(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 2 573 497 A2**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
27.03.2013 Bulletin 2013/13

(51) Int Cl.:
F28D 21/00 *(2006.01)*

(21) Application number: **12185413.7**

(22) Date of filing: **21.09.2012**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(30) Priority: **23.09.2011 FI 20110325**

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(54) **Thermal energy recovery unit, and arrangement for utilizing thermal energy of flue gases**

(57) The invention relates to a thermal energy recovery unit in connection with a furnace of a building, comprising a flue duct (110) for conveying flue gas released from the furnace. The recovery unit comprises a liquid container (120) arranged around the flue duct (110) for collecting thermal energy in the flue gas conveyed in the flue duct into the liquid in the liquid container (120), and at least one liquid connection (101, 102) for connecting the liquid container (120) of the recovery unit to another recovery unit so as to enable transfer of the liquid in the liquid container between the recovery units.

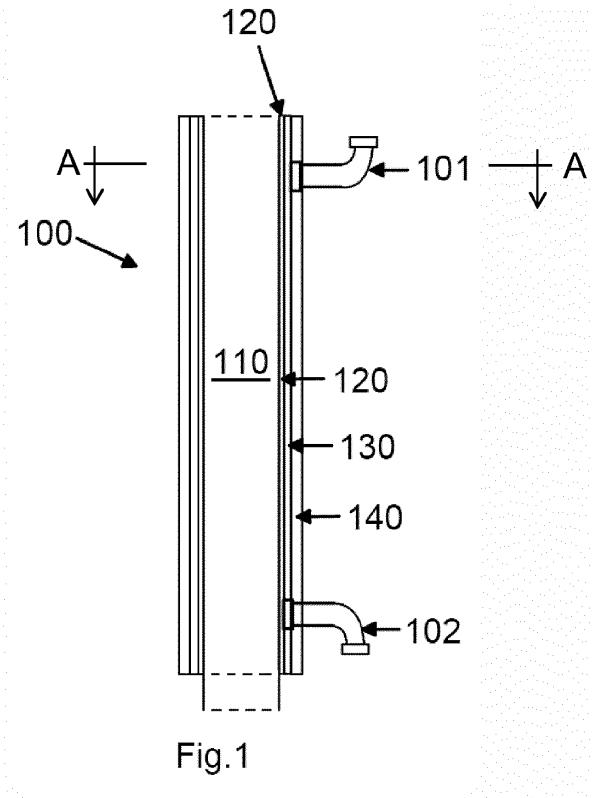

Fig.1

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Description

Field

[0001] The invention relates, on one hand, to a recovery unit in accordance with the preamble of claim 1 and, on the other hand, to an arrangement in accordance with the preamble of claim 6, by which the thermal energy contained in flue gases is utilizable in a building.

Background

[0002] As energy costs keep rising, more and more attention is paid to thermal self-sufficiency and minimization of waste heat in buildings. One object in the building is recovery of thermal energy contained in the flue gas released in connection with the use of a fireplace, an oven, a sauna stove or the like furnace.

[0003] Known solutions for recovering thermal energy from the chimney of a furnace have been lacking in ease of installation.

Brief description

[0004] An object of the invention is thus to provide equipment so as to solve the above-mentioned problems. This is achieved by the invention in accordance with the characterizing parts of independent claims 1 and 6. Preferred embodiments of the invention are disclosed in the dependent claims.

[0005] Advantages of the invention are presented in the following in connection with a more detailed description of particular embodiments of the invention.

List of figures

[0006] The invention is now described in closer detail in connection with preferred embodiments, with reference to the accompanying drawings, in which

[0007] Figure 1 is a side view of a thermal recovery unit;

[0008] Figure 2 is a sectional view of the thermal recovery unit at A A in Figure 1;

[0009] Figure 3 illustrates an example of interconnection of the recovery units.

Description of some embodiments

[0010] The present figures do not show the thermal energy recovery unit and the arrangement for utilizing thermal energy of flue gases in scale but the figures are schematic, illustrating the structure and operation of the preferred embodiments in principle. The structural parts indicated by reference numerals in the attached figures correspond to the structural parts marked with reference numerals in this specification.

[0011] The embodiments relate to a chimney structure to be arranged in connection with a furnace. In the chimney structure it is possible to store thermal energy to be utilized further in the heating of a building or household water. The furnace may be e.g. a fire place, an oven, a sauna stove, a boiler or a corresponding furnace with a flue.

[0012] Figure 1 shows an embodiment of a heat recovery unit 100 to be used in a chimney-like structure. The recovery unit is a tubular, multilayered structure that will be described in the following.

