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(54) Abstract Title: **An electrical storage device heater for a vehicle**

(57) A heater system 100 is disclosed for an electrical storage device such as a high voltage battery 103. The system 100 is connectable to an external power source 112 to maintain the temperature of the battery 103 above a predetermined threshold for so as long as the system 100 remains connected to the external power source 112. Other system components, such as an AC/DC converter 108 and a controller 114 may be connected to the battery heater system 100 outside of a battery system 102 allowing the battery heater system 100 to act as a modular component that can be easily included in or excluded from a vehicle as an option. The battery heater system 100 can be designed so that it can be connected along with an engine block heater to the power source 112 using a single common connector.

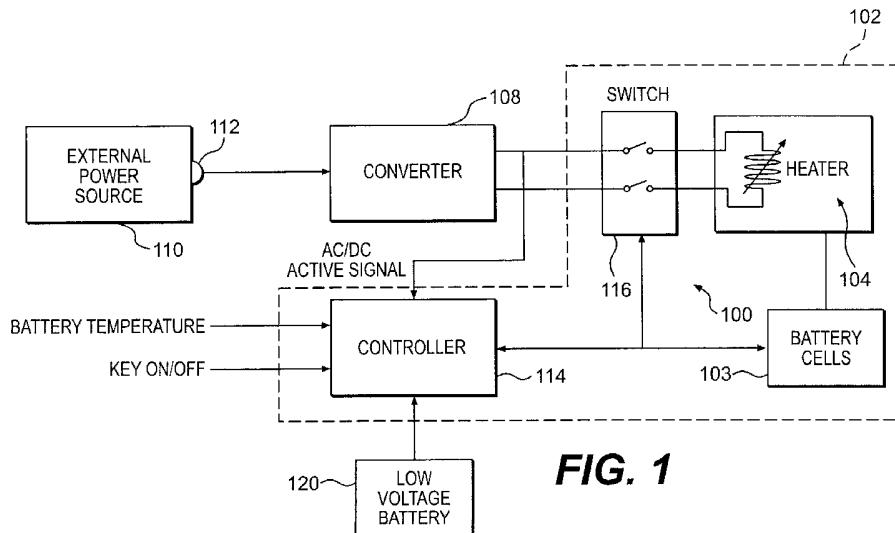


FIG. 1

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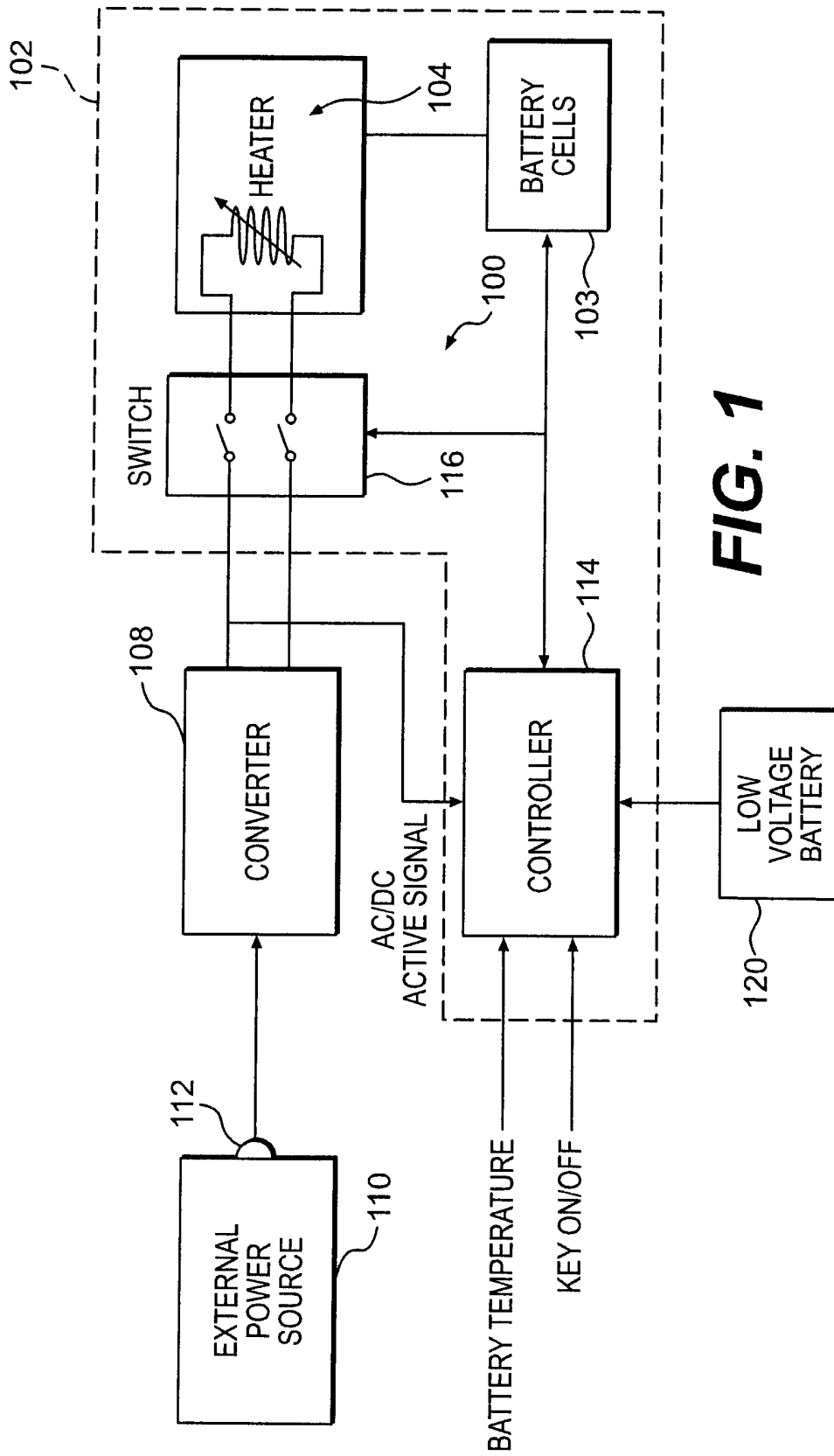


