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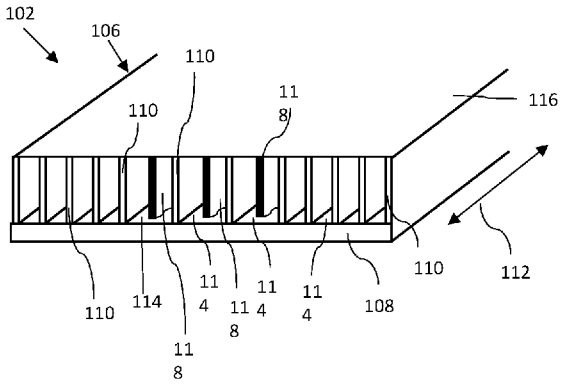

Fig. 2

(57) Abstract: An apparatus (102; 202) for transferring heat from a heat source (104) to a fluid when the apparatus (102; 202) is connected to the heat source (104) is disclosed. The apparatus (102; 202) includes a heat sink (106; 206) with a heat sink base (108) and fins (110) extending in a longitudinal direction (112). The heat sink base (108) and the fins (110) form longitudinal channels (114) for streams of the fluid. The apparatus (102) further includes one or more flaps (118) having a longitudinal extension (119) and being located in the longitudinal channels (114). By means of the flaps (118), turbulence is introduced, which enhances mixing of heated fluid (heated by the fins) with the main stream of initially cold fluid through the longitudinal channels (114), whereby the heat transfer efficiency of the heat sink is improved. A network access node for a wireless communication system is also provided, wherein the network access node comprises an apparatus (102; 202) of the above-mentioned sort.

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AN APPARATUS FOR TRANSFERRING HEAT FROM A HEAT SOURCE TO A FLUID

Technical Field

The invention relates to an apparatus for transferring heat from a heat source to a fluid, wherein the apparatus comprises a heat sink. Further, the invention relates to a method for producing an apparatus of the above-mentioned sort. The invention also relates to a network access node for a wireless communication system, wherein the network access node comprises an apparatus of the above-mentioned sort. The network access node may comprise a base station.

Background

Heat sinks are used in various fields of technology, for example in the field of telecommunications, where a heat sink may be installed in a network access node, for example a base station unit or radio unit, to provide cooling. Cooling in a network access node is often needed because of the heat sources or heat generators present in the network access node, for example transmitters, printed circuit boards, optical transducers, power amplifiers etc. In general, a heat sink has a plurality of fins.

Summary

The inventor of the present invention has found drawbacks in conventional cooling solutions, for example in the field of telecommunications. The cooling capacity of a conventional heat sink may be improved by increasing the air flow through the heat sink or by increasing the cooling area of the heat sink, for example by increasing the number of fins. However, the inventor of the present invention has found that in some conventional applications, an increase in air flow is not advisable due to limitation on the noise generated by fans used for creating an air flow through the heat sink. The inventor of the present invention has found that an increase of the number of fins in conventional heat sinks may lead to drawbacks, such as a higher flow resistance, which reduces the flow rate at a given fan power. Some conventional cooling solutions are not sufficiently efficient with an acceptable sound or noise level.

An object of embodiments of the invention is to provide a solution which mitigates or solves the drawbacks and problems of conventional solutions.

The above-mentioned and further objects are solved by the subject matter of the independent claims. Further advantageous embodiments of the invention can be found in the dependent claims.

According to a first aspect of the invention, the above-mentioned and other objects are achieved with an apparatus for transferring heat from a heat source to a fluid when the apparatus is connected to the heat source, wherein the apparatus comprises a heat sink, wherein the heat sink comprises

a heat sink base, and

two or more fins,

wherein the fin has a longitudinal extension extending in a longitudinal direction,

wherein the heat sink base and the fins form longitudinal channels for streams of the fluid,

wherein the apparatus comprises one or more flaps having a longitudinal extension, and

wherein the flap is located in one of the longitudinal channels.

An advantage of the apparatus according to the first aspect is an improved cooling, for example an improved cooling of the heat source. An advantage of the apparatus according to the first aspect is an improved cooling performance and/or an improved cooling efficiency. An advantage of the apparatus according to the first aspect is that the cooling capacity of the heat sink is improved without increasing the flow resistance of the heat sink. An advantage of the apparatus according to the first aspect is that the cooling capacity of the heat sink is improved without increasing the fan power and thus without increasing the noise of the fan creating the stream or fluid through the heat sink.

An advantage of the apparatus according to the first aspect is that the flap introduces turbulence, such as small-scale vortical motions in the longitudinal channels. The turbulence breaks up the boundary layers and enhances the mixing of heated fluid (heated by the fins) with the main stream of initially cold fluid through the longitudinal channels. Hereby, the flow conditions are enhanced and the fluid can travel through the heat sink in an efficient manner and convey, or carry, heat away from the heat source and fins in an improved manner. The heat transfer efficiency or thermal conductivity of the heat sink is thereby improved, such that the heat source, for example an electric or electronic component, and/or the area around the heat source, are/is efficiently cooled. A result of the improved heat transfer efficiency or thermal conductivity of the heat sink is that the volume and weight of the apparatus can be reduced, which is an advantage for a network access node for a wireless communication system, for example a base station. For example, a smaller, a low-weight, or a less efficient, fan can be used. Consequently, the network access node can be produced in a more efficient manner and take up less space when installed. The temperatures of typical electric or electronic components of a typical base station can be decreased significantly.

It is to be understood that the fluid may comprise a gas, a gas mixture (such as air), a liquid, or a mixture thereof. For some embodiments, the flap may be referred to as a reed, or a fluttering reed. It is to be understood that the flap is flexible or bendable. For some embodiments, the flap is configured to flap or flutter when exposed to the stream of fluid.

