely one exemplary embodiment of a heat exchanger and a condensing boiler is shown in Fig. 4 and that many variations are possible.

[0068] With reference to Figs. 5a and 6a, the integral casting 6 of the heat exchanger body 2 here comprises one or more core holes 18, 18', wherein the heat exchanger 16 comprises one or more core plugs 20, 20' arranged in at least one of the one or more core holes 18, 18' for closing off said at least one of the one or more core holes 18, 18'.

[0069] Such core holes 18, 18' can provide improved, e.g. easier and/or more efficient, casting of the integral casting 6, wherein such core plugs 20, 20' can subsequently close off the core holes 18, 18' such that the heat exchanger 16 can be free of open core holes during operation.

[0070] In an embodiment, with reference to Fig. 6a-b, at least one of the one 18' or more core holes 18, 18' provides a shortcut fluid path S between two sections of the operating fluid channel 10 which sections are spaced away from each other along the operating fluid flow path P by a primary path length L_1 , wherein a respective shortcut path length L_s of the shortcut fluid path S is short compared to the primary path length L_1 , wherein at least

one 20' of the one or more core plugs 20, 20' is configured to block a flow of operating fluid along the shortcut fluid path S.

[0071] It has been found that such a core hole configuration can provide improved manufacturability of the heat exchanger 16, in particular regarding casting of the integral casting 6, wherein such a core plug 20' can prevent that operating fluid can flow in the shortcut fluid path S during operation.

[0072] An exemplary pattern assembly for producing a part of a mold, in particular a sand mold, for casting an integral casting 6 of a heat exchanger body 2, can essentially resemble the integral casting as shown in Fig. 5a or 6a, divided into mutually connectable sections. The pattern assembly comprises: one or more flue gas draft core sections which each extend along a respective flue gas draft core main axis; and at least one operating fluid channel core section, wherein the operating fluid channel core section defines an operating fluid channel core path which loops around and thereby encloses the respective flue gas draft core main axis of each of the one or more flue gas draft core sections.

[0073] Such a pattern assembly can advantageously be used for producing an integral casting 6 of a heat exchanger body 2 according to the present invention.

[0074] Specifically, in an embodiment, a method of producing an integral casting 6 of a heat exchanger body 2 comprises: providing a pattern assembly as described herein; using the pattern assembly to produce a part of a mold for casting an integral casting 6; and casting an integral casting 6 using the produced part of the mold.

[0075] While the invention has been explained using exemplary embodiments, it will be appreciated that these do not limit the scope of the invention, which scope is provided by the claims. For example, a flue gas draft can extend along a substantially straight path, or alternatively along an at least partly curved and/or angled path. A flue gas flow direction may be a substantially downward direction, or alternatively a different direction. A cross sectional area of a flue gas draft may be of various shapes, including but not limited to an elongated shape. An operating fluid may or may not be pressurized and a heat exchanger body may be configured accordingly. An operating fluid flow path which loops around and thereby encloses each of the one or more flue gas drafts need not necessarily enclose each of the one or more flue gas drafts individually. An operating fluid flow path may or may not include repeated sequential patterns, e.g. of outer sections, end sections and/or intermediate sections. Further examples of alternatives have been provided throughout the description. These and other variations, combinations and extensions are possible and are considered within the scope of the invention, as will be appreciated by the skilled person.

List of reference signs

[0076]

2.	Heat exchanger body
4.	Condensing boiler
6.	Integral casting
8, 8', 8".	Flue gas draft
5 10.	Operating fluid channel
12.	Fluid channel wall
14.	Fin
16.	Heat exchanger
18, 18'.	Core hole
10 20, 20'.	Core plug
A.	Cross sectional area of operating fluid channel
F.	Operating fluid flow direction
G.	Flue gas flow direction
15 h.	Height of operating fluid channel
L ₁ .	Primary path length
L _s .	Shortcut path length
P.	Operating fluid flow path
P _E .	End section of operating fluid flow path
20 P _H .	Section of operating fluid flow path which section extends along a convex hull of a lemniscate along which said path substantially extends
P _I .	Intermediate section of operating fluid flow path
25 P _O .	Outer section of operating fluid flow path
r.	Radius of curvature of operating fluid flow path
S.	Shortcut fluid path
30 w.	Smallest width of flue gas draft

