



## Electronic Printed Circuit Cooling Device and Embodiment therefor

The present invention relates to the problem posed by the cooling of printed circuits comprising electronic components of diverse sizes, some of which exhibit strong thermal dissipation. It is particularly intended for electronics cards mounted in a rack, for example of the "Double Europe" format. The device according to the invention may be employed particularly for the cooling of simple printed circuits or for the cooling of more complex structures, for example comprising a "mother" printed circuit equipped with a "daughter" printed circuit, the two circuits being connected to each other by connectors installed among the components.

The use of electronics cards mounted in a rack traditionally poses the problem of removing the heat released during operation. This problem is generally resolved by employing forced air circulation, produced with the aid of a ventilation system often integrated in the rack. This forced ventilation generally makes ambient air flow through free spaces existing between the electronics cards mounted in the rack. The passage of ambient air, at the temperature of the room where the rack is located, removes by convection the heat being released and therefore prevents excessive heating of the cards. The method may furthermore be improved if cooled air is circulated instead of ambient air.

This solution presents the advantage of being simple to implement. In particular, it does not impose any design constraint for the electronics cards installed in the rack, and does not necessitate any modification. It furthermore presents the advantage of not complicating the operations of mounting – dismounting the cards in the rack.

However, the removal of heat by means of air circulation reaches its limits as soon as the number of electronics cards inserted in the rack becomes such that the free spaces between cards allow only a small flow of air. The problem is further accentuated if some of the electronics cards comprise components of different heights and components with strong thermal dissipation. The appearance of "hot zones" on the surface of the cards may be observed in this case, where the air flow is locally insufficient to remove the heat and prevent excessive heating of the components. Excessive



heating may in particular give rise to intermittent faults that are difficult to identify, which greatly reduces the reliability of the equipment in question.

Another solution to the problem posed by the removal of heat, particularly in the case of using cards which comprise components with strong thermal dissipation, consists in fitting a metal structure forming a heat sink on the strong dissipation cards, which is applied adequately onto the surface of the electronics card. This structure's face which is in contact with the card generally has a relief corresponding optimally to the impression of the card equipped with its components. This relief makes it best possible to ensure contact of the heat sink with the strong dissipation components. The contact is subsequently completed by applying a thermally conductive material of generally paste-like structure onto the contact surfaces. The electronics card and the heat sink are mechanically assembled, preferably removably, the assembly being mounted integrally in the rack. Methods for producing heat sinks are described in particular by the Applicant in French Patents FR 92 06041 and FR 95 01972.

The heat dissipated by the components is thus removed by conduction, the heat sink itself being cooled depending on the case by convection, thermal conduction on its periphery or, if the thermal dissipation is large, by circulating a coolant in its thickness.

The use of a heat sink as described above presents several drawbacks. Such a heat sink presents the drawback of being specific to the card whose relief it matches: any change of the card's installation entails a corresponding modification of the heat sink. Another drawback is associated with the need to produce close contact between the sink and the surface of the components to be cooled. The need for close contact necessitates precise mechanical production of the heat sink, particularly as regards the shape of the relief corresponding to the impression of the card. Such production generally requires machining, the expense of which may significantly increase the cost price of the electronics card equipped with the heat sink. Furthermore, the necessity of fixing the sink mechanically to the card in order to ensure satisfactory contact means that the maintenance operations of the electronics card are onerous. This is because the replacement of a component involves dismounting the heat sink, then cleaning the card in order to remove the thermally conductive material. Lastly, the cooling

achieved by such a sink is conditioned by the thermal resistance of the sink's constituent material, i.e. its ability to diffuse heat from the hot zones in contact with the faces of the components with strong thermal dissipation, toward the temperature exchange zones. In the case of a sink cooled by fluid circulation, for example, the cooling of a strong dissipation component will be carried out by indirect heat exchange between this component and the fluid through the thermal resistance constituted by the thickness of the wall of the sink.

10 In order to overcome all the aforementioned drawbacks and ensure satisfactory cooling, the device according to the invention has a structure comprising at least:

A rigid, preferably substantially plane wall in particular allowing easy insertion of the device into a rack equipped with electronics cards,

15 A thin, flexible wall with controlled elasticity having a shape similar to that of the rigid wall and of low thermal resistivity, the edges of which adhere to the edges of the rigid walls so as to create a leaktight heat exchange space whose volume can vary.