In an implementation form of an apparatus according to the first aspect, the heat sink comprises a heat sink top, wherein the two or more fins is/are located between the heat sink base and the heat sink top, and wherein the heat sink base, the heat sink top and the fins together form the longitudinal channels. An advantage with this implementation form is that circumferentially closed longitudinal channels are formed, ensuring more efficiently that the streams of fluid remain in contact with the fins over the entire length of the heat sink. Hereby, an improved control of the flow conditions through the heat sink is achieved, and the heat of the heat sink can be transferred in a more efficient manner, whereby the heat transfer efficiency or thermal conductivity of the heat sink is improved. An advantage with this implementation form is that the cooling is further improved.

In an implementation form of an apparatus according to the first aspect, the longitudinal extension of the flap extends in the longitudinal direction. An advantage with this implementation form is an efficient interaction between the flap and the stream of fluid, whereby the mixing of heated fluid (heated by the fins) with the main stream of initially cold fluid through the longitudinal channels without increasing the flow resistance is improved. The heat of the fins can be transferred to the fluid in an improved manner, whereby the heat transfer efficiency and the cooling efficiency of the heat sink are further improved. An advantage with this implementation form is that the cooling is further improved.

In an implementation form of an apparatus according to the first aspect, the flap is configured to flutter from the stream of fluid through the longitudinal channel. An advantage with this implementation form is that the cooling is further improved.

In an implementation form of an apparatus according to the first aspect, the flap is configured to flutter in the longitudinal channel. An advantage with this implementation form is that the cooling is further improved.

In an implementation form of an apparatus according to the first aspect, the flap is configured to provide turbulence in the stream of fluid. An advantage with this implementation form is an enhanced mixing of heated fluid (heated by the fins) with the main stream of initially cold fluid,

such that heat can be transferred to the fluid in an efficient manner, whereby the heat transfer efficiency and the cooling efficiency of the heat sink are further improved. An advantage with this implementation form is that the cooling is further improved.

In an implementation form of an apparatus according to the first aspect, the longitudinal channel has an inlet and an outlet for the stream of fluid, wherein the flap is attached at a position adjacent to the inlet of the longitudinal channel. An advantage with this implementation form is that turbulence is enhanced in the beginning, or adjacent to the entry, of the longitudinal channel, such that heat can be transferred by way of the stream of fluid through the longitudinal channel in an efficient manner. The heat transfer efficiency and the cooling efficiency of the heat sink are thereby further improved. An advantage with this implementation form is that the cooling is further improved.

In an implementation form of an apparatus according to the first aspect, the flap is attached in the longitudinal channel. An advantage with this implementation form is that a simple and efficient way of implementing the flap is provided. An advantage with this implementation form is that the cooling is further improved.

In an implementation form of an apparatus according to the first aspect, the flap is attached to one or more of the group of:

- the heat sink base;
- the heat sink top; and
- the fin.

An advantage with this implementation form is that the flap can be attached to one or more existing parts of the heat sink, providing a simple and flexible configuration. An advantage with this implementation form is that the cooling is further improved.

In an implementation form of an apparatus according to the first aspect, the apparatus comprises one or more rigid members,

wherein the flap is attached to the rigid member, and

wherein the rigid member is attached to one or more of the group of:

- the heat sink base;
- the heat sink top; and
- the fin.

An advantage with this implementation form is that the rigid member provides stability, making the implementation of the flap robust. Further, a flexible way of implementing the flap is

provided. An advantage with this implementation form is that the cooling is further improved. For some embodiments, the rigid member may comprise a pin.

In an implementation form of an apparatus according to the first aspect, the rigid member is immovable in relation to one or more of the heat sink base, heat sink top and fin,

wherein the flap comprises a first end portion and a second end portion,

wherein the longitudinal extension of the flap extends from the first end portion to the second end portion,

wherein the first end portion of the flap is attached to the rigid member, and

wherein the first end portion of the flap is immovable in relation to the rigid member.

An advantage with this implementation form is that a simple yet robust way of implementing the flap is provided. An advantage with this implementation form is that the cooling is further improved.

In an implementation form of an apparatus according to the first aspect, the flap is spaced apart from the fin. When the flap comprises the first end portion, the first end portion of the flap may be spaced apart from the fin. An advantage with this implementation form is that the stream of fluid can flow on both sides of the flap, whereby turbulence is efficiently enhanced and heat can be transferred in an efficient manner. The heat transfer efficiency and the cooling efficiency of the heat sink are thereby improved. An advantage with this implementation form is that the cooling is further improved.

In an implementation form of an apparatus according to the first aspect, the heat sink is configured for a fluid in the form of a gas or a gas mixture. An advantage with this implementation form is that heat can be transferred in an efficient manner, whereby the heat transfer efficiency or thermal conductivity and the cooling efficiency of the heat sink are further improved. An advantage with this implementation form is that the cooling is further improved. For alternative embodiments, the heat sink may be configured for a fluid in the form of a liquid or a mixture of gas and liquid, such as steam, or vapour.

In an implementation form of an apparatus according to the first aspect, one or more of the longitudinal channels houses/house one of the flaps. An advantage with this implementation form is that the cooling is further improved.

According to a second aspect of the invention, the above-mentioned and other objects are achieved with a method for producing, or manufacturing, an apparatus configured to transfer

heat from a heat source to a fluid when the apparatus is connected to the heat source, wherein the apparatus comprises a heat sink comprising

a heat sink base, and

two or more fins,

wherein the fin has a longitudinal extension extending in a longitudinal direction, and

wherein the heat sink base and the fins form longitudinal channels for streams of the fluid,

wherein the method comprises:

attaching one or more flaps having a longitudinal extension in one or more of the longitudinal channels.

Advantages of the method according to the second aspect correspond to advantages of the apparatus according to the first aspect and its implementation forms or embodiments mentioned above or below.

