

COOLING DEVICE FOR COOLING A PLURALITY OF HEAT-EMITTING ELECTRONIC COMPONENTS ARRANGED ON A CIRCUIT BOARD, AND SYSTEM COMPRISING THE COOLING DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to a cooling device for cooling a plurality of heat-emitting electronic components arranged on a circuit board, and a system comprising such a cooling device and a circuit board with a plurality of electronic components arranged on it.

Electronic components such as CPUs or GPUs that emit heat during operation require cooling; in this connection, both the cooling capacity and the efficiency of the cooling are decisive for the efficiency of the electronic components.

In systems that have a plurality of circuit boards with heat-emitting electronic components, the cooling of the electronic components or more precisely, the removal of heat from the electronic components is a space and cost problem.

These days, such systems are also being made ever more compact or more systems are being provided in an extremely cramped space, which is disadvantageous for the cooling so that there is also an increase in the required cooling capacity and in the power that the cooling consumes.

Purely passive cooling devices, which cool the components exclusively by means of cooling fins, for example, are often unsuitable in this connection due to their often insufficient cooling capacity. Even conventional cooling systems with fans often have an insufficient cooling capacity or require so much

power to sufficiently cool the electronic components that the power consumption for the cooling is often almost half the total power consumption of the system.

The prior art already includes various alternatives to pure passive cooling and to pure air cooling based on fans or blowers.

Liquid-based cooling systems are one alternative, especially since the heat emission to water is roughly 100 times greater than to air; even higher values can be achieved with other liquid coolants. It is thus possible to carry away a comparatively large amount of heat with comparatively small water-filled tubes.

In the prior art, there have basically been three different alternatives for liquid-based cooling systems up to this point.

The first is a classic water cooling in which individual electronic components are each associated with a heat sink through which water or another cooling medium is pumped, usually via flexible tube lines. In this case, however, it is problematic that an automated production is either impossible or can only be achieved with difficulty because of the presence of the flexible tube lines. In addition, leaks can occur due to aging phenomena and installation errors. It is also disadvantageous that only the components that contact the heat sinks are cooled.

Alternatively to this, an immersion cooling is known in the prior art. In this case, the entire system or more precisely the circuit boards of the system are positioned in an immersion bath so that the liquid can circulate around and cool all of the components. To achieve this, however, a low-corrosion, nonconductive, liquid coolant such as oil must be used as the cooling liquid or cooling medium. Solutions of this kind, however, are usually difficult to seal so that leaks and “water” damage are likely. In addition, such systems are heavy and

not portable because of the large quantity of liquid that is required for them. If conductive foreign objects get into the system or more precisely into the liquid, short-circuiting of the circuit boards can also occur.

A relatively new solution also provides a cooling by means of a mixed system or more precisely by means of two liquids that are separate from each other. Directly against the circuit board or more precisely, the components arranged on it, a nonconductive, low-corrosion liquid in a sealed system is provided, which absorbs the heat from the components and transmits it to a directly adjacent liquid-cooled plate. Another cooling medium circulates through the plate and in this way, carries away the heat. Since such systems can be embodied in a sealed way and do not require any individual flexible tubes at least directly on the circuit board, they are relatively easy to produce; because of the quantities of liquid used, they remain relatively heavy.

The object of the invention, therefore, is to overcome the above-mentioned disadvantages and to provide a cooling device for cooling a plurality of heat-emitting electronic components arranged on a circuit board, which is simultaneously simple and cost-effective to produce and, with a comparatively low weight, enables an effective cooling of the plurality of components arranged on the circuit board.

This object is attained with the combination of features according to claim 1 and claim 12.

According to the invention, a cooling device is proposed for cooling a plurality of heat-emitting electronic components arranged on a circuit board. The cooling device has a distributor unit and at least one cooling satellite. The distributor unit, which is preferably embodied as dimensionally stable, has a coolant inlet and a coolant outlet, and can be flowed through by a coolant from its coolant inlet to its coolant outlet along a predetermined and fixed coolant path. The at least one cooling satellite is anchored to the distributor unit in a

predetermined spatial position relative to the distributor unit and has a heat sink, a coolant inlet, and a coolant outlet. The heat sink of the at least one cooling satellite can be contacted over a large area with at least one electronic component of the plurality of electronic components. In addition, the coolant can flow through the cooling satellite from its coolant inlet to its coolant outlet along the coolant path, with the coolant path extending through the distributor unit and the at least one cooling satellite as well as along parts of the heat sink of the cooling satellite.