FIG. 1

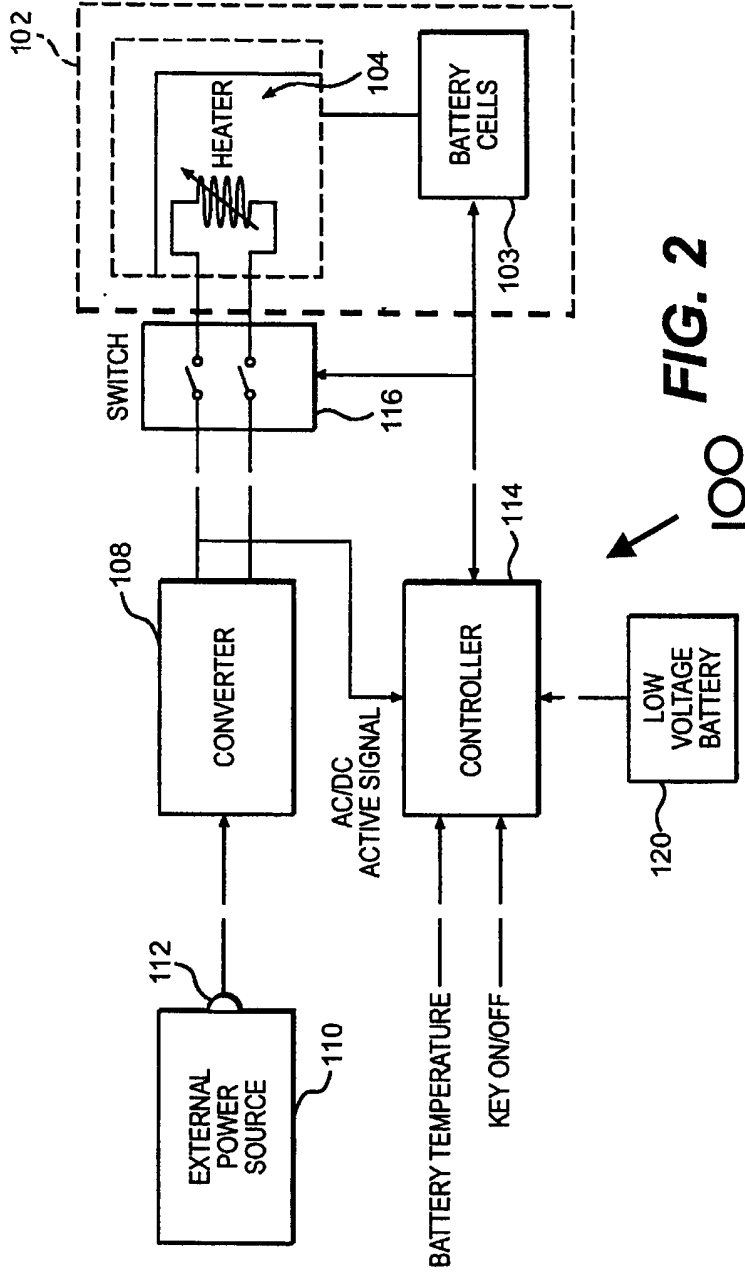


FIG. 2

100

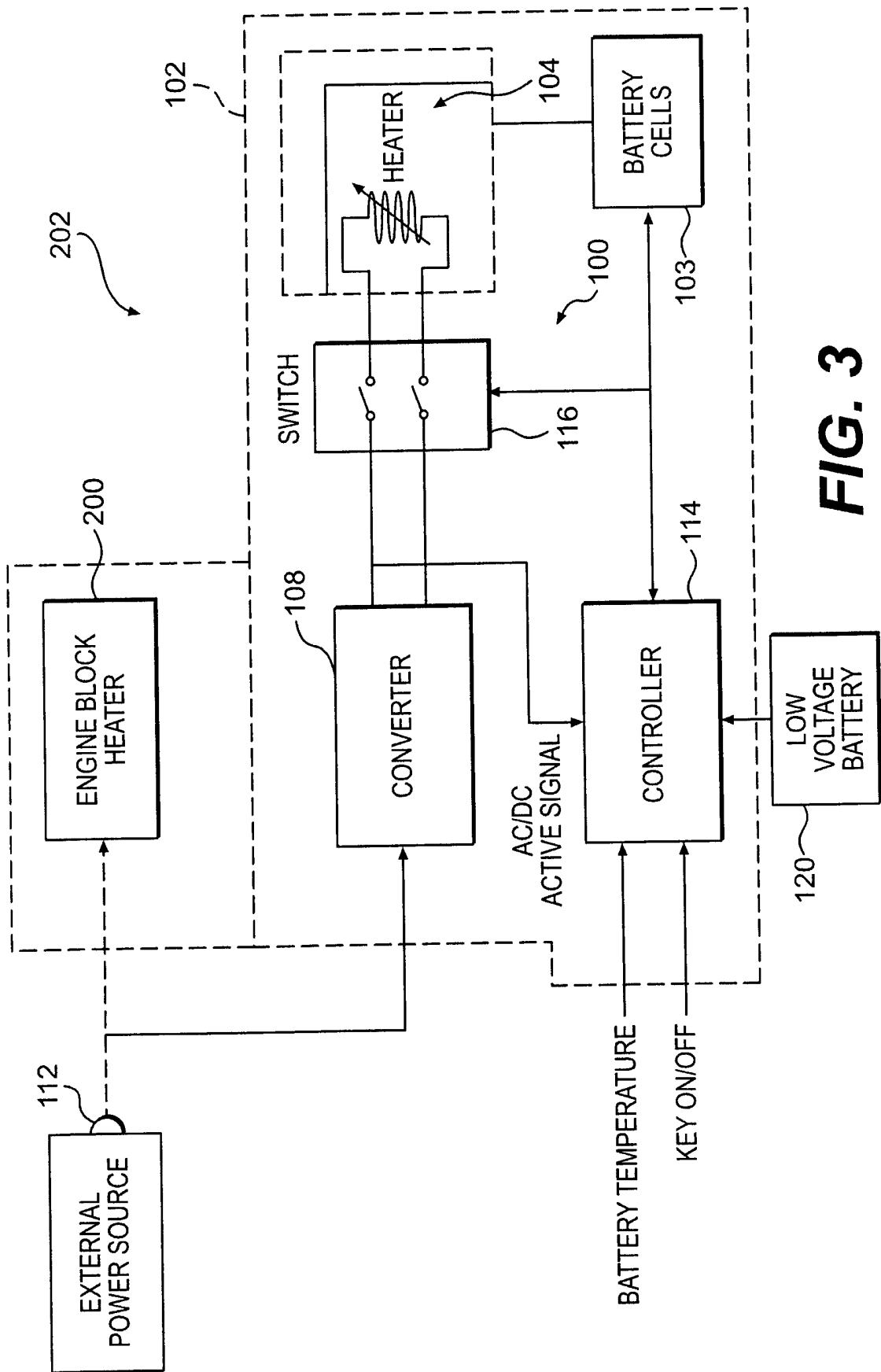


FIG. 3

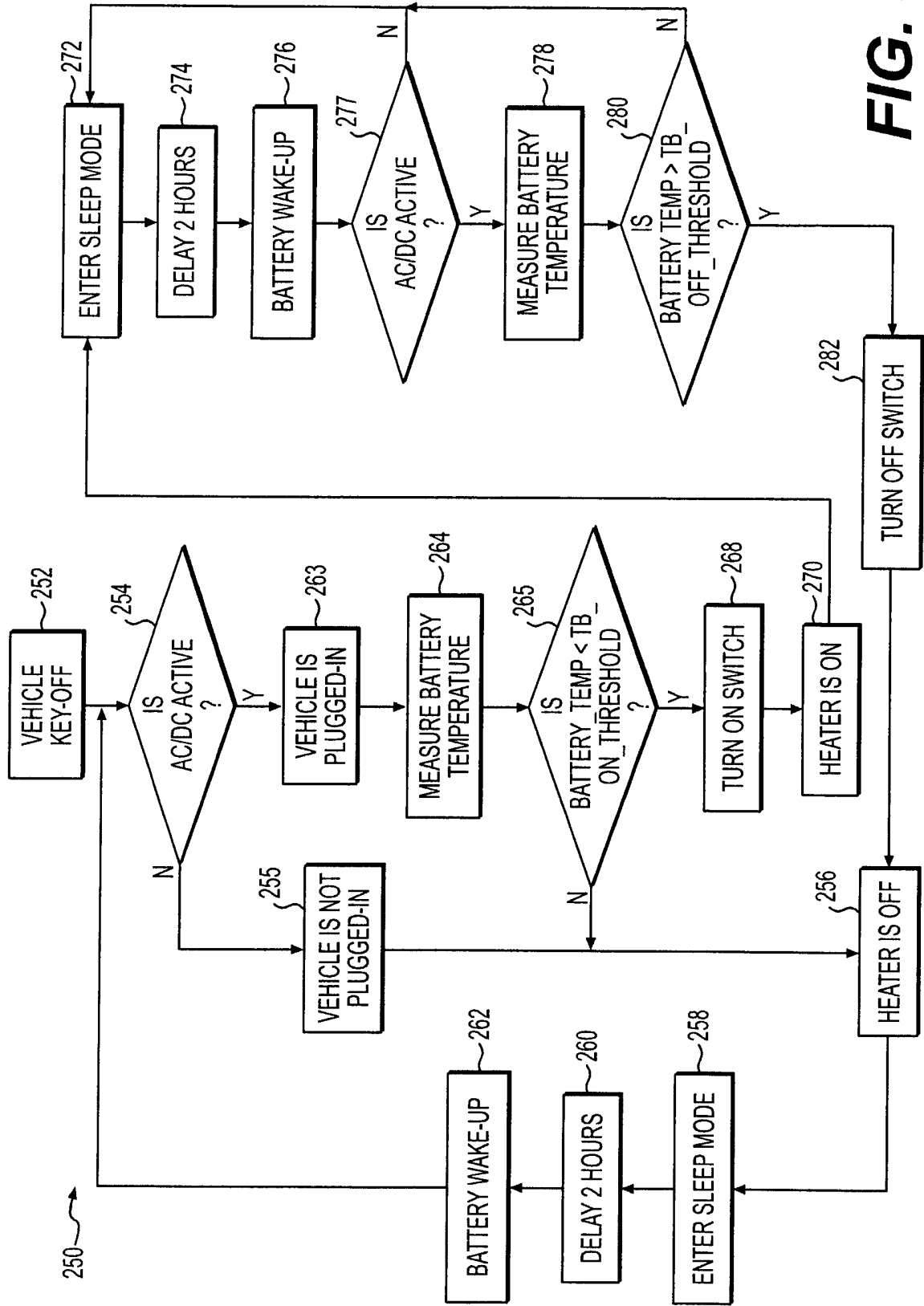


FIG. 4

AN ELECTRICAL STORAGE DEVICE HEATER FOR A VEHICLE

This invention relates to thermal controls for an electrical storage device in a vehicle and in particular to a system and method for heating an electrical storage device.

Electric and hybrid electric vehicles have become increasingly popular to meet the demand for fuel-efficient, environmentally-friendly transportation. Such vehicles often include an electrical storage device, such as a high-voltage traction battery, for powering an electric motor to drive the vehicle, either alone or in conjunction with an internal combustion engine, fuel cell engine, or other prime mover.

