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(54) **HEAT EXCHANGER AND BOILER COMPRISING THE HEAT EXCHANGER**

WÄRMETAUSCHER UND DEN WÄRMETAUSCHER UMFASSENDER KESSEL

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- **PATENT ABSTRACTS OF JAPAN vol. 018, no. 594 (M-1703), 14 November 1994 (1994-11-14) -& JP 06 221792 A (NIPPON STEEL CORP), 12 August 1994 (1994-08-12)**

EP 1 735 577 B1

Description

[0001] The present invention relates to heat exchangers, in particular to heat exchangers employed in boilers and exhaust gas boilers.

[0002] It has been realised that in certain situations during operation of pin tube boilers unwanted and unacceptably high noise levels may arise. Tubes having surface enlarging elements such as pins used in boilers have been described in previous patent publications such as US 5,626,187, WO 03/005467 A1, WO 03/033969 A1, WO 90/02916 A1.

[0003] The present invention relates to boilers having a convection chamber including a number of tubes for the exchange of heat, specifically boilers including tubes fitted with surface enlarging elements such as a number of pins for the improved exchange of heat.

[0004] Certain boilers of this type have been proven to produce unacceptably high levels of noise, and a need for suppressing or cancelling the noise exists. This noise has been identified as consisting of single frequency tones in the range 300-700 Hz. Thorough investigations of the noise generating mechanisms responsible for the generation of the tones have been analysed and it has been realised that the tones originate in the convection chamber of the boiler.

[0005] Solution strategies fall into four categories. The first, and most simple, is to reduce the noise after the source, e.g. by installation of a duct silencer in the exhaust from the boiler.

[0006] The other strategies consist in forestalling or disrupting the feedback mechanism. Results from a cold test showed that reductions of up to 60 dB could be attained if the feedback mechanism was forestalled or suppressed.

[0007] The second strategy is to introduce damping in the convection chamber, in order to prevent the acoustic response from reaching levels at which it can begin to significantly influence the unsteady flow structures that are its source, and thus to preclude feedback.

[0008] The third strategy is the introduction of dividing plates to move the frequencies of the modes that are prone to feedback out of the range of the excitation frequencies.

[0009] The fourth strategy is the modification of the pins to reduce the uncoupled excitation sufficiently that feedback never takes place or to disrupt the interaction mechanisms that are responsible for the transfer of energy from the mean flow to the fluctuating flow and acoustic fields.

[0010] These general categories are not mutually exclusive and a final solution may involve elements of all four.

[0011] Sound or noise suppressing means have been described in patent publications such as EP 0 876 539.

[0012] The above need together with numerous objects, advantages and features which will be evident from the below detailed description of the presently and preferred embodiment of the heat exchanger for exchanging heat between a first and a second medium according to the present invention are obtained according to the teachings of the present invention by a heat exchanger for exchanging heat between a first and a second medium, the heat exchanger comprising:

a casing having a compartment enclosing a plurality of substantially parallel tubes, the compartment comprising an inlet and an outlet arranged such that the first medium is constrained to flow from the inlet to the outlet in a flow direction substantially parallel to the tubes,

a plurality of elongate surface enlarging elements for the improved exchange of heat each having a first end attached to one of the tubes and extending obliquely and generally transverse relative to the flow direction to a second unattached end. The heat exchanger is characterized in that it further comprises at least one sound suppressing plate mounted between at least two of the tubes such that the compartment is subdivided into two or more sub-compartments, each of these sub-compartments comprising a plurality of the tubes.

[0013] Surprisingly the plate dampens the noise generated in the boiler without causing an additional loss of pressure. The tubes with the surface enlarging elements may be placed such that the highest number of tubes per area is achieved and thereby minimising the space between the surface enlarging elements. The plate may comprise several pieces of material assembled into a single structure. Alternatively the plate is a unitary piece of material and may be bent or shaped such that the plate fits closely in the space between the tubes, e.g. between the surface enlarging elements.

[0014] The tubes may be arranged in the heat exchanger in a number of geometrical configurations such as placed side-by-side resulting in an overall geometry resembling a square or rectangular shape, preferably the tubes are configured in a honeycomb-like structure.

[0015] The surface enlarging elements may be formed by a sheet including a base part and a part including a number of elements having a free end. Alternatively the surface enlarging elements may be formed individually, e.g. the surface enlarging elements may be formed in a separate process and subsequently attached to the tube. Alternatively the surface enlarging element may be formed integrally with the tube.

[0016] In the currently preferred embodiment of the present invention the second unattached end is located upstream of the first end relative to the flow direction. Surface enlarging elements know in the art have been orientated such that the free end of the surface enlarging element is located downsteam of the first end relative to the flow direction and subsequently problems with condensing water accumulating on the surface and in the joint of the surface enlarging element and the tube have been seen. Previously the surface enlarging elements have been orientated this way because assumptions were that this orientation would yield the lowest pressure drop whilst gaining maximum or near maximum heat transfer, however surprisingly it has been realised that orientating the surface enlarging elements this way has improved the noise level whilst the pressure drop remained the same.

[0017] In the currently preferred embodiment of the present invention the surface enlarging elements may be substantially tubular shaped. The surface enlarging elements are preferably tubular shaped, i.e. pin shaped. The cross section of the surface enlarging elements may take on other shapes, such as trapezoidal, square, rectangular, elliptical or any combination and/or variation thereof.