The basic inventive idea, therefore, is to provide a distributor unit in which a cooling satellite or a plurality of cooling satellites is provided by means of which particular electronic components of the circuit board are selectively contacted and cooled. In this case, the distributor unit, which can be provided in the form of a distributor plate, has a fixed and predetermined position relative to the circuit board and is preferably dimensionally stable, thus enabling a simple and automated assembly. In addition, the distributor unit or more precisely, the coolant transported therein, can absorb not only the heat that is transported via the cooling satellites, but also heat that is transported by means of other heat-transporting phenomena to the distributor unit or more precisely to the coolant that is conveyed therein so that the electronic components of a circuit board can be divided into two groups. A first group is provided to be cooled directly by the cooling satellites and a second group whose electronic components do not rest directly against the cooling satellites, can use other heat-transporting phenomena to emit heat to the distributor unit, which heat is absorbed by the latter and carried away.

Both the distributor unit and the cooling satellites can respectively have a plurality of coolant inlets and a plurality of coolant outlets through which a flow can pass along a coolant path or along a plurality of parallel coolant paths.

This advantageously permits the cooling device to be embodied in a

modularized way and permits the cooling device to be arranged individually for different circuit boards. Circuit boards are usually of a standard size so that for all circuit boards of a given size, the same distributor unit can be provided, which itself is of a particular shape and size that are adapted to the size of the circuit board. Depending on the position of the electronic components on the circuit board that are to be cooled directly, the cooling satellite or cooling satellites can be placed

in a grid or freely on the distributor unit; the coolant inlet and coolant outlet of the cooling satellite or the coolant inlets and coolant outlets of the cooling satellites must be fluidically connected to a cooling duct provided in the distributor unit so that a flow passes through each cooling satellite along a combined flow path or along different flow paths of the coolant from the coolant inlet to the coolant outlet of the distributor unit.

For this purpose, an advantageous modification of the cooling device includes the fact that the distributor unit is embodied as flat or frame-shaped. In a particularly advantageous variant, the distributor unit is embodied as flat and in the form of a distributor plate and more preferably, has a length and width equal to the length and width of the circuit board.

The distributor unit is also in particular embodied as at least partially hollow and on its interior, has one or more cooling ducts; the flow path of the coolant or more precisely, the coolant path is partially defined by the cooling duct(s) of the distributor unit and by the cooling satellites.

If the distributor unit is embodied as frame-shaped, then the circuit board or more precisely, the electronic components arranged on it is/are at least partially flanked. This particularly also includes an embodiment in which the distributor unit is embodied of two parts and the circuit board is positioned between the parts of the distributor unit so that the parts or more precisely the layers of the distributor unit are positioned diametrically opposite from each

other relative to the circuit board and the parts of the distributor unit are spaced apart from each other by the width or length of the circuit board.

A variant of the cooling device, in which the distributor unit has a cooling surface, which when used properly, is oriented facing the electronic components on the circuit board, is also advantageous. More preferably, the cooling surface is oriented parallel to the surface of the circuit board or orthogonal to it. In this case, the cooling surface is used to absorb heat that is emitted – for example by means of convection or through the air between the electronic components and the cooling surface – by electronic components of the circuit board, which are not in contact, or at least not directly in contact, with one of the cooling satellites, and that is absorbed by the cooling surface.

As has already been described above, an embodiment of the cooling device in which the interior of the distributor unit has at least one cooling duct that defines the coolant path is advantageous. The cooling duct in this case is used both for transporting the coolant from the cooling duct inlet of the distributor unit to the cooling duct inlets of the respective cooling satellites and for transporting away the heat from a possibly present cooling surface of the distributor unit so that by means of the coolant, which flows through the cooling duct or cooling ducts, the heat absorbed from the cooling satellites and also the heat directly absorbed by the distributor unit can be transported out of the cooling device.

In an alternative and likewise advantageous variant, the cooling device includes the fact that the cooling duct is composed of multiple parts. In addition, a first part of the cooling duct extends from the coolant inlet of the distributor unit to the coolant inlet of a cooling satellite and a second part of the cooling duct extends from the coolant outlet of a cooling satellite to the coolant outlet of the distributor unit.

In this case, depending on the exact embodiment of the cooling device,

multiple different subvariants are possible.

In a first variant, one part of the cooling duct fluidically connects the coolant inlet of the distributor unit to all of the coolant inlets of the cooling satellites. A second part of the cooling duct also fluidically connects all of the coolant outlets of the cooling satellites to the coolant outlet of the distributor unit. The cooling satellites in this case are arranged fluidically parallel to one another.

In a second variant, the cooling satellites are arranged fluidically in series. A first part of the cooling duct fluidically connects the coolant inlet of the distributor unit to the coolant inlet of a first cooling satellite. A second part of the cooling duct fluidically connects the coolant outlet of the first cooling satellite to the coolant inlet of a second cooling satellite. This design, i.e. the connection of the cooling satellites in series through parts of the cooling duct that connect the cooling satellites to one another, can optionally extend to the last of the series-connected cooling satellites. A last part of the cooling duct connects the coolant outlet of the last cooling satellite to the coolant outlet of the distributor unit.