Means comprising channels such that a coolant can be made to penetrate and diffuse in the heat exchange space.

The device according to the invention presents the advantage of being simple to produce. In particular, its manufacture does not require machining. The contact with the surface of the card to be cooled is achieved by filling the exchange space with the coolant. The device therefore also presents the advantage that it can be used for different versions of electronics cards. Furthermore, the contact of the device and the card is made by pressure and advantageously does not require any mechanical assembly between the card to be cooled and the device.

30 The heat exchange is achieved by circulation of the fluid, which ensures removal of the heat released by the hot surfaces of the card and the fluid across the flexible wall. The heat exchange achieved in this way presents the advantage that it allows uniform cooling of the surface of the card.

The channels are equipped with self-closing nozzles, which advantageously make it possible to disconnect the device according to the invention from the main cooling circuit in a rapid and simple way without loss of fluid.

Other characteristics and advantages will become apparent from the following description. This description is illustrated by Figures 1 to 8, in which:

- Figure 1 shows a schematic representation of the principle of the device according to the invention, seen in its entirety.

10 - Figure 2 shows a schematic representation of the device according to the invention in a cross section.

- Figure 3 shows the illustration of a first exemplary embodiment of the means allowing diffusion of the coolant in the heat exchange space,

15 - Figure 4 shows the illustration of another exemplary embodiment of said means.

- Figure 5 shows the illustration of an alternative embodiment of the flexible wall of the device according to the invention.

20 - Figure 6 shows the illustration of a variant of the device according to the invention, which is applicable to the cooling of a mother printed card equipped with a daughter card.

Figure 1 presents a schematic overall view of the device according to the invention.

25 The device principally comprises three elements, a rigid wall 11, a flexible wall 12 as well as two channels for inlet 13 and outlet 14, producing a communication which ensures diffusion of the fluid in the heat exchange space delimited by the rigid wall and the flexible wall. These channels are equipped with self-close nozzles 15 allowing easy and rapid connection to a cooling circuit.

30 The assembly formed in this way constitutes a semi-rigid pouch which has advantageous properties. In contrast to a completely flexible pouch, the presence of the rigid wall 11 in particular allows the device to retain a defined shape even when no fluid is flowing, and facilitates easier fitting in a rack as well as extraction than a flexible pouch. The device can thus be inserted into  
35 a rack, for example in the space formed between two electronics cards.

Likewise, the flexible wall makes the volume of the pouch variable as a function of the pressure of the coolant flowing in it. When the device is placed in its rack, merely the inflation of the pouch ensures that it is brought in contact with the electronics card placed in the vicinity of its flexible wall.

5 Figure 1 represents the device on its own, filled with coolant. There, the flexible wall 12 is shown as a continuous and uniformly convex surface, the self-closing nozzles advantageously preventing the fluid from flowing out of the device.

10 Figure 2 represents a front view of the device 21 when it is in contact with an electronics card 23. This figure illustrates what happens when the device is operational in a rack.

The passage of the coolant, which takes place under a certain pressure, leads to an increase in the volume of the heat exchange space 22, which is  
15 manifested by a deformation of the flexible wall 12. The latter comes to match the relief of the electronics card 23 and ensures close contact of the device with the surfaces of all the components present on the card, whatever their respective thicknesses are. The flexible wall becomes pressed onto the surface of the components to be cooled, and brings the coolant as close as  
20 possible to the strong dissipation zones. The heat exchange between the components and the coolant takes place across the flexible wall 12, whose small thickness advantageously favors this exchange. The device according to the invention thus ensures efficient and uniform cooling of the entire electronics card 23. Owing to the flexibility of the wall 12, which can match  
25 various reliefs, the device according to the invention presents the advantage that it is not specific to a particular electronics card. The same device can be used in a versatile way with different types of card, installed in different ways and comprising components of varied heights. The mobile wall is advantageously made of a material with good thermal conduction.