[0013] Innermost in the structure there is a flue duct 110 for conveying flue gas from the furnace. The flue duct may be a circular, elongated metal tube structure that is open at ends. Immediately around the flue duct there is arranged a liquid container 120 for storing liquid. The container may be constructed, for instance, of two tubes having different cross sections, which tubes are substantially concentrically interfitted, and the ends between the tubes are sealed with end flanges. The walls of the flue duct 110 and the liquid container 120 are of metal, whereby the flue duct and the liquid container, which are in immediate contact with one another, allow thermal energy to be conducted from the flue propagating in the flue duct 110 into the liquid in the liquid container 120. The liquid used in the liquid container 120 is, for instance, water or a liquid blended with an anti-freeze agent containing glycol, for instance.

[0014] Apart from being circular in cross section, the flue duct and the tube structures of the liquid container surrounding it, may also have other, e.g. oval, elliptical as well as angular, polygonal shapes.

[0015] To give an example, the liquid container in one recovery unit may have a capacity of about half a litre up to a few litres, i.e. for instance, from 0.5 to 10 litres, preferably from 0.5 to 7 litres, the capacity varying depending on the transversal thickness as well as the length of the liquid container. The recovery space may be pressurized to about 4 bar, for instance, to be in line with the pressure in the water supply network.

[0016] In accordance with the above, the liquid container 120 is a substantially closed space, except for one or more liquid connections 101, 102 arranged therein. The purpose of the liquid connection is to allow liquid flow outside the heat recovery unit or from outside the recovery unit into the liquid container 120. In an embodiment the liquid connection 101, 102 connects the heat recovery unit 100 to another, similar recovery unit and a liquid connection therein. When needed, a liquid transfer pipe may be arranged between the liquid connections of different recovery units.

[0017] In an embodiment the recovery units to be interconnected through the liquid connections will be placed consecutively as extensions of one another in a chimney, as shown in Figure 3. In a second embodiment, one or more flue transfer units without ability to convey or store liquid are connected to the end of the recovery unit. Also in this case the liquid containers of the recovery units are interconnected, which may be implemented by a liquid transfer pipe bypassing the flue transfer unit.

[0018] In an embodiment the recovery unit further com-

prises an air space 130, which is arranged outside the liquid container 120. By means of the air space it is possible to provide an air duct, for instance, between an outdoor space and an indoor space of a building, when a plurality of recovery units are interconnected to form a chimney-like structure.

[0019] With the air space and the air duct provided thereby there is achieved the significant advantage that air flushing can be arranged by means thereof on the outer surface of the liquid container, and consequently condensation of water on the outer surface of the liquid container may be prevented better than before, and the water possibly condensed thereon may be removed.

[0020] An additional advantage with the air space and the air duct provided thereby is that the air space 130 may be utilized for supplying replacement air into the furnace. Thus, replacement air may also be heated, because it arrives in the furnace along the surface of the water container having a heated exterior. In cases where the furnace is not in use, the liquid container or the air space may be furnished with a small electric resistor so as to prevent condensation and to provide pre-heating. In that case the material in the furnace is made to burn more efficiently. As a result of more efficient combustion, more heat is generated in the furnace for being stored in the liquid in the liquid container of the heat recovery unit.

[0021] Further, the air space and the air duct provided thereby also has an additional advantage that heated outdoor air may be used for heating a room space by conducting it along the air duct directly into the room air. When needed, outdoor air may also be used for cooling the chimney in order to eliminate a fire risk.

[0022] Outside the air space, in close proximity to the outer surface of the recovery unit it is also possible to arrange an insulation space 140 for insulating material. The insulating layer/jacket 140 may be arranged directly outside the liquid container 120, or if the recovery unit also comprises an air duct 130, outside said air duct. In an embodiment a specific space is provided for insulating material, whereby the insulation space will be between two tubular walls. In that case the insulating material is readily replaceable, when necessary.

[0023] In a second embodiment, the insulating material may consist of a construction block of expanded clay aggregate or foamed concrete surrounding the flue duct 110 and the liquid container 120.

[0024] Figure 2 shows a cross section of an embodiment of a heat recovery unit at A - A in Figure 1. As can be seen, at the centre of the unit there is a round flue duct 210 for conveying flue through the recovery unit into a subsequent recovery unit or a flue transfer unit, or out of the building. The flue duct 210 is surrounded by a liquid container 220. Outside it there is an air space 230, which, in turn, is surrounded by an insulating layer 240.