A third variant includes a mixture of the first two variants in which groups of cooling satellites arranged fluidically in series are fluidically connected to one another in parallel.

In order to insure the most effective possible cooling of the cooling surface of the distributor unit, an advantageous variation of the cooling device includes the fact that the cooling duct extends in a meandering fashion in the distributor unit. Through a smooth meandering curve, it is simultaneously possible to form a fixed pattern or grid, which allows the cooling satellites to be fastened to the distributor unit in a particularly simple way and fluidically connected to the cooling duct. For example, the meandering curve can be marked or recognizable on the cooling surface of the distributor unit so that from the

outside, for example by means of drilling, the cooling duct can be opened and a section of the cooling satellite such as the supply line or discharge line explained below can be inserted into it.

There is also an advantageous variant of the invention in which the distributor unit has two layers, which are separate from each other, are fluidically connected only by means of the at least one cooling satellite, and can be flowed through by the coolant. The layers can be positioned right next to or adjoining each other or can be spaced apart from each other. The coolant inlet of each cooling satellite in this case is fluidically connected directly to a first layer of the two layers or more precisely, is connected directly to a part of the cooling duct extending in the first layer. In addition, the coolant outlet of each cooling satellite is fluidically connected directly to a second layer of the two layers or more precisely, is directly connected to a part of the cooling duct extending in the second layer. In addition, the coolant inlet of the distributor unit is positioned and fluidically connected in the first layer and the coolant outlet of the distributor unit is positioned and fluidically connected in the second layer. Correspondingly, the coolant inlet of the distributor unit is preferably fluidically connected to the part of the cooling duct that extends in the first layer and the coolant outlet of the distributor unit is preferably fluidically connected to the part of the cooling duct that extends in the second layer.

In order to connect the at least one cooling satellite to the distributor unit both mechanically and fluidically, an advantageous variant of the cooling device also includes the fact that a cooling satellite and preferably each of the cooling satellites has at least one tubular supply line and one tubular discharge line. The tubular supply line fluidically connects the coolant inlet of the cooling satellite to the heat sink. The tubular discharge line fluidically connects the heat sink to the coolant outlet of the cooling satellite. Preferably, the cross-sectional area of the supply line through which the coolant can flow corresponds to the flow-through cross-sectional area of the discharge line and particularly with a

serial or series connection of the cooling satellites, also corresponds to the flow-through cross-sectional area of a cooling duct provided in the distributor unit, thus enabling a uniform volumetric flow of the coolant along the entire coolant path. Correspondingly, the flow of coolant passes through the supply line and discharge line so that the supply line and discharge line each define a section of the coolant path. The supply line and discharge line connect the cooling satellite to the distributor unit and anchor it thereto. In addition, the supply line and discharge line also keep the cooling satellite in the predetermined position relative to the distributor unit.

Possible cross-sectional shapes for the supply line and discharge line include both angular shapes and round shapes. Preferably, the supply line and discharge line are embodied spaced apart from each other, wherein there is also an advantageous variant in which the supply line and discharge line are arranged coaxial to each other. In this case, it is particularly advantageous that the respective inner line can be simultaneously connected to the heat sink and/or be integrally embodied by it and that the inner line thus serves as a cooling fin or cooling surface that the coolant flowing through the outer line circulates around. In this case, it is advantageous if the outer line extends into a first layer of the distributor unit and the inner line extends into a second layer of the distributor unit, which, viewed from the cooling satellite, is positioned behind the first layer.

It is also advantageous if the supply line and/or the discharge line has a width or diameter that corresponds to the width or diameter of the cooling duct in the distributor unit so that the cooling duct in the distributor unit is sealed by an insertion of the supply line or discharge line into the cooling duct and the coolant must flow through an opening provided in the supply line or discharge line. For this purpose, in the section with which the supply line or discharge line extends into the distributor unit, the supply line and/or discharge line is provided with a preferably lateral opening through which the coolant can flow

out of the cooling duct of the distributor unit into the supply line or, respectively, out of the discharge line into the cooling duct of the distributor unit.

An advantageous embodiment variant of the cooling device includes the fact that the at least one cooling satellite adjacent to the heat sink forms a hollow space, which defines a section of the coolant path and can be flowed through by the coolant. The at least one cooling satellite also has cooling fins connected to the heat sink in the hollow space.

Preferably, this is also accompanied by the fact that the cooling fins extend into the supply line and/or discharge line so that the coolant circulates around the cooling fins already in the supply line and/or discharge line.

