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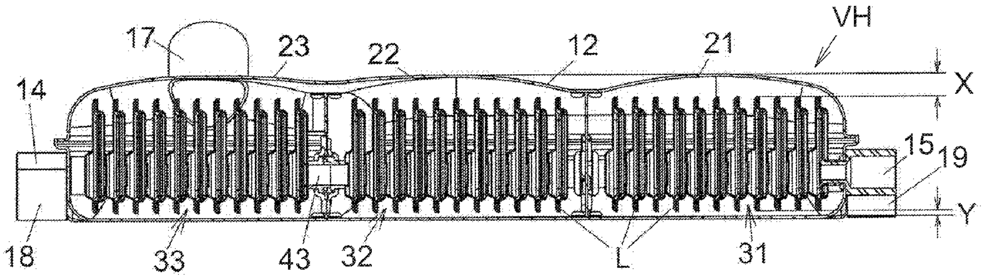
(54) Title: A HEAT EXCHANGER



(57) Abstract: A heat exchanger (11) includes a heat-exchanger housing (VH) having an upper delimiting surface (12) and a lower delimiting surface (13) and provided with a secondary medium inlet (16) and a secondary medium outlet (17), and a heat exchanger pack (VP) which is fully enclosed in the housing and which includes a primary medium inlet (14) and a primary medium outlet (15), wherein the heat exchanger pack (VP) is provided with N-number of sections of heat exchange elements (31 , 32, 33), and wherein the upper delimiting surface (12) of the heat- exchanger housing (VH) arches over each section of heat exchange elements (31 , 32, 33) with the highest level of the arch being located centrally above respective sections.

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A HEAT EXCHANGER

Technical field

The present invention relates to the field of heat exchangers and more particularly to the design of the heat-exchanger housing such as to achieve effective functioning of the heat exchanger. More specifically, the invention relates to an energy saving heat exchanger for showers, and also to the construction of the heat exchanger.

Background of the invention

It is extremely important to protect the environment in present day societies when manufacturing new products. Endeavours are made through the medium of varying legislation to encourage people and their use of natural resources to be as considerate as possible to the environment. Industry is also rewarded in different ways, when it adapts its products to something that is friendlier to the environment. In present day recycling societies it is important to take care of and reuse everything that leads to energy savings and energy conservation. The reuse of energy is highly relevant in this context.

For example, when using typical showers a large amount of thermal energy is consumed by mixing incoming cold water with incoming water that has been heated to a selected shower temperature, whereas the waste water from the shower is led directly to the shower drainage system, causing thermal energy to be lost through said system.

The use of a conventional heat exchanger in this shower application results in soiling of the heat exchanger due to the fact that contaminating and solid particles block the heat exchanger and prevent the through flow of secondary water. Moreover, this soiling of the heat exchanger tends to create bacterial growth accompanied by foul smells.

Object of the invention

The purpose of a heat exchanger constructed in accordance with the present invention is to retain the energy which would otherwise be considered as wastage as a result of the heat exchange, for instance when taking a shower.

Another aim is to enable the temperature of the secondary medium to be reduced so as to minimize the growth of bacteria.

A further aim of the invention is to provide a heat exchanger that needs to be installed only once and that requires the absolute minimum of maintenance and whose design affords a long useful life.

Still another aim of the invention is to provide a heat exchanger whose construction contributes towards keeping the interior of the heat exchanger clean from dirt particles.

Still another aim of the invention is to provide a heat exchanger which will constitute an economically beneficial and also an environmental beneficial investment by virtue of a longer duration of usefulness in typical households.

Summary of the invention

These aims are fulfilled by the invention set forth in the accompanying independent claim. Beneficial embodiments of the invention are set forth in the dependent claims.

The invention relates to a heat exchanger, for instance a heat exchanger in which the media used is water and which can therefore be placed beneath a shower tub or shower basin. In this use application, the heat exchanger will utilize the energy in the shower drainage water/waste water to heat cold water delivered to the shower.

The heat exchanger comprises a box-like housing which includes a heat-exchanging pack comprised of N-number of heating element sections which, in turn, comprise a number of flat or lamella-like channels for transporting primary medium, e.g. cold water, to the mixer fitting of the shower. The purpose of the channels is to take-up heat from the secondary medium that is led around the primary channels. In order to maximize the use of the thermal energy of the secondary medium, for instance the thermal energy of the drainage water, the secondary medium is led in a meandering path through several heat-exchanger sections, where the secondary medium flows around several parallel flat primary medium conducting channels in each of said sections. In the illustrated embodiments $N = 3$, i.e. the heat exchanging pack consists of three sections of heating elements. In other conceivable embodiments, N may be $1 \leq N \leq 10$ or more.

The heat exchanger has an efficiency of up to 65% with minimum internal soiling of the heat-exchanger housing. Tests carried out by us have shown that soiling is the greatest problem regarding effective functioning of the heat exchanger since it was noted that such contamination also resulted in impairment due to sludge formations. In order to alleviate these soiling and sludging problems, the inlet and outlet in the heat-exchanger housing are placed at the highest possible point in an heat-exchanger section. The particles of dirt floating on the surface of the liquid are flushed out automatically, therewith keeping the housing clean.