Claims

- 35 1. A heat exchanger body (2) for transfer of heat from a flue gas to an operating fluid, in particular of a condensing boiler (4), wherein the heat exchanger body (2) comprises an integral casting (6) from aluminium or an aluminium alloy and comprises:
- 40 - one or more flue gas drafts (8, 8', 8") each configured to guide a flow of flue gas in a flue gas flow direction (G); and
- 45 - an operating fluid channel (10) configured to guide a flow of operating fluid in an operating fluid flow direction (F) along an operating fluid flow path (P),
- 50 wherein, viewed in the flue gas flow direction (G), the operating fluid flow path (P) loops around and thereby encloses each of the one or more flue gas drafts (8, 8', 8").
- 55 2. The heat exchanger body according to claim 1, wherein, viewed perpendicular to the flue gas flow direction (G), the operating fluid flow path (P) ascends or descends substantially monotonically along the flue gas flow direction (G).

3. The heat exchanger body according to claim 1 or 2, wherein the operating fluid flow path (P) forms a substantially singular operating fluid flow path (P).
4. The heat exchanger body according to any of the preceding claims, wherein, viewed in the flue gas flow direction (G), the operating fluid flow path (P) loops around each of the one or more flue gas drafts (8, 8', 8'') at least two times, preferably at least three times, preferably at least four times, preferably at least five times.
5. The heat exchanger body according to any of the preceding claims, wherein the one or more flue gas drafts (8, 8', 8'') comprise at least two flue gas drafts (8, 8', 8''), wherein the at least two flue gas drafts (8, 8', 8'') comprise at least one pair of neighboring flue gas drafts (8, 8'; 8', 8''); wherein, viewed in the flue gas flow direction (G), between each pair of neighboring flue gas drafts (8, 8'; 8', 8'') one or more intermediate sections (P_I) of the operating fluid flow path (P) extend, such that the operating fluid flow path (P) loops around and thereby encloses each flue gas draft (8, 8', 8'') individually.
6. The heat exchanger body according to claim 5, wherein the at least two flue gas drafts (8, 8', 8'') comprise two flue gas drafts (8, 8'), wherein, viewed in the flue gas flow direction (G), the operating fluid flow path (P) extends substantially along a lemniscate (i.e. 8-shape or ∞-shape) and loops around and thereby encloses each of the two flue gas drafts (8, 8') individually.
7. The heat exchanger body according to any of claims 5 - 6, wherein the operating fluid flow path (P) alternately loops around each one of the at least two flue gas drafts (8, 8', 8''), preferably changing over to a different respective one of the at least two flue gas drafts (8, 8', 8'') at least four times, for example ten times.
8. The heat exchanger body according to any of claims 5 - 7, wherein the operating fluid flow path (P) comprises outer sections (P_O) which bound two opposite sides of the heat exchanger body (2), end sections (P_E) which bound two opposite end sides of the heat exchanger body (2), and said intermediate sections (P_I), wherein the height (h), measured in the flue gas flow direction (G), of the operating fluid channel (10) is substantially variable along the operating fluid flow path (P), wherein said height (h) is substantially reduced along at least one, preferably each, of the intermediate sections (P_I) of the operating fluid flow path (P), compared to said height (h) along said outer sections (P_O) of the operating fluid flow path (P).
9. The heat exchanger body according to any of claims 5 - 8, wherein the operating fluid flow path (P) comprises outer sections (P_O) which bound two opposite sides of the heat exchanger body (2), end sections (P_E) which bound two opposite end sides of the heat exchanger body (2), and said intermediate sections (P_I), wherein a cross sectional area (A) of the operating fluid channel (10), viewed in the operating fluid flow direction (F), along an outer section (P_O) and an intermediate section (P_I) which are at substantially the same level along the flue gas flow direction (G), is substantially constant, wherein a cross sectional area (A) of the operating fluid channel (10), viewed in the operating fluid flow direction (F), substantially increases along the flue gas flow direction (G).
10. The heat exchanger body according to any of the preceding claims,
 - a. wherein the operating fluid flow path (P) is curved, wherein the one or more flue gas drafts (8, 8', 8'') each have a respective smallest width (w) measured in a plane perpendicular to the flue gas flow direction (G), wherein, along the operating fluid flow path (P), the radius of curvature (r) of the operating fluid flow path (P) is larger than a quarter of the respective smallest width (w) of the nearest of the one or more flue gas drafts (8, 8', 8''), said width (w) being measured at the same level along the flue gas flow direction (G) compared to said radius of curvature (r) and/or
 - b. wherein the operating fluid channel (10) is substantially formed by one or more fluid channel walls (12) which extend substantially along the operating fluid flow path (P), wherein the walls (12) have a continuous inner surface so as to be free from forming cavities in which air may collect and/or
 - c. wherein at least one of the one or more flue gas drafts (8, 8', 8'') comprises an array of fins (14) extending into the respective flue gas draft (8, 8') from one or more walls of said flue gas draft (8, 8', 8''), wherein the fins (14) are configured to increase a flue gas contact surface area of said flue gas draft (8, 8', 8'').
11. A heat exchanger (16) for transfer of heat from a flue gas to an operating fluid, in particular of a condensing boiler (4), wherein the heat exchanger (16) comprises the heat exchanger body (2) according to any of the preceding claims for transfer of heat from the flue gas to the operating fluid, wherein the integral casting (6) of the heat exchanger body (2) comprises one or more core holes (18, 18'), wherein the heat exchanger (16) comprises one or more core plugs (20, 20') arranged in at least one of the one or more core