[0025] In an embodiment the described structure consists of a plurality of nested tubular wall structures. They include the flue duct wall, inner and outer walls of the liquid container, inner and outer walls of the air space, and inner and outer walls of the insulation space. Said walls are preferably made of metal, such as thin sheet, but they may also be of some other appropriate material, for instance ceramic material. In particular, the insulation space and its inner and outer walls may be formed by a construction block of expanded clay aggregate or foamed concrete, which is arranged to surround other structures. This construction block of expanded clay aggregate or foamed concrete may be similar in cross section to the other structures of the recovery unit, as shown in Figure 2, but it may also differ therefrom. Consequently, the construction block of expanded clay aggregate or foamed concrete may be, in cross section, a square-shaped or other polygonal component, while the liquid container and the flue duct are circular in cross section.

[0026] Figure 2 also shows a liquid connection 201, by means of which the recovery unit may be connected, for instance, to another recovery unit, to the heating system of a building or to a boiler in a building. Even though the liquid connection 201 is shown in the figure to protrude from the heat recovery unit, the connection may also be placed at the end of the unit, in which case it will not be visible after installation.

[0027] Figure 3 gives an example how a chimney structure may be provided by combining recovery units, and thereby it is also possible to form a connection to the heating system of a building for releasing the collected thermal energy to be used elsewhere in the building. The figure shows three recovery units 300A, 300B and 300C. In this example it is assumed that the recovery units are at least substantially identical with one another.

[0028] As can be seen, the recovery units are interconnected by means of liquid connections. For instance, the liquid connection 301 B of the recovery unit 300A is connected to the liquid connection 302A of the recovery unit 300B. In this manner the liquid containers of different recovery units may be chained and, if so desired, it is possible to provide liquid circulation between the liquid containers of different recovery units.

[0029] The liquid connections of the recovery units may also be employed in such a manner that the recovery unit or the chimney structure provided by a plurality of recovery units is connected to the heating system of a building. In that case the heating system may include a circulation pump that circulates liquid in the recovery units and further conveys heated liquid into a floor heating system, for instance. Figure 3 gives as an example a liquid connection 301A of the recovery unit 300A that is connected to a pipe 350 leading to the heating system of a building. In an embodiment the coupling to the heating system may be implemented in such a manner that the recovery unit at one end of the chimney structure is connected to a water circulation pipe that supplies liquid already cooled in the building to the chimney structure. The recovery unit at the other end of the chimney structure, respectively, releases liquid heated by the effect of flue gases into the heating system of a building.

[0030] In an embodiment the liquid circulation between

the recovery units and the building may be implemented in a gravity-flow manner. This is enabled by the fact that the capacity of the liquid container is remarkably small, whereby the liquid therein warms up quickly in an isothermal manner throughout the thickness of the liquid container. The lower end of the chimney may thus be coupled to an input of cooled-down circulation water, whereby, thanks to a buoyant force, cooler liquid rises in the recovery units upwards in the chimney. From the upper end of the chimney, on the side of the room space, the heated liquid may be forwarded to the heating system of the building. In this manner the liquid circulation goes on without external pump control. If a separate circulation pump is used in this embodiment, the circulation of water will continue despite the stalling of the pump, for instance, during a power failure.

[0031] The above embodiments describe preferred embodiments of the recovery unit.

[0032] The dimensions of the recovery units may vary in many ways, but preferably the dimensions of the recovery unit are the following. The capacity of an individual liquid container in a recovery unit is preferably about 5.5 litres, but it may vary, for instance, in the ranges of about 4 to 7 litres or 0.5 to 8 litres, the capacity varying depending on the transversal thickness as well as the length of the liquid container. The distance between the inner and outer walls of the liquid container is preferably about 10mm, but it may vary, for instance, in the range of about 5 to 15mm or about 5 to 20mm. Preferably, the length of the unit is about one metre.

[0033] Thanks to the small capacity and thin liquid cover the liquid in the water container warms up more quickly and more uniformly than before. The quick warming up makes it possible to avoid efficiently condensation of moisture on the outer surface of the liquid container that would otherwise conventionally take place. Prevented condensation enables the present recovery unit to be installed in conventional living premises without a risk of moisture damage.

[0034] The quickly warming outer surface of the liquid container also enables simultaneous heat transfer from the flue gases to the air flowing in the air duct. Thus the replacement air to be conveyed to the furnace or the room space may be pre-heated to enhance the combustion in the furnace and to prevent draft in the room space.

