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(54)

Heat exchanger for a boiler

(57) A heat exchanger for a boiler, including side-by-side conduits 78 each extending through a plurality of fin plates 80 arranged transversely thereto, each fin plate 80 including at least one spacer 86 arrange to abut an adjacent plate. Capping end chambers 90,92 are provided each having first and second chambers communicating with first, second and third groups of the conduits 78 to achieve an efficient flow pattern.

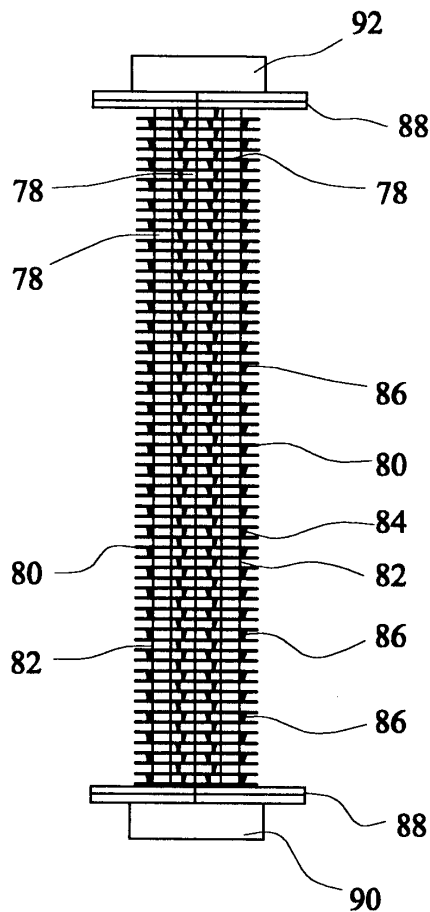


FIG. 4

Description

[0001] The present invention relates to a heat exchanger for a boiler, a method of assembling a heat exchanger, and a method of operating a heat exchanger. The invention also relates to a boiler, and to a method of supplying gas to a heat exchanger in a boiler.

[0002] According to the present invention there is provided a heat exchanger as set forth in claim 1 appended hereto. Also according to the present invention there is provided a method for assembling a heat exchanger as set forth in claim 6 appended hereto. Further according to the present invention there is provided a boiler as set forth in claim 8 appended hereto. Other features and aspects of the invention will be apparent from the claims and the description which follows.

[0003] According to a first aspect of the present invention there is provided a heat exchanger including a plurality of side-by-side conduits, each extending through a plurality of side-by-side plates spaced from each other, with the plane of each plate extending transverse to the longitudinal extent of the conduits, each plate including at least one spacer arranged to abut an adjacent plate.

[0004] The spacer may be integral with the plate. The spacer may be formed by deforming a portion of a plate, preferably a portion of the plate through which a conduit extends.

[0005] The conduits may extend through each plate with there being a further opening in each plate extending from each conduit through which a connection means, such as a braising rod, may extend.

[0006] According to a second aspect of the present invention there is provided a method of assembling a heat exchanger, comprising locating conduits through a plurality of side-by-side plates that are spaced from each other, with each plate including a spacer arranged to abut an adjacent plate.

[0007] The method may comprise locating plates on two conduits and then inserting further conduits through openings in the plates. The method may comprise inserting further conduits in the form of a magazine of conduits. The method may comprise swaging the ends of the conduits in order to secure the plates and the conduits in position.

[0008] According to another aspect of the present invention there is provided a heat exchanger including a plurality of side-by-side conduits which are connected to a chamber unit at each end, wherein a first chamber unit at a first end of the conduits includes a first chamber being in communication with a first group of the conduits; a second chamber unit at a second end of the conduits includes a first chamber being in communication with the first group of conduits and also a second group of conduits different from the first group of conduits; and the first chamber unit also including a second chamber at the first end in communication with the second group of conduits.

[0009] Optionally, the second chamber at the first end

is in communication with the second group of conduits and a third group of conduits, and the heat exchanger may also include a second chamber at the second end in communication with the third group of conduits.

[0010] The present invention also includes a method of operating such a heat exchanger comprising passing fluid into the first chamber at the first end, through the first group of conduits, into the first chamber at the second end via the first group of conduits, into the second group of conduits at the second end and then to the second chamber at the first end via the second group of conduits.

[0011] The method may also comprise causing fluid to pass from the second chamber at the first end to a second chamber at the second end through the third group of conduits.

[0012] According to a further aspect of the present invention there is provided a boiler including a heat exchanger at an upper region, and a turbine unit including a first turbine arranged to draw air towards a burner, a chamber arranged to cause combusted gas and air to flow towards and to rotate a second turbine, the second turbine being arranged to drive the first turbine, hot gases from the second turbine being arranged to be directed upwardly towards the heat exchanger.