holes (18, 18') for closing off said at least one of the one or more core holes (18, 18').

12. The heat exchanger according to claim 11, wherein at least one (18') of the one or more core holes (18, 18') provides a shortcut fluid path (S) between two sections of the operating fluid channel (10) which sections are spaced away from each other along the operating fluid flow path (P) by a primary path length (L_i), wherein a respective shortcut path length (L_s) of the shortcut fluid path (S) is short compared to the primary path length (L_i), wherein at least one (20') of the one or more core plugs (20, 20') is configured to block a flow of operating fluid along the shortcut fluid path (S). 5
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13. A condensing boiler (4) for heating an operating fluid, the condensing boiler (4) comprising a heat exchanger (16) according to any one of claims 11 - 12 for transfer of heat from a flue gas to the operating fluid. 20

14. A pattern assembly for producing a part of a mold, in particular a sand mold, for casting an integral casting (6) of a heat exchanger body (2) according to any of claims 1 - 10, wherein the pattern assembly comprises: 25
 - one or more flue gas draft core sections which each extend along a respective flue gas draft core main axis; and 30
 - at least one operating fluid channel core section, wherein the operating fluid channel core section defines an operating fluid channel core path which loops around and thereby encloses the respective flue gas draft core main axis of each of the one or more flue gas draft core sections. 35

15. A method of producing an integral casting (6) of a heat exchanger body (2), the method comprising: 40
 - providing a pattern assembly according to claim 14;
 - using the pattern assembly to produce a part of a mold for casting an integral casting (6); and 45
 - casting an integral casting (6) using the produced part of the mold. 50

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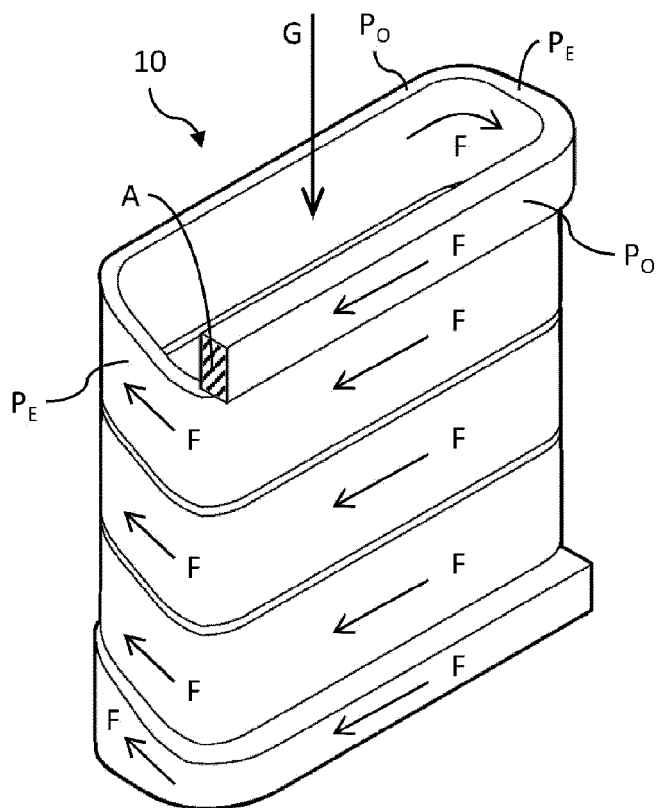


