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(71) Applicant: **GRAPH ON LTD** [BG/BG]; 22, Veslets str.,entr. A, floor 4, 1000 Sofia (BG).

(72) Inventor: **NAYDENOV, Veselin Bozhidarov**; z.k "Geo Milev" bl.240, entr. V, floor 8, app.66, 1111 Sofia (BG).

(74) Agent: **YANAKIEVA-ZLATAREVA, Maria Nikolova**; ZLATAREVI Agancy, z.k. DIANABAD, bl. 31b, entr. b, app. 14, 1172 Sofia (BG).

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(54) **Title:** HEATING DEVICE FOR LEAD-ACID BATTERIES OPERATING UNDER LOW TEMPERATURES AND A BATTERY WITH THIS DEVICE

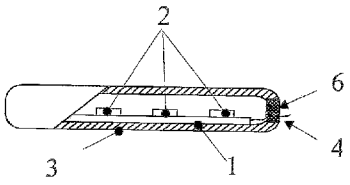

Fig .1

(57) **Abstract:** The inventions will find use in the industrial production of lead-acid battery cells and batteries. The device consumes a small amount of energy and has a service life longer than the lead-acid battery cells and the batteries themselves. The heating device is a circuit board (1, 5) with LEDs (2) mounted thereon and with electrical terminals (4), which circuit board (1, 5) is of high thermal conductivity and is located in a hermetically sealed housing (3) resistant to sulfuric acid electrolytes and having temperature stability from 150 °C to 300 °C and being in tight contact with the hermetically sealed housing (3). The circuit board (1) is of metal or is flexible (5) - from polymeric layered material with at least one layer of high thermal conductivity or from flexible metal. The invention concerns to battery comprising a housing with walls and bottom in which housing electrodes, separators and an electrolyte are arranged and functionally connected in a known manner to form at least one cell and/or battery, and comprises at least one heating device as it is described above.

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HEATING DEVICE FOR LEAD-ACID BATTERIES OPERATING UNDER LOW TEMPERATURES AND A BATTERY WITH THIS DEVICE

THECHNICAL FIELD

The invention relates to a device for heating lead-acid batteries, as well as a battery with such a device that are designed to operate under conditions of low temperatures and will find use in the industrial production of lead-acid battery cells and batteries.

BACKGROUND OF THE ART

For most of the applications, the main types of produced lead-acid starter, traction and stationary rechargeable cells and batteries are used in low ambient temperatures, primarily in rail, water and road transport as well as in stationary battery plants used for back-up power supply of telecommunication and information systems and equipment, of various kinds of power systems, pumping stations for petroleum products and hydro systems, to supply power to transport servicing and reserve facilities, in the military and in other fields. The use of lead-acid batteries at temperatures lower than -30 °C is difficult due to the fact that lowering of the temperature increases their internal resistance. Furthermore, with a fully discharged battery, when the electrolyte concentration is 1.10 g/cm^3 of sulfuric acid, the electrolyte freezes at a temperature of -10 °C. According to thermodynamic laws, the electrochemical charging and discharging processes of lead-acid batteries are strongly dependent on temperature, and under low ambient temperatures, as a result of the increased internal resistance, their charging is

significantly hampered and, accordingly, in the discharge the battery cannot reach the prescribed nominal discharge capacity. In order to ensure the operation of lead-acid batteries under low ambient temperatures, it is necessary to keep them in a fully charged state and to take special precautions to prevent them from freezing.

A solution according to DE 102009052975 A1 is known, where a heating device which is a heat-insulated container is used for heating the battery. The container is made of a heat-insulating material to which, in various embodiments, battery-powered heaters are added. If it is necessary to warm or maintain a certain temperature, the container closes and the battery stays in the space formed by the thermally insulated container at a temperature higher than the ambient temperature. A major disadvantage of this solution is the need to provide for a substantial space for the container, which limits its application with respect to the types of consumer devices in which it can be accommodated.