[0013] The boiler may include fluid supply means for the heat exchanger being provided downstream beneath the turbine unit. Disconnecting means may be provided for disconnecting the fluid supply means from the heat exchanger at a location towards the lower region of the boiler, for instance in the region upstream of the first turbine or beneath the turbines. Disconnection of those means may permit the heat exchanger to be removed easily from the boiler such as by moving the heat exchanger upwardly through a housing of the boiler.

[0014] The turbines may include a shaft that connects those turbines. Shaft cooling means may be provided to cool the shaft and/or a shaft bearing. Those means may supply a fluid such as water. The rate of fluid supply to cool the bearing or the shaft may be variable. Fluid that has cooled the bearing or the shaft may be arranged to evaporate into the second turbine.

[0015] According to a further aspect of the present invention, a boiler includes heated gas supply means arranged to supply heated gas to a heat exchanger, the boiler further including gas directing means arranged to cause gas moving from the gas supply means to the heat exchanger to be directed from having a first cross-sectional area perpendicular to the direction of travel of the gas, to a second cross-sectional area perpendicular to the direction of travel of the gas at a downstream location to the first cross-sectional area, the first cross-sectional area and the second cross-sectional area being different.

[0016] The first cross-sectional area may be annular. The second cross-sectional area may be non annular and may be multi-sided and may be quadrilateral and

may be substantially square. The direction of travel of the gas at the first and second cross-sectional areas may be substantially the same direction.

[0017] The directing means may comprise a member having side walls extending outwardly in the downstream direction. Gas may be arranged to flow between the side walls. The directing means may include deflector means. Deflector means may be arranged to be located at different extents with respect to the direction of travel of the gas. At least two opposed side walls may include deflectors. The deflectors may be arranged to be at a downstream and an upstream end of the directing means. The deflectors may be arranged to be at an angle with respect to the direction of travel of the gas and that angle may be, for instance, between 10 and 20° and is preferably in the region of 15° to the direction of travel of the gas.

[0018] According to a further aspect of the present invention there is provided a method of supplying gas to a heat exchanger in a boiler comprising changing the cross-sectional area of the gas with respect to the perpendicular to the direction of travel of the gas from an upstream location to a downstream location nearer the heat exchanger.

[0019] The method may comprise maintaining the general direction of travel of the gas in substantially the same direction whilst the cross-sectional area of the gas flow changes. The method may comprise altering the cross-sectional area from an annular cross-sectional area and may comprise altering the cross-sectional area to a non-annular cross-sectional area such as a multi-sided cross-sectional area such as a quadrilateral or a square. The method may comprise deflecting the gas in order to change the cross-sectional area.

[0020] The present invention can be carried into practice in various ways but one embodiment will now be described, by way of example, and with reference to the accompanying drawings, in which:

Figure 1 is a schematic cross-sectional view of a boiler;

Figure 2 is a schematic perspective view of an air deflector arrangement 60;

Figure 3 is a plan view of a heat exchanger 16;

Figure 4 is an end view of Figure 3;

Figure 5 is a view showing one of the end plates;

Figure 6 is a view showing the details of an internal fin used in the heat exchanger; and

Figure 7 is a schematic side view showing fluid flow through the heat exchanger.

[0021] Figure 1 shows a boiler 10 having a housing

11 including an air intake 12 and a turbine unit 14 that is arranged to direct air towards a heat exchanger 16 with air subsequently exiting the housing through an exhaust 18. Entry and exit connections 20 and 22 are shown at the bottom of the housing for carrying fluid for heating by the boiler, such as water for a central heating system. The combined boiler shown in the preferred embodiment also provides a mains cold water input 24 and a direct hot water output 26 for the boiler.

[0022] The water from the central heating input 20 and from the cold water input 24 travels up through the heat exchanger via a pump 28 and a flow pipe 30 into the heat exchanger. Hot water from the heat exchanger 16 passes downwardly through a return pipe 32 to the outlets 22 and 26. The flow and return pipes 30 and 32 have detachable connections 34 which, when detached, allow the exhaust 18 and the heat exchanger 16, together with the pipes 30 and 32, to be conveniently removed from the boiler housing 11 by causing upwards movement of those parts relevant to the housing.

[0023] The boiler may have an output in the region of about 35 Kw. Typically, the turbine rotates in the region of 50,000 r.p.m. or in the region of 85,000 r.p.m.

