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(54) **HEAT EXCHANGER AND ASSEMBLY OF A HEAT EXCHANGER AND A BURNER**

(57) The invention relates to a heat exchanger, comprising:

- a casing, comprising:
- a substantially U-shaped body as seen in cross-section and extending in a longitudinal direction, wherein a base of the U-shape body comprises a gas outlet opening and wherein an open end, opposite to the base, of the U-shape body comprises a receiving space for receiving a burner, and
- two end plates arranged at the two longitudinal end zones of said U-shape body;

- a plurality of pipes arranged within said casing and connected to said end plates, through which pipes in use a liquid can flow;

- a plurality of connecting means for providing a liquid through flow connection between at least two pipes at each longitudinal end zone of said U-shape body, such that liquid flowing through a first pipe of the at least two pipes is directed to the other pipe of the at least two pipes, wherein a first part of the pipes is arranged in a first pattern defining two legs of a substantially U-shape as seen in cross-section, said first pattern being arranged substantially parallel to legs of said U-shape body, and wherein a second part of said pipes are arranged within a space at least partly bounded by said first pattern.

The invention further relates to an assembly of a heat exchanger according to the invention and a burner, wherein the burner is arranged in said receiving space.

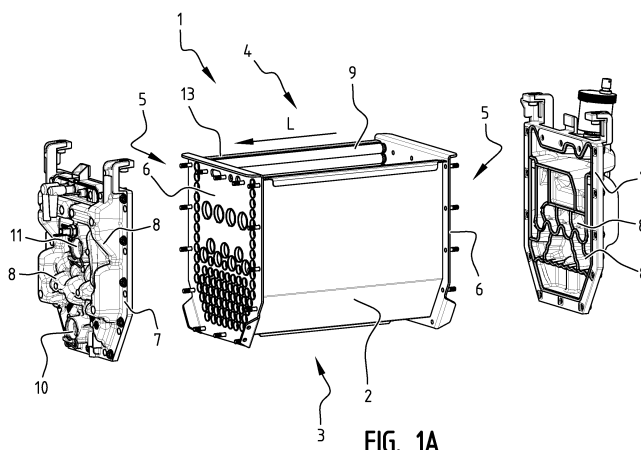


FIG. 1A

Description

[0001] The invention relates to a heat exchanger, comprising:

- a casing, comprising:
 - a substantially U-shaped body as seen in cross-section and extending in a longitudinal direction, wherein a base of the U-shape body comprises a gas outlet opening and wherein an open end, opposite to the base, of the U-shape body comprises a receiving space for receiving a burner, and
 - two end plates arranged at the two longitudinal end zones of said U-shape body;
- a plurality of pipes arranged within said casing and connected to said end plates, through which pipes in use a liquid can flow;
- a plurality of connecting means for providing a liquid through flow connection between at least two pipes at each longitudinal end zone of said U-shape body, such that liquid flowing through a first pipe of the at least two pipes is directed to the other pipe of the at least two pipes

wherein a first part of the pipes is arranged in a first pattern defining two legs of a substantially U-shape as seen in cross-section, said first pattern being arranged substantially parallel to legs of said U-shape body, and wherein a second part of said pipes are arranged within a space at least partly bounded by said first pattern.

[0002] Such a heat exchanger is known from European patent EP-B1-0687870 in the name of the same applicant. It is an object to improve the heat exchanger described in EP-B1-0687870.

[0003] In an embodiment of the heat exchanger according to the invention said receiving space is arranged between at least a part of the pipes of the first pattern located near the open end of the U-shape body in such a manner that in use at least a part of the pipes of the first pattern surround a flame provided by said burner.

[0004] An advantage of this embodiment is that the casing is protected from the heat of the flame by said pipes of the first pattern that surround said flame. In the heat exchanger described in EP-B1-0687870 the flame was present in an area not bounded by pipes. Practically the heat exchanger therefor had a sealing arranged to protect the casing from the heat, which sealing is quite expensive. An advantage of this embodiment is therefore that no or less sealing is required, thereby reducing the costs of the heat exchanger.

[0005] In another embodiment of the heat exchanger according to the invention a distance between all pairs of adjacent pipes of each leg of the first pattern is maximally 0.5 mm, preferably maximally 0.1 mm.

[0006] It is noted that said distance is defined as the

distance between the adjacent outer surfaces of each pair of adjacent pipes. An advantage of such small distances between adjacent pipes of the legs of the first pattern is that the mass flow of flue gas that will flow through the spaces between adjacent pipes to an area between the pipes of the legs of the first pattern and the casing is restricted, such that the flue gas that will enter this area will be cooled down by the liquid in the pipes to such an extent that the flue gas will have a relatively low temperature that is more or less similar to or slightly higher than the temperature of the walls of these pipes. As a result the casing will only be exposed to this relatively low temperature, such that no or less sealing of the casing is required, thereby reducing the costs of the heat exchanger.

[0007] It is noted that in the heat exchanger described in EP-B1-0687870 a distance between at least some pairs of adjacent pipes was larger than the above described maximum distances, such that more flue gas could enter the area, which flue gas entering the area therefore could have a higher temperature, and such that the U-shaped body required a substantially U-shape sealing covering said U-shape body to protect it from the heat. Such a relatively large sealing is quite expensive.

[0008] In another embodiment of the heat exchanger according to the invention said heat exchanger comprises a sealing arranged between the outer surface of the pipes arranged at a first end of each leg of the first pattern near the open end of the U-shape body and the substantially U-shaped body.

[0009] An advantage of this sealing that hot flue gas is prevented from flowing in the area between the pipes of the first pattern and the casing via a space present between the pipes arranged at the first ends of each leg of the first pattern and the U-shaped body, because this space is sealed off by said sealing. This way a relatively small amount of sealing is required for protecting the casing from being exposed to hot temperatures, at relatively low costs.

[0010] In another embodiment of the heat exchanger according to the invention the distance between the legs of the U-shape body and the pipes of the first pattern is maximally 1.0 mm, preferably maximally 0.4 mm.

[0011] It is noted that said distance is defined as the distance between the outer surfaces of the pipes of the first pattern that are facing the U-shape body and the legs of the U-shape body. An advantage of such a relatively small distance is that the volume of the area between the pipes and the U-shape body is relatively small, thereby also contributing to the restriction of the mass flow of flue gas into this area and thereby contributing to the reduction in temperature to which the casing is exposed.