[0018] The surface enlarging element may define a length between the first and the second ends in the interval 10 to 60 mm, such as 20 to 55 mm, such as 40 to 50 mm, such as 41 to 50 mm, preferably 43 mm. The length of the surface enlarging element may be the same for all surface enlarging elements or the length may vary, e.g. the surface enlarging elements may have two different lengths. Alternatively the length of the surface enlarging elements may increase or decrease along the tube. Further alternatively the length of the surface enlarging elements may be random or pseudo randomly chosen. Still further alternatively the length of the surface enlarging elements may be varied as a function of the distance from a specific point on the tube, e.g. from the first surface-enlarging element.

[0019] Preferably the surface enlarging elements are made from steel, such as stainless steel, or alternatively aluminium or copper. The surface enlarging elements are preferably made from a material having a melting point at a high temperature and having a high thermal conductivity.

[0020] Alternatively the surface enlarging elements may define a curve. The surface enlarging elements may define curves that are differentiable, or alternatively curves that include bends or breaks, the surface enlarging elements may further alternatively include a number of bends or breaks.

[0021] The sound suppressing plate includes a plurality of apertures having a size within the range 0,01 mm to 2 mm, such as 0,5 to 1,5 mm, such as 0,75 mm to 1,25 mm, preferably substantially equal to 1 mm. The apertures of the sound suppressing plate may have different sizes, or all apertures may have substantially the same size. The placement or distribution of the apertures may be substantially uniform across the plate or apertures may be located in a number of specific areas.

[0022] The apertures may be substantially elliptical, circular, square, rectangular or any combination thereof. Preferably the apertures are all substantially elliptical. Alternatively a first plurality of apertures may have one geometrical configuration and a second plurality of apertures may have another geometrical configuration, further alternatively multiple pluralities may each have a specific geometrical configuration, thereby combining all of the geometrical configurations mentioned above.

[0023] Preferably the sound suppressing plate is made from steel, stainless steel, aluminium, galvanised steel or alternatively made from a ceramic material.

[0024] The sound suppressing plate may have a thickness of 0,508 mm (0,020") to 5,08 mm (0,2"), such as 1,016 mm (0,040"), such as 2,032 mm (0,080"), such as 3,048 mm (0,120"), preferably 1 mm.

[0025] In the currently preferred embodiment of the present invention the first medium is flue gas or air and the second medium is mainly water and/or steam. The first medium is preferably located in between the tubes and carries the heat from a furnace or the like to the heat exchanger chamber. Other embodiments utilising other fluids may, however, be envisioned. As heat is absorbed from the first medium through the surface enlarging elements to the second medium, and the second medium being water, the water may eventually reach a point where the water is evaporated into steam, dependant on the pressure in the tubes.

[0026] According to the teachings of the present invention a boiler, particularly a boiler for being installed in an ocean going vessel, may comprise a heat exchanger including any of the above mentioned aspects. The boiler according to the teachings of the present invention may be installed in ocean going vessels, such as in freighters, cargo boats, cargo vessels, general ships, tankers or the like.

[0027] In the following the invention will be explained more detailed with reference to the accompanying drawings, in which:

Fig. 1 is a diagrammatical cross sectional view of a boiler comprising a heat exchanger according to the present invention,

Fig. 2 is a diagrammatical vertical cross sectional view of the of Fig. 1,

Fig. 3 is a diagrammatical cross sectional segmental top-down view of the convection chamber of the boiler of Fig. 1, and

Fig. 4 is a diagrammatical elevated view of the segment of Fig. 3.

[0028] Fig. 1 is a horizontal cross sectional side view of a boiler comprising a heat exchanger according to the present invention, the boiler in its entirety is designated the reference numeral 10. The boiler 10 comprises a burner outlet 12 mounted at the top of the boiler 10. The burner outlet 12 is in fluid communication with the furnace chamber 14 located inside the boiler 10. The burner outlet 12 releases a flame 16 into the furnace chamber 14. The hot gas escapes the furnace chamber 14 via an opening 18 in the side wall 20. The hot flue gas passes from the bottom of the convection chamber 22 along a number of tubes 24. The tubes 24 are fitted with a number of pins having at least two different lengths. In the presently preferred embodiment of the present invention, the lower part of the tubes 24 is fitted with 15 rows of pins having a length of 34 mm. These short pins are fitted to the tube for receiving the flue gas directly from the furnace chamber 14 and cools it approximately 150°C. Fitting the tube with long pins in this section may cause the long pins to melt. In a section above the section comprising the short pins 26, at least one section comprising longer pins may be included. In the presently preferred embodiment the longer pins have a length of approximately 43 mm.

[0029] All the pins may be welded onto the tube by resistance welding, such as by resistance butt-welding, resistance flash-welding, resistance percussive-welding, resistance seam-welding, resistance spot-welding alternatively any other welding technique, further alternatively combinations thereof. The pins may be formed integrally with the tube 24 during the forming of the tube or part of the tube. In the presently preferred embodiment of the present invention the pins on the tubes 24 are pulled or pushed through a matrix having a cross section smaller than that of the tube 24 fitted with a number of pins, thereby causing the longer pins to be bent at an angle with respect to the surface of the tube 24. Preferably the short pins 26 are not bent, but embodiments where the smaller pins are also bent may be envisioned. Due to tension and other physical phenomena the long pins are bent approximately 5 mm from the surface of the tube 24. The pins may be weakened at a specific location if the pin is to be bent at a different distance from the tube 24.

[0030] In the presently preferred embodiment of the present invention the pins are placed in substantial registration but configurations where a first pin is placed shifted with respect to a second pin placed above or below the first pin may be envisioned. As an alternative to placing the pins in level circles around the tube the pins may be placed so that they form a staircase like structure, this configuration is often seen in heat exchangers employing surface enlarging elements having a continuous surface. Reference is made to the patent publications US 3,752,228, US 4,258,782, US 4,227,572, US 4,648,441, US 5,240,070, US 5,046,556, US 3,621,178 and US 5,617,916.