Currently available electric and hybrid electric vehicles tend to operate more effectively in moderate and warm climates and less effectively in extremely cold climates. This is because high voltage traction batteries tend to lose power as battery cell temperature drops (e.g., below approx. 20°C). This power decrease results in reduced vehicle performance, fuel economy and drivability. At extremely low temperatures, the traction battery may have insufficient power to even start the vehicle.

Maintaining a proper battery temperature is desirable to ensure optimal vehicle performance in many different climates. Sustaining the battery temperature at a desired level can be challenging because the battery temperature can be affected by many factors, such as the battery condition, the battery cell temperature, the battery charge condition when the vehicle is turned off, and the ambient temperature. Self-powered battery heaters are able to maintain a minimum battery temperature level only for short time periods because the amount of power available for heating is limited by the storage capacity of the battery itself. Thus, self-

powered battery heaters are unsuitable when the battery needs to be heated for an extended time period and/or when the battery needs to be warmed to a higher temperature to ensure optimal vehicle performance.

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It is an object of this invention to provide a system for an electrical storage device of a motor vehicle that can maintain the temperature of the electrical storage device in a controlled manner so as to ensure optimum performance.

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According to a first aspect of the invention there is provided a system for heating an electrical storage device in a vehicle wherein the system is connectable to an external power source and comprises a heater coupled to the electrical storage device for heating the electrical storage device, a switch for selectively coupling the external power source to the heater, a controller that receives an input corresponding to a temperature of the electrical storage device and operates the switch based on at least the temperature of the electrical storage device.

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The heater may comprise at least one thermoelectric heating element.

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The external power source may be an AC power source and the system may be connected to the AC power source.

At least one of the switch and the controller may be disposed outside the electrical storage device.

30

The controller may be further operable to control the switch based on a key on/off condition.

The system may further comprise an AC/DC converter that is connectable to the AC power source and is operable to power the heater.

35

The controller may be further operable to control the switch based on an AC/DC output from the AC/DC converter.

5 At least one of the AC/DC converter, the switch and the controller may be disposed outside the electrical storage device.

 Alternatively, the external power source may be a supplemental electrical power source disposed in the vehicle.

 In which case, the system may further comprise a DC/DC converter that is connectable to the supplemental electrical power source.

 According to a second aspect of the invention there is provided a motor vehicle having an engine block heater and an electrical storage device heater system in accordance with said first aspect of the invention wherein the engine block heater and the electrical storage device heater system are jointly connectable to an external power source.

 According to a third aspect of the invention there is provided a method for controlling a system connectable to an external power source used to heat an electrical storage device the method comprising determining whether the system is connected to the external power source and, if it is determined that the system is connected to the external power source switching on a heater to heat the electrical storage device at least when the temperature of the electrical storage device is below a predetermined temperature threshold.

35 The method may further comprise checking the temperature of the electrical storage device temperature,

closing a switch to connect the heater to the external power source if the electrical storage device temperature is below the predetermined temperature threshold and opening the switch to disconnect the heater from the external power source if the electrical storage device temperature is above the predetermined temperature threshold.

Checking the electrical storage device temperature may comprise entering a sleep mode for a predetermined time period and checking the electrical storage device temperature during a wake-up mode.

The method may further comprise re-entering the sleep mode after at least one of the switch closing step and the switch opening step.

The step of opening the switch may be conducted if the system is not connected to the external power source.

The invention will now be described by way of example with reference to the accompanying drawing of which:-

Figure 1 is a block diagram illustrating a battery heater system according to the invention;

Figure 2 is an alternative embodiment of a battery heater system according to the invention;

Figure 3 is a block diagram illustrating an example of the use of the battery heater system in conjunction with an engine block heater; and

Figure 4 is a flow diagram illustrating a method for controlling the battery heater according to one embodiment of the invention.

Figure 1 is a block diagram illustrating components of a battery heater system 100 according to one embodiment of the invention. Generally, the invention is directed to a vehicle battery heater system 100 that is powered by an external power source e.g., a 120V AC power source outside the vehicle or a supplemental low-voltage or accessory battery on-board the vehicle) outside a high-voltage battery system 102 or other electrical storage device. The battery system 102 includes one or more battery cells 103. By using an external power source that is separate from the high-voltage battery system 102 to operate the heater system 100, the invention can keep the battery system 102 warm and regulate the temperature of the battery system 102 reliably when the vehicle is exposed to a cold environment.