When, for instance, showering is terminated, the dirt particles, which are lighter than water and which are present in the residual drainage water in the heat exchanger, rise up to the surface in respective inlet and outlet means and are flushed away when showering is next commenced. This ensures that the housing is always filled with water. In order to facilitate passage of the dirt through and out of the heat exchanger housing still further, the ceiling above each section has an arched shape whose highest level is situated centrally above respective sections of the housing, by ceiling meaning the upper delimiting surface of the housing. Thus, the ceiling of each section has the form of a convex channel which follows the waste-water channel to its outlet, in other words the dirt is carried on the surface of the waste water in the narrower convex space. The dirt is forced out by the bubbles of air that enter the heat exchanger when the shower is next used. Located upstream of the waste-water inlet is a heavy particle trap in the form of a T-pipe into which metal waste and heavy particles fall. As a result such particles will not accompany the water into the housing.

There are two different flows of water into and out of the housing. Secondary medium, or waste water, which is warm and contains thermal energy to be recovered, and then primary medium, or cold water, to be heated by passing through the heat exchanger and then being conducted to the shower under the counter-flow principle. The secondary medium is led through channels built in the heat-exchanger housing thereby enabling the emission of sufficient thermal energy by heat-transfer contact with the primary medium channels before it leaves the housing. Primary medium channels, which each consists of two metal sheets mutually joined to form rectangular sheet metal channels, lead cold water through the heat-exchanger housing. Cold water has time to absorb thermal energy from the waste or drainage water present around the primary medium channels/cold water channels during this through flow process.

Each cold water channel includes two outwardly curved stainless thin metal plates/metal plates which are joined together such as to form a water channel therebetween. Cold water that passes through the cold water channels in the heat-exchanger housing, these channels being filled with waste water heated to about 35°C has time to be heated when the metal plates have a temperature higher than the cold water. This heat exchanging process is able to save up to 65% warm or hot water in the shower.

Application of the present invention has given two results. Firstly, a major part of the thermal energy of waste water, or drainage water, is recovered from a showering process. This implies that the thermal energy of the waste water taken from a shower tub or basin is used to heat cold water that is intended to pass to the shower nozzle. Secondly, when applying the present invention the temperature of the waste water is beneficially reduced significantly, therewith reducing the possibility of the growth of highly active bacteria in the waste pipes, such growth being able to result in, inter alia, local stoppages and also stoppages in community waste pipes.

Brief description of the accompanying drawings

The invention will now be described in more detail with reference to exemplifying embodiments and also with reference to the accompanying drawings, in which

Figure 1 is a perspective view of a heat exchanger according to one embodiment of the invention;

Figure 2 is top view of the heat exchanger shown in Figure 1;

Figure 3 is a perspective view of a heat exchanger pack according to the invention;

Figure 4 is a top view of the heat exchanger shown in Figure 2 but with the upper delimiting surface removed;

Figure 5a is a sectional view taken on line A – A in the heat exchanger shown in Figure 2;

Figure 5b is a sectioned view of part of a second embodiment of the invention;

Figure 6 is a side view of the heat exchanger equipped with inlet means and outlet means.

Description of the invention

Figure 1 illustrates a heat exchanger 11 that includes an upper delimiting surface 12 and a lower delimiting surface 13, wherewith in the case of the illustrated embodiment these surfaces are joined together such as to form a heat-exchanger housing VH. The housing is provided with a primary medium inlet 14 and a primary medium outlet 15. The housing is provided with a primary medium inlet 16 and a secondary medium outlet 17. The heat exchanger thus functions according to the counter flow principle. The direction of primary medium flow is marked P while the direction of secondary medium flow is marked S. The heat exchanger also includes a first drainage system 18 and a second drainage system 19, both of which are intended for emptying the heat exchanger.

Figure 2 shows the heat exchanger from above. As will be seen from the figure the upper delimiting surface 12 is divided into three parallel surface sections 21, 22, 23, each of which is elongated in a direction that coincides with the flow direction of the secondary medium within the heat exchanger. Each secondary medium inlet and outlet of the heat-exchanger housing is disposed at the highest level of the upper delimiting surface 12 of the housing so that any particles that float in the secondary medium will reach the outlet and therewith be carried away when the shower is in use.

Figure 3 illustrates a heat exchanging pack VP comprised of three heat exchanging elements 31, 32, 33, of which the third heat exchanging element 33 is provided with a first connection A_1 to the primary medium inlet and the first heat exchanging element 31 is provided with a second connection A_2 to the primary medium outlet. Each heat exchanging element is comprised of eleven parallel lamellae L in which primary medium is intended to flow. All lamellae L in a heat exchanging element is connected flow-wise to a common input I and to a common output U, such that the first heat exchanging element 31 will include an input 31I and an output 31U. Correspondingly, the second heat exchanging element 32 is provided with an input 32I and an output 32U, and the third heat exchanging element includes an input 33I and an output 33U. Each of the three heat exchanging elements is connected at one end to an adjacent element, such that the output 33U of the third heat exchanging element 33 will be connected to the inlet 32I of the second heat exchanging element 32, and such that the output 32U of the second heat exchanging element 32 will be connected to the inlet 31I of the first heat exchanging element 31, and such that the primary medium will meander through the three heat exchanging elements of the heat exchanger pack VP.