From patent application US 20170005498 A1, a battery heating device is known, which is a second, auxiliary battery connected to the main one and to a user device. A temperature sensor, usually mounted to the user device, is provided. The auxiliary battery includes a heating element which, according to various embodiments, is mounted on all sides of the auxiliary battery or on a part thereof. Both the main and the auxiliary batteries can be of a different type, including lead-acid. The second, auxiliary, rechargeable battery is connected through its terminals to the terminals of the main battery, the connection being capable of simultaneously feeding the user device, the temperature sensor and the heating element. The heating element is provided in various embodiments that include the following types: resistive, carbon, conductive polymer, nicron or certain chemical species such as electrolyte additives, a thin film of one or more layers of electrodes with high load/impedance, or constitutes a thin battery. The auxiliary battery is isolated from the main battery through a thermally insulating layer of

the type of polystyrene foam, mineral wool, plastic, and, according to various embodiments, it is covered partially or completely by the thermal insulation layer.

Both known solutions have the drawbacks that a substantial amount of electricity is required to heat up the main battery, which quickly exhausts the second auxiliary battery for which external power is required. Moreover, with the use of an extra battery, the total weight of the battery increases considerably.

SUMMARY OF THE INVENTION

The purpose of the present invention is to achieve efficient heating of batteries that operate under low temperature conditions, which takes up a small space, has low energy consumption and allows for programmable optimization of the operating conditions of the batteries.

A device for heating lead-acid batteries operated under low temperatures, which according to the invention is a circuit board with LEDs mounted thereon and with electric terminals, wich circuit board having a high thermal conductivity and being located in a hermetically sealed housing, resistant in a medium of sulfuric acid electrolytes and having a temperature stability from 150 °C to 300 °C and being in tight contact with the hermetically sealed housing.

According to one embodiment of the invention, the circuit board is rigid.

It is envisaged that the rigid circuit board is made of a polymeric layered material with at least one layer of high thermal conductivity or metal.

According to another embodiment of the invention, the circuit board is flexible.

The plastic circuit board is provided to be made of a polymeric layered material with at least one layer of high thermal conductivity or metal.

The hermetically sealed housing is suitably made of a rigid thermo-resistant and acid-resistant material of the group of glass, metal, polymer or other suitable

material and is sealed with a thermo-resistant and acid-resistant polymeric material.

The tight contact of the circuit board with the hermetically sealed housing, according to one suitable embodiment, is accomplished by a board fixing groove.

According to another embodiment, the hermetically sealed housing is a plastic envelope of thermo-resistant and acid-resistant material.

In order to achieve higher efficiency, it is provided that the hermetically sealed housing is additionally filled with an electro-insulating and heat-conducting material.

To monitor the temperature operation, a temperature sensor is fixed to the hermetically sealed housing.

The invention also relates to a battery with a heating device comprising housing with walls and a bottom, in which housing electrodes, separators and electrolytes forming at least one cell/battery are arranged and are functionally connected in a known manner. According to the invention, the battery comprises at least one heating device, which is a circuit board with LEDs mounted thereon and with electrical terminals, wich circuit board being highly heat conducting and located in a hermetically sealed housing, resistant in the environment of electrolytes of sulfuric acid and having temperature stability from 150 °C to 300 °C. In addition, the hermetically sealed housing of the heating device is embedded in at least one of the following: the walls, the bottom, the plates or the separators, and the contact of hermetically sealed housing with the electrolyte is provided. At least one temperature sensor is placed on the outside of at least one of the walls and/or inside the housing.

Depending on the particular design, a temperature sensor is fixed to the hermetically sealed housing of the heating device.

The place of installation of the hermetically sealed housing of the heating device is optional depending on the type of the battery, as determined by the electrolyte movement possibility in order to achieve the best heat exchange.

As current practice requires increased requirements for lead-acid batteries in terms of the efficiency of their operation, the present invention has achieved increase of the security of power supply to the consumers by providing optimal conditions for the operation of lead-acid batteries under low ambient temperatures. Warming up of the battery electrolyte has been achieved with the starter lead-acid batteries, which enables a safe start of internal combustion engines that are under low ambient temperatures. The heating device and the battery with built-in such device provide the possibility, in addition to maintaining optimal operating temperatures, to also provide, by programming, the thermal conditions for operation when storing the batteries, when they are in a standby mode or in preparation for operation. The device consumes a small amount of energy and has a service life longer than the lead-acid battery cells and the batteries themselves. It is suitable for use in all types and designs of lead-acid battery cells and batteries, thus greatly improving their performance. In addition, the heating device and the battery with such device are fully compatible with the possibilities for recycling lead-acid batteries.