[0035] Because the heat recovery units in accordance with the described embodiments are relatively light and small in size, it is possible to mount the chimney using manual force, and the mounting does not require a crane, for instance. Consequently, the solution may also be implemented on a renovation site, where retro-installation of a large chimney is very difficult or often quite impossible, in practice. Further, maintenance of the chimney, such as replacement of the insulation material in the recovery units, is easy.

[0036] It will be apparent to a person skilled in the art that as technology advances, the basic idea of the invention may be implemented in many different ways. The invention and its embodiments are thus not restricted to the examples described above.

Claims

1. A thermal energy recovery unit in connection with a furnace of a building, comprising a flue duct (110) for conveying flue gas released from the furnace, whereby:

   a liquid container (120) is arranged around the flue duct (110) to collect the thermal energy in the flue gas conveyed in the flue duct into the liquid in the liquid container (120);
   the liquid container comprising at least one liquid connection (101, 102) for connecting the liquid container (120) of the recovery unit to a liquid container of a second recovery unit so as to enable liquid transfer between the liquid containers of the recovery units,
   characterized in that
   around the liquid container (120) there is arranged an air space (130) for collecting the thermal energy in the flue gas conveyed in the flue duct (110) further into the air in the air space, whereby
   the wall surrounding the flue duct forms an inner wall of the liquid container, and the outer wall surrounding the liquid container forms an inner wall of the air space.

2. The thermal energy recovery unit of claim 1, **characterized in that** the thermal energy recovery unit comprises on its outer surface an insulating jacket (140) that is arranged to form an outer surface of the air space (130).

3. The thermal energy recovery unit of any one of the preceding claims, **characterized in that** the liquid container (120) comprises an inner wall set against the flue duct (110), and outside the inner wall an outer wall, and that the distance between the inner wall and the outer wall is 5 to 20mm.

4. The thermal energy recovery unit of any one of the preceding claims, **characterized in that** the capacity of the liquid container (120) is 0.5 to 8 litres.

5. The thermal energy recovery unit of any one of the preceding claims, **characterized in that** the liquid connection (301 A) is arranged to protrude substantially perpendicularly from the liquid container such that the liquid connection (301A) extends outside the outer surface of the thermal energy recovery unit.

6. An arrangement for recovering thermal energy in connection with a furnace of a building, comprising

a recovery unit (100) which includes:

a flue duct (110) and a liquid container (120) arranged around it to collect thermal energy in the flue gas conveyed in the flue duct into the liquid in the liquid container (120);
the liquid container comprising at least one liquid connection (101, 102) for connecting the liquid container (120) of the recovery unit to a liquid container of a second recovery unit so as to enable liquid transfer between the liquid containers of the recovery units,
characterized in that
around the liquid container (120) there is arranged an air space (130) for collecting thermal energy in the flue gas conveyed in the flue duct (110) further into the air in the air space, and
the wall surrounding the flue duct forms an inner wall of the liquid container and the outer wall surrounding the liquid container forms an inner wall of the air space, and
recovery units (300A, 300B, 300C) are arranged consecutively into a chimney-like structure, and that
a liquid connection (301A) comprised by at least one recovery unit (300A) is connected to a heating system or a hot-water tank of a building.

7. The arrangement of claim 6, **characterized in that** the air spaces of the consecutively arranged recovery units (300A, 300B, 300C) are arranged in the chimney-like structure to provide a continuous air space extending from one recovery unit to another from an indoor space of a building to an outdoor space of a building so as to supply replacement air into the furnace and/or to supply cooling air for cooling the chimney and/or to supply heating air inside the building.

8. The arrangement of claim 6 or 7, **characterized in that** insulation spaces of the consecutively arranged recovery units (300A, 300B, 300C) are arranged in the chimney-like structure to provide a continuous insulation space extending from one recovery unit to another.

