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- (73) Patenthaver: **SEW-EURODRIVE GmbH & Co. KG, Abt. ECG, Ernst-Blickle-Strasse 42, 76646 Bruchsal, Tyskland**
- (72) Opfinder: **PRAUTZSCH, Harald, Dieselstrasse 4, 73479 Ellwangen, Tyskland**
- (74) Fuldmægtig i Danmark: **Zacco Denmark A/S, Arne Jacobsens Allé 15, 2300 København S, Danmark**
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**US-A1- 2002 162 678**  
**US-B1- 6 787 896**



**Description**

5 The invention relates to a device and to an electronic instrument, for example for monitoring or determining a temperature, and to a method for determining, monitoring and/or recording the temperature of a cooling member and of a heat source.

Heat sources of this kind occur, for example, in power semiconductors, cooling circuits, combustion chambers and reaction chambers.

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EP 0 654 176 discloses a fastening device for semiconductor switch elements, wherein semiconductor switch elements attached to a circuit board are pressed against a cooling member.

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DE 692 09 772 discloses a housing arrangement for a functional component, wherein an electronic circuit is arranged in a cavity and said cavity is filled with an electrically insulating fluid.

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DE 198 07 718 discloses an electronics assembly, wherein a clamp grips a circuit substrate and the clamp comprises a connection contact in a through-opening of a housing, said contact being connected to the conducting tracks of the circuit substrate.

25

DE 199 20 401 discloses an arrangement and a method for temperature estimation, wherein measuring the temperatures of two sensors provides the temperature of an electronic apparatus.

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The website of Quick-Ohm Küpper & Co. GmbH, Wuppertal/Germany, dated 16 March 2005, discloses thermal adhesives having thermal conductivities of 7.5 W/mK and higher. The website of Quick-Ohm Küpper & Co. GmbH, dated 25 December 2003, discloses heat-conducting foils consisting of carbon fibre composite.

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The data sheet published by Philips Semiconductors, Eindhoven/Netherlands, for the line "KTY82-1", dated 26 March 1998, discloses silicon temperature sensors that have a positive temperature resistance coefficient and can be used in measurement and control systems.

US 5 831 333 A discloses an arrangement and a method for controlling the contact site temperature of a semiconductor chip in an electronic system, wherein a temperature sensing apparatus is arranged in the same covering as the semiconductor chip, as a result of which the temperature of the temperature sensing apparatus very closely corresponds to the actual contact site temperature.

EP 1 498 947 A2 discloses an electronic circuit comprising a power semiconductor component and a protection means for protecting the power semiconductor component from overheating, wherein a power semiconductor component is attached to a cooling member in a heat-conducting manner by a metal housing surface, wherein a semiconductor component is attached to a first outer surface of the circuit substrate in a heat-conducting manner by a protection means and the cooling member is applied to a second outer surface of a circuit substrate, wherein the outer surfaces are connected in a heat-conducting manner. The circuit substrate does not comprise any internal layers.

EP 1 455 391 A1 discloses a power semiconductor module having a sensor component, wherein a sensor component is arranged directly on a main surface of an insulator member by a mounting surface and is in thermally conductive contact with a cooling member on its side facing away from the insulator member.

US 6 787 896 B1 discloses a semiconductor assembly, wherein a multilayer substrate has a core having a core thickness, and an upper face and a lower face, wherein a semiconductor slice is arranged on the upper face of the multilayer substrate and wherein a heat spreader is arranged on the lower face, wherein the substrate has a first metal covering, at least one via and a second metal covering, the first metal covering is arranged beneath the semiconductor slice and is thermally coupled thereto, the at least one via is arranged beneath the first metal covering and in the core of the multilayer substrate, the second metal covering is arranged beneath the at least one via and is thermally coupled to the heat spreader, and the at least one via establishes a connection between the multilayer substrate and the heat spreader, wherein the at least one via is of a length that substantially corresponds to the core thickness.

US 20020005272A discloses a cooling system for a multichip module, wherein electronic components are linked to a cooling member by means of flexible foils.

US 20020157821A1 discloses a thermal regulation system for a plurality of loads having a plurality of serial evaporation apparatuses, wherein a PID controller is used to vary the mass flow rate of a coolant.

- 5 US 5 522 215 A discloses a wafer cooling device, wherein PID controllers are used to actuate Peltier elements, which cool a wafer to a predetermined temperature.

US 2002/0162378 A1 discloses an electronic apparatus, wherein the heat from an electronic component is conducted into a neutral conductor layer of a substrate by means of through-  
10 holes that are formed directly beneath the electronic component and filled with thermal grease, and from there is conducted into the atmosphere. In a further example embodiment, a conventional screw is used to fasten a housing to a substrate.

The problem addressed by the invention for a device or electronic instrument is that of  
15 bringing a sensor as close as possible to the temperature level of a cooling member.

According to the invention, the problem in relation to the device is solved according to the features stated in claim 1, the problem in relation to the electronic instrument is solved according to the features stated in claim 12, and the problem in relation to the method for  
20 determining the temperature of a heat source, in particular of a power semiconductor, is solved according to the features stated in claim 15.

Essential features of the invention in relation to the electronic instrument are stated in claim 12. In particular, said instrument comprises a circuit board equipped with a sensor, and a  
25 cooling member, the sensor being connected to the cooling member in a heat-conducting manner.

In this respect, it is advantageous that the temperature of power semiconductors or other heat sources can be determined, and so the risk of overheating can be avoided. In  
30 particular, safety is thus increased. By means of the improved temperature determination, the control characteristics of the electronic instrument are also improved.

According to the invention, in the electronic instrument the circuit board is releasably connected to the cooling member. In this respect, it is advantageous that no additional  
35 intermediate elements are required.

According to the invention, in the electronic instrument the circuit board is a multilayer circuit board and thus has multiple layers. It is thus possible to have vias between the conducting tracks of various layers. In this way, advantageous electrical or thermal conditions can be achieved.

In an advantageous design, those metal regions of the internal layers that are provided in the spatial vicinity of the sensor are electrically connected to at least one metal region on the surface facing the cooling member. In this respect, it is advantageous that a good heat-conducting connection to the cooling member is established and that metal regions have a higher thermal conductivity than the circuit board substrate material, in particular so as to achieve substantially the same temperature level as the cooling member in those regions of the internal layers that are spatially close to the sensor, in particular those whose distance from the points at which the parts of the sensor contact the circuit board is less than the thickness of the circuit board. As a result, the sensor is even more effectively coupled to the temperature level of the cooling member.