According to a third aspect of the invention, the above-mentioned and other objects are achieved with a network access node for a wireless communication system, wherein the network access node comprises an apparatus according to any one of the embodiments or implementation forms mentioned above or below. The inventor of the present invention has found that some cooling solutions for network access nodes are not efficient enough. An advantage of the network access node according to the third aspect is an improved cooling of the network access node, and/or an improved cooling performance or an improved cooling efficiency with regard to the network access node. Otherwise, advantages of the network access node according to the third aspect correspond to advantages of the apparatus and its implementation forms or embodiments mentioned above or below. The network access node may comprise a base station. However, it is to be understood that implementation forms or embodiments of the apparatus according to the first aspect of the invention may be applied to units or apparatuses different from a network access node for a wireless communication system.

Further applications and advantages of the implementation forms or embodiments of the invention will be apparent from the following detailed description.

Brief Description of the Drawings

The appended drawings are intended to clarify and explain different embodiments of the invention, in which:

Fig. 1 is a schematic front view of an embodiment of the apparatus according to the first aspect of the invention;

Fig. 2 is a schematic perspective front view of the apparatus illustrated in Fig. 1;

Fig. 3 is a schematic sectional view of the longitudinal channel with a flap according to an embodiment of the apparatus according to the first aspect of the invention;

Fig. 4 schematically illustrates front views of examples of the position of the flap in the longitudinal channel according to embodiments of the apparatus according to the first aspect of the invention;

Figs. 5a-b are schematic perspective views of the flap attached to a rigid member according to embodiments of the apparatus according to the first aspect of the invention;

Fig. 6 is a schematic partial perspective front view of another embodiment of the apparatus according to the first aspect of the invention; and

Fig. 7 is a schematic flow chart illustrating aspects of embodiments of the method according to the second aspect of the invention.

Detailed Description

Figs. 1 and 2 schematically illustrate an embodiment of the apparatus 102 for transferring heat from a heat source 104 to a fluid, when the apparatus 102 is connected to the heat source 104, according to the first aspect of the invention. The apparatus 102 may be connected to one or more heat sources 104, for example two heat sources 104 as shown in Fig. 1, or more heat sources 104. The heat source 104 may comprise an electric or electronic component attached or mounted to a printed circuit board, PCB. The electric or electronic component may be a transmitter, an optical transducer, a power amplifier or any other heat-generating component, or any other heat-generating electric or electronic component. However, it is to be understood that the heat source 104 in alternative embodiments may be a component not mounted to a PCB. The heat source 104 or heat sources 104, and for example also the PCB, may for example be part of a network access node for a wireless communication system. The network access node may comprise a base station.

With reference to Figs. 1 and 2, the apparatus 102 includes a heat sink 106. The heat sink 106 may be configured for a fluid in the form of a gas or a gas mixture (such as air), but is not limited thereto. In some embodiments, the heat sink 106 may instead be configured for a fluid in the form of a liquid or a liquid mixture, such as an oil, or any other liquid. For some embodiments, the fluid may comprise a mixture of gas and liquid, such as vapour. The heat sink 106 includes a heat sink base 108 and two or more fins 110. In general, the heat from the heat source 104 is conveyed to the fin 110 where the heat is then transferred to the fluid close

to the fin 110. For some embodiments, the fin 110 may be connected to the heat sink base 108. The fin 110 may be connected to the heat sink base 108 by being attached to the heat sink base 108 or by being integrally formed with the heat sink base 108. With reference to Fig. 2, the fin 110 has a longitudinal extension 111 (see Fig. 3) extending in a longitudinal direction 112. The heat sink base 108 and the fins 110 form longitudinal channels 114 for streams of the fluid. For some embodiments, it may be described that the longitudinal channels 114 guide the fluid, for example in the form of gas and/or liquid, through the heat sink 106 and enables heat from the fins 110 to be transferred to the fluid. The stream of fluid may be natural or forced, for example generated with one or more fans. Thus, the heat sink 106 may in some embodiments be used in combination with one or more fans.

For some embodiments, and as illustrated in in Figs. 1 and 2, the heat sink 106 may include a heat sink top 116. When a heat sink top 116 is present, the two or more fins 110 are located between the heat sink base 108 and the heat sink top 116, such that the heat sink base 108, the heat sink top 116 and the fins 110 together form the longitudinal channels 114. However, it is to be understood that the heat sink top 116 may be excluded in some embodiments. When the heat sink 106 comprises a heat sink top 116, circumferentially closed longitudinal channels 114, or conduits, are formed, as shown in Figs. 1 and 2. In embodiments where the heat sink top 116 is excluded, circumferentially unclosed longitudinal channels 114 are instead formed. The fin 110 may be integrally formed with the heat sink top 116, or attached thereto in other manners.

With reference to Fig. 1, the heat sink 106 may be configured to be thermally coupled to the heat source 104 or sources 104 via the heat sink base 108 and/or the heat sink top 116. Thus, one or more of the heat sink base 108 and the heat sink top 116 may be configured to be thermally coupled to the heat source(s) 104. Thus, the fin 110 may be thermally coupled to the heat source 104 via the heat sink base 108 and/or the heat sink top 116. For some embodiments, the fin 110 may be directly thermally coupled to a heat source 104, i.e. not via the heat sink base 108 or the heat sink top 116.

With reference to Figs. 1 and 2, the apparatus 102 includes one or more flaps 118 having a longitudinal extension 119 (see Fig. 5a). It is to be understood that the flap 118 may be described as flexible or bendable, such as a flexible or bendable tongue. The flap 118 may be referred to as a reed, or a fluttering reed. The flap 118 is located in one of the longitudinal channels 114. The flap 118 may thus be located between two fins 110. When a heat sink top 116 is used, the flap 118 may be located between the heat sink base 108 and the heat sink

top 116. It may be described that one or more of the longitudinal channels 114 houses/house one or more of the flaps 118. Thus, all or a subset of the longitudinal channels 114 of the heat sink 106 may house one or more flaps 118. When a longitudinal channel 114 houses more than one flap 118, the flaps 118 may for example be arranged after one another in the longitudinal direction 112, or side by side. For some embodiments, the flap 118 is spaced apart from the fin 110. The flap 118 may be located between two fins 110 such that the flap 118 is spaced apart from the fins 110 and extends between the heat sink base 108 and the heat sink top 116. However, the flap 118 may be located in other ways, for example as described below in connection with Fig. 4.