[0012] In another embodiment of the heat exchanger according to the invention the second part of the pipes are arranged such that a formula:

$$v_g = \frac{F_g}{A} = C$$

is substantially fulfilled, wherein:

v_g is the velocity of flue gases flowing from said burner in the direction of the base of said U-shape body in m/s in use of the heat exchanger;

F_g is the flow rate of flue gases flowing from said burner in the direction of the base of said U-shape body in m³/s in use of the heat exchanger;

A is the surface area between adjacent pipes of the second part of the pipes;

C is a substantially constant value of maximally 12 m/s.

[0013] Relatively hot flue gas has a relatively large volume and vice versa. As such, as seen in a flow direction of the flue gas, the flue gas coming from the burner has a relatively large flow rate as the flue gas is relatively hot, thereby requiring a relatively large surface area between adjacent pipes arranged near the burner space in order to have the velocity of the flue gas being maximally said value C . The pipes arranged near the outlet opening however require a smaller surface area there between in order to have the velocity of the flue gas being maximally said value C , as the flue gas is already cooled down to some extent by the heat exchanger and the flow rate is relatively small. An advantage of a substantially constant velocity of the flue gas throughout the heat exchanger is that such a substantially constant velocity reduces the pressure drop. It is therefore an advantage of this embodiment to arrange said second part of the pipes such that this formula is fulfilled.

[0014] It is noted that in particular at low loads C may be less than said maximum value of 12 m/s.

[0015] In another embodiment of the heat exchanger according to the invention the connecting means are arranged to provide a liquid through flow connection between groups of at least two determined pipes at each longitudinal end zone of said U-shape body in such a manner that a second formula:

$$\frac{Q}{A_{eff} \cdot v_l} = k$$

is substantially fulfilled, wherein:

Q is the quantity of heat transferred to the liquid flowing in each pipe in kJ in use of the heat exchanger;

A_{eff} is the effective heat transferring surface of each pipe in m² in use of the heat exchanger;

v_l is the velocity of the liquid flowing in each pipe in m/s in use of the heat exchanger, and

k is a maximum value of 170 kJ/m³.

[0016] An advantage of this embodiment is that the heat exchanger is designed such that the distribution of the liquid flow over determined groups of pipes is chosen such that the quantity of heat Q discharged from the flue gas and transferred to the liquid flowing in each pipe is substantially constant anywhere in the heat exchanger. As a result thereof, the pipes are exposed to less thermal stresses as the pipes are exposed to more or less similar heat transfer. Furthermore, the liquid flow through the pipes is optimized with respect to pressure drop and blockage of the pipes due to lime scale deposition is prevented by preventing the pipes from becoming too hot. This is especially advantageous in heat exchangers where a relatively large number of pipes with a relatively small throughflow area is used.

[0017] In another embodiment of the heat exchanger according to the invention at least one of the connecting means comprises a liquid distributor for substantially equally distributing liquid over pipes being connected to said connecting means.

[0018] Without such a liquid distributor it is possible that the liquid is not equally distributed over the pipes connected to the connecting means. This way, some pipes with less liquid flowing there through can become too hot and thereby exposed to high thermal stresses. An advantage of the liquid distributor is therefore that the liquid is substantially equally distributed over pipes that are connected to said connecting means, thereby reducing the thermal stresses of the pipes.

[0019] In another embodiment of the heat exchanger according to the invention the second part of the pipes comprise at least three groups of pipes, wherein a first group located near the base of the U-shape body has a first, smallest diameter, wherein a second group located near the first group at a side of the first group opposite to the base of the U-shape has a second diameter, and wherein a third group located near the open end of the U-shape body has a third, largest diameter, which third group is located at a predetermined distance from the second group.

[0020] An advantage of this arrangement of the pipes is that the third group is arranged nearest to the burner space. The flue gas coming from the burner is cooled down relatively fast by this third group of pipes arranged near the burner with relatively large diameter and thereby relatively large liquid flow, such that the production of NOx is efficiently reduced. Between the third and second group said predetermined distance is present, such that over this distance the flue gas is substantially not cooled down and a relatively large time period is provided for the conversion of CO into CO₂, such that the emission of CO is reduced and preferably prevented.

[0021] It is noted that said distance is preferably between 10 and 40mm, more preferably between 20 and 30mm. Said distance is defined between the outer surfaces of the row of pipes of the third group and the row

of pipes of the second group arranged nearest to the third group and especially between the facing outer surfaces thereof.

[0022] In another embodiment of the heat exchanger according to the invention a part of the pipes of the first group is arranged at least partly between a part of the pipes of the second group.

[0023] An advantage of such an arrangement is that the flow of flue gas along substantially the whole outer surface of the pipes arranged upstream of said part of pipes of the second group as seen in the direction of the flow of flue gases is enhanced.

[0024] The invention also relates to an assembly of a heat exchanger according to any of the claims 1 - 10 and a burner, wherein the burner is arranged in said receiving space.

[0025] Such an assembly provides the advantages of the heat exchanger described above.

[0026] In an embodiment of the assembly according to the invention the assembly comprises the heat exchanger according to at least claim 2, wherein the burner is arranged in said receiving space in such a manner that in use at least a part of the pipes of the first pattern surround a flame provided by said burner.

[0027] As described above such an assembly provides the advantage that said part of the pipes of the first pattern protect the casing from heat of the flame of the burner.

[0028] In another embodiment of the assembly according to the invention said burner comprises a damper.

[0029] Such a (Panel Helmholtz resonance) damper efficiently dampens any noise of the heat exchanger.

[0030] Practically said burner comprises a burner plate that is connected to or is integrally formed with said damper.

[0031] An advantage of this embodiment is that the functions of the burner plate and the damper are combined in one integrally formed or connected element.

[0032] In another embodiment of the assembly said burner comprises a gas/air-mixture distribution plate that is connected to or integrally formed with said damper and/or burner plate.

[0033] An advantage of this embodiment is that the functions of the burner plate and/or the damper and/or the gas/air-mixture distribution plate are combined in one integrally formed or connected element.

[0034] In particular, said (Panel Helmholtz resonance) damper may be provided with through holes for distributing the gas/air-mixture, such that said damper functions also as said gas/air-mixture distribution plate.

[0035] Practically said assembly comprises a sealing that is provided between the casing and the gas/air-mixture distribution plate.