As will also be seen from Figure 3 a first intermediate wall 35 is disposed between the first heat exchanging element 31 and the second heat exchanging element 32, and that a second intermediate wall 36 is disposed between the second heat exchanging element 32 and the third heat exchanging element 33. Each intermediate wall is curved K at its free end, with the intention of facilitating directional changes in the flow of a passing secondary medium.

Figure 4 shows the heat exchanger pack VP mounted in its lower delimiting surface 13. The intermediate walls 35, 36 are constructed so as to connect with both the lower delimiting surface 13 and the upper delimiting surface and also to co-act with six holders 41 in the heat-exchanger housing, so as to fixate the intermediate walls on the one hand and the heat exchange elements on the other hand. The curved free end of the intermediate walls connects with the heat-exchanger housing, while the opposite ends of said intermediate walls are fastened in a media connecting device 43 between two adjacent heat exchange elements. In addition, the connection A_1 of the third heat exchange element 33 is coupled to the primary medium inlet 14 and the connection A_2 of the first heat exchange element 31 is coupled to the primary medium outlet 15.

Figure 5a is an enlarged sectional view of the heat exchanger according to Figure 2 taken on the line A – A in Figure 2, where the secondary medium outlet 17 is shown externally and internally in part with the outlet being placed so that the secondary medium can flow freely to the outlet from the highest level of the heat-exchanger housing VH, i.e. in the absence of any edge from the heat-exchanger housing that could prevent horizontal flow of said medium along the inside of the upper delimiting surface of the housing to the secondary medium outlet 17. Also shown is the primary medium inlet 14, which is partially hidden behind the first drainage system 18. The other side of the heat exchanger includes the second drainage system 19, which is partially hidden by the primary medium outlet 15. The figure clearly illustrates the heat exchanging elements 31, 32, 33 comprised of said lamellae L, and the medium connecting device 43 located between the second and the third heat exchanging elements 32, 33. The number of lamellae in each section of a heat exchanging element is K, where $5 \leq K \leq 15$. In the illustrated embodiments K = 11. As before mentioned, the upper delimiting surface 12 of the heat-exchanger housing VH is divided into three mutually parallel surface sections 21, 22, 23, where each surface section has an upwardly/outwardly arc shape so that the highest level of the delimiting surface 12 will be situated above each section of a heat exchanging element. The greatest distance between the upper extension of the lamellae and the upper delimiting surface 12 is X mm, where $6 \leq X \leq 12$ at respective sections. The heat exchanger pack for each section is mounted in the heat-exchanger housing centrally beneath each section at a spacing from the lower delimiting surface 13 of the housing VH of Y mm, where $2 \leq Y \leq 5$. In the case of the embodiment shown in Figure 5a, the lower delimiting surface is completely flat beneath the sections, i.e. the heat exchanging elements 31, 32, 33, although other designs are conceivable within the scope of the present invention, namely one in which the lower delimiting surface 13 bulges out beneath each section in a corresponding fashion.

Figure 5b shows one such modification of the lower delimiting surface 13, i.e. a modification in which the surface has been given a curved shape with the greatest distance to the lamellae L centrally beneath heat exchange element 31, 32, 33. In the case of this modification, the pack of heat exchanging elements for each section is mounted in the heat-exchanger housing VH at a greatest distance Z mm, where $6 \leq Z \leq 12$, from the lower delimiting surface 13 of the heat-exchanger housing VH centrally beneath each section.

Figure 6 is a side view of an inventive heat exchanger in which its secondary medium inlet 16 is provided with an inlet means 61, which includes a heavy-particle trap 62. The secondary medium outlet 17 of said heat exchanger is provided with an outlet means 63 that includes a liquid trap 64 which is arranged so that the heat exchanger will always be full of liquid even when no liquid is pressed through or flows through the heat exchanger. The figure also shows the primary medium inlet 14 and the first drainage system 18 situated along the long side of the heat exchanger. It will also be seen from the figure that the upper delimiting surface 12 and the lower delimiting surface 13 are dished, wherewith said two surfaces are joined together along a dividing edge or lip 65 around the entire heat exchanger such as to form the heat-exchanger housing. Other designs of the heat-exchanger housing than that illustrated are also included within the scope of the present invention.

When applied as a shower water heat exchanger, the functioning and the design of the heat exchanger will comprise the use of a box placed beneath the floor of the shower/shower basin, wherein the secondary medium is comprised of the drainage water from the shower/shower basin this water being led through the box to the floor-mounted drain. The cold water channel, which is normally connected to the shower fittings, is connected to the primary medium inlet of the box, wherewith cold water passes through the heat exchanger pack to its primary medium outlet and from there to the cold water connection of the shower fittings. Because the drainage water/waste water herewith flows around the heat exchanger pack and its lamellae in which the cold water flows, the cold water flowing to the shower fittings will be heated in the box by the drainage water, this water having a temperature of about 35°C.