As mentioned above, it is to be understood that the flap 118 is flexible or bendable, i.e. not rigid. For example, the flap 118 may be made of a flexible or bendable material, such that when the stream of fluid flows past the flap 118, the flap 118 starts to flap or flutter, i.e., move in an oscillating manner. In other words, the flap 118 may be configured to flutter from the stream of fluid through the longitudinal channel 114.

Fig. 3 schematically illustrates the flap 118 in the longitudinal channel 114 according to an embodiment of the invention in a cross-sectional view. The flap 118 is arranged between the two fins 110 at a distance from each one of the two fins 110. The longitudinal channel 114 may have an inlet 114a and an outlet 114b for the stream of fluid. The flap 118 may be attached at a position adjacent to the inlet 114a of the longitudinal channel 114, i.e., adjacent to a position where the stream of fluid enters the longitudinal channel 114. The inlet 114a may be formed by, or be positioned at, a leading edge of the longitudinal channel 114.

With reference to Fig. 3, the flap 118 may be configured to flutter in the longitudinal channel 114. The flutter motion provides turbulence in the stream of fluid flowing through the longitudinal channel 114. Thus, the flap 118 may be configured to provide turbulence in the stream of fluid. In Fig. 3, the stream of fluid, in the form of gas or liquid, through the longitudinal channel 114 and the effect of the flap 118 on the stream of fluid are illustrated. Cold, or cool, fluid enters the longitudinal channel 114 at the inlet 114a, as indicated by the arrow 121. The stream of fluid affects the flap 118 as it flows through the longitudinal channel 114, making the flap 118 flutter at a given speed, indicated with dotted lines around the flap 118. The flutter of the flap 118 introduces small-scale vortical motions in the stream of fluid, breaking up the boundary layer and mixing heated fluid close to the fins 110 with the main stream of initially cold fluid. At the outlet 114b of the longitudinal channel 114, heated fluid exits the longitudinal channel 114, as indicated by the arrow 123, and may be conveyed away.

With reference to Fig. 3, the longitudinal extension 119 of the flap 118 may extend in the longitudinal direction 112, i.e., in the same direction as the longitudinal extensions 111 of the fins 110. The longitudinal extension 119 of the flap 118 may thus be substantially parallel to the longitudinal extension 111 of the fin 110. However, the flap 118 may in some embodiments instead have a longitudinal extension 119 extending in a direction different from the longitudinal direction 112. The longitudinal extension 119 of the flap 118 may, for example, extend at an angle, such as an angle in the range of zero to 180 degrees, such as a right angle, to the longitudinal direction 112. When the flap 118 flutters when there is a stream of fluid in the longitudinal channel 118, said angle may certainly continuously change when there is a stream of fluid in the longitudinal channel 118. The longitudinal extension 119 of the flap 118 may be considered as the main extension of the flap 118 in an unaffected state, i.e. when not affected by the stream of fluid in the longitudinal channel 114. With reference to Fig. 5a, for some embodiments, the flap 118 may be described to have a transverse extension 125 extending in a direction transverse to direction of the longitudinal extension 119 of the flap 118.

For some embodiments, the flap 118 may replace a fin 110 or a portion of a fin 110. With reference to Fig. 1, in a heat sink 106 with a plurality of evenly spaced fins 110, one or more fins 110 may be replaced with a flap 118 according to any one of the herein described embodiments. The flap 118 may then, for example, be located midway between two fins 110 where another fin 110 would otherwise have been located. The flap 118 may replace a fin 110 fully or only partly. With reference to Fig. 3, a middle fin 110a located between two other fins 110 may for example be fully or partly replaced with a flap 118. The flap 118 is here located adjacent to the inlet 114a of the longitudinal channel 114. A middle fin 110a extending from the flap 118 and along the rest of the longitudinal channel 114 may, or may not, be present, as indicated with dashed lines in Fig. 3. Embodiments of the apparatus 102 ensures that the pressure drop between the inlet 114a and the outlet 114b of the longitudinal channel 114 is not increased while yet enhancing cooling performance.

The dimensions of the flap 118 may be adapted based on the dimensions of other parts of the heat sink 106, as well as adapted to specific cooling requirements. For example, the length of the longitudinal extension 119 of the flap 118 may be proportional to the spacing between the fins 110. In order to balance the cooling effect and additional flow resistance, a ratio of 1.5:1 to 6:1, such as 3:1 to 4:1, between the length of the longitudinal extension 119 of the flap 118 and the spacing between the fins 110 may be selected. However, other ratios are also possible. If the spacing between two fins 110 is s, the length of the longitudinal extension 119 of the flap 118 may hence be selected to be, for example, about 2 to 6 times s to achieve a suitable

balance. The thickness of the flap 118 may be selected based on various factors, such as the velocity of the stream of fluid and the material of the flap 118. For example, for a high-density compact fin heat sink, where the spacing between the fins 110 is small, a thickness of the flap 118 of 10 to 50 μm may be selected.

The material of the flap 118 may be selected to be robust and durable with good thermal and dimensional stability. In some embodiments, the material of the flap 118 may be selected to withstand temperatures of up to 300°C. Possible materials of the flap 118 may include a polymer, a polymer composite, a metal, a metal alloy, fibres, a textile etc.

With reference to Figs. 1 and 2, for some embodiments, the flap 118 is attached in the longitudinal channel 114. The flap 118 may be attached to one or more of the heat sink base 108, heat sink top 116 and fin 110. In the embodiment shown in Figs. 1 and 2, the flap 118 is attached to the heat sink base 108 and the heat sink top 116 and is located between two fins 110. However, in some embodiments, the flap 118 may be attached to only one of the heat sink base 108 and heat sink top 116, or attached only to one or more of the fins 110. Fig. 4 schematically illustrates five non-limiting embodiments or alternatives of possible attachments of the flap 118 in the longitudinal channel 114, such as the attachment to one or more of the heat sink base 108, heat sink top 116 and fin 110.