[0036] Said gas/air-mixture distribution plate is arranged upstream of the burner plate and distributes the gas/air-mixture prior to passing through the burner plate. As the gas/air-mixture distribution plate and the burner plate are connected or integrally formed in one element, the gas/air-mixture exiting the gas/air-mixture distribution

plate cannot by-pass the burner plate. Said sealing prevents the gas/air-mixture from entering the burner room alongside said element comprising the gas/air-mixture distribution plate and the burner plate. The gas/air-mixture flowing through the gas/air chamber will cool down the gas/air chamber and the gas/air-mixture distribution plate/damper. The life time of the burner is hereby enhanced.

[0037] The invention is further elucidated with reference to figures shown in a drawing, in which:

Figures 1A and 1B show a heat exchanger according to the invention, respectively in an exploded perspective view and in a vertical cross sectional view; Figure 2 schematically shows the distribution of the liquid flow through the pipes of the heat exchanger; Figures 3A and 3B disclose the effect of liquid distributors according to the invention; and Figure 4 is a perspective view of a burner according to the invention; and Figure 5 is a perspective view of an assembly according to the invention.

[0038] Figures 1A and 1B show a heat exchanger 1. Said heat exchanger 1 comprises a casing with a substantially U-shaped body 2 as seen in cross-section and extending in a longitudinal direction L. The base 3 of the body 2 arranged at the lower end of the body 2 comprises a gas outlet opening (not shown). At the end opposite to the base 3, i.e. the upper end, the body 2 is open and comprises a receiving space 4 for receiving a burner (not shown). The flue gases from the burner flow downwards through the casing 1 and are discharged via said gas outlet opening. At each longitudinal end zone 5 of the body 2 the body 2 comprises an end plate 6. A plurality of pipes 9 is arranged within said casing and is connected to said end plates 6, in particular to holes in said end plates 6. In use of the heat exchanger 1 a liquid, practically water, flows through the pipes 9 for taking up heat from the flue gases, thereby heating the water and cooling the flue gases. Panels 7 are provided to cover the end plates 6. Each panel 7 comprises a plurality of hollow spaces 8, each hollow space 8 connecting at least two pipes 9 at each longitudinal end zone 5 of the body 2, such that liquid flowing through a first pipe 9 of the at least two pipes 9 is directed to the other pipe 9 of the at least two pipes 9. Liquid flowing through the pipes 9 thereby flows from the one longitudinal end zone 5 to the other longitudinal end zone 5 via the plurality of pipes 9 and hollow spaces 8. A water inlet 10 and a water outlet 11 are provided in one panel 7 at one longitudinal end zone 5, for feeding relatively cold water to the pipes 9 via the water inlet 10 and for discharging relatively hot water from the pipes 9 via the water outlet 11. Said hot water may be used for central heating or tap water.

[0039] As is clearly shown in figure 1B, a first part of the pipes 9 is arranged in a first pattern 12 defining two legs of a substantially U-shape as seen in cross-section,

said first pattern being arranged substantially parallel to legs of said U-shape body 2. The receiving space 4 for the burner is arranged between at least a part of the pipes 9 of the first pattern 12 located near the open end of the body 2 in such a manner that in use at least a part of the pipes 9 of the first pattern 12 surround a flame provided by said burner. This way, said part of the pipes 9 of the first pattern 12 protect the casing from the heat of the flame. A distance between all pairs of adjacent pipes 9 of each leg of the first pattern 12 is preferably maximally 0.5 mm, more preferably maximally 0.1 mm, thereby restricting the mass flow of flue gas that will flow through the spaces between adjacent pipes 9 to an area between the pipes of the legs of the first pattern 12 and the casing, such that the flue gas that will enter this area will be cooled down by the liquid in the pipes 9 to such an extent that the flue gas will have a relatively low temperature that is more or less similar to or slightly higher than the temperature of the walls of these pipes 9. The distance between the legs of the U-shape body 2 and the pipes 9 of the first pattern 12 is preferably maximally 1.0 mm, more preferably maximally 0.4 mm, thereby also contributing to the restriction of the mass flow of flue gas into this area and thereby contributing to the reduction in temperature to which the casing is exposed. A sealing 13 is arranged between the outer surface of the pipes 9 arranged at a first end of each leg of the first pattern 12 near the open end of the body 2 and the body 2, thereby sealing off the space there between and thereby preventing the flue gases from flowing in the area between the pipes 9 of the first pattern 12 and the casing via said space.

[0040] A second part of said pipes 9 are arranged within a space 14 at least partly bounded by said first pattern 12. The second part of the pipes are arranged such that a formula:

$$v_g = \frac{F_g}{A} = C$$

is substantially fulfilled, wherein:

v_g is the velocity of flue gases flowing from said burner in the direction of the base of said U-shape body in m/s in use of the heat exchanger;

F_g is the flow rate of flue gases flowing from said burner in the direction of the base of said U-shape body in m³/s in use of the heat exchanger;

A is the surface area between adjacent pipes of the second part of the pipes;

C is a substantially constant value of maximally 12 m/s.

[0041] Relatively hot flue gas has a relatively large volume and vice versa. As such, as seen in a flow direction of the flue gas, the flue gas coming from the burner arranged in the receiving space 4 has a relatively large flow rate as the flue gas is relatively hot, thereby requiring a

relatively large surface area between adjacent pipes 9 arranged near the burner space in order to have the velocity of the flue gas being maximally said value C. The pipes 9 arranged near the outlet opening in the base 3 of the body 2 therefor require a smaller surface area there between in order to have the velocity of the flue gas being maximally said value C, as the flue gas is already cooled down to some extent by the heat exchanger and the flow rate is relatively small. This is shown in figure 1B, showing that the closer the pipes 9 are arranged to the burner arranged in the receiving space 4, the larger the surface area between the pipes 9.