[0031] Boilers, and heat exchangers, including pin tubes have been known to produce unacceptably high levels of noise. This noise has been identified as mainly consisting of single frequency tones in the range 300-700 Hz. Thorough investigations of the noise generating mechanisms responsible for the generation of the tones have been analysed and it has been realised that the tones originate in the convection chamber of the boiler.

[0032] Periodic fluctuations in the airflow behind the pins on the tubes 24 may induce unsteady pressure fluctuations on the pins themselves, which internally act as an acoustic source. Assuming there is no feedback, these sources can reasonably be approximated as point dipoles having a frequency distribution peaked around a frequency that can be derived from the dimensionless Strouhal number, where the Strouhal number is defined as the peak frequency of the pressure fluctuations multiplied with the diameter of the pins and divided with the free stream mean flow speed.

[0033] Without feedback, the frequency response of the acoustic forcing in the convection chamber 22 is dependant on the structure of the chamber and assuming there is little or no damping the frequency giving the maximum response to a given forcing is identical to the eigenfrequency of the convection chamber 22. However, when there is significant damping, the frequency giving the maximum response deviates from the real part of the complex eigenfrequency of that mode. This mathematical subtlety has important consequences for the prediction of observed frequencies.

[0034] It has been empirically determined that configuring the tubes 24 such that the bent pins are bending towards the air flow reduces the noise generated by the periodic fluctuations in the airflow behind the pins without additional loss of pressure. In all previous embodiments of boilers including tubes having surface enlarging elements, such as pins or fins, the surface enlarging elements are bent in a direction following the direction of the air flow, i.e. downstream.

[0035] Noise may further be reduced by introducing sound absorbing material on the side walls of the convection chamber 22, e.g. Rockwoll, alternatively between the outside of the walls 36, 44, 40 and 42, further alternatively sound absorbing material may be applied or affixed to the outside of the boiler, e.g. on, or alternatively in, the exhaust duct leading out from the boiler.

[0036] After the flue gas has passed the section comprising the short pins 26 and the section comprising the long pins 28, the flue gas is exhausted from the boiler 10 through an exhaust outlet 30.

[0037] The boiler 10 is further equipped with a water reservoir 32 in fluid communication with the tube connections 24. The hot flue gas transfers heat to the tubes 24 through the surface of the tube 24 and the surface enlarging elements, e.g. the pins on the tubes, and thereby transfers heat to the water or steam inside the tubes 24 collected from the water reservoir 32. The water is heated and evaporates inside the tubes 24 and the steam rises into the steam room 34 where the steam may condens into water again and may be returned to the water reservoir 32 via tubes in the side walls of the furnace chamber 14. In the presently preferred embodiment of the present invention the steam is released into a not illustrated system where the steam is utilised for other purposes, such as heating the oil used in the burner 12 and for driving a pump system, also not illustrated here. The water inside the boiler 10 may be replenished from an external source of water.

[0038] Fig. 2 is a cross-sectional view of the boiler of Fig. 1 along the line A-A. Fig. 2 illustrates the placement of the tubes 24 in the convection chamber 22 constituted by four rows of tubes 36, 38, 40 and 42. The tubes are interconnected with a metal bar welded between neighbouring tubes, thereby creating a wall. The furnace chamber 14 is constituted by a panel wall 44. At the top of the tubes constituting the wall 42 some of the tubes are bent outward for establishing the exhaust outlet 30, also no metal bars are welded to the tubes in this region.

[0039] Fig. 2 further illustrates the placement if the burner outlet 12 in the furnace chamber 14. A number of stays 46 are employed to support the top and bottom of the steam chamber 34.

[0040] In the convection chamber 22, two sound absorbing elements 50, 52 are shown placed in between the tubes 24. The sound absorbing elements 50, 52 serve, partly, to divide the convection chamber 22 and thereby altering the audio characteristics of the convection chamber 22. The sound absorbing elements 50, 52 are preferably of a type characterised by not causing a loss of pressure. In the presently preferred embodiment of the present invention the sound absorbing elements 50, 52 are plates of the material described in EP 0 876 539 B1. The sound absorbing element employed in the presently preferred embodiment of the present invention are marketed by Sontech Noisecontrol, a company of Sweden, with the product name AcustiMet.

[0041] Fig. 3 is a zoomed view of the box B illustrating the sound absorbing element 52 and a number of tubes 24 of the boiler of Fig. 1 and 2. The tubes 24 are placed in a honey-comb like configuration for achieving the highest density of pins and tubes, but other configurations may be envisioned such as square, circular or any other geometrical configuration or combinations hereof. The sound absorbing element 52 is bent so that it may be placed in the narrow space between at least two adjacent pins 28. In the presently preferred embodiment of the present invention, the space between pins varies between 3 to 5 mm. The theoretical spacing between the pins is 6 mm.

[0042] Fig. 4 is a schematic view along the line C-C of Fig. 3 illustrating the spatial distribution of the pins 28 relative to the flow of the hot gas, illustrated by the arrows R, and the placement of the sound absorbing element 52.

[0043] Once the noise is generated in the boiler, it propagates to the ship primarily through the exhaust ducting. Any noise that is transferred through the boiler structure to the machine room is most likely insignificant against the much higher interior background noise levels from, for instance, the ventilation system.

[0044] Regular duct silencers provide acoustic attenuation with sound absorptive materials behind perforated metal sheets arranged in baffles. The installation of a silencer in the exhaust ducts of the boiler does not remove the source of the noise, but instead absorbs the noise after it is generated. A 1m silencer can give a reduction in the range of approximately 15-30 dB(A), depending on the pressure drop that can be accommodated.