With reference to Figs. 5a and 5b, for some embodiments, the apparatus 102 may include one or more rigid members 120, wherein the flap 118 is attached to the rigid member 120. For some embodiments, the rigid member 120 may comprise a pin. The rigid member 120 is in turn attached to one or more of the group of: the heat sink base 108; the heat sink top 116; and the fin 110. With reference to Fig. 5a, the flap 118 may comprise a first end portion 118a and a second end portion 118b, wherein the longitudinal extension 119 of the flap 118 extends from the first end portion 118a to the second end portion 118b. The first end portion 118a of the flap 118 may be attached to the rigid member 120. The second end portion 118b of the flap 118 may represent a free end portion and is thus free to flutter. Fig. 5b schematically illustrates the rigid member 120 with the flap 118 attached in the longitudinal channel 114. In the embodiment shown in Figs. 5b, the rigid member 120 is attached to the heat sink base 108 between two fins 110, such that the first end portion 118a is spaced apart from the fin 110. The rigid member 120 may be made of a material comprising or consisting of a polymer, a polymer composite, a metal or a metal alloy. For some embodiments, the rigid member 120 may be excluded.

With reference to Fig. 5b, the flap 118 and/or the rigid member 120 may be movably or immovably attached to one or more of the heat sink base 108, heat sink top 116 and fin 110. The flap 118 and/or the rigid member 120 may be movably or immovably attached to one another. In other words, the flap 118 or the rigid member 120 may be arranged to move, e.g. rotate, or be fixed in relation to the part(s) to which it is attached. The flap 118 and/or the rigid member 120 may be movably attached, for example, by way of a mechanical locking, such any one of the group of: a thread attachment; a friction attachment; a positive locking attachment; a bayonet attachment; a snap-on attachment; and a snap-in attachment. For some embodiments, the flap 118 and/or the rigid member 120 may be immovably attached, for example, by way of adhesive or welding.

For some embodiments, the flap 118 and/or the rigid member 120 may be integrally formed with one or more of the heat sink base 108, heat sink top 116 and fin 110, as well as with one another.

In some embodiments, the rigid member 120 may be immovable in relation to one or more of the heat sink base 108, heat sink top 116 and fin 110, wherein the first end portion 118a of the flap 118 may be immovable in relation to the rigid member 120. The first end portion 118a of the flap 118 may, for example, be glued or welded to the rigid member 120. The rigid member 120 may, for example, be glued or welded to one or more of the heat sink base 108, heat sink top 116 and fin 110. However, several other alternatives are possible.

With reference to Fig. 6, another embodiment of the apparatus 202 for transferring heat from a heat source to a fluid, when the apparatus 202 is connected to the heat source, according to the first aspect of the invention is schematically illustrated. Several features of the embodiment of the apparatus 202 of Fig. 6 may correspond to features of the embodiment of the apparatus 102 of Figs. 1 to 5 and are thus not repeated here to avoid repetition. In the embodiment illustrated in Fig. 6, the apparatus 202 includes seven flaps 118, wherein the flap 118 is located in one of the longitudinal channels 114. However, for other embodiments, the apparatus 202 may include more of fewer flaps 118 than seven flaps 118. For some embodiments, one and the same longitudinal channel 114 may house two or more flaps 118. In the embodiment illustrated in Fig. 6, the rigid member 120, to which the flap 118 is attached, is held in a recess 222 formed by the heat sink top 116. Additionally or alternatively, the rigid member 120 may be held in a recess in the heat sink base 108. For some embodiments, the flap 118 may replace a fin 110 and take its position. For some embodiments, the flap 118 may replace a longitudinal portion of a fin 110, and after the flap 118, or before the flap 118, in the longitudinal

direction 112, a fin 110 substantially in line with the rigid member 120 in the longitudinal direction 112 may continue. For some embodiments, 30 to 50 mm of the leading end of the fin 110 may be removed and replaced by a flap 118. For some embodiments, the rigid member 120 may be positioned 4 to 10 mm from a leading edge 224 of the longitudinal channel 114. Other distances form the leading edge 224 are also possible. For some embodiments, the spacing between two adjacent fins 110 without any flap 118 therebetween may be 2 to 3 mm. For some embodiments, the spacing between two adjacent fins 110 with a flap 118 therebetween may be 4 to 6 mm. However, other dimensions are possible.

With reference to Fig. 7, aspects of embodiments of the method for producing or manufacturing an apparatus 102 configured to transfer heat from a heat source 104 to a fluid, when the apparatus 102 is connected to the heat source 104, according to the second aspect of the invention are schematically illustrated. The apparatus 102 can be any one of the above-described embodiments of the apparatus 102 according to the first aspect. The method includes the step of attaching 701 one or more flaps 118 having a longitudinal extension 119 in one or more of the longitudinal channels 114. The one or more flaps 118 may be attached in any one of the above-described ways.

The parts or units of the heat sink 106, 206 may be made of any suitable material, for example a heat-conducting material, such as any suitable metal or metal alloy, for example aluminium, copper, or any heat-conducting polymer or polymer composite. As mentioned above, the fluid may be a gas or gas mixture including air, Freon, or any other suitable gas or gas mixture, or the fluid may be a liquid, such as water, or a fluid known under the name R135A or R1233ZD, or any other suitable liquid. For some embodiments, the fins 110 do not have to be parallel to one another.

Embodiments of the invention also comprise a network access node for a wireless communication system, wherein the network access node comprises an apparatus 102, 202 according to any one of the embodiments disclosed above. The network access node herein may also be denoted as a radio network access node, an access network access node, an access point, or a base station, e.g. a Radio Base Station (RBS), which in some networks may be referred to as transmitter, “gNB”, “gNodeB”, “eNB”, “eNodeB”, “NodeB” or “B node”, depending on the technology and terminology used. The radio network access nodes may be of different classes such as e.g. macro eNodeB, home eNodeB or pico base station, based on transmission power and thereby also cell size. The radio network access node can be a Station (STA), which is any device that contains an IEEE 802.11-conformant Media Access Control

(MAC) and Physical Layer (PHY) interface to the Wireless Medium (WM). The radio network access node may also be a base station corresponding to the fifth generation (5G) wireless systems. The network access node may include an active antenna, a remote radio unit (RRU) or a base band processor. The network access node may include one or more antennas. The network access node may have a housing which houses the antenna. Alternatively, the antenna may be mounted outside the housing of the network access node, for example with a distance to the housing of the network access node.