In an advantageous design, the metal region on the surface facing the cooling member is connected to the cooling member electrically and/or at least in a heat-conducting manner. In this respect, it is advantageous that thermal paste can be used, for example, to improve the heat transfer. However, direct contact is also already sufficiently thermally conductive. In this way, not only is the electric potential equalised, but so too is the temperature. The heat of the cooling member can thus be introduced into the circuit board – like electric current on the conducting tracks, the heat preferably flows on the metal conducting tracks in the process.

In an advantageous design, a fastening element is used for the connection. In this respect, it is advantageous that a cost-effective element such as a screw or the like can be used.

In an advantageous design, the electrical connections comprise vias. In particular, connection elements of the sensor on the surface facing the cooling member are electrically connected by means of soldered connections, the connection elements of the sensor being connected by means of vias to conducting tracks of the surfaces facing away from the cooling member or to internal layers of the circuit board. In this respect, it is advantageous that the sensor signals can be diverted over short paths into other conducting tracks that have large creepage paths to the potential of the cooling member. However, the heat of the

cooling member can also be transported into internal layers in a simple manner, in particular to establish a homogeneous temperature level in the internal layers of the circuit board.

5 In an advantageous design, the soldered connections are implemented by means of SMD technology. In this respect, it is advantageous that mass production can be provided.

In an advantageous design, the metal regions comprise or substantially consist of copper, in particular they are conducting tracks of the circuit board. In this respect, it is advantageous that high electrical and thermal conductivity can be produced by a single material.

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In an advantageous design, the cooling member is connected to cooling surfaces of power semiconductors in a heat-conducting manner, in particular either directly or indirectly by means of at least one ceramic plate or other thermally conductive materials, e.g. heat-conducting foil. In this respect, it is advantageous that high thermal conductivity is provided for dissipating the heat of the power semiconductors to the cooling member, but also that a large insulating gap can be produced between the cooling member and the power semiconductors.

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Essential features of the invention in relation to the method for determining the temperature of a heat source, in particular of a power semiconductor, are stated in claim 15. In particular, the heat source is connected to a cooling member in a heat-conducting manner and the sensor is connected to the cooling member in a heat-conducting manner, wherein

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- the temperature of the sensor is determined,
- a measure for the temperature increase within a time period is determined,
- 25 - the temperature of the heat source is determined from the total of the temperature of the sensor and the measure multiplied by a correction factor associated with the temperature increase.

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In this respect, it is advantageous that the method is very simple to carry out, in particular to program, and requires only minimal amounts of storage resources and computing power.

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In an advantageous design, the measure for the temperature increase within a time period is determined by determining the difference between the latest and the closest previously measured temperature of the sensor, the time period between the measurements of the sensor temperature always being the same or substantially the same. In a corresponding

design, the measure for the temperature increase within a time period is determined by determining the gradient of the curve over time of the sensor temperature, i.e. the first time derivative. In this respect, it is advantageous that the manner of discovering the temperature functions simply and quickly but still leads to an adequate result in many technical applications.

In particular, in an additional advantageous design, a table of correction factors is used instead of the correction factor, a correction factor being assigned to each gradient value and/or to each ambient temperature value and/or to other variables and being used accordingly. In this respect, it is advantageous that the aforementioned method can be improved further.

In an additional advantageous design, in the method a converter uses and/or records the detected temperature for control purposes when supplying power to an electric motor.

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In an additional advantageous design, in the method, if a predefined threshold for the temperature detected by the sensor is exceeded

- the pulse-width-modulation frequency and/or the power supply of the converter is reduced,
- 20 - the converter is switched off
- and/or a warning signal is sent to the system operator.

The dependent claims set out further advantages.

25 The invention will now be described in greater detail on the basis of drawings, in which:

Fig. 1 is a sectional view of a device according to the invention,

Fig. 2 is a sectional view of another device according to the invention,

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Fig. 3 is a sectional view of a third device according to the invention,

Fig. 4a is a plan view of a fourth device according to the invention,

Fig. 4b is a plan view of an internal layer of a multilayer circuit board of the fourth device according to the invention.

5 In the device according to the invention in accordance with Fig. 1, the circuit board 1 is designed as a multilayer circuit board and thus comprises a plurality of planes in which copper tracks can be provided.

The circuit board 1 is connected to the cooling member 6 by a screw acting as a fastening means 2 for the purpose of releasable connection.

10

On the side of the circuit board 1 facing the cooling member, a sensor 4 is soldered on by its connection tabs 5. Said sensor is advantageously designed in SMD technology. From these soldered contacts, an electrical connection in the form of a via is provided through all the layers of the circuit board 1 in order to connect to conducting tracks on the top of the circuit board 1. The measurement signals of the sensor are thus passed on to the top of the circuit board 1 by means of said vias, as a result of which a sufficient insulating gap can be provided between the signal lines and the electrically conductive cooling member.

15

This also makes it possible to electrically and thus also thermally connect conducting tracks in other planes, in particular internal layers of the multilayer circuit board 1, above the sensor to copper regions on the underside of the circuit board, which regions can be brought into direct contact with the cooling member. As a result, the temperature level of the cooling member is also imparted on the sensor by means of the internal layers of the circuit board. The sensor is, so to speak, surrounded or embedded in the temperature level of the cooling member, although the cooling member itself does not fully surround said sensor.

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In particular, the fastening means 2, which presses the circuit board 1 and thus also the aforementioned copper regions on the underside of the circuit board against the cooling member 6, is also used for the thermal connection.

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In addition, the fastening means 2 is used to mechanically connect the circuit board 1 to the cooling member 6. The circuit board and the cooling member are thus connected by means of a fastening element for releasably connecting the cooling member to the circuit board, for example by a screw.

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The sensor 4 is arranged in a recess in the cooling member 6 that is filled with thermal paste 3. Advantageously, the recess can be filled before the sensor 4 is mounted.

5 The recess is designed and dimensioned such that the necessary air gaps and creepage paths to the sensor and its connections are adhered to.

In addition, in regions that are not visible in Fig. 1, the circuit board 1 is equipped with power semiconductors, e.g. IGBTs, the cooling surfaces of which are connected to the cooling member 6 in a heat-conducting manner. For this purpose, the cooling surfaces can be  
10 connected to the cooling member either directly or indirectly by means of a ceramic plate.

Advantageously, the sensor 4 is designed as a temperature sensor for monitoring the temperature of the power semiconductors. By means of this temperature detection, precise control of the power semiconductors is improved.