[0045] Installation of a silencer is a simple, effective and flexible solution. The selection of an appropriate silencer to give the required acoustic attenuation for an acceptable pressure loss, without an attendant increase in noise caused by flow through the silencer itself is a relatively straightforward engineering procedure.

[0046] It should also be noted that if there are noise propagation paths other than through the exhaust ducting, failing to tackle the noise problem at source still allows the possibility for the tones to be observed.

[0047] The introduction of acoustic absorption into the convection chamber is designed to prevent the initial acoustic response of the chamber from attaining levels sufficient to precipitate the feedback process. Results from the cold test indicate that this could be a very successful way of eliminating the interaction mechanism and thus of dramatically reducing sound levels.

[0048] The acoustic absorption in the convection chamber could be plates, such as solid plates or perforated plates.

[0049] The perforated plate works by supporting a pressure difference across it while allowing a flow through the small holes in the plate. The pressure drop is caused by a combination of inertial and viscous forces and leads to a loss of acoustic energy corresponding to the difference in the work done by the pressure on the two sides of the plate. Physically, this energy is converted to heat by viscous actions in the flow through the plate. By placing the plates strategically in the chamber, very high absorption can be achieved for certain modes.

[0050] Results from the cold test show that significant attenuation can be achieved using perforated plates. In one test, all the tones were completely removed, leading to an attenuation of approximately 50 dB.

[0051] The first questions that need to be addressed if installing perforated plates as an acoustic solution concern the arrangement of plates that gives the most damping and the amount of damping that is necessary to forestall the feedback mechanism. Unfortunately, results from the cold test can not be applied directly to the boiler, as the modal structure of the boiler chamber is quite different from that of the cold test chamber. This is partly due to the different geometry and partly due to the large vertical temperature gradient in the boiler.

[0052] The first step is to identify a correspondence between the observed frequencies and the frequencies of the eigenmodes of the untreated boiler. This requires measurements of the tonal frequencies from an untreated boiler, as well as a calculation of the eigenfrequencies of the convection chamber of the boiler. Once the modes that are prone to feedback are identified, the optimal arrangement of plates can be determined by calculating the damping in each mode for different arrangements. By appropriately scaling results from the cold test, it is possible to make an educated estimate of an appropriate amount of damping and thus to evaluate whether the chosen arrangement should provide sufficient damping to forestall the feedback mechanism.

[0053] The procedure for determining the best arrangement of plates in a convection chamber is similar for each boiler size.

[0054] The acoustic properties of the plate are described by its resistivity, which describes the relationship between the pressure drop across the plate and the flow velocity through it. Resistivity has the same units as acoustic impedance and the optimal resistivity of a plate is equal to the impedance of the air in which it is placed. This is a critical issue that must be addressed when approaching the perforated plate as a solution strategy in a hot boiler, where the temperature varies considerably along the axis of the chamber. The issue of the appropriate resistivity must be addressed in the calculations to determine the optimum plate arrangements. The issue of which hole size delivers the optimum resistivity at a given temperature must also be addressed.

[0055] An alternative to the perforated plate is absorbing material located on the walls of the chamber. The single most important practical issue is to identify such a material that can withstand the high temperatures in the boiler while providing sufficient acoustic absorption to forestall the feedback mechanism.

[0056] An insulating material located on the walls would experience a certain deterioration of the acoustic properties of the material with time, unless regularly and appropriately cleaned.

[0057] Provided a suitable material can be found the procedure for installing it appropriately is broadly similar to that for the perforated plates. However in this case, the issue of how much damping is necessary to forestall the feedback mechanism is of primary importance, and the principal questions concern the number of walls on which the absorbing material needs to be placed and the amount, specifically the depth of material that is necessary to achieve the required damping.

[0058] Scaling of results from the cold test allows an educated estimate of what constitutes sufficient damping and, together with calculations of the damping in each mode, whether a given arrangement should provide sufficient damping to forestall the feedback mechanism.

[0059] An alternative solution to introducing absorption to the chamber is to divide the chamber up with solid plates in an attempt to create a number of smaller chambers whose cross-sectional modes have frequencies that are greater than the peak excitation frequencies of the maximum flow speeds observed in the boiler.

[0060] It is the temperature at the top of the chamber that determines the lowest frequency at which a given cross-sectional mode can exist. The temperature at the top of the boiler is approximately 300°C. In order that the frequency of the lowest cross-sectional eigenmode should be greater than 700Hz at a temperature of 300°C, the longest length of a sub-chamber should be no more than approximately 30cm. This corresponds to dividing the chamber into triangular sub-chambers each enclosing three pin tubes.

[0061] The final solution strategy is to address the unsteady flow in an attempt to bring about an excitation that does not lead to an acoustic response that can interact significantly with the flow. There are two ways of approaching this. First, feedback may be avoided, or delayed to higher flow speeds, if the Strouhal number can be reduced so that the peak excitation frequency remains below the lowest frequency of the cross-sectional modes. Second, it may be possible to exploit three-dimensional effects in the flow to produce an excitation that is less coherent, less correlated and less susceptible to the influence of the acoustic response.

[0062] Tests have shown that the most significant improvement came when the 43mm pins were bent in the standard way, but in the opposite direction, so that they were oriented oblique to the flow with the unattached end of the pins upstream of the attached end. This configuration resulted in an improvement in the noise levels and a delay in the onset of the tones to higher velocities.