The heat-exchanger housing also has self-cleansing properties, as a result of placing the inlet and the outlet for secondary medium, e.g. the drainage water, at the highest possible point of the box. The heat exchanger is therewith almost completely maintenance-free.

In the shower application of the heat exchanger, attention has been paid to the flow of water through the cold water channels (lamellae) of the heat exchanger, i.e. through the heat exchanger pack. In this regard, the spacing between respective lamellae has been adapted according to the rate at which the water flows through the heat exchanger, in order to prevent adhesion of dirt particles. The free passage between upper and lower lamellae permits the particles to readily pass between the secondary medium inlet and the secondary medium outlet without fastening to the surfaces of the heat-exchanger housing or of the lamellae as they pass through the heat exchanger and out through the conventional drain.

All liquid transporting channels and all other parts of the heat exchanger are comprised of a non-corrosive material so as to maintain a smooth surface for the flow of liquid. The outwardly curved convex shape of the upper delimiting surface along the secondary medium channel facilitates the travel of the dirt particles through the heat exchanger.

By choosing a thinner material for the manufacture of the lamellae than the thickness chosen with respect to the heat-exchanger housing there is gained additional space that enables more effective heat transfer to be achieved from the heat exchanger in comparison with the small space that is taken up. Because the lamellae are comprised of thin material, there is obtained additional space which allows more lamellae to be provided in one and the same section and thus in one and the same heat exchanger pack. This has resulted in higher efficiency with retained primary medium flow. This property has also resulted in an enhanced energy transfer.

The secondary medium inlet and outlet of the heat exchanger seated on the upper delimiting surface are pivotal. This facilitates fitting of the heat exchanger in small spaces, for instance beneath the tub or basin of a shower. Because the heat exchanger is always full of liquid by virtue of being provided with a liquid trap or seal, and because liquid in the heat exchanger has been able to obtain a temperature corresponding to the ambient temperature, for instance a temperature of about 20°C in the case of a shower application, it is possible to achieve a heat exchange within the heat exchanger from the very outset of the flow of liquid through the exchanger.

For example, with the application of water as a medium in the case of a shower application, the drainage water inlet and outlet are placed at the highest point on the box. The inlet and outlet are so positioned that dirt and contaminating particles, such as soap, skin residues, etc. in the drainage water will rise to the surface of the water during a showering process and accompany the drainage water out from the box and through the outlet. If the outlet had been placed further down on the box, the contaminants would have remained in the box and have minimum possibility of accompanying the drainage water from the box and would be liable to form blockaging sludge or require dismantling and cleansing of the box at regular intervals. When the box is given, instead, a design with which the drainage water is led out through the lid (the highest point on the box) the box will be cleansed automatically. The dirt particles or contaminants will rise up in the water that remains at the end of a showering session and stay at the highest point of the water, i.e. at the inlet and outlet. The box is constantly full of water, whereby the dirt particles and contaminants in the drainage water are unable to dry out and adhere to box surfaces. There is also obtained at the same time a water-seal mechanism that prevents the emissions of malodorous gases and replaces a possible water seal in the shower basin or tub.

The relatively small water volume of the box, about 7 litres, affords, among other things, the advantages whereby the last rinsing used to rinse soap etc. from the body has time to be flushed out of the box before showering is fully completed. The waste water that remains in the box upon conclusion of a showering process will therewith be relatively clean water. The maximum effect of the box will be achieved relatively quickly, due to the small amount of warm water required for a heat exchange in the box.

A contributory reason for the cleansing effect of the heat exchanger is the broad convex shape of the inner surface of the upper delimiting surface that follows the flow of secondary medium from inlet to outlet. All contaminants are collected on the highest point of the underlying surface and passed out from the heat exchanger. The contaminating particles that remain after cessation of the flow of secondary medium are initially passed out at the beginning of the next flow of secondary medium by liquid bubbles that enter through the secondary medium inlet.

In order to obtain energy from the box directly when beginning to shower, the box is filled with waste water that has at least room temperature.

A heavy-particle trap in the form of a T-pipe is connected upstream of the secondary medium inlet, where metal scrap and heavy particles fall down and thereby prevented from entering the heat exchanger.

The entire heat exchanger is made of acid proof steel and can therefore be cleaned with any cleaning agent whatsoever.

CLAIMS

1. A heat exchanger (11) comprising a heat-exchanger housing (VH) that has an upper delimiting surface (12) and a lower delimiting surface (13) and also a secondary medium inlet (16) and a secondary medium outlet (17), wherein the housing completely encloses a heat exchanger pack (VP) having a primary medium inlet (14) and a primary medium outlet (15), wherein the heat exchanger pack (VP) has N-number of sections of heat exchange elements (31, 32, 33), wherein each section consists of K, where $5 \leq K \leq 15$ numbers of elongate mutually parallel flat primary medium channels (L) whose ends are each coupled together by means of a transfer channel (43) for connection to adjacent sections or connection to the inlet/outlet (14, 15) for the supply and the exit of primary medium to/from the heat exchanger pack (VP), **characterised in** that the upper delimiting surface (12) of the heat-exchanger housing (VH) has over each section of said heat exchange elements (31, 32, 33) an arched shape whose highest level is located centrally over respective sections; and in that the secondary medium inlet (16) is situated at the highest level of the arched upper delimiting surface (12) of the first section; and in that the secondary medium outlet (17) is located at the highest level of the arched upper delimiting surface (12) of the last N^{th} section.