[0042] As is further shown in figure 1B, the second part of the pipes comprises three groups of pipes 9, wherein a first group 15 located near the base 3 of the body 2 has a first, smallest diameter, wherein a second group 16 located near the first group 15 at a side of the first group 15 opposite to the base 3 of body 2 has a second, intermediate diameter, and wherein a third group 17 located near the open end of the body 2 has a third, largest diameter. As said third group 17 of pipes 9 has the largest diameter of the three groups, the flow rate of liquid flowing there through is also the largest of the three groups, thereby cooling down the flue gas coming from the burner relatively fast and efficiently reducing production of NO_x. Between the third group 17 and the second group 16 a certain distance of preferably between 10 and 40mm, more preferably between 20 and 30mm, is present, such that over this distance the flue gas is substantially not cooled down and a relatively large time period is provided for the conversion of CO into CO₂, such that the emission of CO is reduced and preferably prevented. The pipes 9 of the second group 16 have an intermediate diameter adapted to the amount of heat to be absorbed from the already partly cooled down flue gases, and the pipes 9 of the first group 15 have the smallest diameter adapted to absorb heat from the more cooled down flue gases. A part of the pipes 9 of the first group 15, in particular three pipes 9 thereof, is arranged at least partly between a part of the pipes 9 of the second group 16, wherein said part of the pipes 9 of the first group 15 and said part of the pipes 9 of the second group 16 are arranged alternately in a direction substantially orthogonal to the direction of the flow of the flue gases. As a result thereof, the flow of flue gas is directed along substantially the whole outer surface, in particular also along the lower surface, of the pipes 9 arranged directly upstream of said part of pipes 9 of the second group 16 as seen in the direction of the flow of flue gases.

[0043] Figure 2 schematically shows the distribution of the liquid flow through the pipes 9 of the heat exchanger. This shows that the pipes 9 are divided over in total twenty-two groups. Appointment of the pipes 9 to each group is established with said hollow spaces 8 that connect any desired number of selected pipes 9 to a specific group. Liquid enters the first group I via the liquid inlet 10 that is in medium through flow connection with group I and exits the last group XX via liquid outlet 11 that is in me-

dium through flow connection with group XX. The liquid flows alternatingly between the two end zones 5 via the groups in sequential order, thus via group I to group II, from group II to group III, etc. The number of pipes 9 belonging to each group and the selection of pipes 9 belonging to each group may be chosen as desired. Preferably, the selection and number of pipes 9 belonging to each group are chosen to fulfil a second formula:

$$\frac{Q}{A_{eff} \cdot v_l} = k$$

is substantially fulfilled, wherein:

Q is the quantity of heat transferred to the liquid flowing in each pipe in kJ in use of the heat exchanger;
 A_{eff} is the effective heat transferring surface of each pipe in m^2 in use of the heat exchanger;
 v_l is the velocity of the liquid flowing in each pipe in m/s in use of the heat exchanger, and
 k is a maximum value of 170 kJ/m^3 .

[0044] Using this formula the liquid flow is distributed such that the quantity of heat Q discharged from the flue gas and transferred to the liquid flowing in each pipe is substantially constant anywhere in the heat exchanger.

[0045] Figures 3A and 3B show the effect of liquid distributors according to the invention. Said liquid distributors may be provided in any desired hollow space 8 for distributing the liquid over the pipes 9 connecting to that hollow space 8. Figure 3A shows a plurality of three pipes 9 of a group that are connected via a hollow space 8 to three pipes 9 of a subsequent group. The liquid tends to follow the largest curvature and thereby to enter the most outer pipe 9 of the three pipes of the subsequent group. The middle pipe therefor receives less liquid and will therefor become relative hot and exposed to high thermal stresses. With use of the liquid distributors shown in figure 3B each pipe 9 of a group is connected to a pipe 9 of the subsequent group. The liquid is thereby evenly distributed over the pipes 9 belonging to a specific group, independent of the location of the pipe 9.

[0046] Figure 4 is a perspective view of a burner according to the invention. Said burner comprises a casing 18. In said casing 18 an element is provided comprising a ceramic burner plate 19 and a damper 21 that also functions as an aluminium gas/air mixture distribution plate and that is arranged upstream from the burner plate 19. An anorganic insulation material 20 is provided between the burner plate 19 and the damper/distribution plate 21. A sealing 22 is provided between the casing 18 and the damper/distribution plate 21, such that the gas/air-mixture is prevented from entering the burner room alongside said element comprising the damper/distribution plate 21 and the burner plate 19. As the damper/distribution plate 21 and the burner plate 19 are com-

bined in one element, the gas/air-mixture exiting the damper/distribution plate 21 cannot by-pass the burner plate 19. The gas/air-mixture flowing through the gas/air chamber will cool down the gas/air chamber and the gas/air-mixture distribution plate/damper 21. The life time of the burner is hereby enhanced.

[0047] Figure 5 shows an assembly of the heat exchanger of figures 1A, 1B and the burner of figure 4. The U-shape body 2 and the panels 7 of the heat exchanger are shown, as well as the casing 18 of the burner. The burner is arranged such in the receiving space of the body 2, that the flames coming from the burner plate are surrounded by the upper pipes 9 of the legs of the first pattern 12 of pipes 9.

[0048] It is noted that the invention is not limited to the shown embodiments but also extends to variants within the scope of the appended claims.

Claims

1. Heat exchanger, comprising:

- a casing, comprising:

- a substantially U-shaped body as seen in cross-section and extending in a longitudinal direction, wherein a base of the U-shape body comprises a gas outlet opening and wherein an open end, opposite to the base, of the U-shape body comprises a receiving space for receiving a burner, and
- two end plates arranged at the two longitudinal end zones of said U-shape body;

- a plurality of pipes arranged within said casing and connected to said end plates, through which pipes in use a liquid can flow;
- a plurality of connecting means for providing a liquid through flow connection between at least two pipes at each longitudinal end zone of said U-shape body, such that liquid flowing through a first pipe of the at least two pipes is directed to the other pipe of the at least two pipes,

wherein a first part of the pipes is arranged in a first pattern defining two legs of a substantially U-shape as seen in cross-section, said first pattern being arranged substantially parallel to legs of said U-shape body, and

wherein a second part of said pipes are arranged within a space at least partly bounded by said first pattern.

2. Heat exchanger according to claim 1, wherein said receiving space is arranged between at least a part of the pipes of the first pattern located near the open end of the U-shape body in such a manner that in

use at least a part of the pipes of the first pattern surround a flame provided by said burner.

3. Heat exchanger according to claim 1 or 2, wherein a distance between all pairs of adjacent pipes of each leg of the first pattern is maximally 0.5 mm, preferably maximally 0.1 mm.
4. Heat exchanger according to any of the preceding claims, comprising a sealing arranged between the outer surface of the pipes arranged at a first end of each leg of the first pattern near the open end of the U-shape body and the substantially U-shaped body.
5. Heat exchanger according to any of the preceding claims, wherein the distance between the legs of the U-shape body and the pipes of the first pattern is maximally 1.0 mm, preferably maximally 0.4 mm.
6. Heat exchanger according to any of the preceding claims, wherein the second part of the pipes are arranged such that a formula:

$$v_g = \frac{F_g}{A} = C$$

is substantially fulfilled, wherein:

v_g is the velocity of flue gases flowing from said burner in the direction of the base of said U-shape body in m/s in use of the heat exchanger;
 F_g is the flow rate of flue gases flowing from said burner in the direction of the base of said U-shape body in m³/s in use of the heat exchanger;
 A is the surface area between adjacent pipes of the second part of the pipes;
 C is a substantially constant value of maximally 12 m/s.