[0063] Onset of the tone around 250 Hz was delayed from 8.7ms-l to 9.3ms-l (7%), compared with the standard 43mm pin configuration, but the attendant noise level was 7 dB higher at onset and 3 dB higher at max. The tone around 420 Hz was delayed to 15.8ms-l from 13.9ms-l (14%) with a decrease of 7 dB in noise level at onset and 5 dB at maximum. Finally, the 690 Hz tone was delayed from 21.1 ms-1 to 23.6ms-1 (12%) with a 16-dB reduction in noise level at onset.

[0064] These results seem to indicate a delay of approximately 10% in the onset of the tones. Applied to the boiler this would mean that the tone that appeared at 70% load would be delayed to about 75%. After modifications, the tone that appeared at 93% would be delayed to 96%.

Claims

1. A heat exchanger for exchanging heat between a first and a second medium comprising:

a casing having a compartment enclosing a plurality of substantially parallel tubes (24), said compartment comprising an inlet (18) and an outlet (30) arranged such that said first medium is constrained to flow from said inlet (18) to said outlet (30) in a flow direction substantially parallel to said tubes,

a plurality of elongate surface enlarging elements (28) for the improved exchange of heat each having a first end attached to one of said tubes (24) and extending obliquely and generally transverse relative to said flow direction to a second unattached end, **characterised in that**

the heat exchanger further comprises at least one sound suppressing plate (52) mounted between at least two of said tubes (24) such that said compartment is subdivided into two or more sub-compartments, each of these sub-compartments comprising a plurality of said tubes (24).

2. The heat exchanger according to claim 1, wherein said second unattached end is located upstream of said first end relative to said flow direction.

3. The heat exchanger according to any of the preceding claims, wherein said surface enlarging elements (28) are substantially tubular shaped.

4. The heat exchanger according to any of the preceding claims, wherein said surface enlarging element (28) defines a length between said first and said second ends in the interval 10 to 60 mm, such as 20 to 55 mm, such as 40 to 50 mm, such as 41 to 49 mm, preferably 43 mm.

5. The heat exchanger according to any of the preceding claims, wherein said surface enlarging elements (28) are made from steel, such as stainless steel, alternatively aluminium or copper.

6. The heat exchanger according to any of the preceding claims, wherein said surface enlarging element (28) defines curve.

7. The heat exchanger according to any of the preceding claims wherein said sound suppressing plate (52) includes a plurality of apertures having a size within the range 0,01 mm to 2 mm, such as 0,5 to 1,5 mm, such as 0,75 mm to 1,25 mm, preferably substantially equal to 1 mm.

8. The heat exchanger according to claim 7 wherein said apertures are substantially elliptical, circular, square, rectangular or any combination thereof.

9. The heat exchanger according to any of the preceding claims, wherein said sound suppressing plate (52) is made from steel, stainless steel, aluminium, galvanised steel or a ceramic material.

10. The heat exchanger according to any of the preceding claims, wherein said sound suppressing plate (52) has a thickness of 0,508 mm (0,020"), to 5,08 mm (0,2"), such as 1,016 mm (0,040"), such as 2,032 mm (0,080"), such as 3,048 mm (0,120"), preferably 1 mm.

11. A heat exchanger according to any of the preceding claims, wherein said first medium is a gas, preferably flue gas and said second medium is mainly water and/or steam.

12. A boiler, particular a boiler for being installed in an ocean going vessel, comprising a heat exchanger according to any of the claims 1 to 11.

Patentansprüche

1. Wärmetauscher zum Austauschen von Wärme zwischen einem ersten und einem zweiten Medium, der Folgendes umfasst:

einen Mantel, der eine Abteilung hat, die mehrere im Wesentlichen parallele Röhren (24) umschließt, wobei die Abteilung einen Einlass (18) und einen Auslass (30) umfasst, die derart angeordnet sind, dass das erste Medium gezwungen wird, von dem Einlass (18) zu dem Auslass (30) in einer Strömungsrichtung, im Wesentlichen parallel zu den Röhren, zu strömen,
mehrere längliche Oberflächenvergrößerungselemente (28) für den verbesserten Austausch von Wärme, die jeweils ein erstes Ende, das an einer der Röhren (24) befestigt ist und sich schräg und im Allgemeinen quer im Verhältnis zu der Strömungsrichtung bis zu einem zweiten, nicht befestigten Ende erstrecken, **dadurch gekennzeichnet, dass**
der Wärmetauscher ferner wenigstens eine Geräuschunterdrückungsplatte (52) umfasst, die derart zwischen wenigstens zwei der Röhren (24) angebracht ist, dass die Abteilung in zwei oder mehr Unterabteilungen unterteilt ist, wobei jede dieser Unterabteilungen mehrere der Röhren (24) umfasst.

2. Wärmetauscher nach Anspruch 1, wobei das zweite, nicht befestigte Ende im Verhältnis zu der Strömungsrichtung stromaufwärts von dem ersten Ende angeordnet ist.

3. Wärmetauscher nach einem der vorhergehenden Ansprüche, wobei die Oberflächenvergrößerungselemente (28) im Wesentlichen röhrenförmig sind.

4. Wärmetauscher nach einem der vorhergehenden Ansprüche, wobei das Oberflächenvergrößerungselement (28) eine Länge zwischen dem ersten und dem zweiten Ende in dem Abstand von 10 bis 60 mm, wie beispielsweise 20 bis 55 mm, wie beispielsweise 40 bis 50 mm, wie beispielsweise 41 bis 49 mm, vorzugsweise 43 mm, definiert.

5. Wärmetauscher nach einem der vorhergehenden Ansprüche, wobei die Oberflächenvergrößerungselemente (28) aus Stahl, wie beispielsweise rostfreiem Stahl, alternativ Aluminium oder Kupfer hergestellt sind.