2. A heat exchanger according to claim 1, **characterised in** that the heat exchanger pack (VP) for each section N is mounted in the heat-exchanger housing (VH) in connection with a planar lower delimiting surface (13) at a distance Y mm from the lower delimiting surface (13), where $2 \leq Y \leq 5$.

3. A heat exchanger according to claim 1, **characterised in** that the heat exchanger pack (VP) for each section N is mounted in the heat-exchanger housing (VH) in connection with an arched lower delimiting surface (13) at a greatest distance Z mm from the lower delimiting surface (13), where $6 \leq Z \leq 12$.

4. A heat exchanger according to claim 3, **characterised in** that the lower delimiting section (13) of the heat-exchanger housing (VH) beneath each section has an arched shape whose lowest level is situated centrally beneath respective sections.

5. A heat exchanger according to any one of claims 1 – 4, **characterised in** that the heat exchanger pack (VP) for each section N is mounted in the heat-exchanger housing (VH) at a greatest distance X mm from the upper delimiting surface (12) of each section in the heat-exchanger housing (VH), where $6 \leq X \leq 12$.

6. A heat exchanger according to any one of claims 1 – 5, **characterised in** that the heat-exchanger housing (VH) is divided into N-numbers of spaces which are each delimited from one another by intermediate walls (35, 36) which are connected to the inner surfaces of the heat-exchanger housing (VH) along three of its side edges such as to form meandering secondary medium channels through the heat exchanger (11), wherein a section of the heat exchanger pack (VP) is situated in each space.

7. A heat exchanger according to any one of claims 1 – 6, **characterised in** that the secondary medium inlet (16) is connected to an inlet means (61) provided with a heavy-particle trap (62).

8. A heat exchanger according to any one of claims 1 – 7, **characterised in** that the secondary medium outlet (17) is connected to an outlet means (64) provided with a liquid seal (64) adapted so that the heat exchanger will be permanently full of secondary medium.

9. A heat exchanger according to any one of claims 1 – 8, **characterised in** that the primary medium and the secondary medium both consist of water.

10. A heat exchanger according to any one of claims 1 – 9, **characterised in** that the secondary medium is comprised of waste water from a shower; and in that the primary medium is comprised of cold water delivered to the shower.