7. Heat exchanger according to any of the preceding claims, wherein the connecting means are arranged to provide a liquid through flow connection between groups of at least two determined pipes at each longitudinal end zone of said U-shape body in such a manner that a second formula:

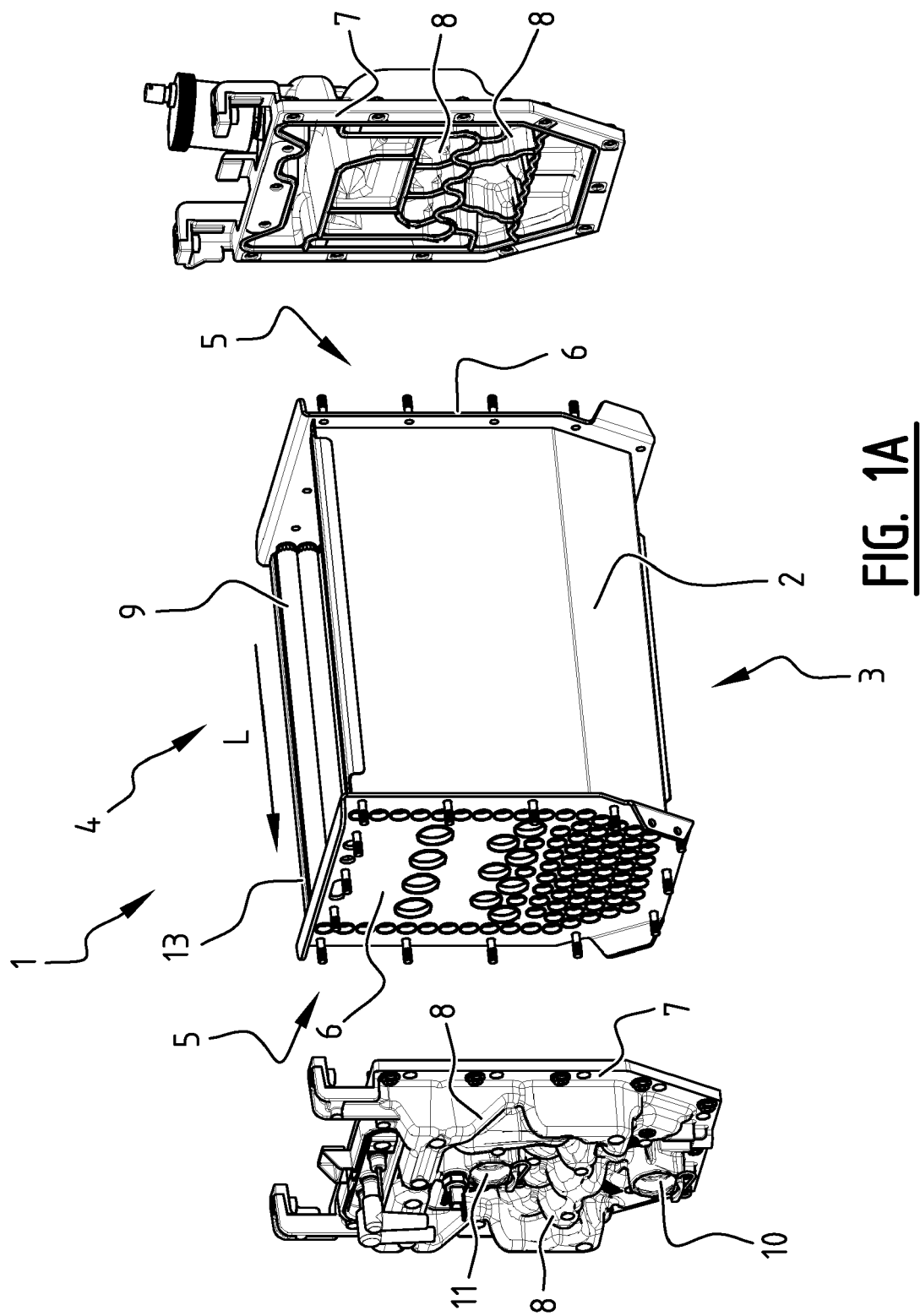
$$\frac{Q}{A_{eff} \cdot v_l} = k$$

is substantially fulfilled, wherein:

Q is the quantity of heat transferred to the liquid flowing in each pipe in kJ in use of the heat exchanger;
 A_{eff} is the effective heat transferring surface of

each pipe in m² in use of the heat exchanger;
 v_l is the velocity of the liquid flowing in each pipe in m/s in use of the heat exchanger, and
 k is a maximum value of 170 kJ/m³.

8. Heat exchanger according to any of the preceding claims, wherein at least one of the connecting means comprises a liquid distributor for substantially equally distributing liquid over pipes being connected to said connecting means.
9. Heat exchanger according to any of the preceding claims, wherein the second part of the pipes comprise at least three groups of pipes, wherein a first group located near the base of the U-shape body has a first, smallest diameter, wherein a second group located near the first group at a side of the first group opposite to the base of the U-shape body has a second diameter, and wherein a third group located near the open end of the U-shape body has a third, largest diameter, which third group is located at a predetermined distance from the second group.
10. Heat exchanger according to claim 9, wherein a part of the pipes of the first group is arranged at least partly between a part of the pipes of the second group.
11. Assembly of a heat exchanger according to any of the claims 1 - 10 and a burner, wherein the burner is arranged in said receiving space.
12. Assembly according to claim 11, wherein the assembly comprises the heat exchanger according to at least claim 2, and wherein the burner is arranged in said receiving space in such a manner that in use at least a part of the pipes of the first pattern surround a flame provided by said burner.
13. Assembly according to claim 11 or 12, wherein said burner comprises a damper.
14. Assembly according to claim 13, wherein said burner comprises a burner plate that is connected to or integrally formed with said damper.
15. Assembly according to claim 13 or 14, wherein said burner comprises a gas/air-mixture distribution plate that is connected to or integrally formed with said damper and/or burner plate.
16. Assembly according to claim 15, comprising a sealing that is provided between the casing and the gas/air-mixture distribution plate.