6. Wärmetauscher nach einem der vorhergehenden Ansprüche, wobei das Oberflächenvergrößerungselement (28) eine Krümmung definiert.

7. Wärmetauscher nach einem der vorhergehenden

Ansprüche, wobei die Geräuschunterdrückungsplatte (52) mehrere Öffnungen einschließt, die eine Größe innerhalb des Bereichs von 0,01 mm bis 2 mm, wie beispielsweise 0,5 bis 1,5 mm, wie beispielsweise 0,75 bis 1,25 mm, vorzugsweise im Wesentlichen gleich 1 mm, haben.

8. Wärmetauscher nach Anspruch 7, wobei die Öffnungen im Wesentlichen elliptisch, kreisförmig, quadratisch, rechteckig oder eine beliebige Kombination derselben sind.

9. Wärmetauscher nach einem der vorhergehenden Ansprüche, wobei die Geräuschunterdrückungsplatte (52) aus Stahl, rostfreiem Stahl, Aluminium galvanisiertem Stahl oder einem keramischen Werkstoff hergestellt ist.

10. Wärmetauscher nach einem der vorhergehenden Ansprüche, wobei die Geräuschunterdrückungsplatte (52) eine Dicke von 0,508 mm (0,020") bis 5,08 mm (0,2"), wie beispielsweise 1,016 mm (0,040"), wie beispielsweise 2,032 mm (0,080"), wie beispielsweise 3,048 mm (0,120"), vorzugsweise 1 mm, hat.

11. Wärmetauscher nach einem der vorhergehenden Ansprüche, wobei das erste Medium ein Gas, vorzugsweise Abgas, ist und das zweite Medium hauptsächlich Wasser und/oder Dampf ist.

12. Kessel, insbesondere Kessel, der in einem Hochseeschiff eingebaut werden soll, der einen Wärmetauscher nach einem der Ansprüche 1 bis 11 umfasst.

Revendications

1. Échangeur thermique permettant un échange de chaleur entre des premier et deuxième milieux, comprenant :

une enveloppe présentant un compartiment renfermant une pluralité de tubes essentiellement parallèles (24), ledit compartiment comprenant une entrée (18) et une sortie (30) agencées de telle manière que ledit premier milieu est contraint à circuler à partir de ladite entrée (18) vers ladite sortie (30) dans une direction de circulation essentiellement parallèle auxdits tubes,
une pluralité d'éléments d'accroissement de surface allongés (28) permettant un échange amélioré de chaleur, chacun présentant une première extrémité fixée à un desdits tubes (24) et s'étendant de manière oblique et essentiellement transversale par rapport à ladite direction de circulation vers une deuxième extrémité non fixée, **caractérisé en ce que**
l'échangeur de chaleur comprend en outre au moins une plaque d'insonorisation (52) montée entre au moins deux desdits tubes (24) de telle manière que ledit compartiment est subdivisé en deux ou plus de deux sous-compartiments, chacun desdits sous-compartiments comprenant une pluralité desdits tubes (24).

2. Échangeur de chaleur selon la revendication 1, dans lequel ladite deuxième extrémité non fixée est située en amont de ladite première extrémité par rapport à ladite direction de circulation.

3. Échangeur de chaleur selon l'une quelconque des revendications précédentes, dans lequel lesdits éléments d'accroissement de surface (28) sont de forme essentiellement tubulaire.

4. Échangeur de chaleur selon l'une quelconque des revendications précédentes, dans lequel ledit élément d'accroissement de surface (28) définit une longueur entre lesdites première et deuxième extrémités dans la plage de 10 à 60 mm, par exemple de 20 à 55 mm, par exemple de 40 à 50 mm, par exemple de 41 à 49 mm, préférablement de 43 mm.

5. Échangeur de chaleur selon l'une quelconque des revendications précédentes, dans lequel lesdits éléments d'accroissement de surface (28) sont réalisés en acier, comme de l'acier inoxydable, ou, en variante, en aluminium ou en cuivre.

6. Échangeur de chaleur selon l'une quelconque des revendications précédentes, dans lequel ledit élément d'accroissement de surface (28) décrit une courbe.

7. Échangeur de chaleur selon l'une quelconque des revendications précédentes, dans lequel ladite plaque d'insonorisation (52) comprend une pluralité d'ouvertures présentant une taille dans la plage de 0,01 mm à 2 mm, par exemple de 0,5 à 1,5 mm, par exemple de 0,75 mm à 1,25 mm, préférablement essentiellement égale à 1 mm.

8. Échangeur de chaleur selon la revendication 7, dans lequel lesdites ouvertures sont essentiellement elliptiques, circulaires, carrées, rectangulaires ou une quelconque combinaison desdites formes.

9. Échangeur de chaleur selon l'une quelconque des revendications précédentes, dans lequel ladite plaque d'insonorisation (52) est réalisée en acier, en acier inoxydable, en aluminium, en acier galvanisé ou en un matériau céramique.

10. Échangeur de chaleur selon l'une quelconque des revendications précédentes, dans lequel ladite plaque d'insonorisation (52) présente une épaisseur dans la plage de 0,508 mm (0,020") à 5,08 mm (0,2"), par exemple de 1,016 mm (0,040"), par exemple de 2,032 mm (0,080"), par exemple de 3,048 mm (0,120"), préférablement de 1 mm.

11. Échangeur de chaleur selon l'une quelconque des revendications précédentes, dans lequel ledit premier milieu est un gaz, de manière préférée un gaz de carneau et ledit deuxième milieu est principalement de l'eau et/ou de la vapeur.

12. Chaudière, en particulier chaudière destinée à être installée sur un navire de haute mer, comprenant un échangeur de chaleur selon l'une quelconque des revendications 1 à 11.