[0024] The air supply and heating arrangement will now be described in greater detail. Air is drawn in through the intake 12 by the rotation of vanes of the first turbine 36. The air is compressed by the vanes 36 into a first annular chamber 38 from which the air exits into the region of an array of downwardly extending gas injection nozzles 40. A combustible gas is supplied to the nozzles 40 through a gas supply pipe 42 coupled to a second annular chamber 44, the downward portion of which is connected to the injection nozzles 40.

[0025] The gas and air are mixed by the injection nozzles and pass an igniter 46 such that the gas mixture from the nozzles 40 burns in a third annular chamber 48. As the gas mixture is ignited in the third annular chamber 48 the gas expands into that chamber. The chamber 48 decreases in cross sectional area from its upper extent to its lower extent such that the speed of the gas increases prior to contact with the vanes of the second turbine 50. The upper turbine 50 is connected to the lower turbine 36 via a shaft 52. Consequently, rotation of the upper turbine 50 causes rotation of the lower turbine 36 and maintains operation of the turbine unit. A starter motor 51 may be provided coupled to the shaft 52, to run the turbine from standstill up to an operating speed.

[0026] There is a gap 54 between the upper and radially outer portions of the upper turbine vanes 50 and a surrounding stationary housing 56. This gap 54 has been selected such that the turbine unit produces mostly heat rather than thrust by allowing a relatively large tolerance between the turbine vanes 50 and the surrounding housing 56. If the gap 54 is too great then insufficient energy will be passed to the turbine to sustain the cycle. If the gap is too small then an insufficient volume of gas will enter the passage 58 from the turbine vanes. The

gap may be, for instance, between 2 and 8 mm and is preferably in the region of 5 mm. It has been found that varying this gap allows a controlled variation of the balance between heat and thrust. For the presently preferred embodiment, it is desired to minimise thrust. In an alternative embodiment, it is desired to generate a balance of both heat and thrust such that the boiler is suitable for use as a combined heat and power unit, such as by using the starter motor as an alternator to draw electrical power.

[0027] The passage 58 is conical in shape with the inner portion of the passage extending upwardly and inwardly. Air exits the passage 58 with a first cross-sectional area, typically annular, and contacts, at its outer periphery, a deflector arrangement 60, shown schematically in chain lines in Figure 1. The deflector arrangement 60 is located above the outlet of the passage 58 and beneath the heat exchanger 16. It will be appreciated that, in plan, the heat exchanger is square. As shown in Figure 2, the deflector arrangement 60 comprises outer walls 62, at right angles to each other that are connected to each other at their side edges and that each extend upwardly and outwardly. A passage 64 extends up between the outer walls and through which the gasses leaving the passage 58 pass. The bottom edges of opposed outer walls 62 include inwardly and upwardly directed flaps 66 that are inclined at between, typically, 10° and 20° to the vertical and are preferably at 15° to the vertical. The other opposed side walls 62 have similar flaps 68 at their upper end that extend inwardly and upwardly and which may be at the same angle as the flaps 66. This arrangement of the deflector causes gas to be directed evenly over the square cross-section of the heat exchanger. The deflector arrangement 60 is located in a chamber 70. The side walls of the chamber 70 are insulated by an insulating layer 72.

[0028] Referring again now to the turbine arrangement 14, the shaft 52 is mounted in a ceramic bearing 74. Water from a suitable supply, such as mains water, is provided to a chamber 76 that surrounds the bearing 74 with that water being dropped at a controlled rate onto the bearing through narrow openings 77 on the inner wall of the chamber. The water drop rate may be controllable by a water rate controller (not shown). Water that contacts and cools the bearing is evaporated and that evaporated water, it has been found, reduces carbon deposits on upstream equipment, and in particular reduces the carbon deposits on the upper turbine vanes 50. This reduces the maintenance requirements for the boiler.

[0029] The heat exchanger 16, shown in Figures 3 to 7, will now be described in greater detail.

[0030] Referring to Figures 3 and 4, end chamber units 90,92 are provided in communication with the water flow and return pipes 30 and 32 shown in Figure 1. Twenty-eight fluid carrying conduits 78 are arranged to extend between those end caps 90,92. The conduits 78 are suitably copper tubes. The conduits 78 each extend

through in the region of sixty fin plates 80, arranged to take heat energy from the passing heated air.

[0031] One of the difficulties in manufacturing the heat exchanger 16 is to ensure that the distance between each of the fin plates 80 is substantially constant to achieve even heat transfer. Further, it is desired to provide a relatively dense structure with a minimum of components, to give good thermal transfer efficiency whilst minimising manufacturing costs. To this end, a stack of fin plates 80 is built up on the conduits 78 that each extend through openings 82,84 in the fin plates 80. The openings 82,84 in the plates are arranged such that the conduits 78 are conveniently staggered in at least two rows. As shown in Figure 6, the majority of the openings 82 are stamped from the fin plates 80 with a clear stamp, such that the surface of the fin plate 80 on either side is substantially flat. However, some of the openings, in this example the four of the openings 84, are stamped out or swaged out, or both, to leave collars 86 projecting slightly (for instance by around 3 mm) from one side of the plate, to provide a spacer element.