As shown in Figure 1, the battery heater system 100 includes a heater 104 for warming the battery cells 103. The heater 104 may have any configuration known and appreciated in the art that is appropriate for regulating the temperature of the battery cells 103. In one embodiment, a plurality of resistive or other thermoelectric heater elements disposed in the battery system 102 act as the heater 104. The heater 104 is coupled to the battery cells 103. The battery cells 103 can be, for example, nickel metal hydride cells, lithium-ion cells, lead acid cells, or any equivalent electric energy storage device.

Although the description is described with respect to the heating of battery cells it will be appreciated that it could also be applied to other electrical storage devices such as ultra-capacitors.

The heater system 100 also includes a converter 108. In the example shown in Figure 1, the converter 108 is an AC/DC converter that converts an AC voltage output from an external AC power source 110 to a lower level DC voltage

output. The AC power source 110 can be, for example, power from a wall outlet in a garage. A connector 112, such as a conventional three-pronged plug, connects the battery heater system 100 to the AC power source 110. The output of the AC/DC converter 108 or a suitable control signal may also be sent to a controller 114 that controls operation of the heater 104 via one or more switches 116, such as relays, mechanical switches, field effect transistors, etc. In one embodiment, the controller 114 also receives signals indicating a battery temperature, a key on/off condition (e.g., whether a key is in the vehicle ignition), and an AC/DC active signal as inputs and controls operation of the switch 116 based on these inputs.

Alternatively, the controller 114 may be powered by, for example, a separate low-voltage battery 120 or other alternative power source. The low-voltage battery 120 may be, for example, a conventional accessory battery having a nominal voltage output of approximately 10V-15V. If the controller 114 is powered by the low-voltage battery 120, the controller 114 can monitor the temperature of the battery system 102 even when the battery heater system 100 is not connected to the AC power source 110. The controller 114 preferably draws a very small current during operation (e.g., on the order of less than 1 mA). Moreover, by intermittently placing the controller 114 into a sleep mode where it draws minimal current, as will be described in greater below, the controller 114 avoids draining the low-voltage battery 120. The components of the heater system 100 may be connected together via any connection structure, such as an electrical harness (not shown).

In the example shown in Figure 1, the controller 114 and the switches 116 are disposed in the battery system 102, while the AC/DC converter 108 may be placed at any location in the vehicle outside the battery system 102. The AC/DC

converter 108 tends to be an expensive component and by placing the AC/DC converter 108 outside of the battery system 102, the battery heater system 100 can be marketed as a separate component as part of a vehicle heating package and can be omitted in vehicles that do not require cold weather assistance.

Note that, as shown in Fig.2, other components in the system (e.g., the controller 114 and/or the switch 116) may be placed outside the battery system 102 as well, if desired, to further enhance modularity by placing these components only in vehicles that require it. Figure 2 illustrates another embodiment of the battery heater system 100 where the AC/DC converter 108, the switch 116 and the controller 114 are all disposed outside the battery system 102.

By placing the AC/DC converter 108 outside the battery system 102 (e.g., near a vehicle engine) only low voltage DC electrical lines as opposed to high voltage AC lines need to be passed through a passenger compartment of the vehicle thereby eliminating possible safety concerns.

Keeping the AC/DC converter 108 separate from the battery system 102 also makes UL certification simpler because certification is needed only for the AC/DC converter 108, as opposed to the entire battery system 102 if the AC/DC converter 108 were included within the battery system 102.

Connecting the battery heater system 100 to the AC power source 110 allows the battery system 102 to be heated for an unlimited time period as long as the connection lasts. This creates a distinct advantage over self-powered battery heaters, which can heat the battery only for a finite time period. Also, the unlimited nature of the AC

power source 110 allows the battery system 102 to be heated to a higher temperature without risking power supply drainage, making it possible to maintain the battery temperature to a level that allows the vehicle to start. In
5 another embodiment, the temperature level may be selected to ensure optimum battery performance.

Note that if a supplemental battery is used as the external power source instead of an AC source then the
10 converter 108 may be a DC/DC converter to change the voltage.

Figure 3 illustrates the battery heater system 100 coupled with an engine block heater 200. In extremely cold
15 regions, vehicles are typically equipped with the engine block heater 200 to keep an engine in good working condition in cold climates. Like the inventive battery heater system 100, the engine block heater 200 is designed to be connected to the AC power source 110. The modular design of the
20 inventive battery heater system 100 allows it to be easily coupled to the engine block heater 200.