Fig. 1a

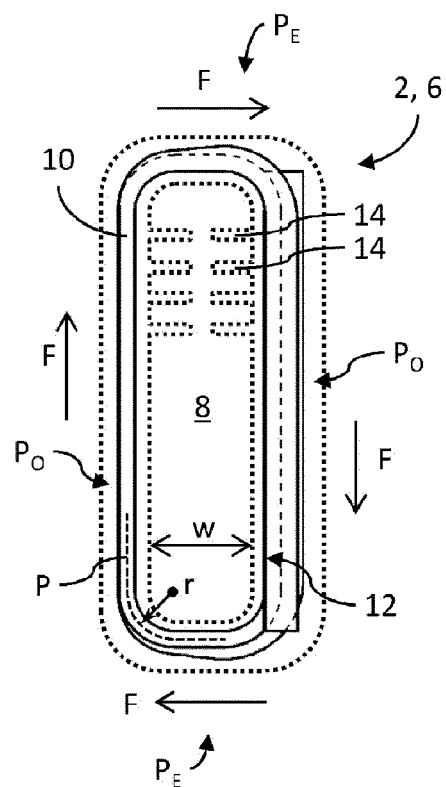


Fig. 1b

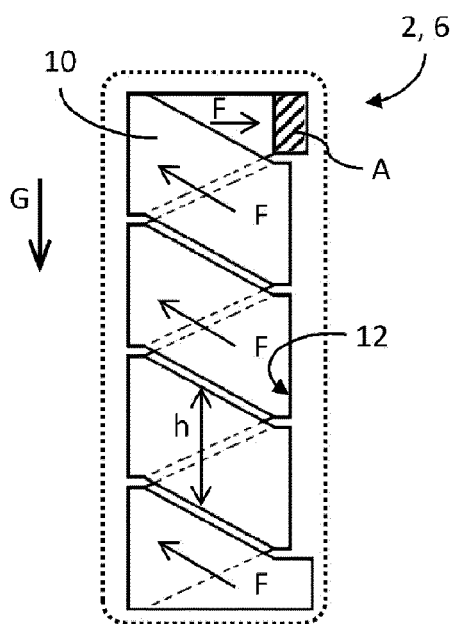


Fig. 1c

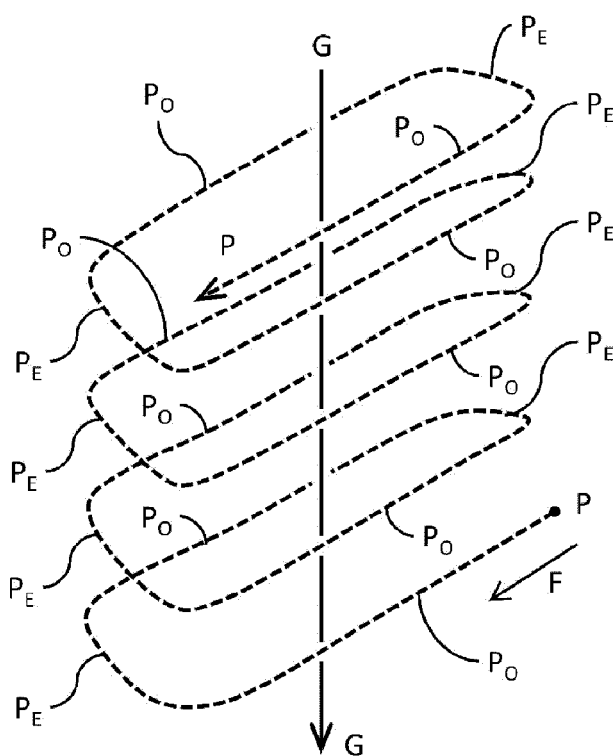


Fig. 1d

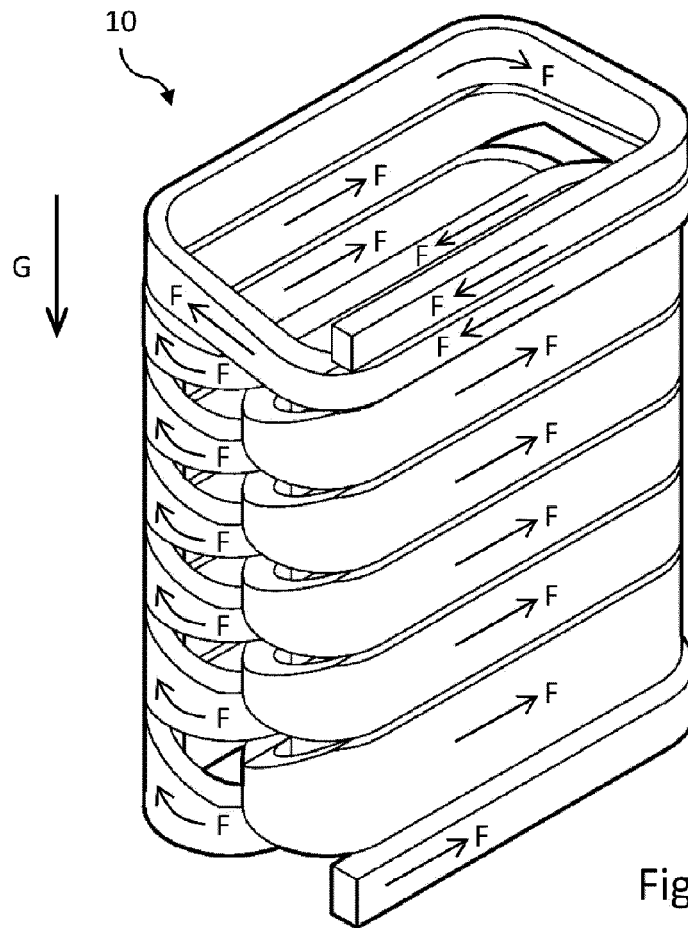


Fig. 2a