[0032] The openings 84 and their associated spacers 86 are all aligned, from one side of the heat exchanger to the other, as shown particularly in Figure 3, such that an even spacing across all of the fin plates is ensured. Referring to Figure 6, the spacers 86 are located, at an upper region of each fin, at one end and slightly inwardly from the second end, and, at a lower region of each fin, at the second end and slightly inwardly from the first end. In this way only four spacers 86 are required to obtain the required spacing with resistance to bending of the fins being provided. Further, two end plates 88 are provided, shown in Figure 5, of greater substance than the fin plates 80, in order to aid a robust structure.

[0033] To assemble the heat exchanger, firstly one of the end plates 88 and the fin plates 80 are mounted on a selected few conduits. Preferably, these first conduits pass through the openings 82 or 84 having spacers 86 nearby. For example, the plates may be assembled on two or more conduits 78 each passing through one of the swaged openings 84. Then the remaining conduits 78 are threaded through, either individually or in a magazine, followed by the second end plate 88. The ends of the conduits 78 are swaged over one end plate 88 before turning the heat exchanger over and swaging the other ends. Thus these parts are held mechanically in position.

[0034] The conduits 78 can be braised to seal them with the fin plates 80 and the end plates 88. A braising rod is threaded through a top slot 83 of each of the openings 82 and 84, conveniently in a single magazine with the majority of the conduits 78. Heat is applied to firmly fix the plates 80,88 to the conduits 78 and improve thermal coupling.

[0035] Referring to Figure 7, the end plates 88 are capped by the chamber units 90 and 92 suitably coupled with a seal (not shown). The first end cap 90 includes first and second chambers 91 and 93, and the second

end cap 92 likewise includes first and second chambers 95 and 97. Cold water enters heat exchanger through one of the end caps 90 and is caused to flow into a first group of the conduits 78a via the first chamber 91. Water exits those conduits 78a into the first chamber of the second cap 92 and flows into a second group of conduits 78b before returning to the second chamber 93 of the first cap 90. Then, water flows to the second chamber 97 of the second cap 92 through a third group of conduits 78c to exit the heat exchanger 16. This flow pattern maximises exposure of the water to the available heat energy. Two corresponding sets of chambers and conduits may be provided for separate water paths in the combination boiler of the preferred embodiment.

[0036] The reader's attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

[0037] All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

[0038] Each feature disclosed in this specification (including any accompanying claims, abstract and drawings), may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

[0039] The invention is not restricted to the details of the foregoing embodiment(s). The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

Claims

1. A heat exchanger for a boiler, comprising:
a plurality of side-by-side conduits (78), each extending through a plurality of side-by-side plates (80) spaced from each other, with the plane of each plate extending transverse to the longitudinal extent of the conduits, each plate including at least one spacer (86) arranged to abut an adjacent plate.
2. A heat exchanger as claimed in claim 1, wherein the spacer (86) is integral with the plate (80).
3. A heat exchanger as claimed in claim 2, wherein the spacer (86) is formed by deforming a portion of the plate (80).

4. A heat exchanger as claimed in claim 3, wherein the spacer (86) is formed by deforming a portion of the plate through which one of the conduits (78) extends.

5. A heat exchanger as claimed in any of claims 1 to 4, comprising:

a first chamber unit (90) at a first end of the conduits (78) including a first chamber (91) being in fluid communication with a first group of the conduits (78a); and

a second chamber unit (92) at a second end of the conduits (78) including a first chamber (95) being in fluid communication with the first group of conduits (78a) and also a second group of conduits (78b) different from the first group of conduits (78a); and

wherein the first chamber unit (90) also includes a second chamber (93) at the first end in fluid communication with the second group of conduits (78b).

6. A method of assembling a heat exchanger for use in a boiler, comprising the step of:

locating conduits (78) through a plurality of side-by-side plates (80) that are spaced from each other with each plate including a spacer (86) arranged to abut an adjacent plate.

7. A method as claimed in claim 6, comprising the steps of:

locating the plates on at least two conduits (78) in a side-by-side and spaced apart arrangement; and

inserting further conduits (78) through openings (82) in the plates (80).

8. A boiler, comprising:

a heat exchanger (16) as claimed in any of claims 1 to 5;

a turbine unit (14) including a first turbine (36) arranged to draw air towards a burner (40), an annular chamber (48) arranged to cause combusted gases to flow towards and rotate a second turbine (50), the second turbine (50) being arranged to drive the first turbine (36), and hot gases from the second turbine (50) being directed upwardly towards the heat exchanger (16).