BRIEF DESCRIPTION OF THE FIGURES

Figure 1 is a cross-sectional view of a battery heating device according to the invention;

Figure 2 is a partial cross-sectional view of a battery heating device according to an embodiment of the invention;

Figure 3 is a schematic diagram of a lead-acid battery of wet cell type with an installed heating device according to the invention.

EXAMPLES OF EMBODIMENTS OF THE INVENTION

The heating device for lead-acid batteries operated in low temperature according to the invention is a circuit board 1, 5 with LEDs 2 mounted thereon, which circuit board 1, 5 is highly heat-conducting and is located in a hermetically sealed housing 3 resistant to sulfuric acid electrolyte environment and having a temperature stability from 150 °C to 300 °C, being in tight contact with the hermetically sealed housing 3.

In addition, the circuit board 1, 5 has electrical terminals 4 to a power supply. The circuit board on which the LEDs 2 are mounted may be rigid 1 or flexible 5, depending on the place of application of the heating device and on the particular type of the battery.

The rigid circuit board 1 is made, according to various embodiments, of a polymeric layered material with at least one layer of high thermal conductivity or metal. When made of metal, the heat dissipation of the heat emitted by the LEDs is better. The circuit board 1 with the LEDs 2 may have a rectangular, round, lattice or other geometric shape that depends on the construction of the lead-acid battery for which the heating device is intended. The circuit board 1, shown in Fig. 1 has a rectangular shape on which 4 LEDs 573-BL-60 or (20 LSH - 170X14,5 - 4C19B - AL) or (OCTL -3 - 150) are mounted. The hermetically sealed housing 3 is of quartz glass, and the terminals 4 are teflon-insulated cables. This exemplary embodiment illustrates the invention but does not limit it.

According to another embodiment, the circuit board is flexible 5, as illustrated in Fig. 2. In this case, it is also intended to be made of a polymeric layered material having at least one layer of high thermal conductivity or metal. The plastic circuit board is usually in the form of strip. Its particular design is determined by the characteristics of the battery cell or battery to which the heating device will be applied.

The LEDs 2 mounted on the circuit board 1, 5 can be of varying number and power. The number of the built in the board – rigid 1 or flexible 5 – LEDs 2 depends on the size, the construction and the quantity of the electrolyte of a specific type of lead-acid battery cell or battery for which the heating device is intended. For example, the heating device may include 5, 10 to 30 and more LEDs 2 so as to effectively heat the lead-acid battery cell or battery with very low power consumption. When the heating device is designed for small-sized and low-capacity lead-acid battery cells or batteries, it is suitable to use low-power light-emitting diodes with current up to 2 mA and power consumption up to 20 mW. If the lead-acid cells or batteries have a capacity of 20 Ah to, for example, 200 Ah, it is good to use standard LEDs that consume power from 40 mW to 90 mW with a current strength of up to 20 mA and voltage up to 3 V. For lead-acid battery cells and batteries with a capacity exceeding 200 Ah, it is appropriate to use standard and mid-range LEDs where the supply current is from 70 mA to 100 mA. In all cases, the power consumption of the LEDs 2 of the heating device is much lower than the capacity of the lead-acid battery cells and batteries.

According to the embodiment shown in Fig. 1, the hermetically sealed housing 3 is made of a rigid thermo-resistant and acid-resistant material of the group of glass, metal, polymer or other suitable material and is sealed with a thermo - resistant and acid-resistant polymeric material 6. Tight contact of the circuit board and/or its heat-transferring part with the hermetically sealed housing is realized, according to an embodiment, by a board fixing groove. Thus, an effective heat transfer to the wall of the hermetically sealed housing 3 has been achieved. The tight contact of the circuit board can also be accomplished by other means, e.g., fixing clips and other fixing means.