If several cooling satellites are provided, then these can also be embodied differently with regard to the length of the section of the coolant path that is defined by the cooling satellites. For example, if a first cooling satellite is to cool an electronic component that requires a more powerful cooling in comparison to another electronic component provided on the circuit board, then the heat sink of the first cooling satellite can be embodied with a larger area and the section of the coolant path extending along the heat sink can be embodied as longer so that more heat can be absorbed and carried away by the coolant flowing through the first cooling satellite. A cooling capacity that is adapted to the respective component to be cooled can also be achieved by means of a local variation of the flow speed of the coolant at the component and the resulting flow effects. The respective cooling satellites are also adapted to the respective electronic component and have supply lines and discharge lines with different lengths, for example, so that despite the different dimensions of the electronic components, the cooling satellites can fit against them properly.

For fastening a respective cooling satellite to the respective electronic

component, the embodiment can also include the fact that the respective cooling satellite is pressed against the electronic component by the anchoring of the distributor plate relative to the circuit board or more precisely, by connecting elements of the distributor plate for anchoring it to the circuit board. Alternatively, a fastening socket can also be provided on at least some of the cooling satellites so that the respective cooling satellites can be anchored directly to the circuit board and can be pressed against the respective electronic component.

In order to be able to anchor the distributor unit and the entire cooling device in a predetermined position relative to the circuit board, the distributor unit is provided with connecting elements for anchoring the distributor unit to the circuit board. The connecting elements have a predetermined position relative to the at least one cooling satellite so that by positioning the distributor unit against the circuit board with the connecting elements, the cooling satellites can simultaneously be positioned on the respectively associated components to be cooled. Correspondingly, the distributor unit can be placed in a predetermined position relative to the circuit board and the cooling satellites can be placed in a predetermined position relative to or on the electronic components.

In addition, the cooling device can have a housing or frame, which is embodied to accommodate the distributor unit and the cooling satellites as well as the circuit board. The housing can also be embodied to accommodate the circuit board. Alternatively, the housing can be open on one side, wherein the circuit board can be inserted into the opening and thus constitutes a cover that closes the open hollow space of the housing. The housing can also integrally form the connecting elements and can thus define the predetermined position or more precisely, the maintaining of the predetermined position of the distributor unit relative to the circuit board.

Another aspect of the invention also relates to a system with a cooling device according to the invention and a circuit board with heat-emitting electronic components arranged on it. In this case, the distributor unit of the cooling device has a predetermined position relative to the circuit board while the heat sink of the at least one cooling satellite is in contact with at least one of the electronic components. The heat sink in this case can be in direct contact with the electronic component; it is also possible for the heat sink to be in contact with the electronic component indirectly via a heat-conducting means such as a thermally conductive pad or thermal paste.

Another advantageous variant of the system is one in which the distributor unit is embodied as flat in the form of a distributor plate and is positioned parallel to and at a predetermined distance from the circuit board and the at least one cooling satellite is positioned between the circuit board and the distributor plate, wherein a supply line and a discharge line of the cooling satellite extend to the distributor plate orthogonally to the circuit board. Alternatively, the distributor unit is embodied as frame-shaped. In this alternative, the distributor unit at least partially surrounds or flanks the circuit board and/or the electronic components arranged on it, wherein preferably the respective layers or sections of the distributor unit are positioned opposite from each other and the cooling satellites are positioned between these sections or layers and fluidically connect them to each other.

Another advantageous embodiment of the system is one in which the system includes a housing while the circuit board and/or the distributor unit integrally form(s) a section of the housing. In this case, the electronic components and the cooling satellites are positioned in an internal space formed by the housing.

In this case, the distributor unit can have a cooling surface, which integrally forms an inner surface of the housing that is oriented toward the internal

space so that heat emitted by the electronic components is at least partially absorbed by the cooling surface and can be carried away via the distributor unit or more precisely, by the coolant flowing through it.

One variant also includes the fact that the housing has a ventilation opening through which the internal space is open to the outside and for example air can flow through the internal space so that in addition to the liquid cooling, an air cooling can also be implemented at the same time.

Another aspect that should also be mentioned is a method for producing the cooling device. This particularly includes the fact that a uniform distributor unit is provided for a plurality of circuit boards. Depending on the position of the electronic components on the circuit board that are to be cooled, openings are then produced in the distributor unit and after this, the supply lines and the discharge lines of the cooling satellites are inserted into these openings; the supply lines and discharge lines are embodied in such a way that the heat sinks of the respective cooling satellites contact the respective electronic components and at the same time, the distributor unit is in the predetermined position relative to the circuit board.