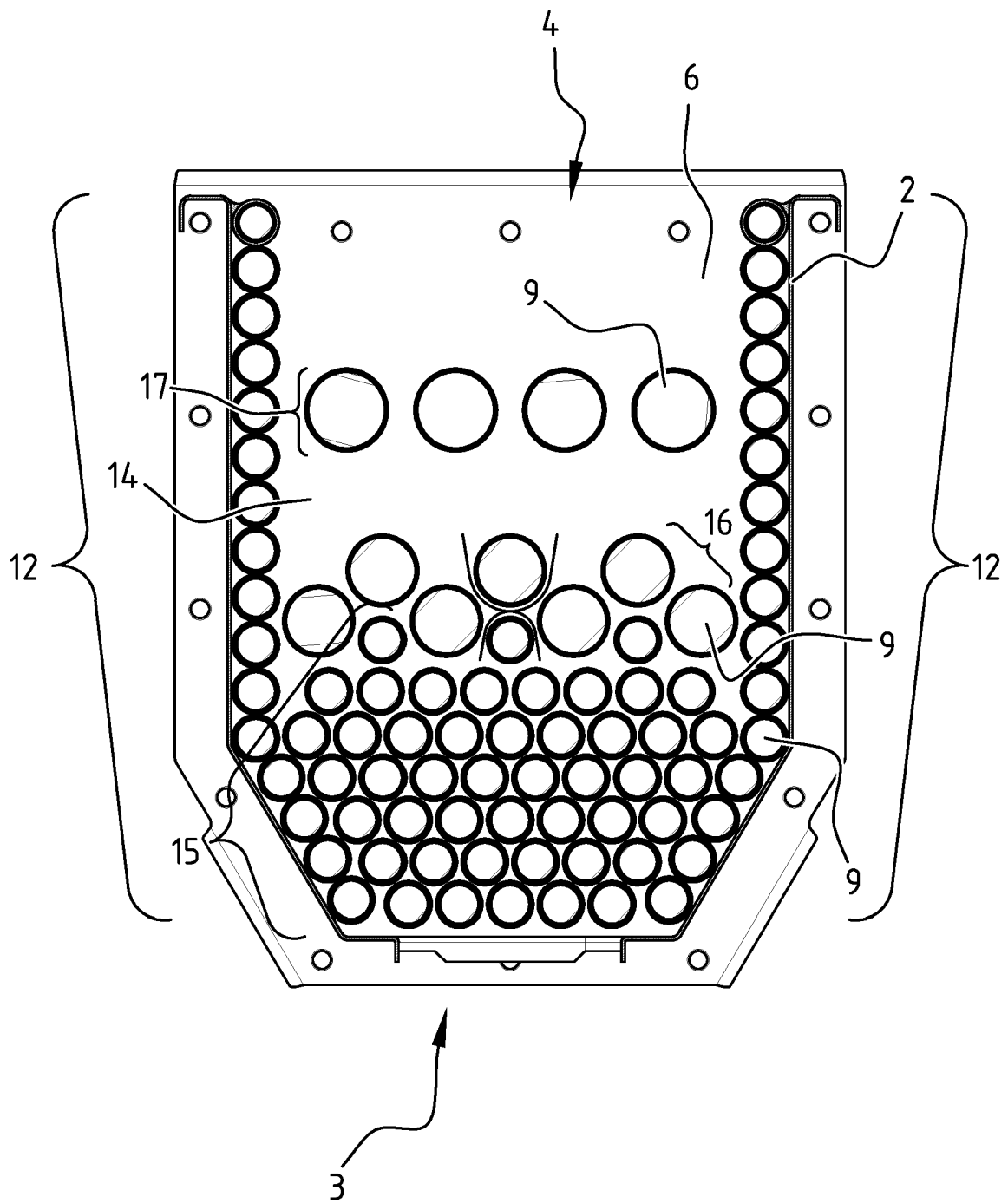


FIG. 1B

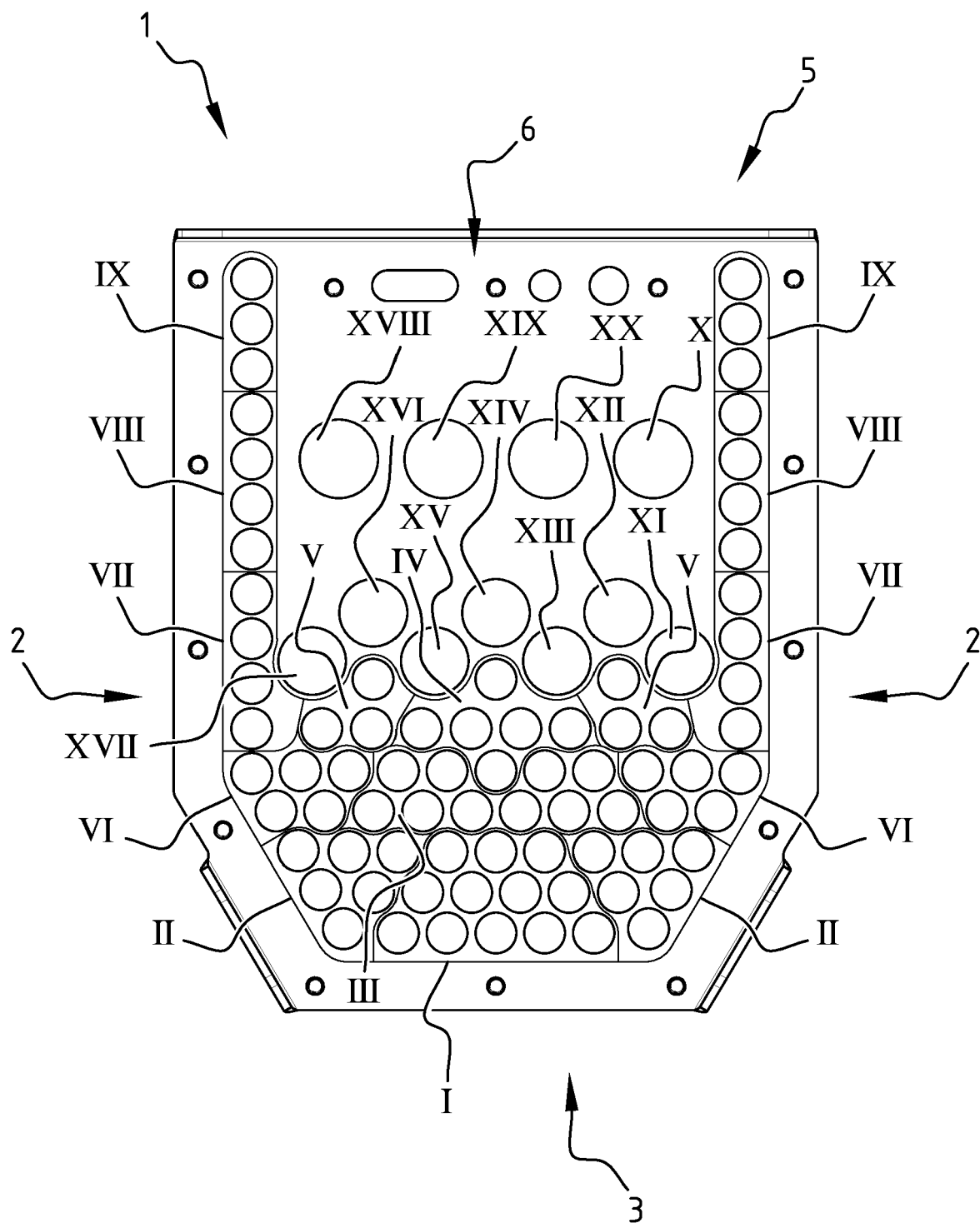


FIG. 2

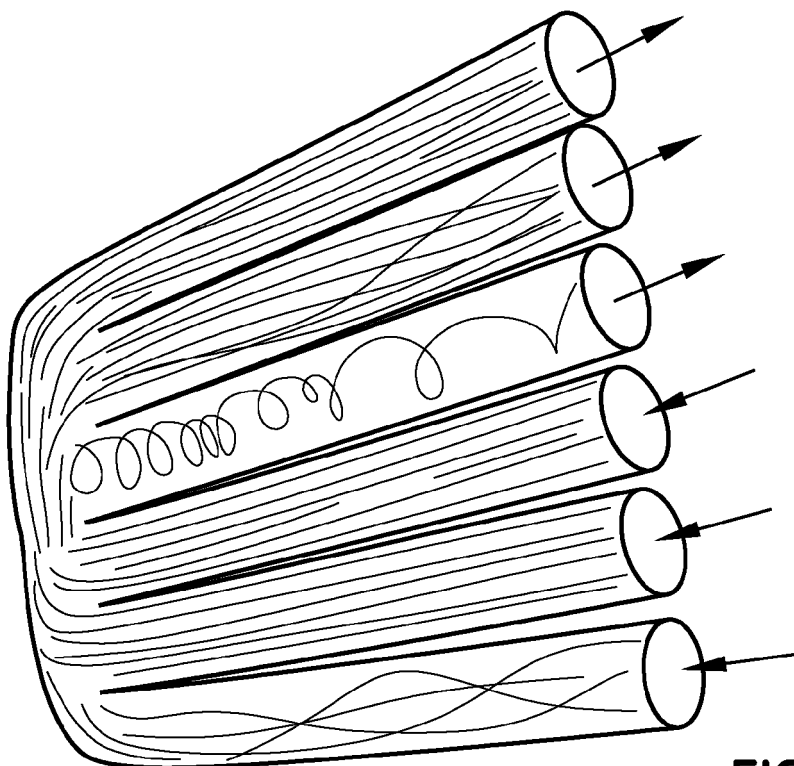