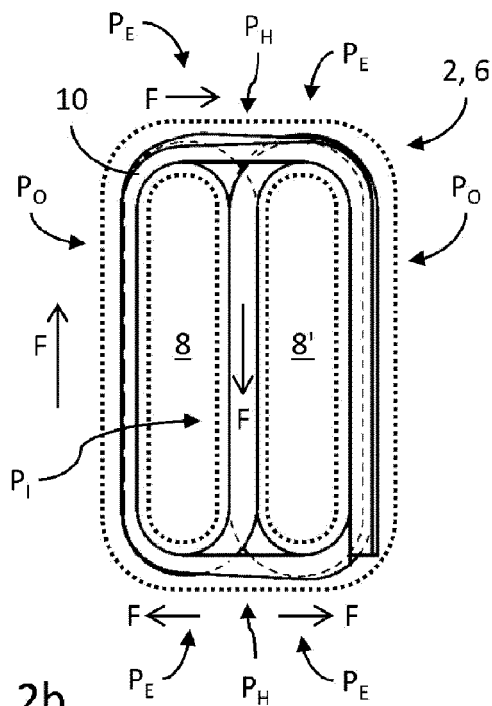


Fig. 2b

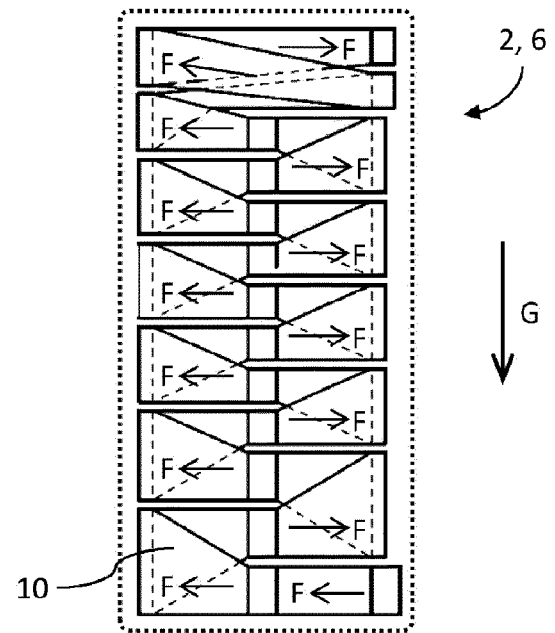


Fig. 2c

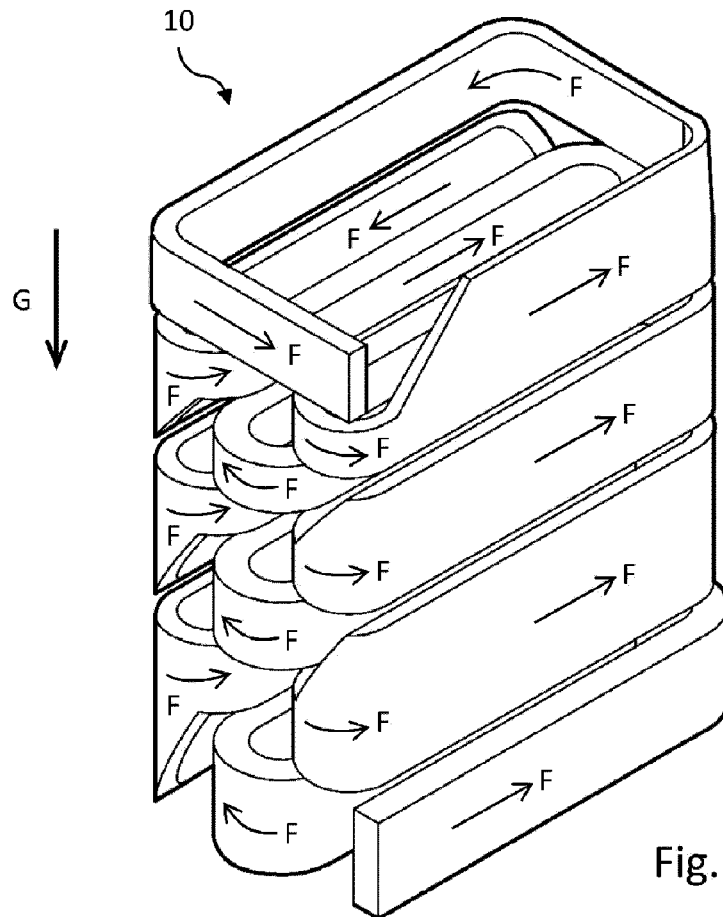


Fig. 3a

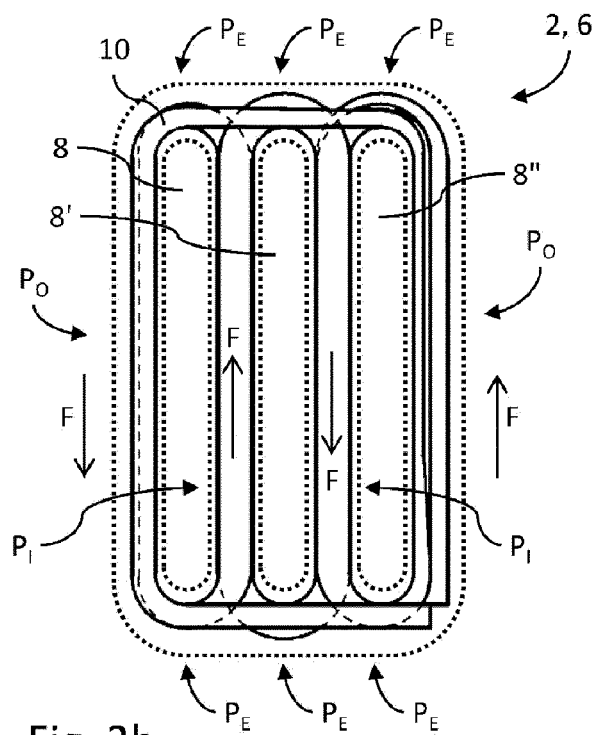


Fig. 3b

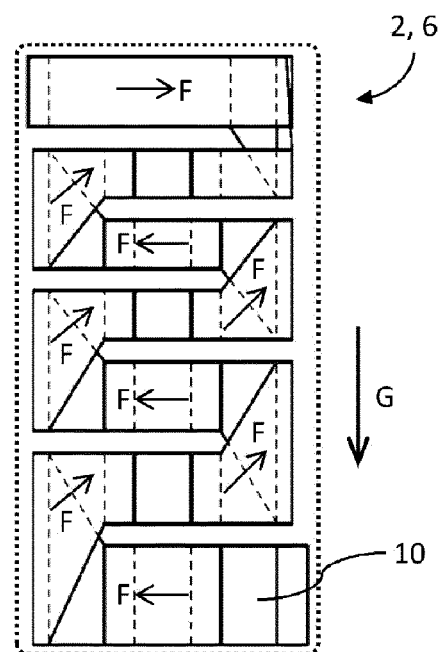


Fig. 3c