15

Primarily, the sensor is coupled to the cooling member 6 in a very thermally conductive manner, i.e. with low heat transfer resistance. The cooling member is directly or indirectly connected to the cooling surfaces of the power semiconductors in a very thermally conductive manner. The sensor 4 is arranged in the spatial vicinity of the power  
20 semiconductors. Therefore, the heat flowing from the power semiconductors via the cooling member only requires short time periods. The temperature curve at the sensor follows the temperatures inside the power semiconductors or the temperatures of the cooling surfaces of the power semiconductors with a lag time of a few seconds. Advantageously, the arrangement is configured such that the lag time is between 1 second and 1 minute or  
25 3 minutes. After this lag time, the temperature of the sensor reaches the stationary value, within the limits of measurement accuracy, if a constant power loss is predefined at the power semiconductor.

In the example embodiment shown in Fig. 2, a circuit board 1 is connected to a cooling  
30 member 6. This connection is established by means of a screw 2.

A sensor 4 is attached to the side of the circuit board 1 facing away from the cooling member 6.

As a multilayer circuit board, the circuit board 1 comprises metal regions in internal layers, which have internal tracks 8, which, due their high thermal conductivity, impart the temperature of a cooling member 6 on the circuit board 1 and in particular in the spatial vicinity of the sensor 4. In this respect, the thermal conductivity of the internal tracks 8 is considerably higher than that of the substrate material 11 of the multilayer circuit board. It is advantageous to use metal materials such as copper or copper alloys for the internal tracks, and plastics materials such as epoxy resin for the substrate material of the multilayer circuit board.

10 In this case, the spatial vicinity of the sensor should be understood as being all the spatial points whose spatial distance from the sensor 4, including the connection tabs 5 or connection devices thereof, is less than the thickness of the circuit board 1.

To establish the thermal link, at least the screw 2 is also used between the cooling member 6 and the internal tracks 8. In this respect, it is advantageous that the hole 10 for the screw 2 is lined with an electrical conductor in the manner of a via, as a result of which the thermal link from the internal tracks 8 to the screw 2 and thus to the cooling member 6 is improved. It is also advantageous that on the circuit board side facing the screw head, metal surfaces are arranged, which establish good thermal contact to the internal layers of the circuit board.

20 To establish the thermal link between the cooling member 6 and the internal tracks 8, in the regions of the circuit board 1 that contact the cooling member 6, metal regions are provided on the circuit board surface and are connected to the internal tracks 8 electrically and in a heat-conducting manner at least by means of the metal-lined hole 10. As a result, a very high heat transfer coefficient is achieved for the heat transfer between the cooling member 6 and internal tracks 8.

The high thermal conductivity of the internal tracks 8 ensures that the imparted temperature close to the sensor 4 is substantially the same as the temperature of the cooling member 6. Due to the low heat capacity of the internal tracks 8, the temperature also follows the changes in the temperature of the cooling member.

35 The exactness of the equalisation of these two temperatures depends on the precise physical characteristics of the thermal link from the internal tracks 8 to the cooling member 6 and on their precise heat capacities. In the process, the geometric configuration of the

internal layers and of the mechanical link from the circuit board to the cooling member is thus selected such that the heat capacities and the heat transfer resistance from the cooling member 6 to the sensor 4 are low.

- 5 The heat is conducted to the temperature sensor 4 at least via the connection tabs 5 and the lines connected thereto in the sensor 4.

The internal tracks 8 shown schematically in Fig. 2 comprise two layers of conducting tracks. In this respect, it is advantageous that the thermal link is improved.

10

The internal tracks 8 of the circuit board 1 are connected to vias 9. Therefore, different internal tracks 8 are electrically and thermally connected to one another and/or to metal surfaces of the circuit board 1, as a result of which the internal tracks 8 can impart the temperature of the cooling member 6 in the vicinity of the sensor 4 in an improved manner.

- 15 In particular, homogeneous temperature distribution can advantageously be achieved.

On the surface of the circuit board 1 facing the sensor 4, structures comprising insulating regions 7 and electrical conducting tracks are provided, by means of which structures the sensor 4 is electrically connected to an evaluation unit (not shown) by means of connection  
20 tabs 5. Said conducting tracks are guided such that a sufficient electrical insulating gap, in particular according to standard EN 61800-5-1, from those metal regions having the electric potential of the cooling member is adhered to. As a result, the sensor 4 can advantageously be operated at a different electric potential from that of the cooling member. In particular, therefore, the sensor can be incorporated in a switching circuit (not shown) without any  
25 complex galvanic decoupling arrangements.

- In the example embodiment according to the invention shown in Fig. 3, the surface where the cooling member 6 bears on the circuit board 1 does not extend in the regions that are opposite the sensor 4 on the side of the circuit board 1 facing away from said sensor. The  
30 sensor 4 is thus mounted in a region of the circuit board whose spatial distance from the contact surface between the cooling member and the circuit board is a multiple, greater than one, of the length of the sensor 4. In this respect, it is advantageous that the sensor 4 can be positioned in a flexible manner while a very good thermal link from the sensor 4 to the temperature level of the cooling member is still possible, in particular by means of internal  
35 tracks 8. Depending on the requirements on the quality of the thermal link, the distance of

the sensor from the contact surface between the cooling member and the circuit board is considerably greater than ten times the length of the sensor.

5 The invention also covers configurations in which the sensor 4 is arranged spatially separate from the cooling member 6 in the sense of the previous paragraph but still on the same side of the circuit board 1 as the cooling member 6.

10 In the example embodiment according to the invention shown in Fig. 4a, a multilayer circuit board 1 on which a sensor 4 is mounted is shown. This sensor 4 is connected to the circuit board 1 by means of connection tabs 40. By means of connection tracks 41 on the circuit board 1, the sensor 4 is connected to an evaluation unit (not shown).

15 A silicon temperature sensor from the line "KTY82-1" from Philips Semiconductors is preferably used as the sensor.

20 A cooling member 6 is connected to the circuit board 1 by means of a screw (not shown) guided through a drilled hole 42. On its surface facing away from the cooling member, the circuit board 1 comprises a metal region 44, which is connected to the head of the screw electrically and thus in a heat-conducting manner.

25 An insulating region 43 is formed around the sensor 4 and electrically isolates the sensor 4 from the electrical potential of the cooling member. In particular, the geometric design of the insulating region 43 is configured according to standard EN 61800-5-1 and depending on the potential difference between the sensor 4 and cooling member 6.

30 Vias 9 establish an electrical and thus also a heat-conducting connection between the metal region 42 and metal regions of the internal layers, i.e. internal tracks, of the circuit board 1.