FIG. 3A

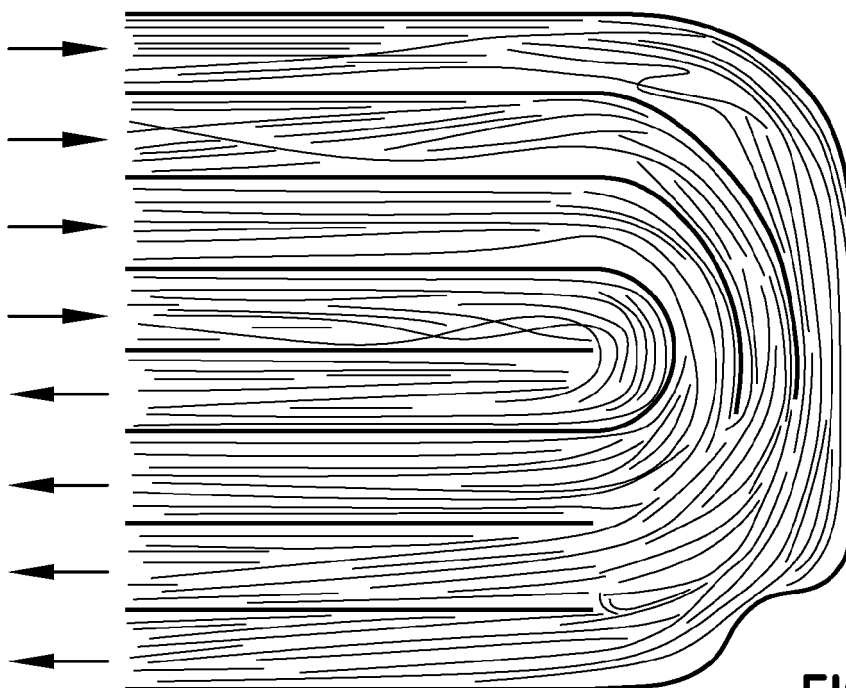


FIG. 3B

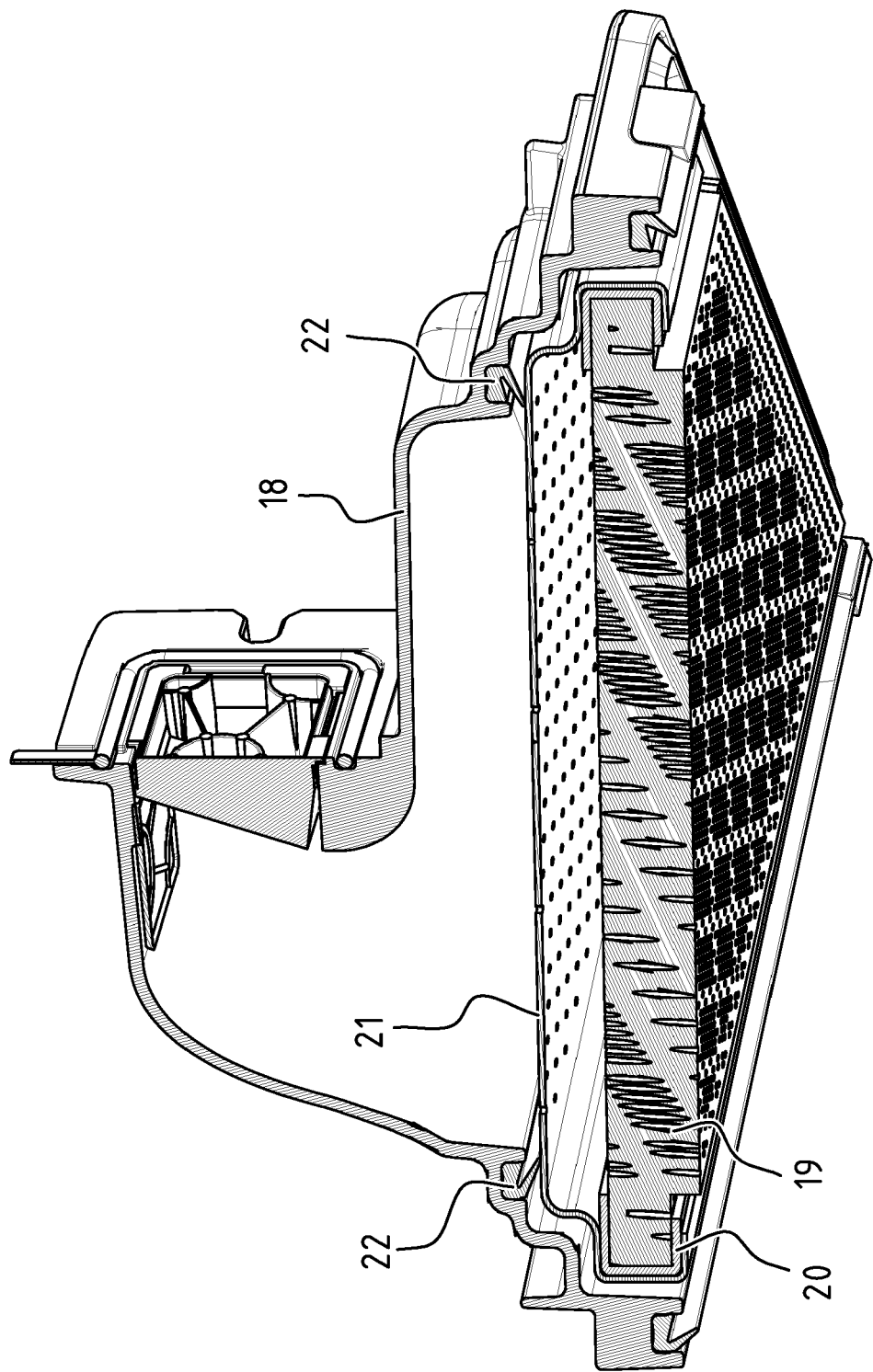


FIG. 4