Finally, it should be understood that the invention is not limited to the embodiments described above, but also relates to and incorporates all embodiments within the scope of the appended independent claims.

CLAIMS

1. An apparatus (102; 202) for transferring heat from a heat source (104) to a fluid when the apparatus (102) is connected to the heat source (104), wherein the apparatus (102) comprises a heat sink (106; 206) comprising

a heat sink base (108), and

two or more fins (110),

wherein the fin (110) has a longitudinal extension (111) extending in a longitudinal direction (112),

wherein the heat sink base (108) and the fins (110) form longitudinal channels (114) for streams of the fluid,

wherein the apparatus (102) comprises one or more flaps (118) having a longitudinal extension (119), and

wherein the flap (118) is located in one of the longitudinal channels (114).

2. An apparatus (102; 202) according to claim 1, wherein the heat sink (106; 206) comprises a heat sink top (116), the two or more fins (110) being located between the heat sink base (108) and the heat sink top (116), and

wherein the heat sink base (108), the heat sink top (116) and the fins (110) together form the longitudinal channels (114).

3. An apparatus (102; 202) according to claim 1 or 2, wherein the longitudinal extension (119) of the flap (118) extends in the longitudinal direction (112).

4. An apparatus (102; 202) according to any one of the claims 1 to 3, wherein the flap (118) is configured to flutter from the stream of fluid through the longitudinal channel (114).

5. An apparatus (102; 202) according to claim 4, wherein the flap (118) is configured to flutter in the longitudinal channel (114).

6. An apparatus (102) according to any one of the claims 1 to 5, wherein the flap (118) is configured to provide turbulence in the stream of fluid.

7. An apparatus (102; 202) according to any one of the claims 1 to 6, wherein the longitudinal channel (114) has an inlet (114a) and an outlet (114b) for the stream of fluid, and

wherein the flap (118) is attached at a position adjacent to the inlet (114a) of the longitudinal channel (114).

8. An apparatus (102; 202) according to any one of the claims 1 to 7, wherein the flap (118) is attached in the longitudinal channel (114).

9. An apparatus (102; 202) according to any one of the claims 1 to 8, wherein the flap (118) is attached to one or more of the group of:

- the heat sink base (108);
- the heat sink top (116); and
- the fin (110).

10. An apparatus (102; 202) according to any one of the claims 1 to 9, wherein the apparatus (102) comprises one or more rigid members (120),

wherein the flap (118) is attached to the rigid member (120), and

wherein the rigid member (120) is attached to one or more of the group of:

- the heat sink base (108);
- the heat sink top (116); and
- the fin (110).

11. An apparatus (102; 202) according claim 10, wherein the rigid member (120) is immovable in relation to one or more of the heat sink base (108), heat sink top (116) and fin (110),

wherein the flap (118) comprises a first end portion (118a) and a second end portion (118b),

wherein the longitudinal extension (119) of the flap (118) extends from the first end portion (118a) to the second end portion (118b),

wherein the first end portion (118a) of the flap (118) is attached to the rigid member (120), and

wherein the first end portion (118a) of the flap (118) is immovable in relation to the rigid member (120).

12. An apparatus (102; 202) according to any one of the claims 1 to 11, wherein the flap (118) is spaced apart from the fin (110).

13. An apparatus (102; 202) according to any one of the claims 1 to 12, wherein the heat sink (106; 206) is configured for a fluid in the form of a gas or a gas mixture.

14. A method for producing an apparatus (102; 202) configured to transfer heat from a heat source (104) to a fluid when the apparatus (102; 202) is connected to the heat source (104), wherein the apparatus (102; 202) comprises a heat sink (106; 206) comprising

a heat sink base (108), and

two or more fins (110),

wherein the fin (110) has a longitudinal extension (111) extending in a longitudinal direction (112), and

wherein the heat sink base (108) and the fins (110) form longitudinal channels (114) for streams of the fluid,

wherein the method comprises:

attaching (701) one or more flaps (118) having a longitudinal extension (119) in one or more of the longitudinal channels (114).

15. A network access node for a wireless communication system, wherein the network access node comprises an apparatus (102; 202) according to any one of the claims 1 to 13.