According to another embodiment shown in Fig. 2, the hermetically sealed housing 3 is a plastic envelope 8 of thermo-resistant and acid-resistant material. The plastic envelope 8 is thermally sealed or glued. A suitable material for the plastic envelope 8 is, for example, teflon. It is possible to use any other material

meeting the required conditions as specified herein, such as a material suitable for installation in lead-acid cells and batteries with gel electrolyte or with glass wool separator 9, between the electrodes 10 of batteries having a rectangular or cylindrical shape. The particular heating device shown in Fig. 2 has three plastic circuit boards 5 representing strips with LEDs 2 with a common connector 11. These three strips with LEDs 2 are placed in a sealed flexible envelope 8 of thermo-resistant and acid-resistant polymeric material with a cable terminal 4. A flexible heating device is thus formed which is suitable to be mounted in a lead-acid battery cell with glass wool separators 9 and an immobilized electrolyte or in a lead-acid battery with a gel electrolyte. Also, the plastic heating device is suitable for installation in cylindrical type lead-acid battery cells as it allows bending.

It is possible, if necessary to further increase the efficiency of the heat transfer from the LEDs, that the hermetically sealed housing 3 is filled with an electro-insulating and heat-conducting material. It is suitable for the hermetically sealed housing 3 to have a fixed temperature sensor (not shown in the figures). This temperature sensor, alone or in combination with other sensors, serves to monitor and control the temperature of the electrolyte in the lead-acid batteries.

The invention also relates to a battery with a heating device, the battery comprising a housing 12 with walls 13 and a bottom 14. In the housing 12 there are also functionally connected in a known manner plates which are electrodes 10, separators 9 and electrolyte 16 forming at least one cell 15 and/or a battery. According to the invention, the battery comprises at least one heating device as explained above consisting of a circuit board 1, 5 with LEDs 2 mounted thereon and with terminals 4 to a power supply, which board 1, 5 is highly heat conducting and is located in a hermetically sealed housing 3, resistant in the environment of sulfuric acid electrolytes and having temperature stability from 150 °C to 300 °C. In addition, the hermetically sealed housing 3 of the heating device is embedded in at least one of the following: the walls 13, the bottom 14,

the electrodes 10 or the separators 9, depending on the type of the battery. The installation of the heating device in the different types of lead-acid battery cells should be done in such a way and in such a place that its contact with the electrolyte must be ensured. Furthermore the battery being a cell 15 or a battery also includes at least one temperature sensor placed on the outside of at least one of the walls 13 and/or inside the housing 12. Depending on the particular design, a temperature sensor is fixed to the hermetically sealed housing 3 and the heating device. This provides an opportunity for reporting and monitoring both the temperature of the heating device as well as of the ambient temperature and of the electrolyte 16. This allows automation and control of heating. Fig. 3 illustrates a general embodiment of a lead-acid battery showing the electrodes 10, respectively positive and negative, representing plates between which the separator 9 is located. In the example shown, the heating device is embedded in the bottom of the battery.

If the use of a programmable device for switching the power on or off of the heating device is provided, it is possible that a temperature sensor may not be used in the hermetically sealed housing 3.

The terminals 4 of the heating devices and of the temperature sensors can be installed in any possible positions and are taken out of the electrolyte 16. Their positions are dependent on both the design features of the lead-acid battery cells and/or the batteries and the individual opportunities of the producers concerned. The power supply to the heating device is intended to be implemented by plugging its terminals either into the terminals of the battery in which it is built or by plugging it into an external power supply.

In the case of a wet cell type battery, it is best that the heating device - through its hermetically sealed housing 3 - be fitted to the bottom 14. In addition to warming the electrolyte under low temperatures, this arrangement results in an exchange of its concentration in height, especially when the wet cells 15 have larger structural

dimensions in height. At the same time, acid stratification is greatly reduced and the concentration polarization of lead stationary cells is reduced, which significantly improves their performance.

When the battery has an electrolyte in the form of a gel, the heating device, through the hermetically sealed housing 3, is mounted in any convenient location, for example to the bottom 14, to the walls 13, between the electrodes 10 or a combination thereof.

With a valve-type battery with glass wool separators 9, the heating device - through its hermetically sealed housing 3 - is mounted to at least one of the separators 9 between the electrodes 10; this provides better contact with the electrolyte immobilized in the glass wool separator 9.