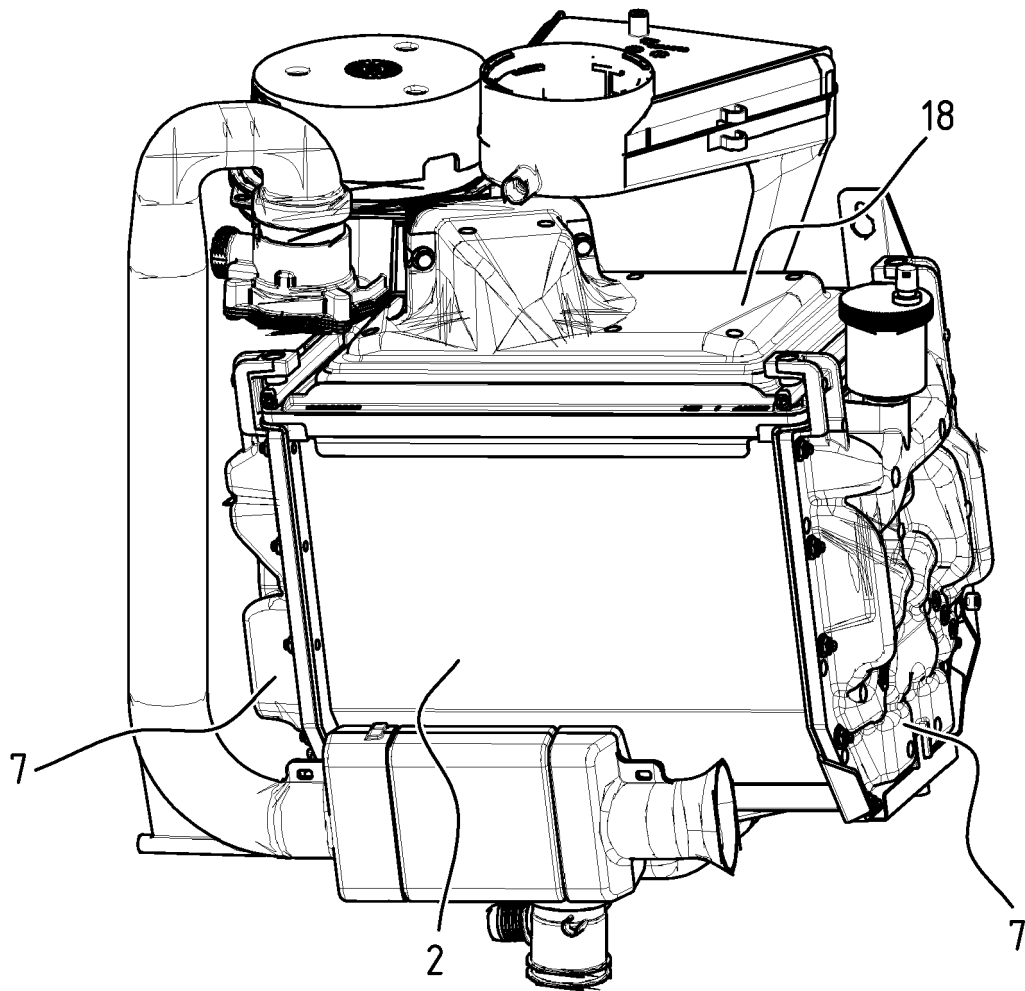


FIG. 5

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP 0687870 B1 [0002] [0004] [0007]