9. A boiler as claimed in claim 8, wherein a gap (54)

between the vanes of the second turbine (50) and a surrounding housing (56) is selected to increase heat output of the turbine unit.

10. A boiler as claimed in claim 8 or 9, comprising:

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fluid supply means (30,32) for the heat exchanger (16) provided downstream of the turbine unit (14); and

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disconnection means (14) for disconnecting the fluid supply means (30,32) from the heat exchanger (16), the disconnection means being provided at a location towards an upstream region of the turbine unit (14).

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11. A boiler as claimed in claim 8, 9 or 10, comprising:

a shaft (52) for connecting the first and second turbines (36,50); and

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shaft cooling means (76) for supplying a cooling fluid to the shaft (52) and/or to a bearing (78) of the shaft, such that evaporated cooling fluid is directed toward the second turbine (50).

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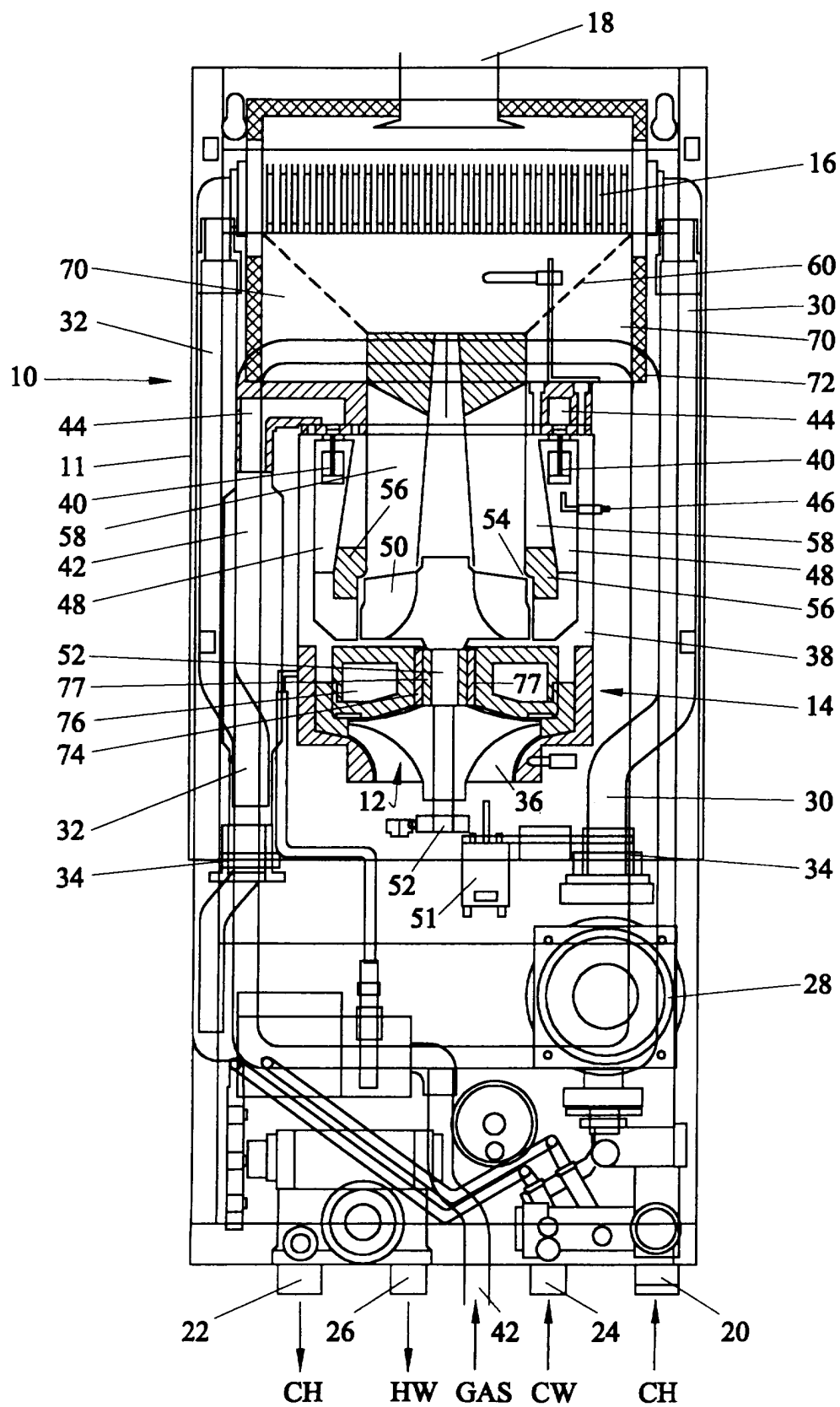