35 Fig. 4b is a plan view of an internal layer 45 of this kind. On said layer, internal tracks 46 are provided, which are connected to the metal regions 44 on the surface by means of vias 9. Said internal tracks 46 also extend in particular to portions 47 that are arranged beneath the sensor 4 when viewed in plan view. A very good thermal link from the sensor 4 to the cooling member 6 is thus created, while at the same time ensuring safe electrical isolation of potential differences.

Due to the plurality of vias 9 used and the internal tracks, a very good thermal link from the sensor 4 to the cooling member is achieved.

5 If, for example, the insulating region 43 creates a gap of approximately 3 mm from the metal region 44 to the connection tabs 40 of the sensor, and if the internal tracks 46 of the multilayer circuit board are approximately 200  $\mu\text{m}$  away from the surface of the circuit board, electrical potential differences of approximately 300 V can be achieved between the sensor 4 and cooling member 8, while at the same time ensuring a very good thermal link between the sensor 4 and cooling member 6.

10

In a further example embodiment according to the invention, the cooling member comprises recesses that enclose parts of the circuit board that is connected to the sensor. In this respect, it is advantageous in particular that the cooling member partly assumes a housing function for the circuit board and that the heat transfer resistance between the circuit board and the cooling member is particularly low.

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In a further example embodiment according to the invention, the sensor 4 is connected to the circuit board 1 by means of connection tabs (5, 40) in SMD technology.

20 In a further example embodiment according to the invention, the sensor 4 is a semiconductor sensor or a platinum resistance sensor, for example of the type pt100 or pt1000.

In a further example embodiment according to the invention, the cooling member is connected to at least one power semiconductor in a very thermally conductive manner. In this respect, it is advantageous that a temperature measure for the temperature of the power semiconductor can be determined by means of the sensor.

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In a further example embodiment according to the invention, the cooling member is connected in a heat-conducting manner to cooling surfaces of power semiconductors either directly or indirectly by means of at least one ceramic plate. In this respect, it is advantageous firstly that the cooling member is electrically insulated from the power semiconductors, and secondly that the heat transfer between the power semiconductors and the cooling member has a high heat transfer coefficient.

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In a further example embodiment according to the invention, other releasable or non-releasable connections instead of the screws 2 are used to connect the circuit board and cooling member. In this respect, integral bonds such as adhesive connections, soldered connections or welded connections, and/or connections using rivets, clamping and/or  
5 latching connections are advantageous.

In a further example embodiment according to the invention, the sensor 4 is at least integrally bonded to the circuit board 1, the connection in particular comprising an adhesive connection, the adhesive connection between the circuit board and the sensor in particular  
10 having a lower heat transfer resistance than a connection between the sensor and the circuit board via connection tabs of the sensor. The sensor is thus secured on the circuit board by means of a heat-conducting adhesive. In particular, this adhesive is applied in the regions corresponding to the regions denoted by 20 in Fig. 1 to 3. The adhesive has a thermal conductivity of 7.5 W/mK or higher. By way of example, the thermal adhesive Quick cool  
15 from Quick-Ohm Küpper & Co. GmbH, Wuppertal/Germany can be used. In this example embodiment, it is advantageous that the thermal link from the sensor 4 to the internal tracks 8 is improved and that the material stress, caused by thermal processes, on the soldered connection of the connection tabs of the sensor on the circuit board is reduced.

20 In further example embodiments according to the invention, the electronic instrument is a television, a frequency converter, an inverter, a power converter, a lighting console, a phase control, a switched-mode power supply, a DC chopper or generally an instrument having a semiconductor relay or thyristor.

25 In a further example embodiment according to the invention, instead of the electrical instrument, an instrument is provided that has a heat source connected to a housing part, for example a cooling member. This cooling member is connected to a multilayer circuit board according to this invention. In this way, the heat source can be monitored in a simple and robust manner.

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In a further embodiment according to the invention, the cooling member is a part of the housing of an internal combustion engine or is connected thereto in a very thermally conductive manner. In this respect, it is advantageous that the temperature of an internal combustion engine can be monitored in a simple manner by means of the sensor.

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In a further example embodiment according to the invention, the cooling member is a component of a heating system. In this respect, it is advantageous that the temperature of heating members and/or combustion chambers of the heating system can be determined and monitored by the sensor 4.

5

In a further example embodiment according to the invention, the cooling member is a component of a chemical system for carrying out chemical reaction processes. In this respect, it is advantageous that the temperature of tanks in the chemical system, and thus the temperature of the substances involved in the chemical reaction, can be determined and monitored by the sensor 4.

10

In a further example embodiment according to the invention, the cooling member is a component of a cooling circuit, for example in a power station. In this respect, it is advantageous that a decentralised temperature monitoring circuit can be created in a manner that is robust, cost-effective and simple to maintain.

15

It has now been found that the determined temperature of the sensor can be used as follows to ascertain the temperature of the power semiconductor and/or cooling member:

20 Preferably, the power semiconductors are operated in a pulse-width-modulated manner, in particular in an electronic instrument such as a converter or the like.

The power loss of the power semiconductors is determined from electrical measured variables such as current and voltage, and from the parameters that define the pulse-width modulation. In particular, the motor current of the electric motor powered by the converter can be provided as the current. By way of example, the DC link voltage of the converter can be provided as the voltage. The pulse-width-modulation ratio is a possible parameter, for example. If the heat transfer resistances between the power semiconductors and sensor and between the cooling member and sensor are now also determined, a person skilled in the art is able to determine the temperature of the power semiconductor and/or of the cooling member from the measured sensor temperature as long as the power loss is kept constant. The lag time must be borne in mind in the process.

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In practice, however, a particularly simple method has proven successful. In this method, the gradient of the temperature curve over time of the sensor temperature is determined. The

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model value for the temperature of the power semiconductor is then formed as the total of the temperature measured by the sensor and the gradient value multiplied by a correction factor. In this case, the correction factor is first determined in the laboratory and can be stored as a parameter in the converter. An extremely simple way of determining the temperature of the power semiconductor has thus been found. The method is particularly effective in applications where the power loss is constant for as long as possible, but at least for the duration of the lag time. For example, a conveyor belt is switched on and driven by the electric motor at a first speed, with a different speed being set only after 10 or 100 minutes. The temperature determination is also adequate in lifting gear that travels upwards for 5 minutes, pauses for 3 minutes and then travels downwards again for 3 minutes.

However, the higher the heat capacities of the electronic instrument components used, the less precise the temperature determination. Therefore, a person skilled in the art will select the heat capacities and also the distances between the components to be as small as possible, unless this impairs other characteristics of the instrument.