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The rack mounting of the device according to the invention may be carried out in a different way depending on whether or not the device for circulating and cooling the fluid is integrated in the rack. If it is, then the bottom of the rack may itself be equipped with self-closing bases intended to  
35 receive the nozzles 15 with which the channels 13 and 14 are equipped. In

this way, the device is fitted by slotting in at a location intended for this purpose, in which case pushing the device into the rack ensures connection of the nozzles and the bases and therefore connection of the device to the fluid flow circuit. If it is not, then the device may be inserted into the rack so  
5 that the self-closing nozzles are directed toward the front of the rack and connected to a flow circuit independent of the rack.

In all mounting scenarios, use of the device involves in particular a preliminary fitting operation and a final purge operation. The device is fitted in  
10 the rack, in proximity to the card to be cooled, preferably when it is empty of any fluid. It therefore occupies a minimal volume. It is utilized by circulating the fluid, which increases the volume of the exchange space 22 delimited by the fixed wall and the mobile wall 12, which becomes pressed onto the electronics card. By flowing through the space 22, the fluid passes in  
15 immediate proximity to the components with strong thermal dissipation and removes the heat, thus producing the cooling. The device is removed from the rack, for example after use or in order to take off the electronics card in contact with the device, after having purged the device of the fluid which it contains, in which case this purge may be carried out by suction of the fluid  
20 through the flow circuit. The space 22 then again occupies a minimal volume and, since the device no longer comes in contact with the electronics card 23, it can be extracted from the rack after having disconnected the self-closing nozzles.

25 Implementation is simplified in the particular case in which, for a given reason, the device according to the invention is not mechanically linked to the electronics card which it cools. In this particular case, the electronics card – cooling device assembly will be inserted into the rack then extracted from the rack together. The drainage operation is not then necessary.

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In order to obtain uniformly efficient cooling of the entire surface of the electronics card, the fluid circulation should genuinely take place uniformly throughout the exchange space 22 delimited by the rigid wall and the flexible wall. To this end, the device according to the invention comprises

means which ensure diffusion of the fluid uniformly in the space 22. Figures 3 and 4 illustrate two possible embodiments of these means.

Figure 3 represents a simple first exemplary embodiment. The tubes 13 and 14 in this example, for example of square or round cross section, are pierced at regular intervals with orifices which are open toward the interior of the exchange space 22. The fluid penetrating into the device through the tubes 13 is diffused into the exchange space 22 through the orifices 31, uniformly over the length of one of the edges delimiting this space. By crossing the exchange space, it passes in contact with the hot surfaces of the electronics card, where the heat exchange takes place, then emerges heated from the exchange space through the orifices 32 of the tube 14.

Such an embodiment presents the advantage of being simple to produce. The communication is achieved simply on the basis of the tubes 13 and 14 which have been perforated, and which may furthermore be made mechanically secure to the fixed wall 11. The dispersion of the fluid across the surface to be cooled takes place tangentially, from one edge of the card to the other.

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Figure 4 represents a second exemplary embodiment of the means which permit uniform diffusion of the coolant.

In this example, the diffusion of the fluid takes place across the rigid wall. The fluid enters the device according to the invention through the channel 41, which directs it into the space formed in the thickness of the rigid wall whose internal face 43 is pierced regularly with orifices 44, which ensures diffusion of the fluid in the exchange space 22 delimited by the rigid wall and the flexible wall (not shown here). The channel 42 ensures flow of the fluid out of the device. This channel, which is similar to the channel 14 in the example of Figure 3, is in the form of the tube pierced with orifices distributed regularly over its length.

The means described in this second example have a more complex structure than those described in the previous example. This embodiment requires, in particular, the production of a hollow rigid wall one face of which is pierced with an orifice, which is more complex to produce than a simple wall.

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Nevertheless, these means ensure uniform diffusion of the fluid throughout the volume of the exchange space. The diffusion takes place perpendicularly to the surface of the electronics card, thus making it possible for cooled fluid to arrive uniformly over the entire surface. The heat exchange between the fluid and the components of the card is thus carried out a very homogeneously.

Figures 1 to 4 illustrate the description of the device according to the invention in its basic form, which is intended particularly to be used for cooling electronics cards mounted in a rack. As explained above, the device is installed in the rack in the manner of an electronics card, in proximity to the card to be cooled. Under the effect of the flow of the fluid at a controlled pressure, the exchange space constituted by the rigid wall and the flexible wall increases in volume so that the flexible wall comes to match the relief of the card. The contact established in this way allows heat exchange between the fluid and the surfaces of the card dissipating heat. This device presents the advantage that it has a simple structure and is versatile, the same device being usable to cool electronics cards comprising different components and installed differently.