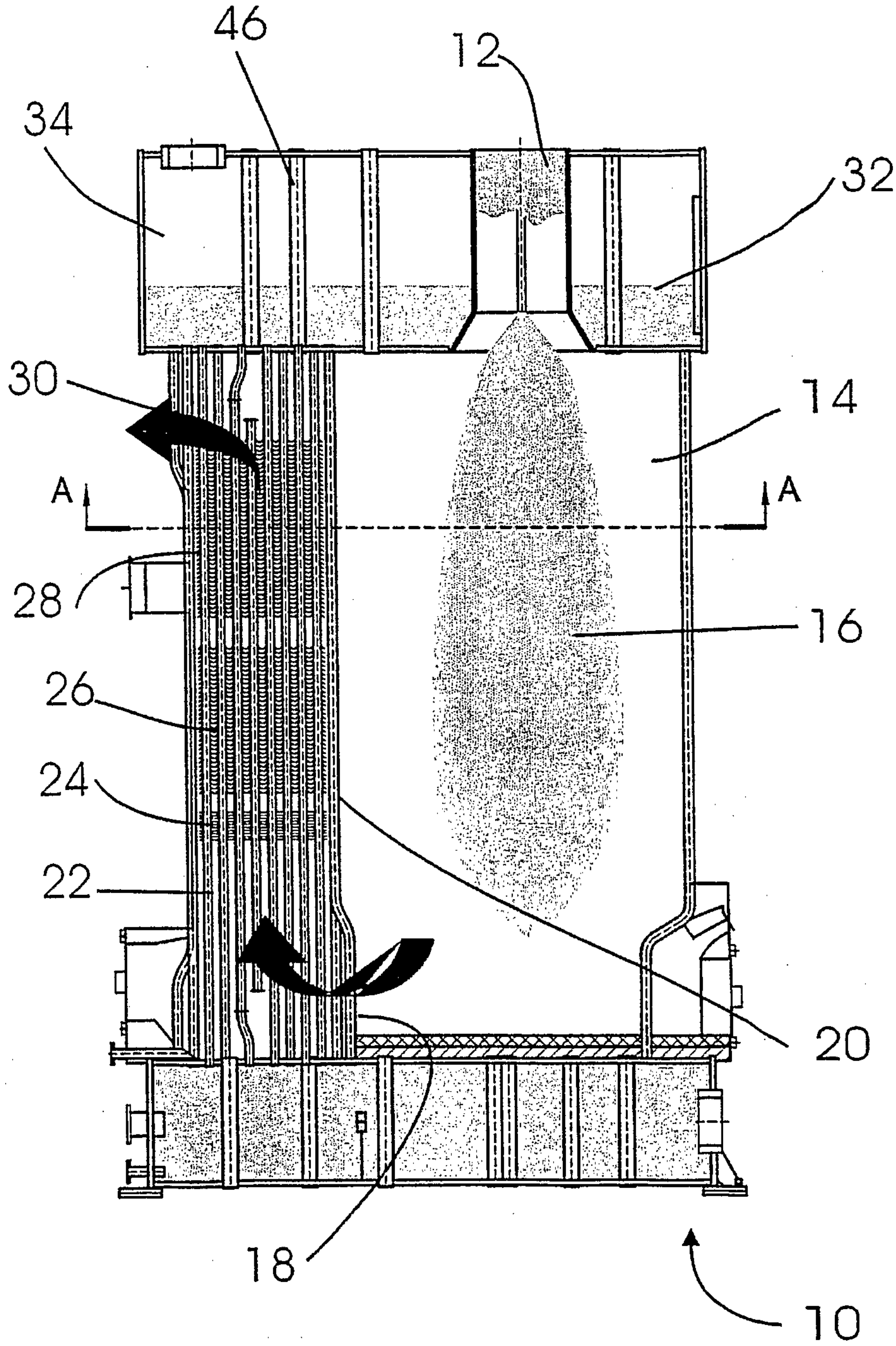

Fig 1

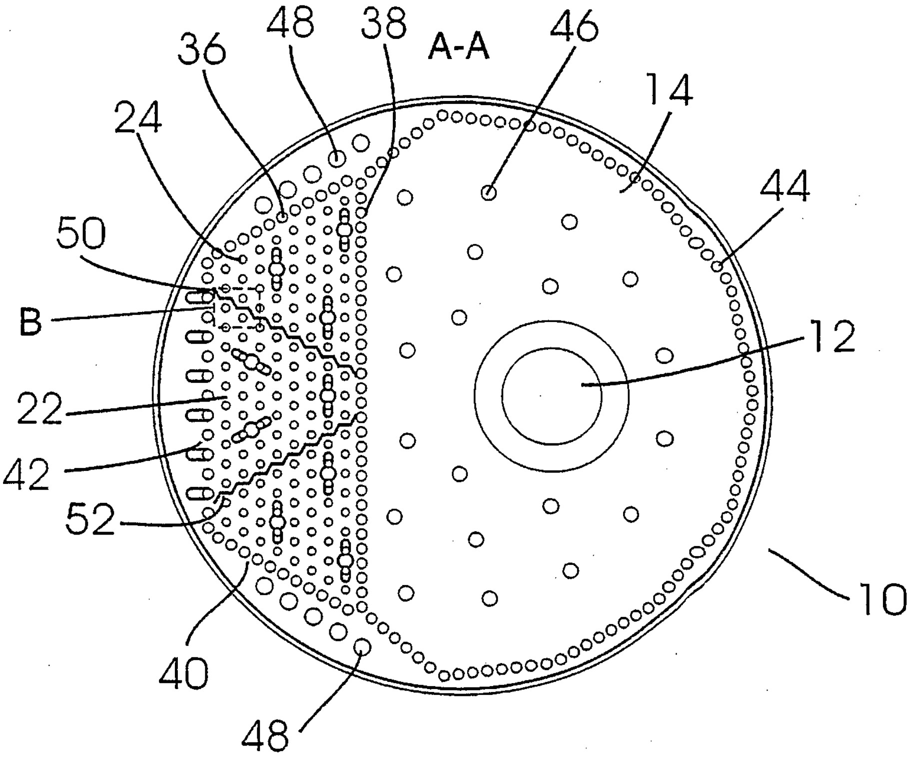

Fig. 2

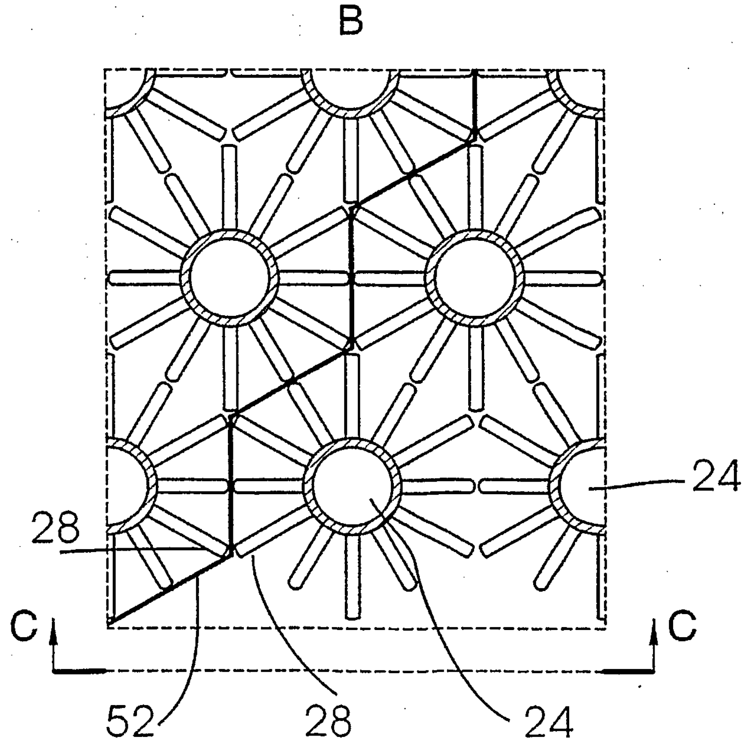