In further example embodiments according to the invention, instead of a single correction factor, a correction factor associated with each gradient value is stored and used.

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In further example embodiments according to the invention, instead of a single correction factor, a correction factor associated with each gradient value and with each ambient temperature is stored and used in the temperature determination.

25 In the two latter cases, higher levels of precision can be achieved.

In further example embodiments, instead of the gradient, one or more higher time derivatives of the curve over time of the temperature determined by the sensor are also determined and used, with correction factors being assigned in each case and stored in the memory of the instrument, for example of the converter.

30

**List of reference numerals**

|    |    |   |
|----|----|---|
|    | 1  | Circuit board, in particular multilayer circuit board |
|    | 2  | Fastening means for releasable connection             |
| 5  | 3  | Thermal paste   |
|    | 4  | Sensor  |
|    | 5  | Connection tabs                                       |
|    | 6  | Cooling member  |
|    | 7  | Insulating regions                                    |
| 10 | 8  | Internal tracks                                       |
|    | 9  | Vias  |
|    | 10 | Hole  |
|    | 11 | Substrate material                                    |
|    | 20 | Regions for heat-conducting adhesives                 |
| 15 | 40 | Connection tabs                                       |
|    | 41 | Connection tracks                                     |
|    | 42 | Drilled hole  |
|    | 43 | Insulating region                                     |
|    | 44 | Metal region  |
| 20 | 45 | Internal layer  |
|    | 46 | Internal tracks                                       |
|    | 47 | Portion   |

## **P a t e n t k r a v**

### **1. Indretning**

omfattende en printplade (1), der er forsynet med en sensor (4), og et kølelegeme (6), hvor sensoren (4) er forbundet varmeledende med kølelegemet (6),  
5 hvor printpladen er forbundet med kølelegemet,

#### **kendetegnet ved, at**

printpladen (1) er en multilayer-printplade (1),

at metalliske områder (44) af multilayer-printpladens (1) indre lag (45) er forbundet elektrisk og termisk med mindst et metallisk område (44) på den overflade, der vender mod kølelegemet (6),  
10 at elektriske forbindelser omfatter gennempletteringer (9), især til fremstilling af et homogent temperaturniveau i printpladens (1) indre lag (45),

at det metalliske område (44) på den overflade, der vender mod kølelegemet (6), er elektrisk forbundet med kølelegemet (6),  
15 at forbindelsen mellem printplade (1) og kølelegeme (6) sker ved hjælp af et fastgørelseselement (2) til frigørlig forbindelse mellem kølelegemet (6) og printpladen (1), især med en skrue,

og at fastgørelsesmidlet (2) er udformet til termisk forbindelse mellem det metalliske område (44) og kølelegemet (6).  
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### **2. Indretning ifølge krav 1,**

#### **kendetegnet ved, at**

metalliske områder (44) har en større varmeledningsevne end printpladebærrermaterialet, især til opnåelse af et temperaturniveau, der i det væsentlige ligner kølelegemet (6), af de områder af de indre lag (45), der rumligt er tæt på sensoren (4), især hvis afstand til berøringspunkterne af sensorens (4) dele med printpladen (1) er mindre end printpladens (1) tykkelse.  
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### **3. Indretning ifølge et af de foregående krav,**

#### **kendetegnet ved, at**

sensorens (4) tilslutningselementer (41) på overfladen, der vender mod kølelegemet (6), er elektrisk forbundet ved hjælp af lodningsforbindelse, hvor sensorens (4) tilslutningselementer (41) er forbundet med lederbaner af overfladerne, der vender væk fra kølelegemet (6), eller med indre baner (8,  
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46) af printpladen (1) ved hjælp af gennemplettering (9).

4. Indretning ifølge et af de foregående krav,

**kendetegnet ved, at**

5 lodningsforbindelserne er udført ved hjælp af SMD-teknik.

5. Indretning ifølge et af de foregående krav,

**kendetegnet ved, at**

- 10 - sensoren (4) er monteret på den side af printpladen (1), der vender væk kølelegemet (6), og/eller  
- sensoren (4) er monteret på den side af printpladen (1), der vender mod kølelegemet (6), og/eller  
- kølelegemet (6) har udsparinger, der omslutter dele af printpladen (1), der er forbundet med sensoren (4).

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6. Indretning ifølge et af de foregående krav,

**kendetegnet ved, at**

20 sensoren (4) er monteret i et område af printpladen (1), hvis rumlige afstand fra berøringsfladen af kølelegemet (6) og printpladen (1) er et multiplum, der overstiger en, af sensorens (4) længde.

7. Indretning ifølge et af de foregående krav,

**kendetegnet ved, at**

25 printpladen (1) og sensoren (4) er forbundet i det mindste materialesluttende, især hvor forbindelsen omfatter en klæbeforbindelse, især hvor klæbeforbindelsen mellem printpladen (1) og sensoren (4) omfatter en lavere varmeovergangsmodstand end en forbindelse mellem sensoren (4) og printpladen (1) via tilslutningsfødder (40) af sensoren (4).

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8. Indretning ifølge et af de foregående krav,

**kendetegnet ved, at**

de metalliske områder (44) omfatter kobber eller består af kobber, og/eller de metalliske områder (44) er lederbaner af printpladen.

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9. Indretning ifølge et af de foregående krav,

**kendetegnet ved, at**

kølelegemet (6) er varmeledende forbundet med køleflader af effekthalvledere, og/eller at

kølelegemet (6) er forbundet varmeledende med køleflader af effekthalvledere enten direkte eller indirekte via mindst en keramikplade og/eller via varmeledefolie.

5

**10.** Indretning ifølge et af de foregående krav,

**kendetegnet ved, at**

kølelegemet er

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- en del af et hus af en forbrændingsmotor,

- og/eller en bestanddel af et varmeanlæg,

- og/eller en bestanddel af et kemisk anlæg til udførelse af kemiske reaktionsprocesser,

- og/eller en bestanddel af et kølekredsløb.

15

**11.** Indretning ifølge et af de foregående krav,

**kendetegnet ved, at**

indretningen er et elektronisk apparat, især en vekselretter, direkte omformer, spændingsmellemkredsomformer eller omformer til forsyning af en elektromotor.