As shown in Figure 3, both the battery heater system 100 and the engine block heater 200 may be connected to the
25 same AC power source 110 through a single connector 112 (e.g., a single plug) as opposed to two separate connectors. The single connector 112 is appropriate because the battery heater system 100 and the engine block heater 200 are usually both needed at the same time in extremely cold
30 climates. This streamlines the vehicle heating package 202 and simplifies connection of the battery heater system 100 and the engine block heater 200 to the AC power source 110. The battery heater system 100 and the engine block heater 200 may be offered together as a modular vehicle heating
35 package 202.

Figure 4 is a flow diagram illustrating a control process 250 used by the controller 114 to control the battery temperature according to one embodiment of the invention. As noted above, the controller 114 may receive
5 inputs corresponding to battery temperature and a key on/off condition. The controller 114 also checks whether it is receiving the AC/DC active signal to determine whether the battery heater system 100 is connected to the AC power source 110.

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In the illustrated control process 250, the controller 114 assumes that the vehicle key is not in a vehicle ignition; that is, the vehicle is in a key-off condition (block 252). The controller 114 then checks whether it is
15 receiving the AC/DC active signal (block 254). If not, the controller 114 assumes that the battery heater system 100 is not connected to the AC power source 110 (block 255) and therefore maintains the heater 104 in an OFF condition (block 256). The controller 114 then enters a sleep mode
20 during which it is inactive. The sleep mode may, for example, reduce the current draw of the controller 114 (block 258). During this sleep mode the controller 114 waits for a selected period of time (e.g., 2 hours block 260) before waking up (block 262). Note that it may be possible
25 to operate the heater when the vehicle is in a key-on condition, provided the battery heater system 100 is connected to the AC power source 110.

If the controller 114 is receiving the AC/DC active
30 signal (block 254), it knows that the battery heater system 100 is connected to the AC power source 110 (block 263). The controller 114 then checks the battery temperature (block 264) to determine whether the battery temperature is less than a selected temperature threshold (block 265). As noted
35 above, the temperature threshold is selected to ensure that

the vehicle will start and/or ensure optimum vehicle performance.

5 If the battery temperature is at or greater than the temperature threshold, the controller 114 switches the heater 104 to the OFF condition if it is turned on or leaves the heater 104 in the OFF condition if it is already turned off (block 256). The controller 114 then enters the sleep mode (block 258) as described above, checking the battery
10 temperature again when it wakes up after the selected time period.

If the battery temperature is less than the temperature threshold (block 265), it indicates that the battery system
15 102 needs to be heated to reach its desired temperature. The controller 114 then turns on the switch 116 to connect the heater 104 to the AC power source 110 (block 268). At this point, the heater 104 is in the ON condition (block
20 270).

The controller 114 then enters a sleep mode (block 272). In this example, the amount of current sent to the heater 102 is low enough so that the heater 104 can remain turned on during the sleep mode without any danger of
25 overheating. Alternatively, the controller 114 may turn the switch 116 on only for a predetermined period of time before turning it off again, without waiting for the controller 114 to wake up out of sleep mode. Note that if the controller 114 is powered by the AC power source 110 rather than the
30 low-voltage battery 120, the controller 114 can monitor the battery temperature 114 continuously rather than only during periodic wake-ups, further optimizing the battery system 102 power without risking overheating.

35 In the example shown in Figure 4, the controller 114 remains in sleep mode for the selected time period (e.g., 2

hours block 274). The controller 114 then wakes up (block 276) and checks whether it is receiving the AC/DC active signal (block 277). If not, it re-enters the sleep mode (block 272). If the controller 114 is receiving the AC/DC
5 active signal, indicating that the battery heater system 100 is connected to the AC power source 110, the controller 114 then measures the battery temperature (block 278). If the battery temperature is at or below the desired temperature threshold (block 280), the controller 114 re-enters the
10 sleep mode (block 272) with the switch 116 closed, thereby allowing current to continue passing through the heater 104 and keep the heater 104 in the ON condition. Of course, if the controller 114 is no longer receiving the AC/DC signal at this stage, the controller 114 opens the switch 116 to
15 switch the heater 104 to an OFF condition.

If the battery temperature is above the temperature threshold (block 278), it indicates that the battery system 102 is at or above the desired optimum temperature, making
20 it unnecessary to continue operating the heater 104. The controller 114 therefore opens the switch 116 to disconnect the heater 104 from the AC power source 110 (block 282) and place the heater 104 in an OFF condition (block 256). The controller 114 then enters the sleep mode (block 258) as
25 described above and delays for the selected time period before waking up to check the battery temperature again.