FIG. 1

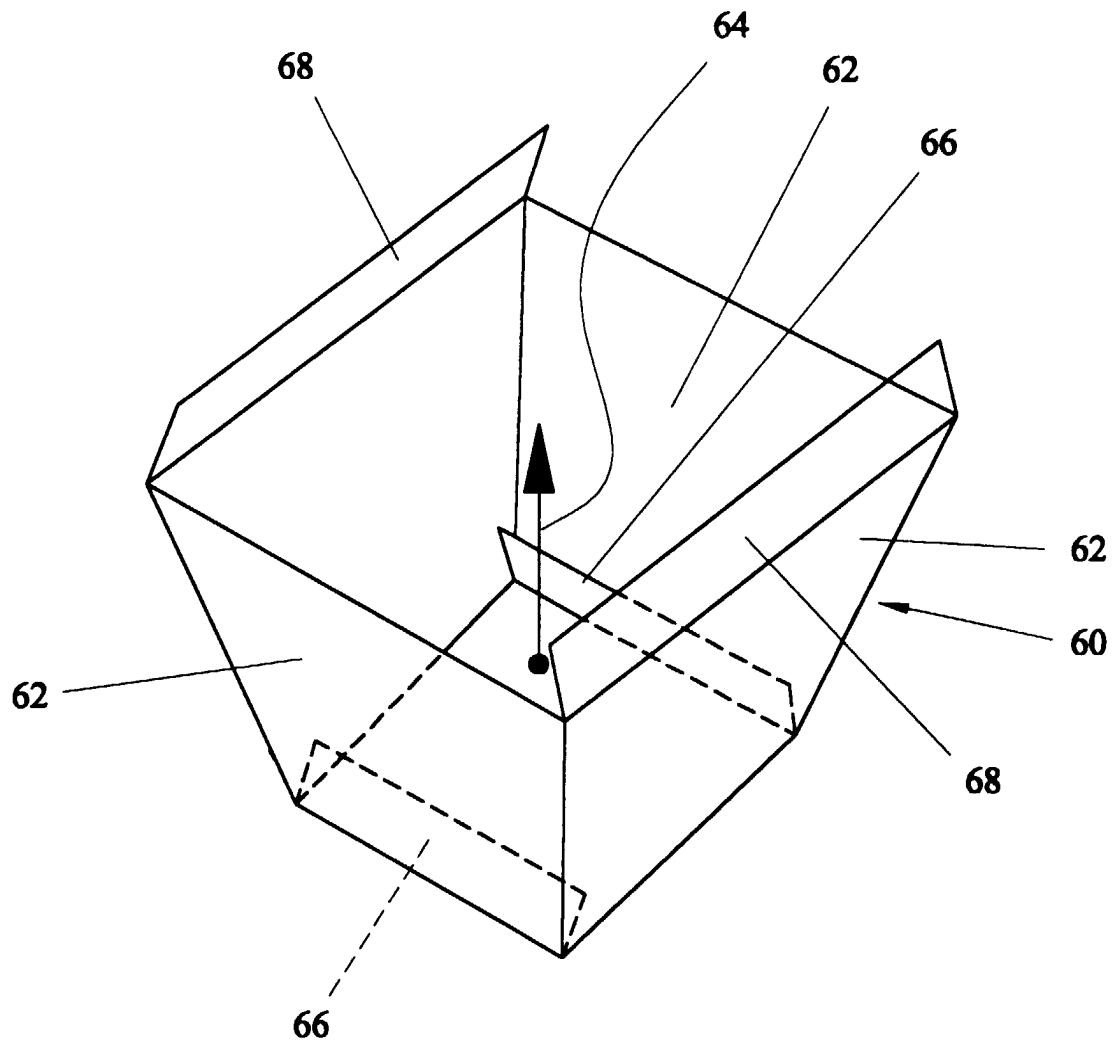


FIG. 2

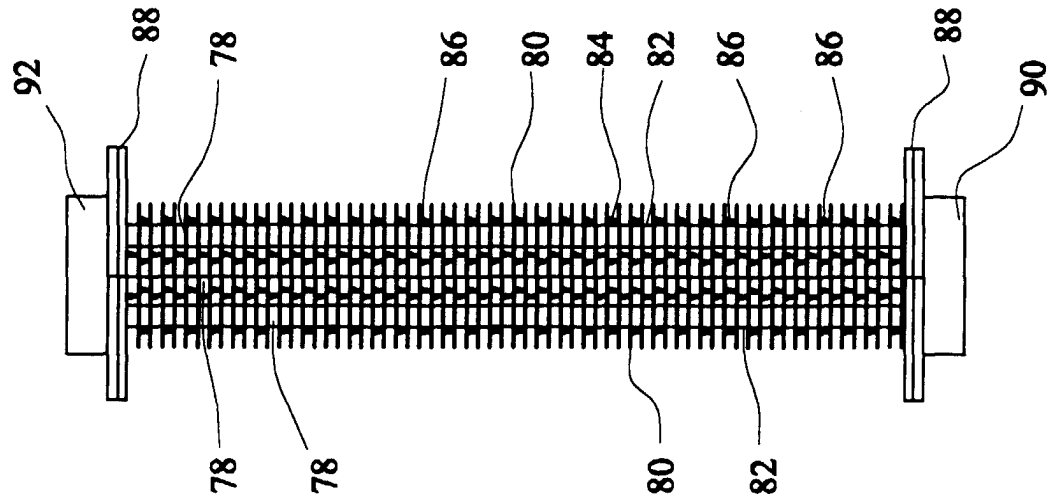