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**12.** Elektronisk apparat,

omfattende en printplade (1), der er forsynet med en sensor (4) i SMD-teknik, og et kølelegeme (6),

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hvor sensoren (4) er forbundet varmeledende med kølelegemet (6),

hvor printpladen (1) er forbundet med kølelegemet (6),

**kendetegnet ved, at**

printpladen (1) er en multilayer-printplade (1),

hvor lederbaner i planer af multilayer-printpladens (1) indre lag er forbundet elektrisk og termisk med mindst et metallisk område (44) på den overflade af multilayer-printpladen (1), der vender mod kølelegemet (6),

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hvor

printpladen (1) er frigørligt forbundet med kølelegemet (6), og

forbindelsen sker ved hjælp af et fastgørelseselement (2) til forbindelse af kølelegemet (6) med printpladen (1),

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hvor fastgørelsesmidlet (2) er udformet til termisk forbindelse mellem lederbanerne i planerne af de indre lag og kølelegemet (6).

13. Elektronisk apparat ifølge krav 12,

5 **kendetegnet ved, at**

sensorens (4) tilslutningselementer på den overflade af multilayer-printpladen (1), der vender mod kølelegemet (6), er elektrisk forbundet ved hjælp af lodningsforbindelse,

10 hvor sensorens (4) tilslutningselementer er forbundet med lederbaner af de overflader af multilayer-printpladen (1), der vender væk fra kølelegemet (6) ved hjælp af gennemplettering (9).

14. Elektronisk apparat ifølge krav 12,

**kendetegnet ved, at**

15 sensorens (4) tilslutningselementer på den overflade af multilayer-printpladen (1), der vender væk fra kølelegemet (6), er elektrisk forbundet ved hjælp af lodningsforbindelse,

20 hvor kølelegemets (6) støtteflade ikke strækker sig ind i de områder, der ligger over for sensoren (4) på den side af multilayer-printpladen (1), der vender væk fra sensoren.

15. Fremgangsmåde til bestemmelse af temperaturen på en varmekilde, især en effekthalvleder,

25 hvor varmekilden er varmeledende forbundet med et kølelegeme (6), og sensoren (4) er varmeledende forbundet med kølelegemet (6),

hvor en multilayer-printplade (1) er forsynet med sensoren (4),

og hvor

- sensorens (4) temperatur bestemmes,

- et mål for temperaturstigningen indenfor et tidsrum bestemmes,

30 - varmekildens temperatur bestemmes ud fra summen af sensorens (4) temperatur og det mål, der er ganget med en korrektionsfaktor, som hører til temperaturstigningen.

16. Fremgangsmåde ifølge krav 15,

35 **kendetegnet ved, at**

målet for temperaturstigningen indenfor et tidsrum bestemmes ved, at forskellen mellem den nyeste og den forinden sidst målte temperatur af sensoren (4) bestemmes, hvor tidsrummet mellem målingerne af sensorens (4) temperatur hele tiden er det samme.

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**17.** Fremgangsmåde ifølge krav 15 eller 16,

**kendetegnet ved, at**

målet for temperaturstigningen indenfor et tidsrum bestemmes ved, at stigningen af det tidsmæssige forløb af sensorens (4) temperatur bestemmes, dvs. den første tidsmæssige afledning.

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**18.** Fremgangsmåde ifølge et af kravene 15 til 17,

**kendetegnet ved, at**

der anvendes en tabel af korrektionsfaktorer i stedet for korrektionsfaktoren, hvor en korrektionsfaktor er tilordnet til hver stigningsværdi og/eller til hver omgivelsestemperaturværdi og/eller til andre størrelser og anvendes tilsvarende.

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**19.** Fremgangsmåde ifølge et af kravene 15 til 18,

**kendetegnet ved, at**

den registrerede temperatur anvendes og/eller registreres af en omformer til regulering ved forsyning af en elektromotor.

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**20.** Fremgangsmåde ifølge krav 19,

**kendetegnet ved, at**

ved overskridelse af en forudbestemt grænseværdi af temperaturen, der registreres med sensoren (4),

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- reduceres pulsbreddemodulationsfrekvensen og/eller effekttilførslen af omformeren,

- frakobles omformeren

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- og/eller sendes et advarselssignal til den, der betjener anlægget.

**21.** Anvendelse af et plan af indre lag og af gennempletteringer (9) af en multilayer-printplade (1), der er forsynet med en sensor (4) i SMD-teknik og er forbundet med et kølelegeme (6) til varmeledende forbindelse af sensoren (4) med kølelegemet (6) langs planet af indre lag og gennempletteringerne (9), hvor gennempletteringerne (9) forbinder metalliske områder (44) af planet af

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indre lag elektrisk og termisk med mindst et metallisk område (44) på den overflade af multilayer-printpladen (1), der vender mod kølelegemet (6), hvilket område er elektrisk og/eller i det mindste varmeledende forbundet med kølelegemet (6).

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**22.** Anvendelse ifølge krav 21,

**kendetegnet ved, at**

kølelegemet (6) med et fastgørelsesmiddel (2) er frigørligt forbundet med printpladen (1),

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og at fastgørelsesmidlet (2) anvendes til at bevirke termisk forbindelse mellem kølelegemet (6) planet af indre lag.