The inventive battery heater system therefore maintains a desired battery temperature indefinitely by connecting the
30 battery heater to an AC power source rather than relying on its own internal power source. Using the AC power source also allows the battery heater system to work in conjunction with an engine block heater and be powered through the engine block heater's connection to the power source,
35 eliminating the need for separate power source connections. The modularity of the inventive battery heater system also

allows it to be included or omitted from a given vehicle easily.

Therefore in summary, the invention is generally
5 directed to a battery heater system that can be connected to
an external power source to maintain a proper temperature of
a high-voltage battery so long as the system remains
connected to the external power source. The external power
source can be, for example, a separate low-voltage battery
10 or a power source such as an AC supply outside the vehicle
itself. The battery temperature can be maintained at a
level that ensures optimal battery performance as well as a
minimum level that ensures the vehicle will start in any
climate.

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It will be appreciated by those skilled in the art that
although the invention has been described by way of example
with reference to one or more embodiments it is not limited
to the disclosed embodiments and that modifications to the
20 disclosed embodiments or alternative embodiments could be
constructed without departing from the scope of the
invention.

CLAIMS

1. A system for heating an electrical storage device in a vehicle wherein the system is connectable to an external power source and comprises a heater coupled to the electrical storage device for heating the electrical storage device, a switch for selectively coupling the external power source to the heater, a controller that receives an input corresponding to a temperature of the electrical storage device and operates the switch based on at least the temperature of the electrical storage device.

2. A system as claimed in claim 1 wherein the heater comprises at least one thermoelectric heating element.

3. A system as claimed in claim 1 or in claim 2 wherein the external power source is an AC power source and wherein the system is connected to the AC power source.

4. A system as claimed in claim 1 or in claim 2 wherein at least one of the switch and the controller is disposed outside the electrical storage device.

5. A system as claimed in any of claims 1 to 4 wherein the controller is further operable to control the switch based on a key on/off condition.

6. A system as claimed in any of claims 1 to 5 wherein the system further comprises an AC/DC converter that is connectable to the AC power source and is operable to power the heater.

7. A system as claimed in claim 7 wherein the controller is further operable to control the switch based on an AC/DC output from the AC/DC converter.

8. A system as claimed in claim 6 or in claim 7 wherein at least one of the AC/DC converter, the switch and the controller are disposed outside the electrical storage device.

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9. A system as claimed in claim 1, wherein the external power source is a supplemental electrical power source disposed in the vehicle.

10 10. A system as claimed in claim 9 further comprising a DC/DC converter that is connectable to the supplemental electrical power source.

15 11. A motor vehicle having an engine block heater and an electrical storage device heater system as claimed in any of claims 1 to 10 wherein the engine block heater and the electrical storage device heater system are jointly connectable to an external power source.

20 12. A method for controlling a system connectable to an external power source used to heat an electrical storage device the method comprising determining whether the system is connected to the external power source and, if it is determined that the system is connected to the external
25 power source switching on a heater to heat the electrical storage device at least when the temperature of the electrical storage device is below a predetermined temperature threshold.

30 13. A method as claimed in claim 12 wherein the method further comprises checking the temperature of the electrical storage device temperature, closing a switch to connect the heater to the external power source if the electrical
35 storage device temperature is below the predetermined temperature threshold and opening the switch to disconnect the heater from the external power source if the electrical

storage device temperature is above the predetermined temperature threshold.

5 14. A method as claimed in claim 13 wherein the step of checking the electrical storage device temperature comprises entering a sleep mode for a predetermined time period and checking the electrical storage device temperature during a wake-up mode.

10 15. A method as claimed in claim 14 wherein the method further comprises re-entering the sleep mode after at least one of the switch closing step and the switch opening step.

15 16. A method as claimed in any of claim 13 to 15 wherein the step of opening the switch is conducted if the system is not connected to the external power source.

20 17. A system for heating an electrical storage device substantially as described herein with reference to the accompanying drawing.

18. A motor vehicle substantially as described herein with reference to the accompanying drawing.

25 19. A method substantially as described herein with reference to the accompanying drawing.



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Application No: GB0514457.1

Examiner: Peter Keefe

Claims searched: All (1-19)

Date of search: 14 September 2005

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

| Category | Relevant to claims | Identity of document and passage or figure of particular relevance |
|----------|------------------------|--|
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| X | 1, 2, 4, 9, 12, 13, 16 | DE 10216906 A1 DYNAMIT NOBEL see abstracts |
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Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^X :



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H1B; H2H

Worldwide search of patent documents classified in the following areas of the IPC⁰⁷

B60L; H01M

The following online and other databases have been used in the preparation of this search report

WPI, EPODOC