The features disclosed above can be combined in any way provided that this is technically possible and the combined features do not conflict with one another.

Other advantageous modifications of the invention are disclosed in the dependent claims and will be described in greater detail below in conjunction with the description of the preferred embodiment of the invention based on the figures. In the drawings:

Fig. 1 shows a first variant of a cooling device and a system comprising a cooling device and a circuit board;

- Fig. 2 shows a second variant of a cooling device and a system comprising a cooling device and a circuit board;
- Fig. 3 shows a third variant of a cooling device;
- Fig. 4 shows a fourth variant of a cooling device;
- Fig. 5 shows a fifth variant of a cooling device in a first view;
- Fig. 6 shows the fifth variant of a cooling device in a second view;
- Fig. 7 shows a first variant of a cooling satellite;
- Fig. 8 shows the first variant of the cooling satellite in a cutaway view;
- Fig. 9 shows a second variant of a cooling satellite;
- Fig. 10 shows the heat sink of the second variant of the cooling satellite;
- Fig. 11 shows a third variant of a cooling satellite;
- Fig. 12 shows a schematic diagram of a first variant of a cooling device that has two layers;
- Fig. 13 shows a sixth variant of a cooling device;
- Fig. 14 shows a schematic diagram of a second variant of a cooling device that has two layers;

The figures are schematically depicted examples. The same reference numerals in the figures are used to indicate the same functional and/or structural features.

Figs. 1 and 2 each show a respective variant of a cooling device 1 together with a circuit board 2 whose electronic components 3 are contacted by the cooling satellites 20 of the cooling device 1 and can be cooled by them.

The cooling device 1 in Figs. 1 and 2 together with the respective circuit board 2 thus simultaneously corresponds to a system 1' composed of the cooling device 1 and the circuit board 2.

The circuit board that is provided by way of examples in Figs. 1 and 2 has three respective electronic components 3 to be cooled; in a different embodiment, more or fewer electronic components 3 requiring cooling can also be provided. The cooling device 1 is respectively adapted to the circuit board and for example has cooling satellites 20 that correspond to the number of electronic components 3 to be cooled and are placed in a corresponding arrangement.

In addition to the electronic components 3 to be cooled, other electronic components that are not shown here can also be provided on the circuit board, which are not or do not have to be cooled directly by the cooling satellites 20 of the cooling device 1.

A distributor unit 10 with two layers 101, 102 is provided in each of the variants of the cooling device 1 disclosed in Figs. 1 and 2. The two layers 101, 102 of the distributor unit 10 are fluidically separate or more precisely, are connected only via the three respective cooling satellites 20 that are fluidically connected in parallel between the layers 101, 102.

Starting from the coolant inlet 11 of the distributor unit 10 that is fluidically connected to the first layer 101, the coolant is guided along a coolant path that is not shown in Figs. 1 and 2 to the three cooling satellites 20, flows through these to the second layer 102 of the distributor unit 10, and is conveyed to the coolant outlet 12 of the distributor unit 10. As it flows through the cooling satellites 20, the coolant absorbs heat, which the electronic components 3 have emitted to the respectively adjacent cooling satellites 20, and transports it away.

The distributor units 10 that are embodied as frame-shaped in the variants shown in Figs. 1 and 2 each form one or more cooling surfaces 13 extending orthogonally to the circuit board 2, which also absorb heat emitted by the components of the circuit board 2 and transmit it to the coolant so that it is even possible to cool the components that are not directly cooled by means of the cooling satellites 20.

The cooling satellites 20 used in the variant according to Fig. 2 will be explained in detail in the description relating to Fig. 11. The cooling satellites 20 of the variant according to Fig. 1 are basically identical in design, but are embodied as flatter; in this case, the supply line 24 and discharge line 25 of the respective cooling satellite 20 from the variant in Fig. 2 extend so that they directly adjoin the circuit board 2.

Figs. 3 and 4 each disclose a respective embodiment of the cooling device 1 in which a distributor unit 10 is provided with only one layer. The respective distributor unit 10 is positioned parallel to the circuit board that is not shown so that the cooling satellite 20 or cooling satellites 20 is/are positioned between the circuit board and the distributor unit 10.

In the variant shown in Fig. 3, a flat distributor unit 10 or distributor plate is provided on which an individual cooling satellite 20 is positioned. The latter is embodied of one piece and is integral to the distributor unit 10. In addition, openings or open spaces 15 are provided in the distributor unit 10 for the sake of saving material and weight.

In the distributor units 10, as shown in Figs. 3 and 4, a respective cooling duct, not shown, is embodied, which defines the coolant path through the distributor unit 10 and the cooling satellites 20. The cooling duct can be embodied of one piece or of several pieces and can connect existing cooling satellites 20 in parallel or serially/in series relative to the coolant inlet 11 of the distributor unit 10 and the coolant outlet 12 of the distributor unit 10.