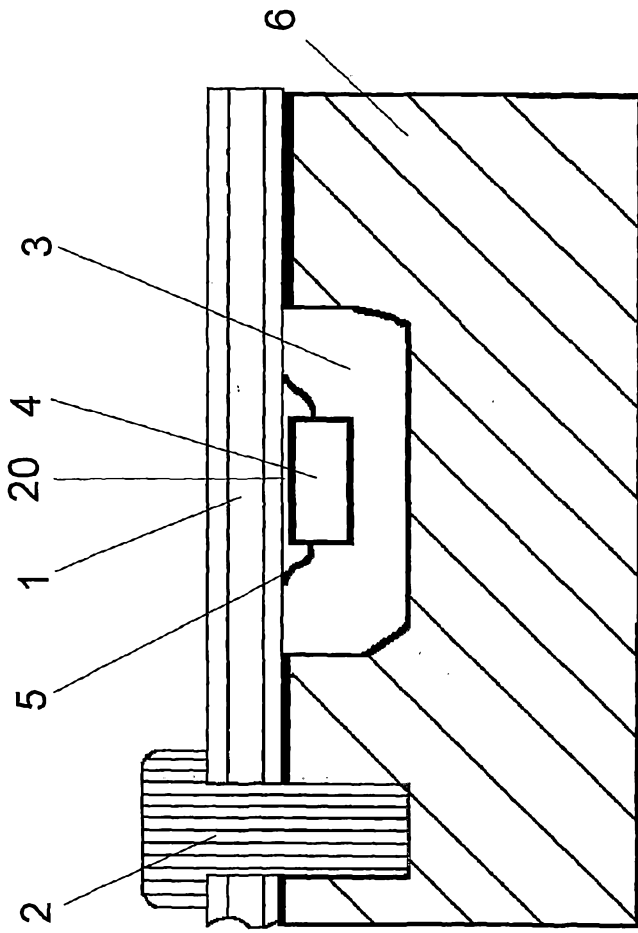


Fig. 1

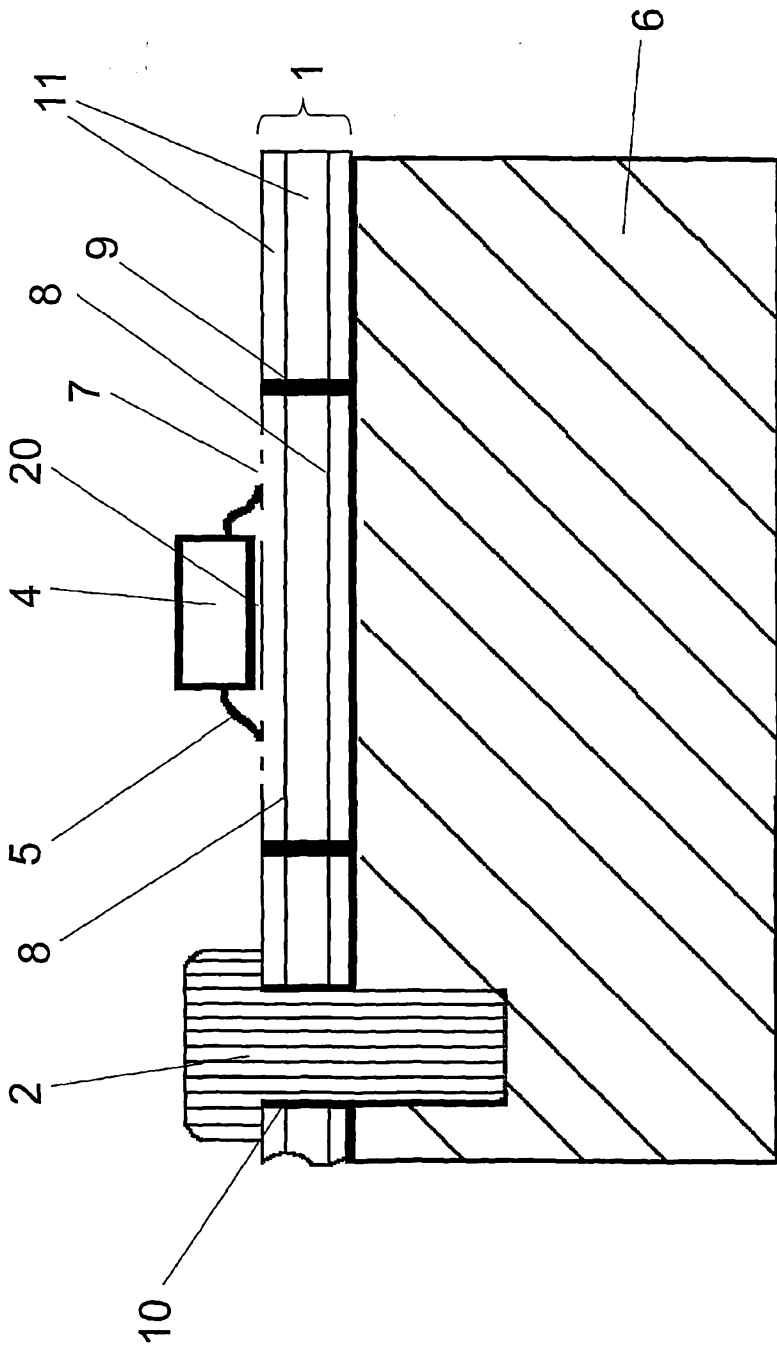


Fig. 2

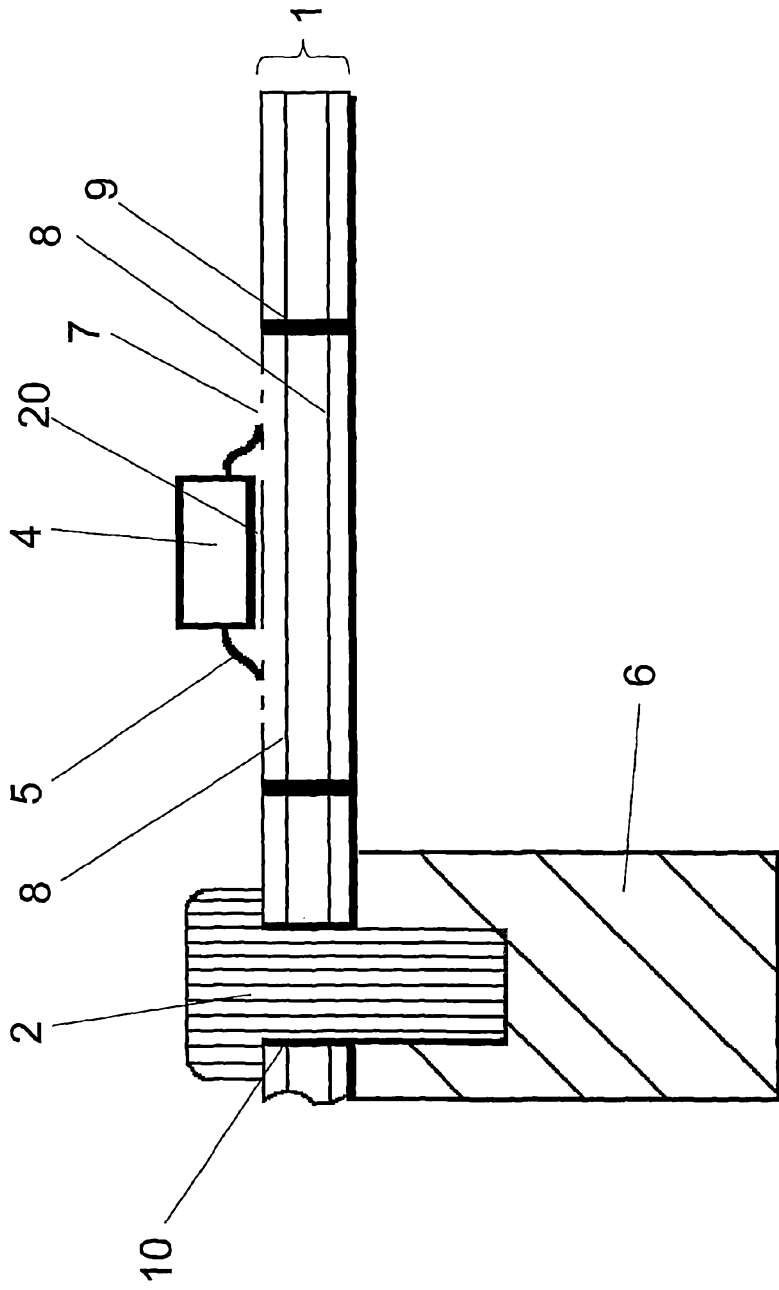