For their part, the following figures present some alternative embodiments making it possible in particular to adapt the device according to the invention to particular constraints.

Figure 5 illustrates a particular embodiment in which the surface of the flexible wall 51 is not uniform but has deformations 52-53 of variable heights, which allow this surface to fit more easily to the relief of the electronics card to be cooled. This embodiment is particularly suitable for cards equipped with components whose heights are very substantially different. This is because it is necessary to substantially increase the pressure of the coolant in order for the flexible wall of a more standard device as described above to correctly match the relief of such cards, which is not always possible or desirable. The presence of relief zones on the surface of the flexible wall advantageously makes it possible to resolve this problem.

The effect of these pre-moulded deformations in the flexible wall of the device is to personalize it, the moulding of the flexible wall being intended to

adapt the device to a particular card or type of cards. Unlike a metal heat sink, moreover, the moulding does not require any particular production accuracy, fitting to the surface in contact being carried out by filling the exchange space 22 with the fluid at a slight pressure. This alternative  
5 embodiment of the device according to the invention, which is easy to produce, therefore constitutes an advantageous alternative to the use of a metal heat sink.

Figure 6 illustrates another alternative embodiment 63 of the  
10 device according to the invention, which is intended for cooling an electronics card 61 equipped with a daughter card 62. To this end, the rigid wall 65 and the flexible wall 64 are pierced with a slot allowing the inter-card connectivity 66 to be passed through in the manner of a lifebelt. The device furthermore comprises a second pouch constituted by the free face of the rigid wall 65  
15 and a second flexible wall 67, which is adapted to the size and relief of the daughter card.

Thus, in so far as the faces on which the components are installed oppose one another, it is advantageously possible to cool all of the electronics card with a single device.

20 This last alternative embodiment may of course be extended to the simultaneous cooling of two independent electronics cards by a single device according to the invention. The device then comprises two flexible walls, each adhering by the edges to one of the faces of the rigid wall. The assembly thus forms two semi-rigid pouches. The device produced in this  
25 way has the advantage of comprising only a single circuit for diffusion of the coolant.

**CLAIMS**

1. A device for cooling electronics cards mounted in a rack, characterized in that it comprises at least:

- a substantially plane rigid wall (11, 63),
- 5       - a flexible wall (12, 64) with controlled elasticity adhering by its edges to one of the faces of the rigid wall and constituting with the rigid wall a heat exchange space (22) of variable volume,
- means (13, 14) making it possible for a coolant to flow and diffuse in the heat exchange space, said means comprising self-closing
- 10       nozzles (15) which facilitate assembly and disassembly of the device, the flow of the fluid at a controlled pressure in the heat exchange space causing the volume of said space to increase so that the flexible wall matches the relief of the card to be cooled, the heat exchange between the electronics card and the coolant thus taking place over the entire surface of
- 15       the card.

2. The device as claimed in claim 1, characterized in that the flexible wall (51) comprises preformed relief parts (52, 53) making it possible to improve the contact of said flexible wall during operation with the surface

20       of an electronics card comprising components of substantially different sizes.

3. The device as claimed in either one of claims 1 and 2, characterized in that it is adapted to cooling an electronics card equipped with a daughter card, the heat exchange space having at least one slot

25       allowing the inter-card connectivity elements to pass through, the device comprising a second flexible wall (67) which forms with the free face of the rigid wall a second heat exchange space intended to cool the daughter card.

4. The device as claimed in any one of the preceding claims,

30       characterized in that the diffusion of the coolant in the heat exchange space takes place from one edge of the exchange space toward the opposite edge by means of tubes having perforations (31, 32) spaced regularly over their length.

5. The device as claimed in any one of the claims 1 to 3, characterized in that the diffusion of the coolant in the heat exchange space takes place uniformly throughout the space, the fluid being conveyed in a space made in the rigid wall and penetrating into the exchange space through orifices (44) made regularly over the face of the rigid wall delimiting the exchange space.