FIG. 4

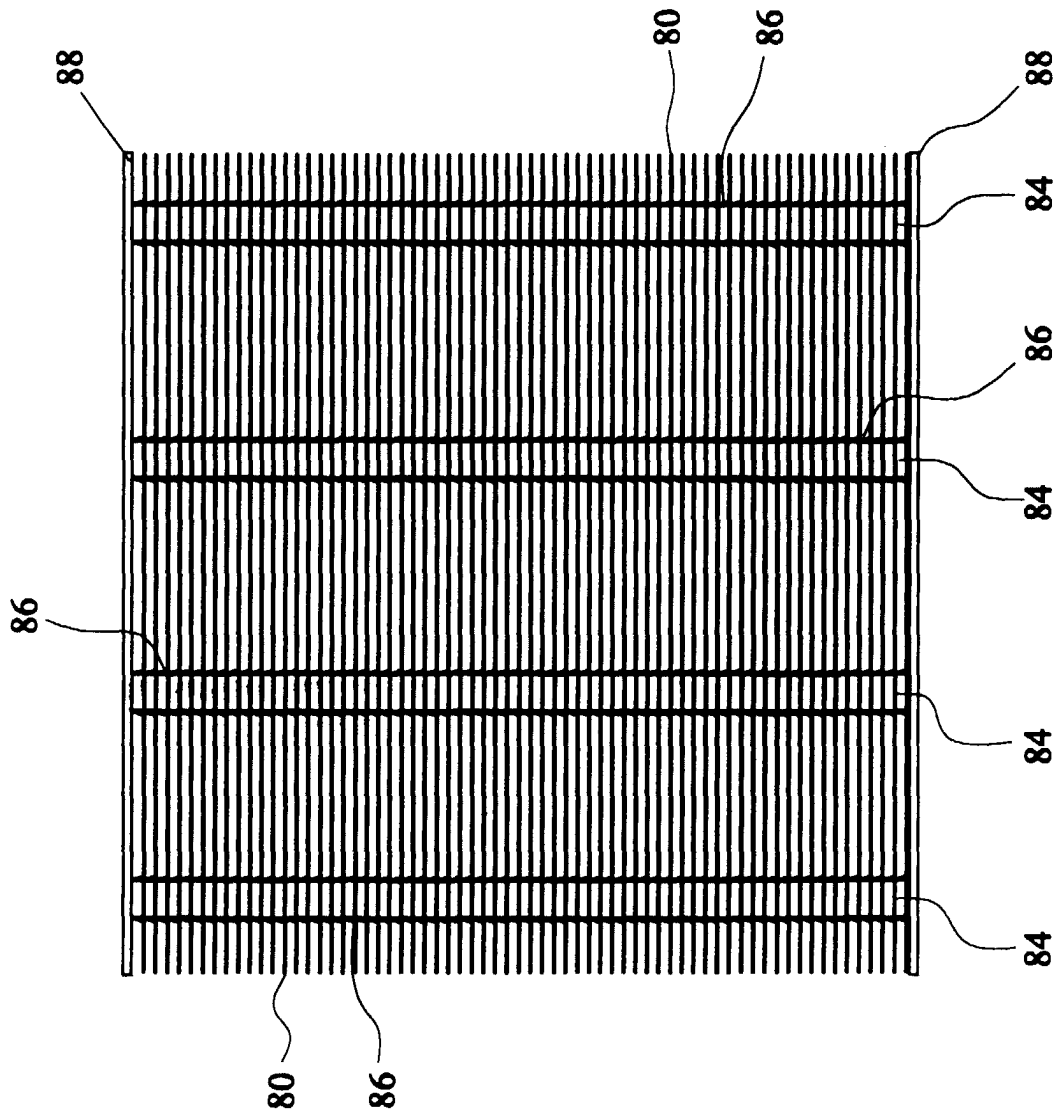


FIG. 3

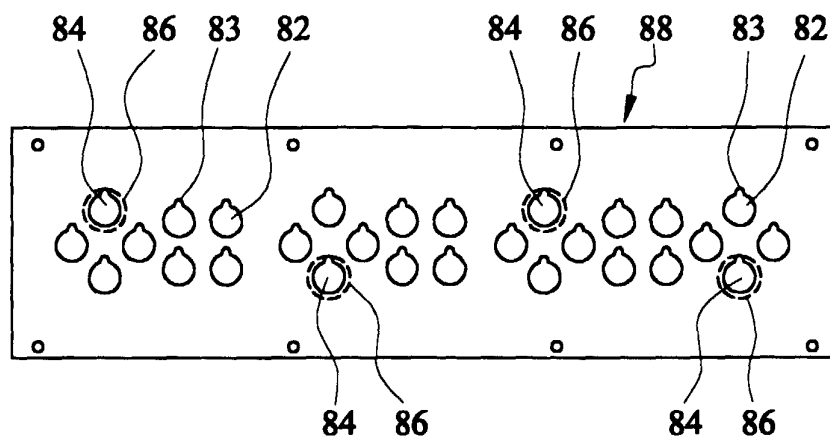