Fig. 3

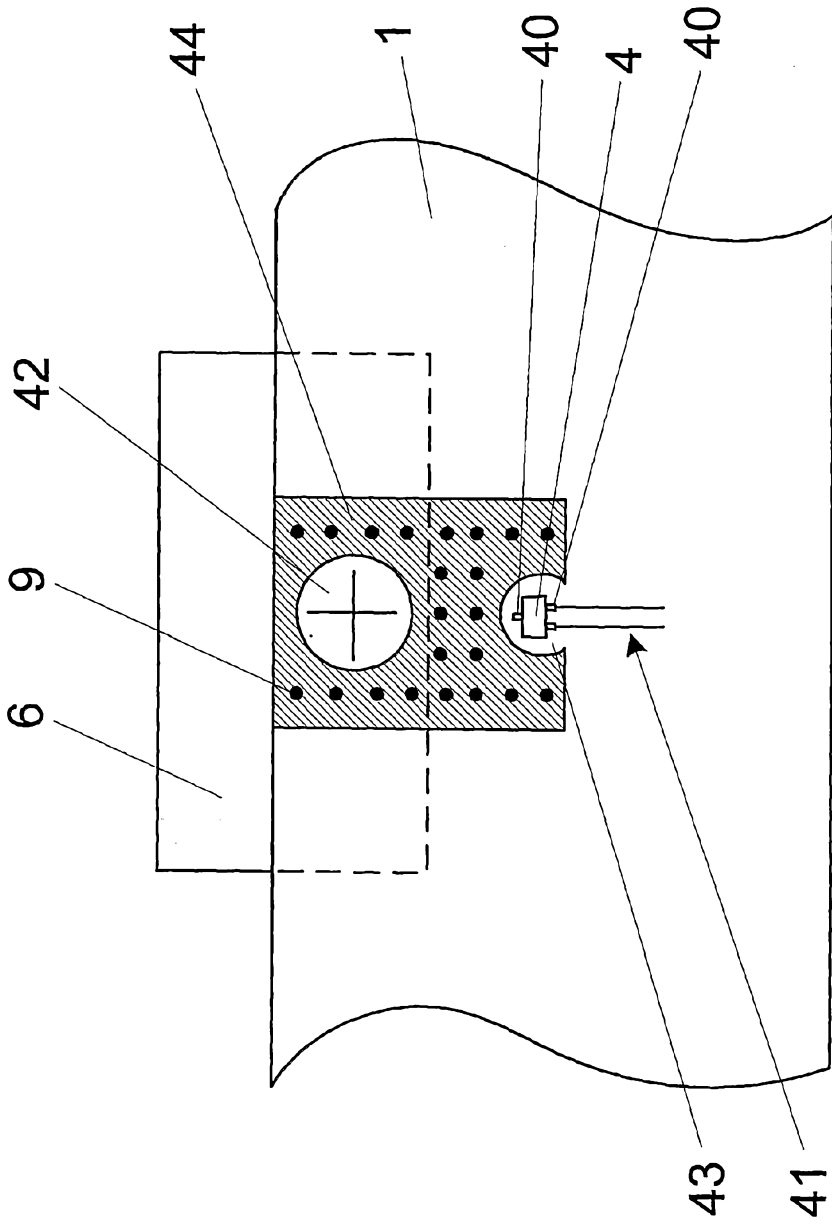


Fig. 4a

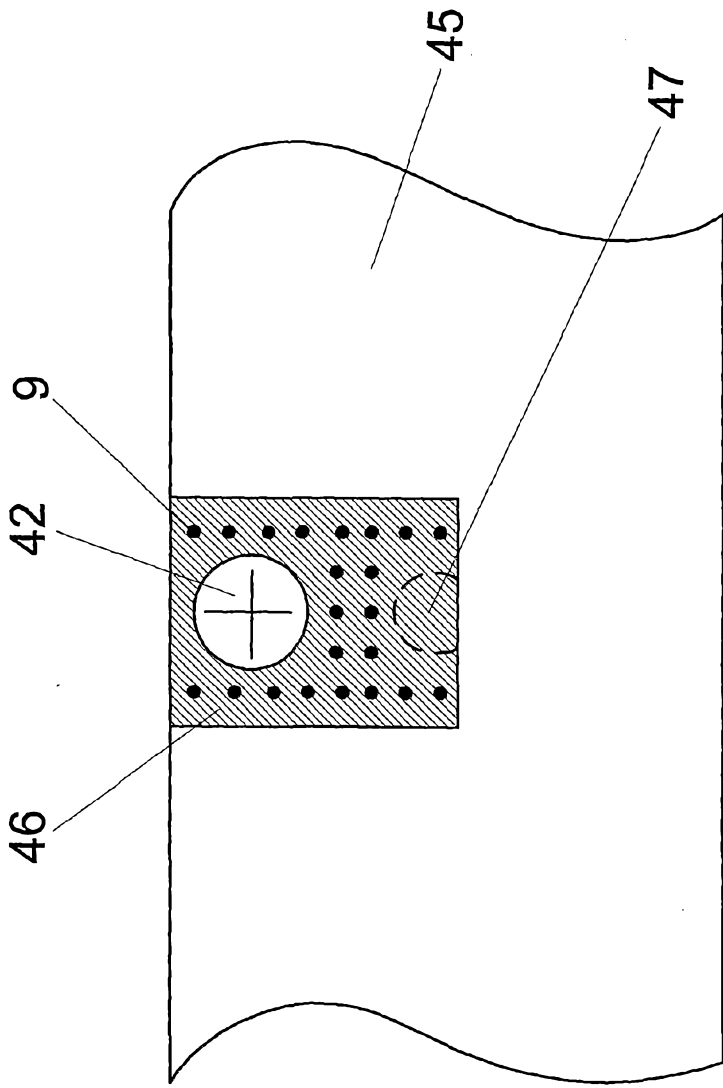


Fig. 4b