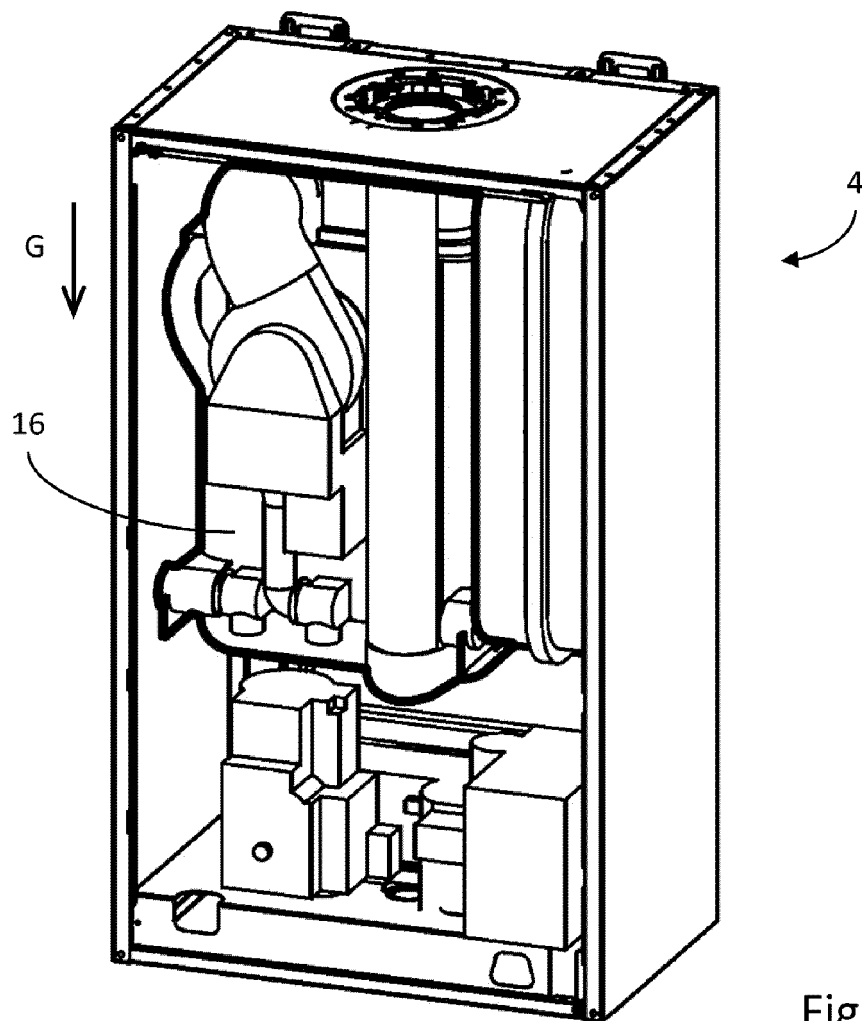


Fig. 4

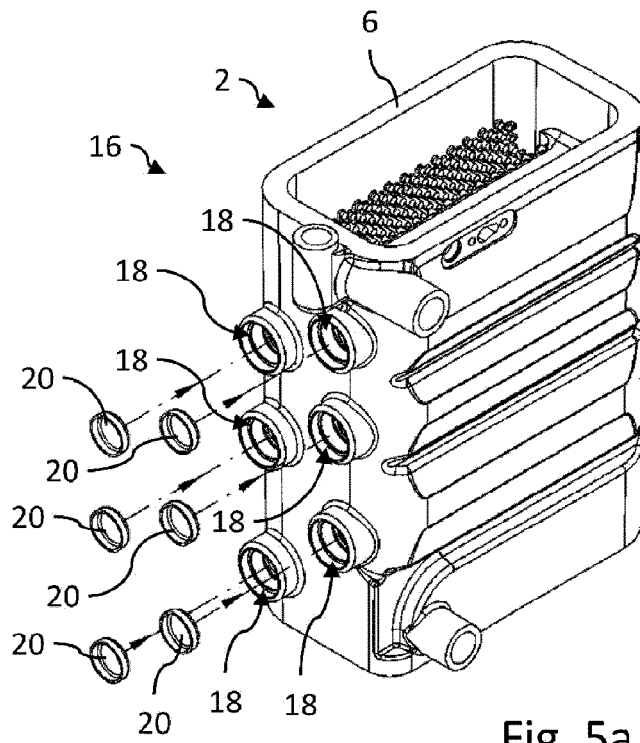


Fig. 5a

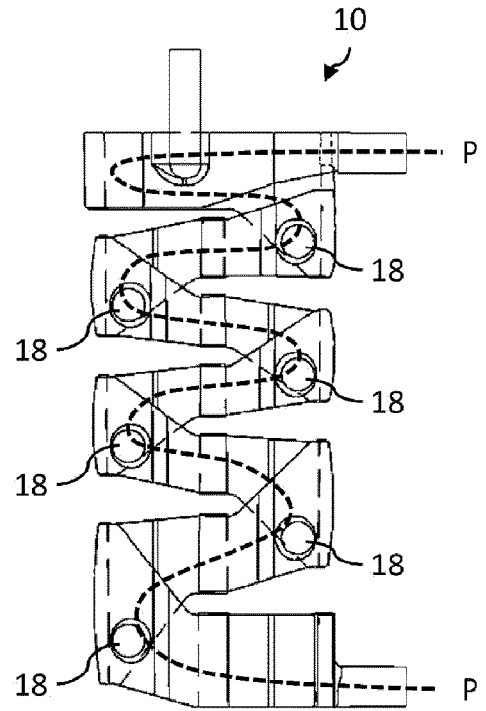


Fig. 5b

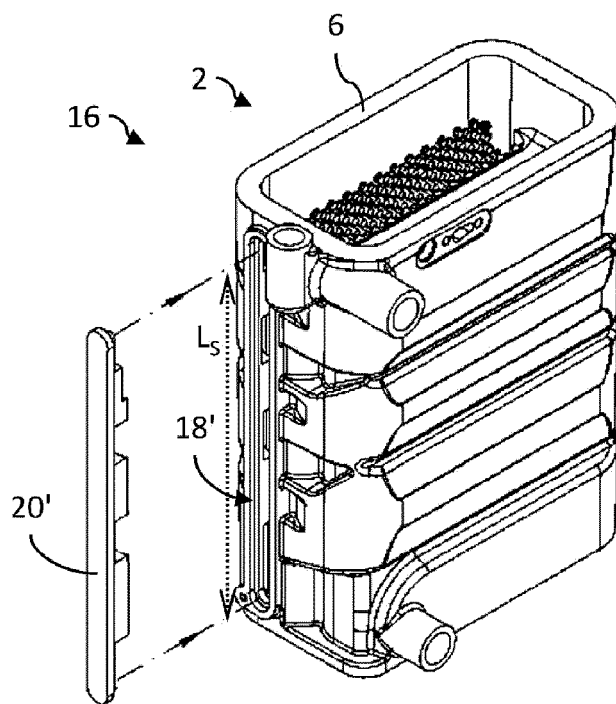


Fig. 6a

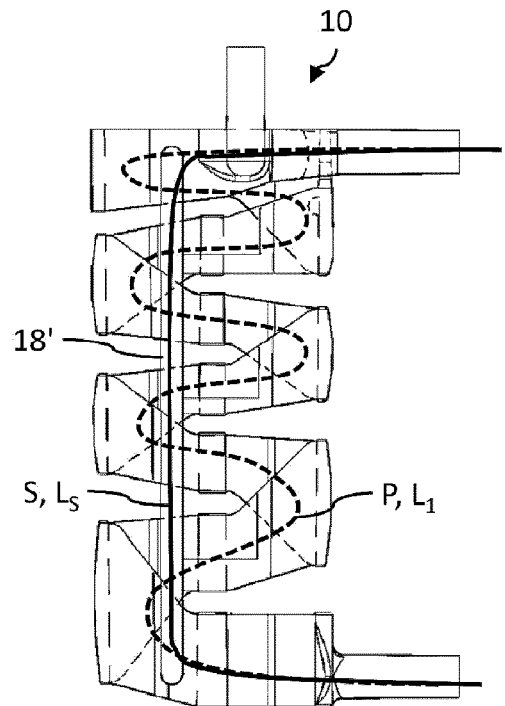


Fig. 6b



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Application Number

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Place of search

Date of completion of the search

Examiner

Munich

5 May 2022

Riesen, Jörg

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X : particularly relevant if taken alone
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A : technological background
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