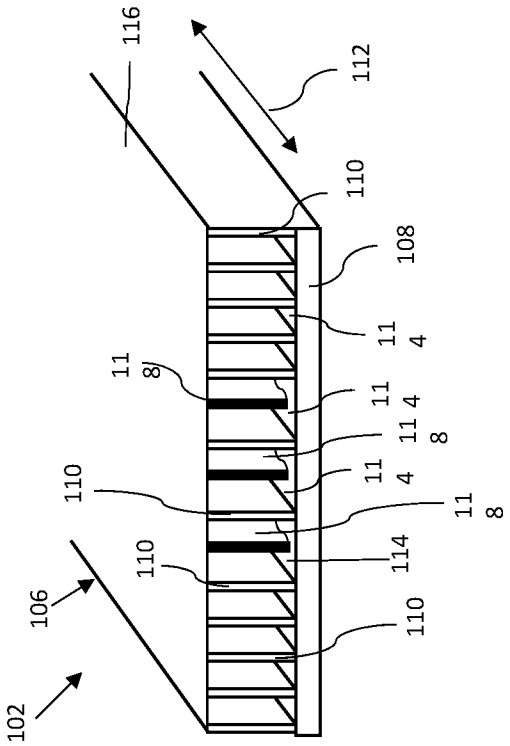

Fig. 2

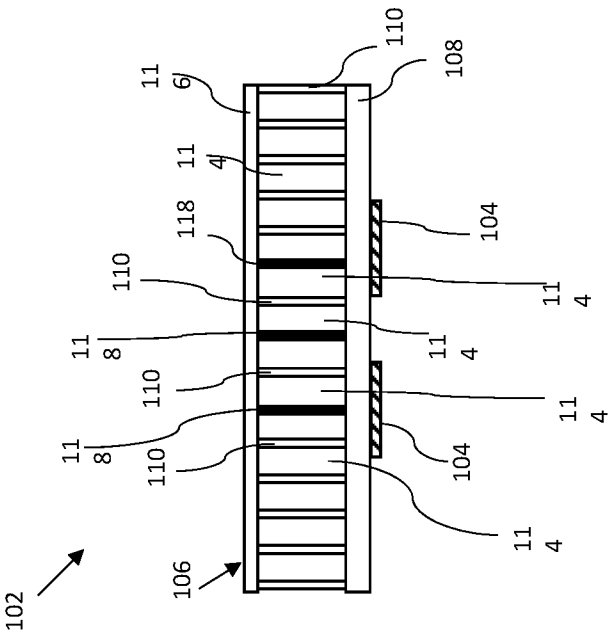

Fig. 1

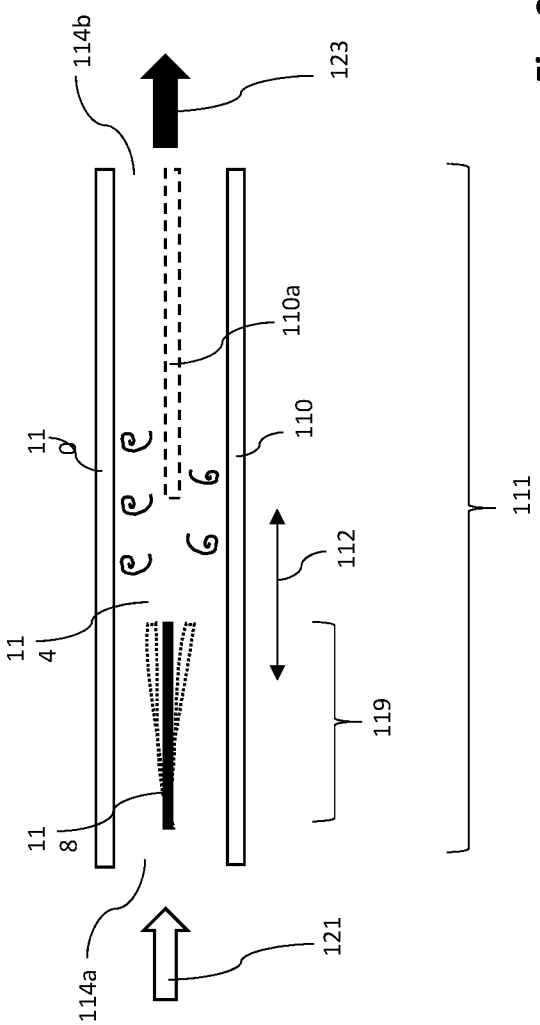

Fig. 3

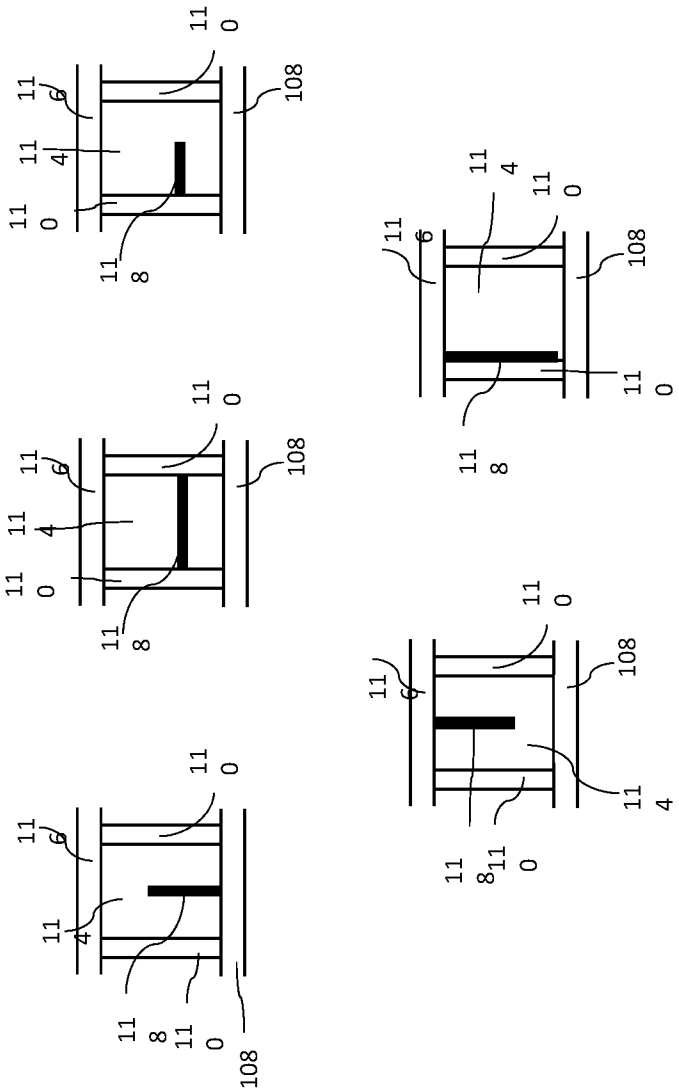
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Fig. 4