Figs. 5 and 6 show another advantageous variant of a cooling device 1, wherein the cooling device 1 is shown in Fig. 5 in an oblique view from below so that the cooling satellites 20, 20' provided on the distributor unit 10 and the cooling surface 13 of the distributor unit 10 oriented toward the electronic components 3 of a circuit board 2, not shown, are visible. In this case, the distributor unit 10 is likewise embodied as a flat distributor plate with a single layer in which the coolant is conveyed through a cooling duct 14 of the kind shown in Fig. 6 from the coolant inlet 11 of the distributor unit 10 to the coolant outlet 12 of the distributor unit 10. The cooling satellites 20, 20' are positioned fluidically in series with each another so that the cooling duct 14 is subdivided into a plurality of sections or parts by the supply lines 24 and discharge lines 25 of the two cooling satellites 20, 20'. A first part 141 of the cooling duct 14 leads from the coolant inlet 11 of the distributor unit 10 to the coolant inlet 21 of a first cooling satellite 20, a third part 143 of the cooling duct 14 leads from the coolant outlet 22 of the first cooling satellite 20 to the coolant inlet 21 of a second cooling satellite 20', and a second part 142 of the cooling duct 14 leads from the coolant outlet 22 of the second cooling satellite 20 to the coolant outlet 12 of the distributor unit 10. In this case, the individual parts 141, 142, 143 of the cooling duct 14 or more precisely, the entire cooling duct 14 extend(s) in a meandering fashion in the distributor unit 10 so that the coolant that flows through the cooling duct 14 cools the entire cooling surface 13 of the distributor unit 10 and carries away the heat.

The cooling duct 14 in the distributor unit 10, as is shown in Fig. 6, can for example be embodied in such a way that the distributor plate is made of a solid material and the cooling duct 14 is milled into it; the top side that is opened as a result of this, as shown in Fig. 6, is then closed by a cover.

In the variant shown in Figs. 5 and 6, two different cooling satellites 20, 20' are provided, which basically differ only in the form of their supply line 24 and discharge line 25. Alternatively, two identical cooling satellites 20, 20' can

also be provided. In the first cooling satellite 20, the supply line 24 and discharge line 25 each have a rectangular flow-through cross-section or more precisely, are embodied as rectangular tubes. The second variant of the cooling satellite 20' includes a round flow-through cross-section for the supply line 24 and discharge line 25 or more precisely, provides a round tube for each of them. In both variants of the cooling satellites 20, 20', the width or diameter of the supply line 24 and discharge line 25 is preferably equal to the width of the cooling duct 14 so that the cooling duct 14 is closed by the insertion or installation of the supply line 24 and discharge line 25 of the cooling satellites 20, 20' and the coolant must flow through the coolant inlets 21 and coolant outlets 22 of the cooling satellites 20, 20' or generally speaking, through the cooling satellites 20, 20'.

The variant of the first cooling satellite 20 from Figs. 5 and 6 is shown in greater detail in Figs. 7 and 8, with Fig. 8 showing a schematic cross-section through the cooling satellite 20. As has already been described above, the supply line 24 and the discharge line 25 are each provided with a respective rectangular tube, which extends from a base body 28 to the coolant inlet 21 and to the coolant outlet 22 of the cooling satellite 20. A hollow space 26 that adjoins the heat sink 23 is defined in the base body 28, wherein the heat sink 23 is preferably composed of a material with a particularly good thermal conductivity such as copper. In addition, the heat sink 23 is embodied for its side oriented away from the hollow space 26 to be contacted by an electronic component 3 of the circuit board 2 directly or via a heat-conducting means. The coolant path P or more precisely the section of the coolant path P extending in the cooling satellite 20 leads from the coolant inlet 21, through the supply line 24 into the hollow space 26, and from the hollow space 26 through the discharge line 25 to the coolant outlet 22 of the cooling satellite 20. The coolant path P extends adjacent to the heat sink 23 in the hollow space 26. The coolant path P can extend in a meandering fashion in the hollow space, wherein the

hollow space 26 can be correspondingly embodied for this or has baffle elements that define coolant path P.

A modification of the variant of the cooling satellite 20 from Figs. 7 and 8 is disclosed in Figs. 9 and 10. In the cooling satellite 20, as shown in Figs. 9 and 10, cooling fins 27 are provided, which are anchored to the heat sink 23 or are embodied integrally with it. The cooling fins 27 are made of a material such as copper, which has a favorable thermal conductivity. The exemplary embodiment shown includes the fact that the cooling fins 27 extend into the supply line 24 and

discharge line 25 of the cooling satellite 20 and essentially to the coolant inlet 21 or coolant outlet 22 of the cooling satellite 20. Heat that is transmitted to the heat sink 23 can therefore be transmitted or emitted to the coolant via the cooling fins 27 over a larger area and along a longer section of the coolant path P and can thus be transported away more effectively.