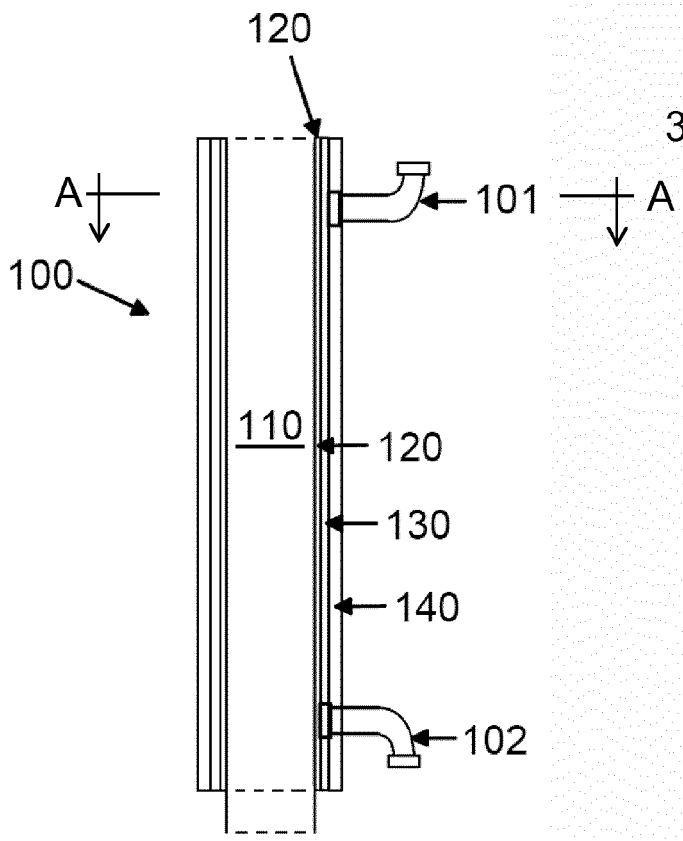

Fig.1

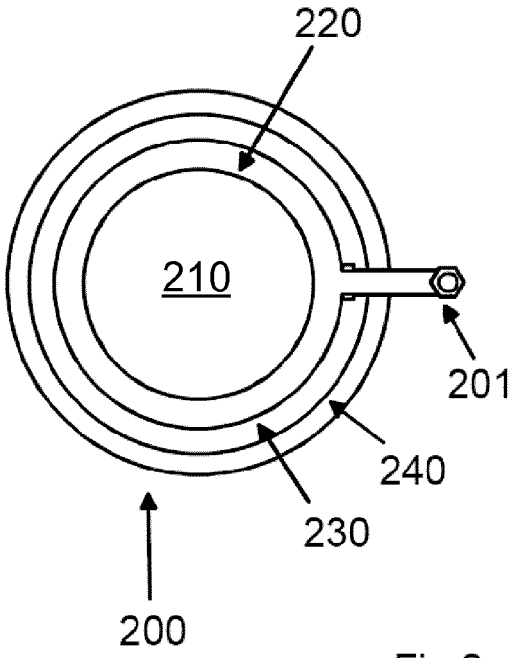

Fig.2

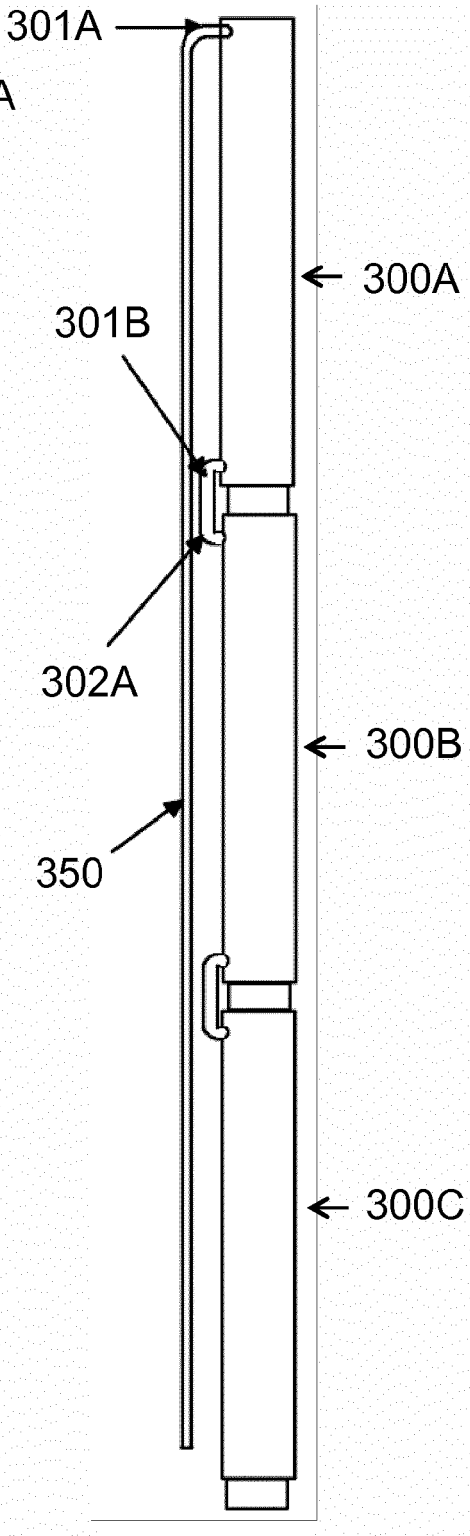

Fig. 3