Fig. 3

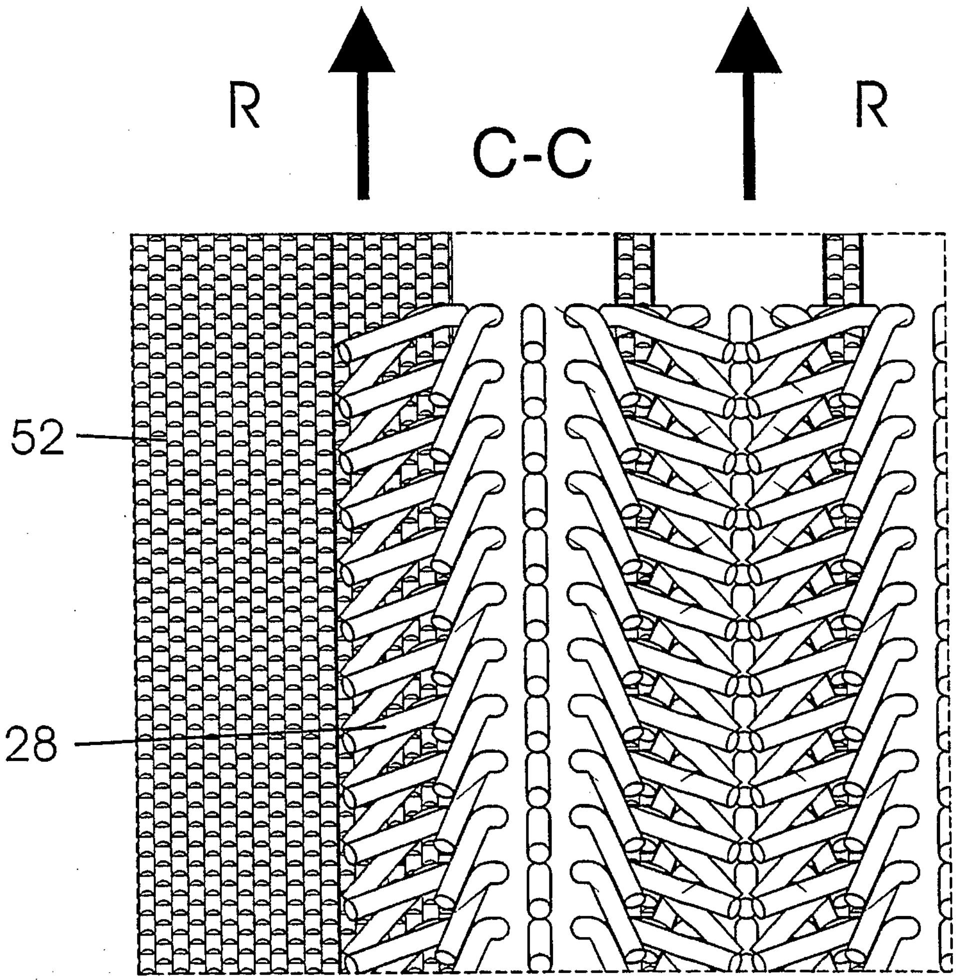

Fig 4

REFERENCES CITED IN THE DESCRIPTION

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