The heating device according to the invention is used in the following manner:

The device itself is manufactured separately in a design as required by the respective battery manufacturer. It is incorporated during the production process of various types of batteries according to the manufacturer's specific design. Once the heating device is energized, the LEDs 2 begin to heat the circuit board 1, 5 on which they are mounted, and the circuit board itself heats the hermetically sealed housing 3 of the device and this heat is transmitted to the electrolyte 16 and from there to the positive and the negative electrodes 10 which, in addition to being in direct contact, are saturated with the electrolyte. The determination of the required temperature to which the lead-acid cells 15 are to be heated is done either by means of the temperature sensor mounted in the housing 12 of the battery cell 15, the sensor being in contact with the electrolyte 16 or by means of a predetermined program for limited time operation of the heating device. In this way, the internal temperature of the lead-acid battery cell 15 is controlled. This also depends on the ambient temperature under which the lead-acid battery cells or batteries are located and which is sensed by the temperature sensor located on the outside of the wall 13 of the housing 12 of the battery.

Thus, the temperature of the active materials, participating in the electrochemical processes of generating electrical power and which are the active mass of the positive and the negative electrodes 10 and the electrolyte 16, is increased. As explained above, the temperature increase of the active materials is achieved by regulating the temperature of the electrolyte 16, which may be in the liquid phase of the wet type lead-acid battery cells, or be gelled in gel lead-acid cells, or immobilized in the AGM (glass wool) separator. No matter where the hermetically sealed housing 3 of the heating device is placed, as described in the examples, it is in contact with the electrolyte 16 in its three applications. It also transfers the heat to the other two active elements, the positive and negative electrodes 10 of the lead-acid cells.

CLAIMS

1. Heating device for heating lead-acid batteries operating under low temperatures, ***characterized in that*** it is a circuit board (1, 5) with LEDs (2) mounted thereon and with electrical terminals (4), which circuit board (1, 5) is of high thermal conductivity and is located in a hermetically sealed housing (3) resistant to sulfuric acid electrolytes and having temperature stability from 150 °C to 300 °C and being in tight contact with the hermetically sealed housing (3).

2. Heating device according to claim 1, ***characterized in that*** the circuit board (1) is rigid.

3. Heating device according to claim 2, ***characterized in that*** the circuit board (1) is of polymeric layered material with at least one layer of high thermal conductivity.

4. Heating device according to claim 2, ***characterized in that*** the circuit board (1) is of metal.

5. Heating device according to claim 1, ***characterized in that*** the circuit board (5) is flexible.

6. Heating device according to claim 5, ***characterized in that*** the circuit board (5) is of polymeric layered material with at least one layer of high thermal conductivity.

7. Heating device according to claim 5, ***characterized in that*** the circuit board (5) is of metal.

8. Heating device according to any one of claims 1 to 7, ***characterized in that*** the hermetically sealed housing (3) is made of a rigid thermo-resistant and acid-resistant material of the group of glass, metal, polymer or other suitable material and is sealed with a thermo-resistant and acid-resistant polymeric material (6).

9. Heating device according to claim 8, ***characterized in that*** there is a groove fixing the circuit board (1) in the hermetically sealed housing (3).

10. Heating device according to any one of claims 1 to 7, ***characterized in that*** the hermetically sealed housing (3) is a plastic envelope of thermo-resistant and acid-resistant material.

11. Heating device according to any one of claims 1 to 10, ***characterized in that*** the hermetically sealed housing (3) is additionally filled with an electro-insulating and heat-conducting material.

12. Heating device according to any one of claims 1 to 11, ***characterized in that*** a temperature sensor is fixed to the hermetically sealed housing (3).

13. Battery with a heating device comprising a housing with walls and bottom in which housing electrodes, separators and an electrolyte are arranged and functionally connected in a known manner to form at least one cell and/or battery, ***characterized in that*** it comprises at least one heating device according to any one of claims 1 to 12, comprising a circuit board (1, 5) with LEDs (2) mounted thereon and electric terminals (4); the circuit board (1, 5) having high thermal conductivity and being located in a hermetically sealed housing (3) resistant to sulfuric acid electrolytes and having temperature stability from 150 °C to 300 °C; the hermetically sealed housing (3) of the heating device is embedded in at least one of the following: the walls (13), the bottom (14), the electrodes (10) or the separators (9), depending on the type of the battery, and the contact of hermetically sealed housing (3) with the electrolyte (16) being provided; and the battery comprises at least one temperature sensor placed on the outside of at least one of the walls (3) and/or inside the housing (12).