FIG. 5

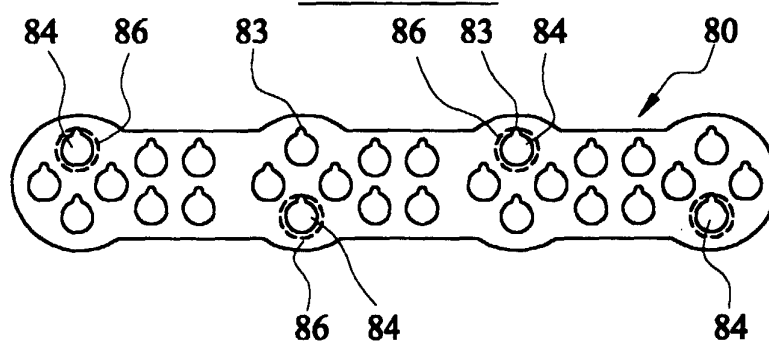


FIG. 6

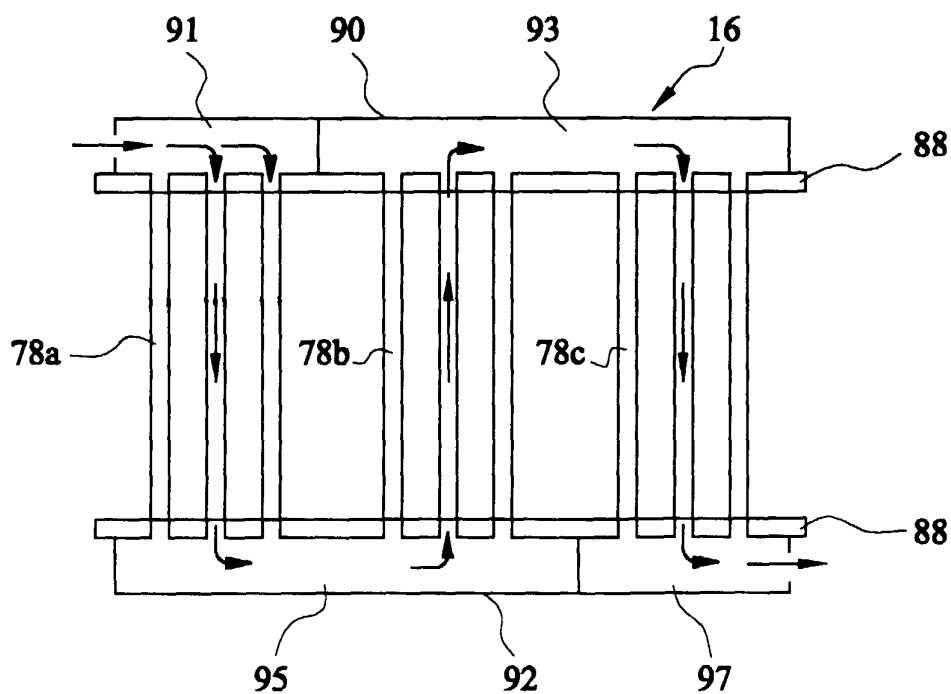


FIG. 7