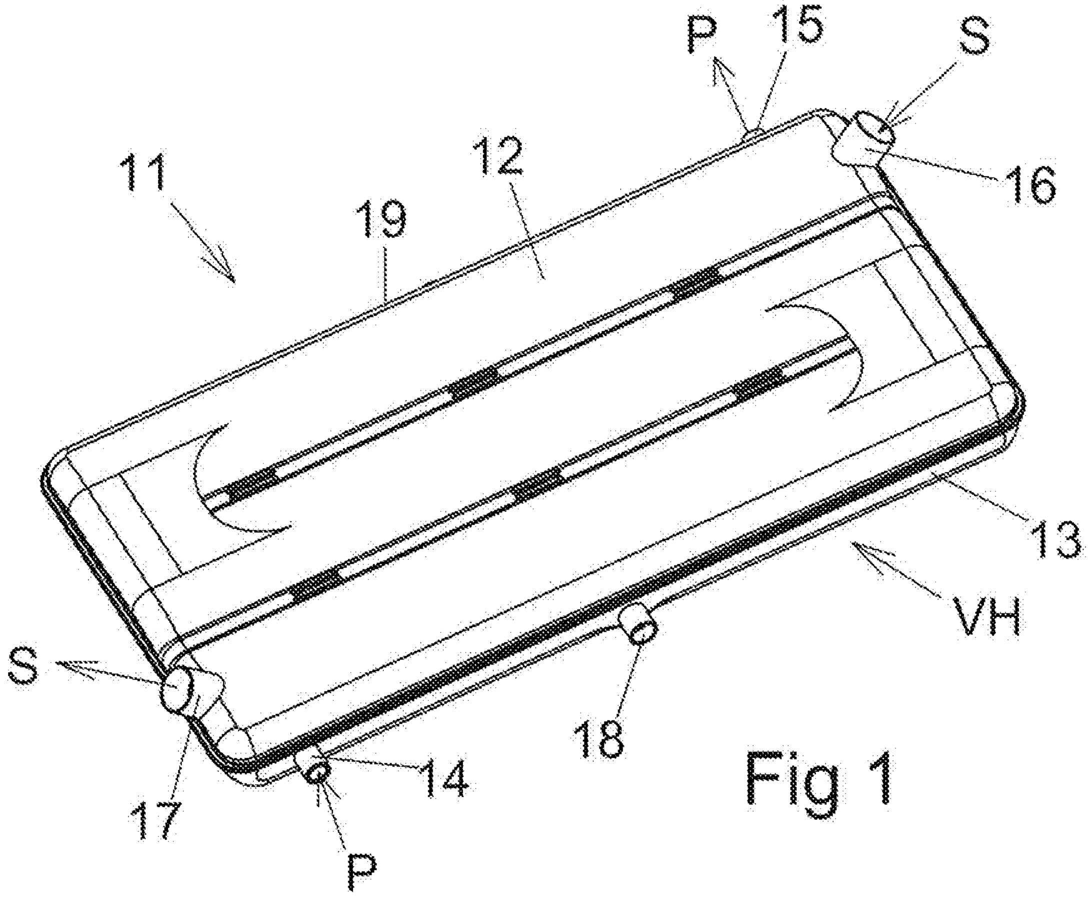


Fig 1