The variant of the cooling satellite 20 shown in Fig. 11 should preferably be used with an embodiment of the cooling device 1 in which, as shown in Fig. 2, two separate layers 101, 102 of the distributor unit 10 are to be connected to each other fluidically by means of one or more cooling satellites 20. The cooling satellite 20 in Fig. 11 basically also includes a base body 28, which is connected to a heat sink 23, not shown, and defines a hollow space 26, likewise not shown, on its interior. The hollow space 26 is connected to the coolant inlet 21 of the cooling satellite 20 via the in this case round, tubular supply line 24 and to the coolant outlet 22 via the in this case round, tubular discharge line 25, wherein the section of the coolant path extending in the base body can be embodied as meandering, as is also indicated in Fig. 14.

In the variants of the cooling device that are shown in Figs. 12 to 14, the distributor unit 10 is respectively divided into a first layer 101 and a second

layer 102, wherein the schematic depiction according to Fig. 14 basically corresponds to the functionality of the respective cooling device 1 from Figs. 1 and 2.

Fig. 12 shows a distributor unit 10, which has a first layer 101 and a layer 102 directly adjoining it. In this case, the first layer 101 corresponds to a distributor for cold coolant in which the coolant is conveyed from the coolant inlet of the distributor unit to all of the coolant inlets 21 of the cooling satellites 20. The coolant flows via the cooling satellites 20 into the second layer 102 and in the course of this, is heated in the cooling satellite 20. In the second layer 102, the coolant from all of the cooling satellites 20 is collected and conveyed to the coolant outlet of the distributor unit. The coolant path P is thus divided into a plurality of sections P1, P2, P3. The coolant is supplied to all of the cooling satellites 20 via the first section P1 of the coolant path. A second section P2 of the coolant path respectively extends through a cooling satellite 20. A third section P3 of the coolant path defines the path of the coolant in the second layer 102 and leads from the coolant outlets 22 of the cooling satellites 20 to the coolant outlet 12 of the distributor unit 10 or more precisely of the second layer 102.

The schematic depiction in Fig. 12 corresponds to the variant in Fig. 13 in which it is evident that a section of the supply line 24 extends through a second layer 102 into a first layer 101 of the distributor unit 10 and a section of the discharge line 25 extends only into the second layer 102, but not into the first layer 101. In this case, the layers 101, 102 of the distributor unit 10 are not embodied as completely congruent, but instead define respective sections in which the layers 101, 102 directly adjoin each other. The distributor unit 10 or more precisely the layers 101, 102 also define(s) open spaces 15 provided for the sake of saving material and weight. In this case, it is advantageous that sections can also be provided in which only one of the layers 101, 102 is present.

Fig. 14 shows a variant of the cooling device 1 or more precisely the system 1' in which the distributor unit 10 is composed of two layers 101, 102 that are spaced apart from each other. The layers 101, 102 are fluidically connected by means of the cooling satellites 20, wherein the cooling liquid or coolant from the coolant inlet 11 in the first layer 101 is distributed along the section P1 of the coolant path P to all of the cooling satellites 20, the coolant flows along the respective section P2 of the coolant path P through the cooling satellites 20 and absorbs heat in the process, and the coolant is collected along the section P3 of the coolant path in the second layer 102 and conveyed to the coolant outlet 12 of the distributor unit 10.

The embodiment of the invention is not limited to the preferred exemplary embodiments disclosed above. On the contrary, there are a number of conceivable variants that make use of the disclosed solution, even with fundamentally different embodiments.

WE CLAIM

1. A cooling device (1) for cooling a plurality of heat-emitting electronic components (3) arranged on a circuit board (2),
 wherein the cooling device (1) has a distributor unit (10) and at least one cooling satellite (20),
 wherein the distributor unit (10) has a coolant inlet (11) and a coolant outlet (12) and a coolant can flow through it from its coolant inlet (11) to its coolant outlet (12) along a predetermined and fixed coolant path (P),
 wherein the at least one cooling satellite (20) is anchored to the distributor unit (10) in a predetermined spatial position relative to the distributor unit (10) and has a heat sink (23), a coolant inlet (21), and a coolant outlet (22),
 wherein the heat sink (23) can be contacted over a large area with at least one electronic component (3) of the plurality of electronic components (3) and the coolant can flow through the cooling satellite (20) from its coolant inlet (21) to its coolant outlet (22) along the coolant path (P),
 wherein the coolant path (P) extends through the distributor unit (10) and the at least one cooling satellite (20) as well as along parts of the heat sink (23) of the cooling satellite (20).
2. The cooling device according to claim 1,
 wherein the distributor unit (10) is embodied as flat or frame-shaped.
3. The cooling device according to claim 1 or 2,
 wherein the distributor unit (10) has a cooling surface (13),
 which when used properly, is oriented facing the electronic components (3) on the circuit board (2).