14. Battery according to claim 13, ***characterized in that*** a temperature sensor is fixed to the hermetically sealed housing (3) of the heating device.

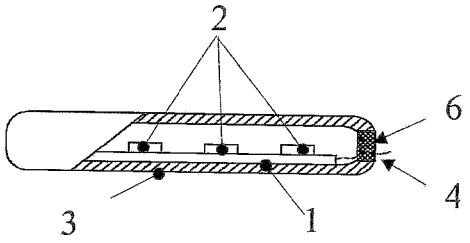

Fig .1

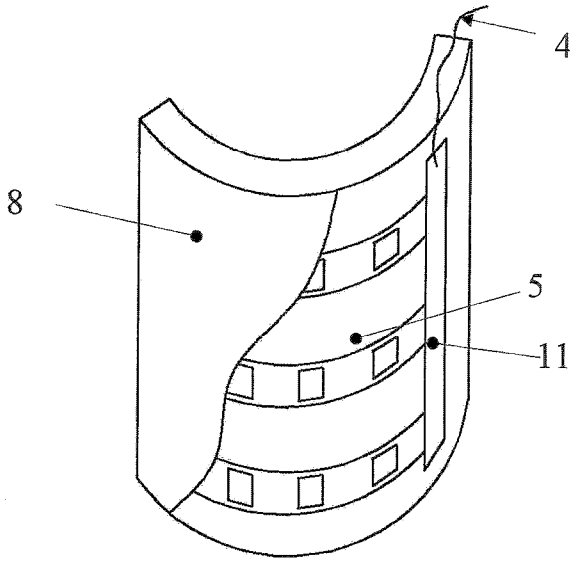

Fig. 2

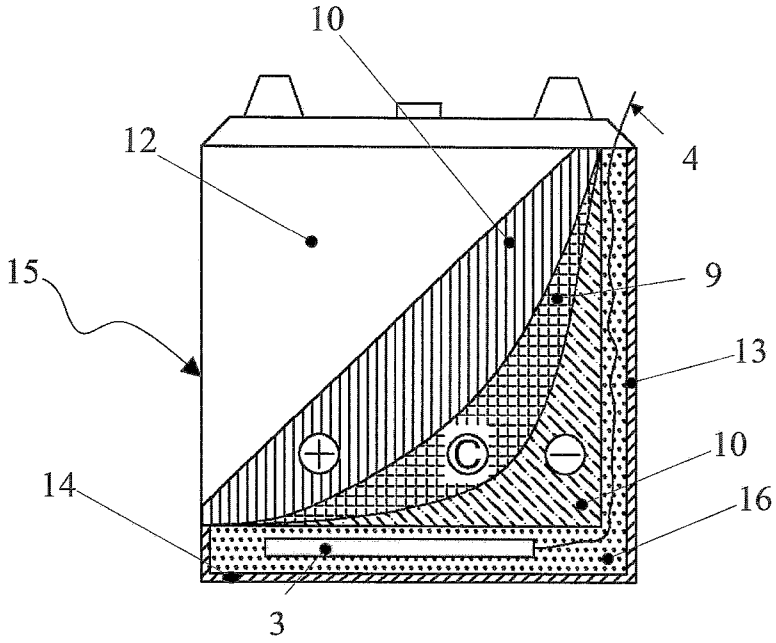

Fig. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/BG2019/000005

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01M10/12 H01M10/625 H01M10/615 H01M10/653 H01M10/657
H01M10/655
ADD.
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01M

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 1 033 525 A2 (OSRAM OPTO SEMICONDUCTORS GMBH [DE]) 6 September 2000 (2000-09-06) abstract; figure 1	1-4,8-12
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A	EP 1 622 213 A1 (PACCAR INC [US]) 1 February 2006 (2006-02-01) abstract; figure 2 paragraph [0018]	13,14

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
3 June 2019	13/06/2019

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

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

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