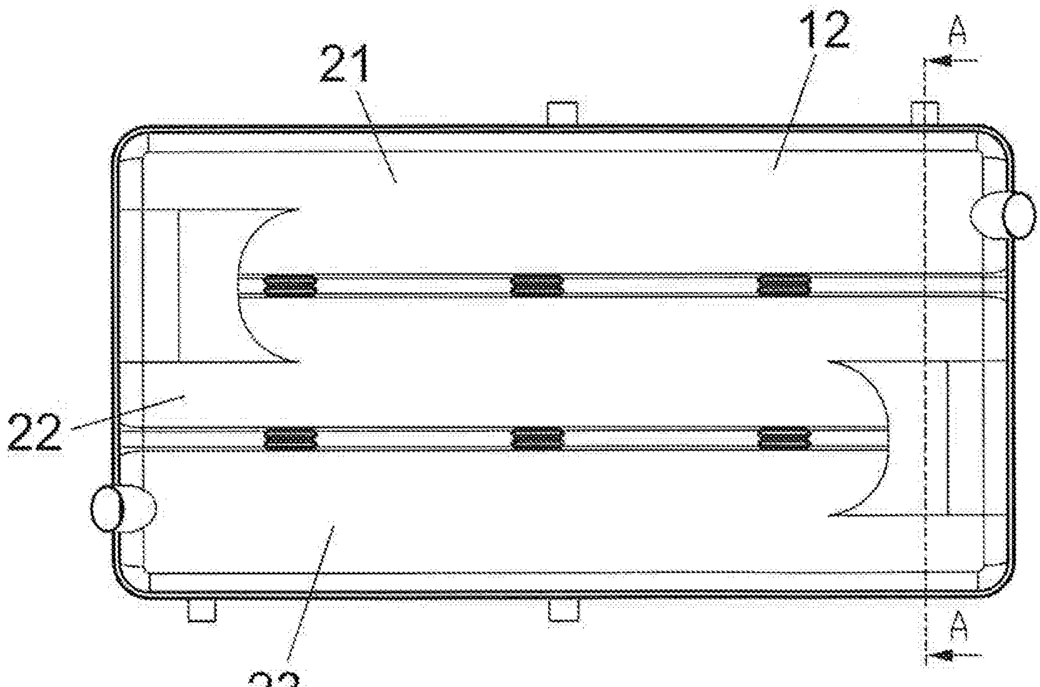
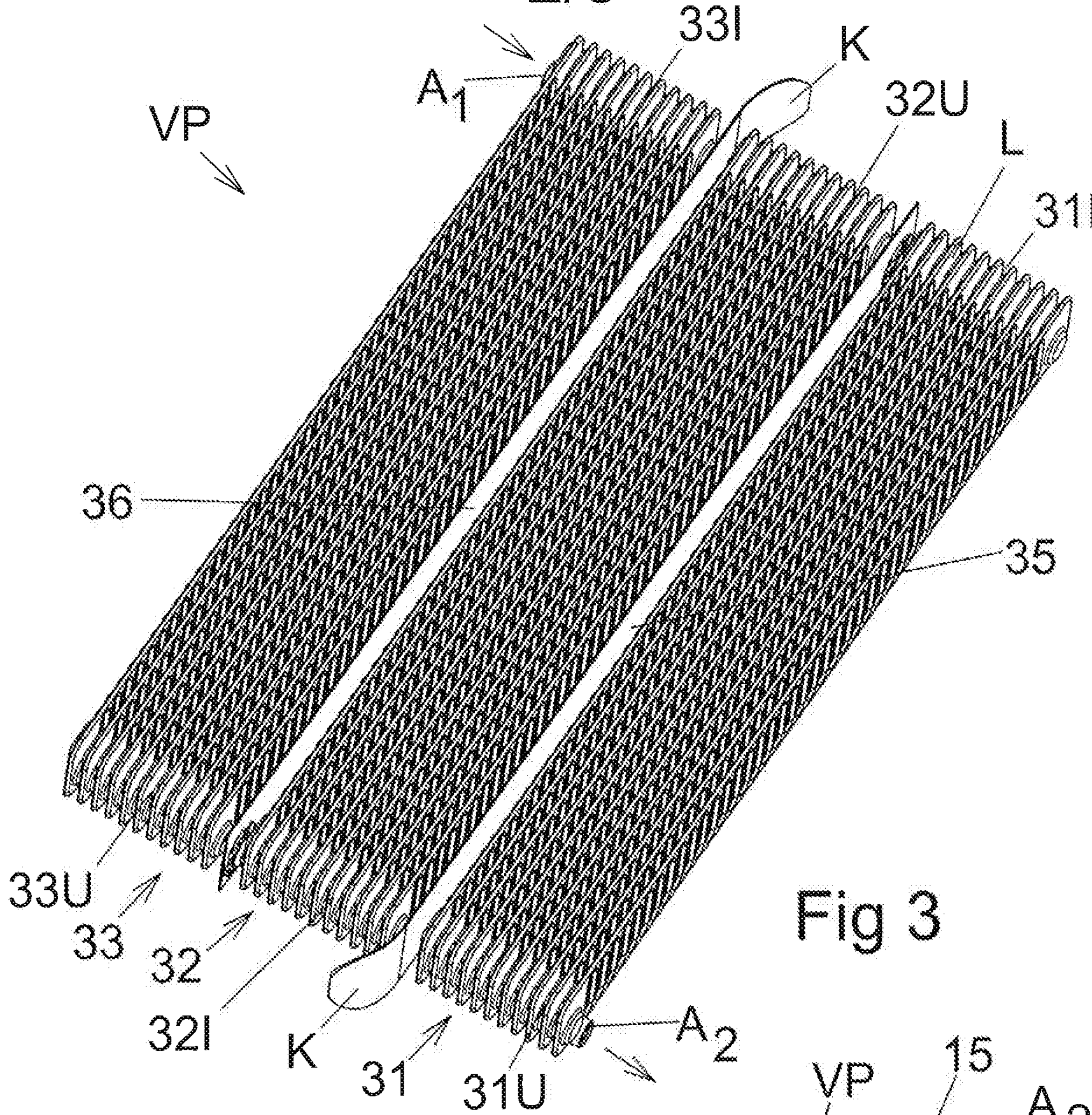