4. The cooling device according to one of the preceding claims,
wherein the interior of the distributor unit (10) has at least one cooling duct (14) that defines the coolant path (P).
5. The cooling device according to the preceding claim,
wherein the cooling duct (14) is composed of multiple parts and a first part (141) of the cooling duct (14) extends from the coolant inlet (11) of the distributor unit (10) to the coolant inlet (21) of a cooling satellite (20) and a second part (142) of the cooling duct (14) extends from the coolant outlet (22) of a cooling satellite (20) to the coolant outlet (12) of the distributor unit (10).
6. The cooling device according to one of the preceding claims 4 or 5,
wherein the cooling duct (14) extends in a meandering fashion in the distributor unit (10).
7. The cooling device according to one of the preceding claims,
wherein the distributor unit (10) has two layers (101, 102) that are separate from each other, are fluidically connected only by means of the at least one cooling satellite (20), and can be flowed through by the coolant,
wherein the coolant inlet (21) of each cooling satellite (20) is fluidically connected directly to a first layer (101) of the two layers (101, 102) and the coolant outlet (22) of each cooling satellite (20) is fluidically connected directly to a second layer (102) of the two layers (101, 102),
and wherein the coolant inlet (11) of the distributor unit (10) is provided in the first layer (101) and the coolant outlet (12) of the distributor unit (10) is provided in the second layer (102).

8. The cooling device according to one of the preceding claims,
 - wherein a cooling satellite (20) has at least one tubular supply line (24), which fluidically connects the coolant inlet (21) of the cooling satellite (20) to the heat sink (23), and one tubular discharge line (25), which fluidically connects the heat sink (23) to the coolant outlet (22) of the cooling satellite (20),
 - the supply line (24) and the discharge line (25) each define a section of the coolant path (P), and
 - the cooling satellite (20) is connected by the supply line (24) and discharge line (25) to the distributor unit (10) and anchored to it and is kept in the predetermined position relative to the distributor unit (10).
9. The cooling device according to one of the preceding claims,
 - wherein the at least one cooling satellite (20) adjacent to the heat sink (23) forms a hollow space (26), which defines a section of the coolant path and can be flowed through by the coolant,
 - wherein in the hollow space (26), the at least one cooling satellite (20) has cooling fins (27) connected to the heat sink (23).
10. The cooling device according to the preceding claims 8 and 9,
 - wherein the cooling fins (27) extend into the supply line (24) and/or discharge line (25).
11. The cooling device according to one of the preceding claims,
 - wherein on the distributor unit (10), connecting elements are provided for anchoring the distribution unit (10) to the circuit board (2),
 - wherein the connecting elements have a predetermined position relative to the at least one cooling satellite (20), and
 - the distributor unit (10) can be placed in a predetermined position relative to the circuit board (2) and the cooling satellites (20) can

be placed in a predetermined position relative to the electronic components (3).

12. A system (1') with a cooling device (1) according to one of the preceding claims and a circuit board (2) with heat-emitting electronic components (3) arranged on it, wherein

the distributor unit (10) of the cooling device (1) has a predetermined position relative to the circuit board (2) and the heat sink (23) of the at least one cooling satellite (20) is in contact with at least one of the electronic components (3).

13. The system according to the preceding claim,

wherein the distributor unit (10) is embodied as flat in the form of a distributor plate and is positioned parallel to and at a predetermined distance from the circuit board (2) and the at least one cooling satellite (20) is positioned between the circuit board (2) and the distributor plate (10), wherein a supply line (24) and a discharge line (25) of the cooling satellite (20) extend to the distributor plate (10) orthogonally to the circuit board (2) or

the distributor unit (10) is embodied as frame-shaped and at least partially surrounds the circuit board (2) and/or the electronic components (3) arranged on it.

14. The system according to one of the two preceding claims,

wherein the system (1') includes a housing (30) and wherein the circuit board (2) and/or the distributor unit (10) integrally form a section of the housing (30),

wherein the electronic components (3) and the at least one cooling satellite (20) are positioned in an internal space formed by the housing (30).

15. The system according to the preceding claim,
 wherein the distributor unit (10) has a cooling surface (13),
 which integrally forms an inner surface of the housing (30) that is oriented toward the internal space