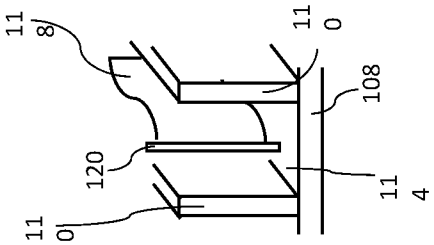


Fig. 5b

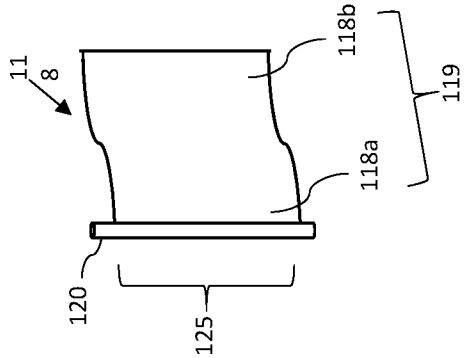


Fig. 5a

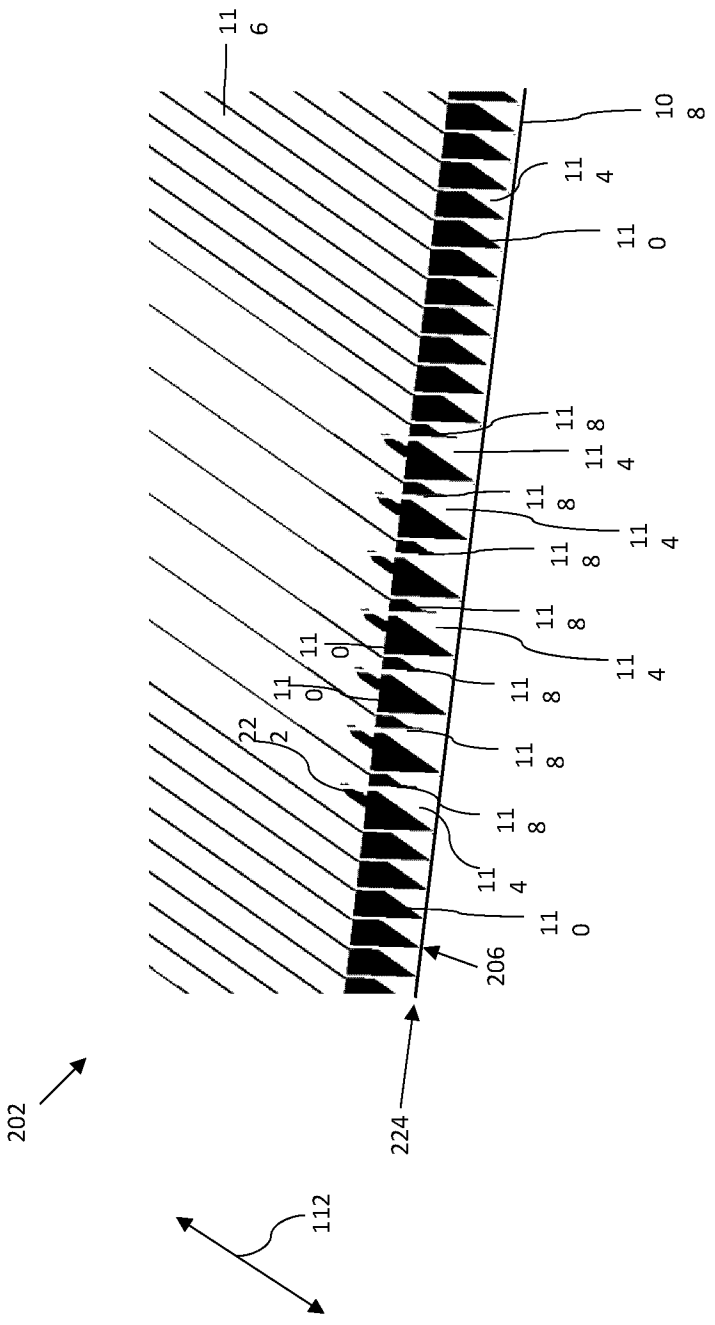
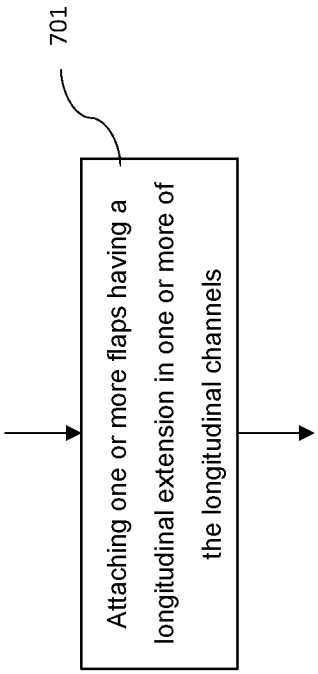


Fig. 6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Attaching one or more flaps having a longitudinal extension in one or more of the longitudinal channels

Fig. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2022/061634

A. CLASSIFICATION OF SUBJECT MATTER
INV. H05K7/20
ADD.

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)
H05K F28F

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	HIDALGO PABLO ET AL: "Small-Scale Vorticity Induced by a Self-Oscillating Fluttering Reed for Heat Transfer Augmentation in Air Cooled Heat Sinks", VOLUME 1: THERMAL MANAGEMENT, 6 July 2015 (2015-07-06), XP093004839, DOI: 10.1115/IPACK2015-48511 ISBN: 978-0-7918-5688-8 Retrieved from the Internet: URL:http://dx.doi.org/10.1115/IPACK2015-48511>	1-9, 12-15
Y	figure 11 page 5, right-hand column, last paragraph - page 6, left-hand column	10,11

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[x] Further documents are listed in the continuation of Box C.

[x] See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 December 2022	20/12/2022

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Prévot, Eric

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Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	US 2012/006511 A1 (KASLUSKY SCOTT F [US] ET AL) 12 January 2012 (2012-01-12) figures 1,2 paragraph [0016] - paragraph [0017]	10,11
A	US 2020/395890 A1 (HUTTING HENDRIK KORNELIS [NL] ET AL) 17 December 2020 (2020-12-17) paragraph [0038] - paragraph [0044] figures 3,4	1-15

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Information on patent family members

International application No
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