Fig 2


33I
K
A1
VP
32U
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31I
36
35
33U
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32
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31
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Fig 3

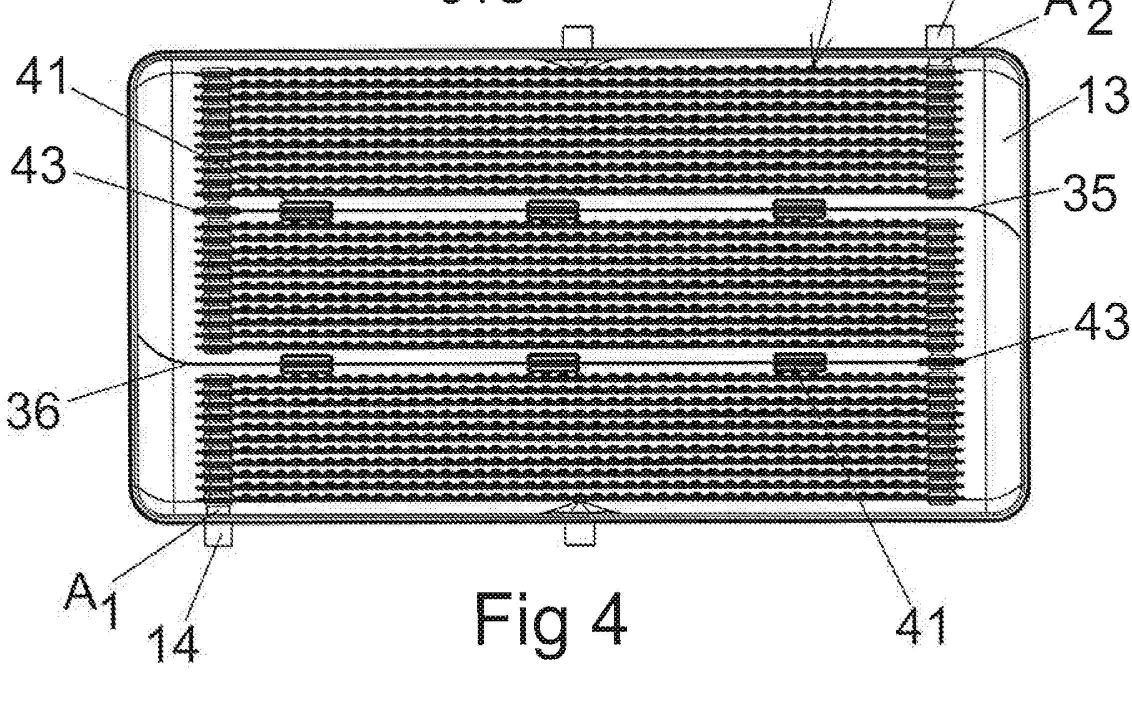
VP
15
A2
41
13
43
35
43
36
A1
14
41

Fig 4

3/3

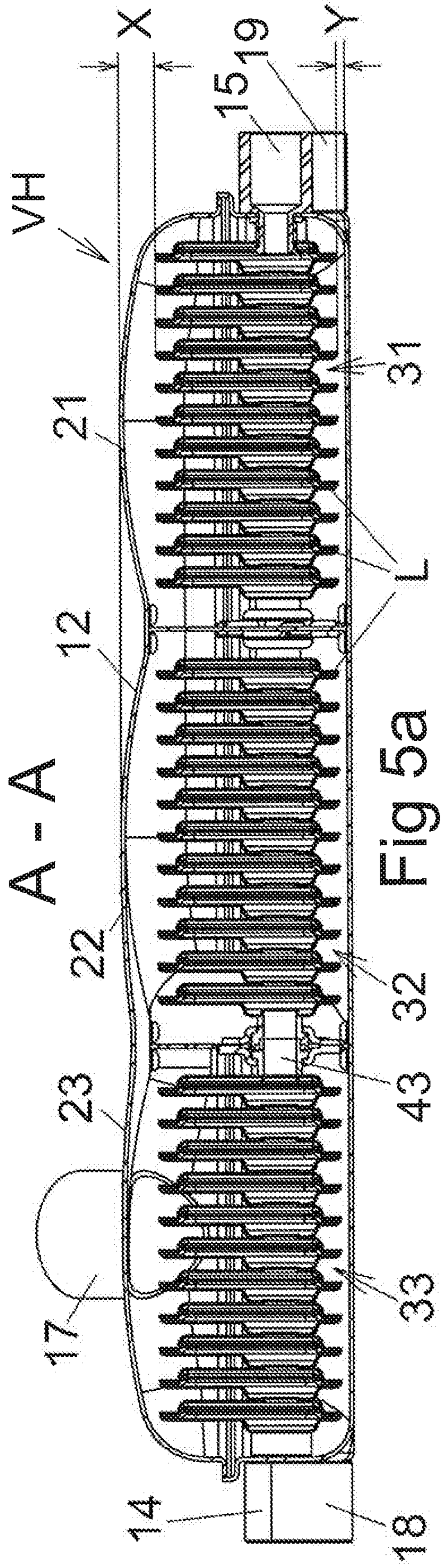

Fig 5a

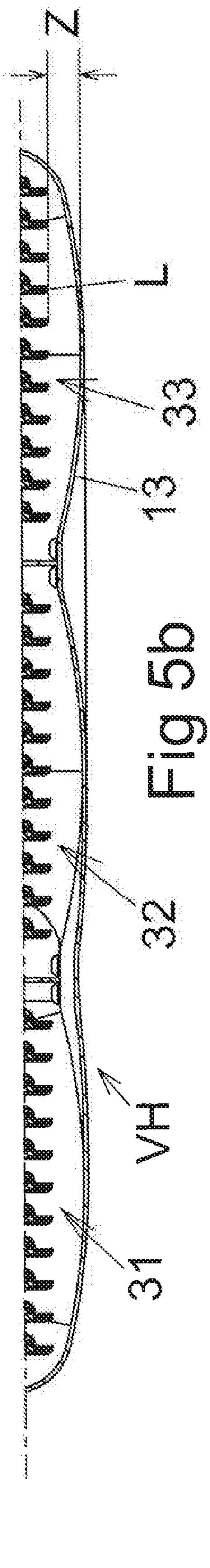

Fig 5b

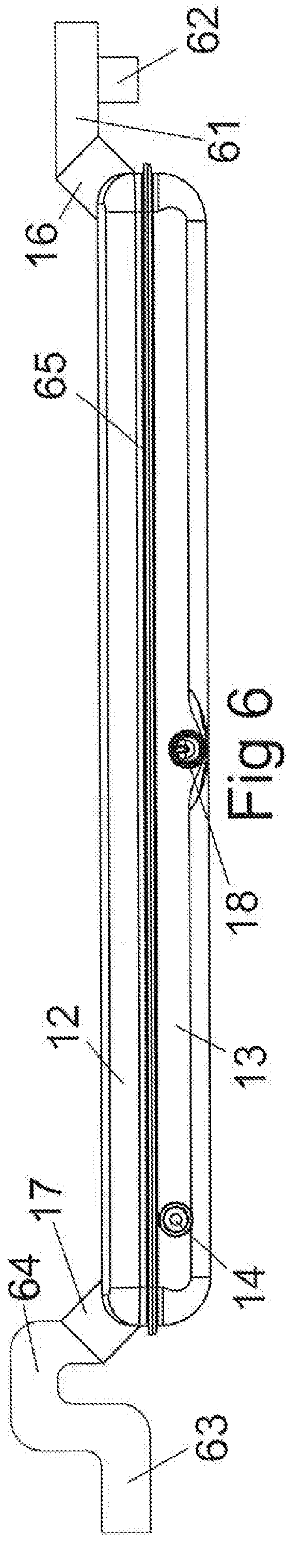

Fig 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2006/050011

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: F28D, F28F, F24D, E03C, A47K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 20040031600 A1 (KONTU), 19 February 2004 (19.02.2004) --	1-10
A	DE 3618225 A1 (FUNKE WÄRMEAUSTAUSCHER APPARATEBAU GMBH), 3 December 1987 (03.12.1987) --	1-10
A	GB 2054819 A (KABUSHIKI KAISHA HISAKA), 18 February 1981 (18.02.1981) --	1-10
P,A	EP 1527816 A1 (METHANOL CASALE S.A.), 4 May 2005 (04.05.2005) --	1-10

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
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Date of the actual completion of the international search	Date of mailing of the international search report
17 May 2006	19-05-2006

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INTERNATIONAL SEARCH REPORT

International application No.
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International patent classification (IPC)

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